(92)
7

REPORT

ON THE SURVEYS

FOR

PROTECTIVE IRRIGATION WORKS

IN THE

DECCAN

BY

H. F. BEALE, Esq., M. Inst. C. E.,
Superintending Engineer,

AND ITS

REVIEW

BY

A. HILL, Esq., C. I. E., M. Inst. C. E.,
Chief Engineer for Irrigation, Bombay.

PRINTED AT THE
BRITISH INDIA PRESS, BYCULLA, BOMBAY.

1909.

D26.231
D9
[illegible]

CONTENTS OF THE VOLUME.

		Pages.
1.	Review by Mr. A. Hill, C.I.E., Chief Engineer for Irrigation	i to iv & 1 to 63
2.	Report by Mr. H. F. Beale, Superintending Engineer	65—68
3.	„ on the Tapti Valley Surveys	69—87
4.	„ „ Godaveri Valley Surveys	89—111
5.	„ „ Mula Valley Surveys	113—128
6.	„ „ Bhima Valley Surveys	129—160
7.	„ „ Krishna Valley Surveys	161—175
8.	„ „ Ghatprabha Right Bank Canal Project—Daddi Storage.	177—206
9.	„ „ „ „ „ „ Surveys	207—337
10.	„ „ Malprabha Valley Surveys	339—347

15598

REPORT ON THE RESULTS OF THE IRRIGATION SURVEY OF THE DECCAN

BY

MR. A. HILL, C. I. E.,

Chief Engineer for Irrigation, Bombay.

INDEX TO THE REPORT

on the Results of the Irrigation Survey of the Deccan,

BY

MR. A. HILL, C.I.E., *Chief Engineer for Irrigation, Bombay.*

PARA.		PAGE.
1	Submits report on the results of the Irrigation Survey of the Deccan ...	1
2	Review divided into two parts	1
	Part I.	
3	Description of Index map	1
4	Table I. of all projects, possible ... ... / Table II. of best projects	2 to 6
5	Method of calculating irrigation possible	6
6	Rates adopted in Table I.	6
7	Rates adopted in Table II, including perennial rate	6 to 7
8	Method of calculating area of irrigation in Table II.	7
9	Method of assessing revenue	7 to 8
10	Period within which revenue may be expected	8
11	Knowledge of the supply of water	8
12	Shows that determination of the cost per acre is a very convenient method of judging the value of a project	8 to 9
13	Miscellaneous profits not included in estimate of revenue	9
14	State of preparation of projects	9
15	The most important of the famine protective works not included in Table II. is the *Kadva Project* in the Nasik District	9
16	Names the rivers on which small productive works are possible	9 to 10
17	No small project to be allowed to interfere with the great protective projects	10
18	Compares the works investigated on the Tapti River with those investigated on the Ghat stream of the Deccan	10 to 11
18 *A*	Successful results due to Mr. Beale	11
	Appendix to Part I.	
	Duty of water	11 to 14
	Part II.	
1	Arrangement of Part II.	15
	Tapti Valley.	
2	Description of Tapti Valley	15 to 16
3	Survey, preliminary, of Tapti Valley	16
	Girna (Tributary of the Tapti).	
4	Selection of site of storage on the Girna	16
5	Nature of foundations	16 to 17
6	Supply available	17
7	Canal alignment	17
8	Instructions for guidance when further survey is ordered	17 to 18
9	Main features of the project recommended	18
10	Probable irrigation and revenue	18

The Panjhra (Tributary of the Tapti).

Para.		Page.
11	No satisfactory project found on the Panjhra River	19

Tapti (Main Stream).

12	Main River Tapti examined	19
13	Hatnur site for storage and perennial crops	19
14	Susti site for an 8-month canal	19 to 20

Aner (Tributary of the Tapti).

15	Aner River	20

General Remarks on Tapti Valley.

16	General results of survey of Tapti Valley	20 to 21
17	Plans to be printed in connection with Tapti storage and Girna Project...	21

Godaveri Valley.

18	Good command obtained in the Godaveri Valley, and Godaveri canals are sanctioned	21
19	All projects practicable in the Godaveri Valley are required for irrigation in the British Territory	21 to 22
20	The Palkhed Project	22
21	The Nasik storage at Gangapur	23
22	The Aundh storage	23
23	The Darna Dam under construction	23
24	The Darna Right Bank Canal Project	23
25	The Pravara Project	24
26	The Mula Project of Ahmednagar	24
27	This project commands excellent land...	24
28	Key to the survey work of the Mula Project	24
29	Description of the Mula Project	24 to 25
30	Storage sites, &c., for this project	25
31	Best arrangement for works for this project	25
32	Plans to be printed	25

Bhima Valley.

33	Physical features of the Bhima Valley	25 to 26

Kukadi Project.

34	Key to the survey work of Kukadi Canal	26
35	Mina water easily delivered into Kukadi	26
36	Ghod water can also be obtained	26 to 27
37	Records of discharge insufficient	27
38	Main features of the Kukadi Canal system practicable	27
39	Separate projects for Ghod, Mina and Kukadi Rivers prepared before importance of Kukadi command was realised	27
39-*A*	Mina Project—Approximate cost	27 to 28
40	Approximate cost of Kukadi Project	28
41-42	Recommendation for preparation of a project when further observations of discharges are available	28 to 29
42-*A*	Reports to be printed as accompaniments	29
42-*B*	Plans to be printed for the Kukadi Project	29

PARA. **Bhima Project.** PAGE.

43 General description of the Bhima Project ... ...29 to 30

44 Recommendation for survey when again undertaken 30

44-*A* **Bhima Tributaries that cannot be used for Protective Irrigation** 31

44-*B* Small Productive Projects seem possible 31

Mutha (Tributary of Bhima).

The Mutha Canal Extension.

44-*C* Mutha Supply well-known for 33 years 31

44-*D* Great protective advantage of the Mutha River only recently ascertained. 31

44-*E* Proposals for storage for the Mutha Extension Project 32

44-*F* Reference to details will be found given in the attached report by the Chief Engineer, Irrigation, and in the preliminary report submitted to the Government of India 32

44-*G* Mutha Extension can relieve tail of the Nira Left Bank Canal 32

Report on the Mutha Extension Project submitted to the Government of India with this Government letter No. W. I,—763, dated 18th March 1909... ... ...32 to 36

Report by the Chief Engineer, Irrigation, on the Mutha Extension Project submitted to Government with Chief Engineer, Irrigation's No. 16, dated 11th January 1909 ... ...37 to 43

Nira River.

The proposed Nira Right Bank Canal and the existing Nira Left Bank Canal.

44-*H* Magnitude and importance of the Nira Project 44

45 Length of Nira Right Bank Canal to be limited to 150 miles 44

46 Storage at Bhatgarh—Lake Whiting 44

47 Storage at Vir Basin 44

48 Nira Right Bank Canal is likely to be productive 45

49 General abstract of projects in the Bhima Valley 45

50 Plans to be printed in connection with the Mina Storage and Bhima Project 45

Krishna Valley.

51 The abundant supply of water of the Krishna cannot be conveyed on to the famine lands 45

52 Physical features of the Krishna Valley ... ... 45 to 46

53 Pumping necessary to get water on to the famine lands 46

54 Head-waters of the Krishna River cannot conveniently be taken into Nira Valley 46

55 Productive works of small command possible on the Krishna River ...46 to 47

56 The best productive work would have storage at Helvak on Koyna ...47 to 48

57 Storage at Dhom on Krishna would probably suit a productive work ... 48

58 Tributaries of the Krishna in the Kolhapur State 48

59 Statement of projects possible in the Krishna Valley 49

60 Reports and plans to be printed 49

Ghatprabha Valley.

61 The whole of the supply of the Ghatprabha can be utilised for irrigation. 49

62 The Gokak Canal on the Left Bank ... ...49 to 50

63 The detailed plans for the Canal to start from the Gokak weir, ready for sanction 50

Ghatprabha Right Bank Project.

64 The Ghatprabha Right Bank Canal. A canal can be taken through the hills by Gokak and command 825,000 acres 50

65 Ghatprabha can use storage for Gokak and additional storage for Gokak can be obtained at Ajra ... .50 to 51

Para.	Ghatprabha Right Bank Project—(*contd.*)	Page.
66	The Markandya supply could be used...	51
66-*A*	Report on the Ghatprabha Project and Chief Engineer's comments and opinions of Revenue Department officers are attached	51
67	Report, plans and estimates to be printed	51
	Note by the Chief Engineer, Irrigation, on the Preliminary Report on the Ghatprabha Right Bank Canal	...51 to 55
	Report by the Chief Engineer on the same subject	...55 to 57
	Letter from the Collector of Belgaum, No. 9496, dated 30th November 1908	57
	Letter from the Collector of Bijapur, No. 1045, dated 26th February 1909	...57 to 58
	Letter from the Commissioner, Southern Division, No. 791, dated 10th March 1909	58
	Malprabha Valley.	
68	Physical features of the Malprabha Valley	59
69	Command of Canal on the Right Bank (south) can be obtained ...	...59 to 60
	Tungabhadra Valley.	
70	Northern tributaries not reliable	60
71	The Wardha is the first reliable stream	60
72	Madag Tank on the Kumudvati River	...60 to 61
73	Best command on the left or northern bank	61
	Gujerat.	
74	Information in connection with Gujerat is scanty	61
75	Mahi River offers the best means of Irrigation in Gujerat	61
76	Another river that may be useful is the Sabarmati River	62
77	Smaller streams	62
78	A contour survey of the low lands of Gujerat is required	62
79	The Index map 8 miles to the inch to be corrected to agree with this Report	62

REPORT ON THE RESULTS OF THE IRRIGATION SURVEY OF THE DECCAN,

BY

Mr. A. HILL, C.I.E.,

Chief Engineer Irrigation, Bombay.

1. I have the honour to submit, as Chief Engineer for Irrigation, a general report on the results of the surveys which have been undertaken on the recommendation of the Irrigation Commission to ascertain what Protective Irrigation Works were possible in the Bombay Presidency.

These preliminary surveys are now completed, and the special office maintained for the work is closed and the staff dispersed, and Mr. Beale, the Superintending Engineer, who had charge of these works, has sent in his reports.

2. I have divided my review of these reports into two parts; the first part containing a statement, Table I, of the irrigation works found possible and a more detailed statement, Table II, of the Protective Irrigation Works, which have been proved to be the best; and the second part containing my comments as Chief Engineer on the results obtained, and describing the main facts brought out by the surveys, and indicating how the surveys should be resumed when the time comes to undertake them in detail, and recording the leading features and noting where the working papers and plans are recorded. Briefly, the second part of my review is to prevent the loss of the valuable work that has been done, and the first part is to give Government concisely a correct view of the results obtained.

Review divided into two parts.

PART I

3. In 1905, I submitted a general report on the Protective Irrigation Works of the Deccan, accompanied by a map illustrating the reliable rainfall area, the famine area and the Irrigation Projects as then proposed. This map of 8 miles to the inch is corrected and brought up to date; the reliable rainfall on the western ghats is indicated by contour lines, with the rainfall in inches per annum marked on them. These contours are for reliable rain only and no contours of rainfall are shown in the famine area. This famine area is indicated by dark colour on the map, the darker the colour the more liable to famine is the area.

Map 8 miles to the inch.

Existing and sanctioned irrigation works are indicated in blue, and those which have been shown to be practicable by the Protective Surveys, in red.

TABLE I.

Tabular Statement of Irrigation Projects possible on the Ghat-fed Rivers of the Bombay Presidency.

Item of this Table.	Number of Project.	Number of years the water-supply has been observed.	Name of Project.	Site of Storage Tank.	Normal supply. M. Cft.	Storage proposed. M. Cft.	Length of Canal.	Size of Canal. Cusecs.	Gross area commanded. Acres.	Possible irrigation monsoon, Rabi and eight months only at 15 acres per m. cft. stored.	Gross Revenue Rs. 4 per acre. Average Lakhs.	Working Expenses Re. 1 per acre. Average Lakhs.	Net Revenue. Lakhs.	Estimated Capital Cost. Lakhs.	Percentage of Net Revenue on Capital.	Remarks.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
							Tapti Valley.									
1	...	...	Aner	Not selected ...		Unreliable.			200,000	...	...	...	...	Not estimated.		.....
2	24	...	Tapti	Hatnur ...	Over 100,000	25,000	90	1,200	200,000	*	...	...	15·6	Not estimated.		* 60,000 acres perennial.
3	24	...	Tapti	Susti	Over 100,000	4,000	100	600	200,000	150,000 †	6	1·5	4·5	Not estimated.		† Will be mainly supplied from riverflow.
4	23	34	Girna... ...	Panjhan ...	Over 32,000	26,000	100	1,000	300,000	...	~~12·01·2~~ ‡	2·6 ‡	9·4 ‡	180 ‡	5·21 ‡	‡ For details, see Table II.
							Godaveri Valley.									
5	25	15	Kadva ...	Palkhed ...	Over 15,000	9,000	80	400	234,000	135,000	5·4	1·35	4·05	196	2·06	.....
			Do. ..	Do. ...	...	15,000	...	...	...	225,000		Not estimated.		...	...	... ..
6	1 and 2	5	Nasik Canal ..	Gangapur ...	Over 10,000	7,000	24	...	22,400	§	...	Do.		65	...	§ Perennial and additional supply to Godaveri Canal and Nasik Water-Supply.
7	2	6	Aundh ...	Mukne ...	Over 7,000	5,000	Would be required for additional storage for Godaveri Canals.								...	.....
8	2	...	Godaveri Canal.	Darna Dam ...	...	8,818	...	...	...	Under construction.			...	...	...	.....
9	3	5	Darna Right Bank Canal.	Pimpalgaon Dokra.	Over 3,500	3,500	47	140	53,000	52,500	2·1	·53	1·57	36·5	4·3	
0	4	30	Pravara Project.	Bhandardara...	...	8,600	...	...	...	Under construction.			...	...	...	.....
1	5	8	Mula Project, Ahmednagar.	Chas and Mandvi.	Over 30,000	15,000	59	1,000	271,000	225,000	9	2·25	6·75	162·5	4·1	
			Alternative.		...	20,000	...	...		200,000		Not estimated.		...	...	

							Bhima Valley.											
		7	Kukari ...	Sakora on the Ghod.	Over 50,000	20,000	...	...	580,000	300,000	12	3	9	311	2·9 ¶	¶ Shows a return of 3·11 when estimated in detail.
13	7	6	Mina	Wadgaon ...	Over 5,000	5,000	28	200	75,000	75,000	3	0·75	2·25	74	3·0	
14	9	4	Bhima ...	.....	...	...	...	...	170,000	...	...	...	...	...	...	
15	...	...	Bhama ...	.....	Over 5,000	5,000	Small productive works are probably practicable on these Ghat-streams, but the canals will not reach the Famine Districts.									
16	...	...	Indrayani ...	.....	5,000	5,000										
17	...	...	Pauna ...	.....	5,000	5,000										
18	...	...	The Mula of Poona District.	.....	5,000	5,000										
19	10	30	Mutha Canal Extension.	Lake Fife ...	Over 30,000	22,000	150	1,000	340,000	...	12*	2·5*	7·6*	175*	4·32*	*For details, see Table II.
20	11	30	Nira Left and Right Bank Canals.	Lake Whiting Vir Basin.	Over 60,000	35,000	150	500 1,500	1,000,000	...	*2·3	*5·1 †2·0	*15·9	*310	*5·15	* Do. do. † Previous Revenue deducted.
							Krishna Valley.									
21	...	3	Krishna ...	Dhom... ...	20,000	10,000	...	...	Over 50,000	Not estimated; will probably be productive, but will not reach Famine Districts.						
22	12	8	Koyna ...	Helwak ...	Over 100,000	15,000	105	...	150,000	Not estimated; will probably be a productive work, but barely reaches the Famine Districts.						
23	...	...	Warna ...	.....	Over 15,000	15,000	The Warna is the boundary line between British and Kolhapur, and the others of these streams lie in Kolhapur Territory. The supply is abundant but cannot be delivered on to the Famine Lands. The Maharaja of Kolhapur is constructing the project on the Bhogava.									
24	...	...	Kasari ...	.....	10,000	10,000										
25	...	...	Bhogava ...	.....	6,000	6,000										
26	...	...	Dudganga ...	.....	10,000	10,000										
27	...	...	Vedganga ...													
							The Ghatprabha (Tributary of Krishna).									
28	13	23	The Gokak Canal	Daddi ...	.....	18,000	84	1,100	497,000	...	11·5 †	2·5 † 0·5‡	8·5 †	179†	4·75 †	†For details, see Table II. ‡Previous Revenue.
29	14	23	The Ghatprabha Right Bank Canal.	Daddi ...	Over 100,000	27,400	140	1,500	560,000	...	13·7§	3·2§	10·5§	221§	4·76§	§For details, see Table II.
							The Malprabha (Tributary of Krishna).									
30	15	3	Malprabha ...	Asoka ...	Over 30,000	20,000	150	...	200,000	Not estimated; probably a productive work, but does not reach famine lands.						
							The Tunghabudra Valley.									
31	...	...	Wardha ...	.....	Not Surveyed											
32		26	Kumudvati ...	Madag Tank ...	Over 10,000	Not sur										

TABL

Tabular Statement of the Best Protective Irrigatio

Name of Project.	Number of years the discharge of the River has been observed.	Normal supply or quantity available in the majority of years.	Storage proposed by the Chief Engineer.	Names of Tanks.	Gross area Commanded.	Area it is proposed to supply.	Maximum length of Canal from Head Regulator to Head of tail distributary.	Proposed size of main Canal.	Area of crops which can be irrigated in normal years	
									Monsoon, Rabi and eight months.	Perennial.
2	3	4	5	6	7	8	9	10	11	12
		m. cft.	m. cft.	Lake	Acres.	Acres.	Miles.	Cusec.	Acres.	Acres.
Nira Left Bank Canal.	30	over 60,000	25,000	Whiting.	300,000	300,000	100	500	56,250	12,50
Nira Right Bank Canal.			10,000	Vir Basin.	700,000	700,000	150	1,500	202,500	30,00
			Total 35,000						Total 258,750	42,50
Gokak Canal ...	23	over 100,000	2,000	Dhupdal	497,000	497,000	84	1,100	108,000	24,00
			18,000							
Ghatprabha Right Bank Canal.			27,400	Daddi.	560,000	560,000	140	1,500	214,090	17,16
			18,000	Ajra ?* [see remarks].	255,000	.....	180			
			Total 47,400, excluding Ajra storage.							
Mutha Canal Extension.	30	over 40,000	22,000	Lake Fife.	340,000	340,000	150	1,000	101,700	25,08
Girna	34	over 32,000	26,000	Panjhan.	430,000	300,000	100 including length of branch.	1,000	112,500	25,00
Mula Canal in Ahmednagar.	7	over 30,000	20,000	Chas and Mandvi.	300,000	271,000	59	800	108,000	20,00
Kukari	6	over 50,000	20,000	On the Ghod River at Sakora.	580,750 for 160 miles.	580,750	160	Kukadi 1,200	270,000	*Nil.*
								Ghod 200	22,500	5,00
									Total. 292,500	
			10,000 to 20,000 ?	On the Kukadi ?	1,600,000 for 250 miles.	*See note in the col. of remarks.				
Bhima	3	over 18,000 ?	15,000	Karda.	170,000	170,000	115	600	45,000	20,00
					Total...	3,718,750	...		1,240,540	178,74
									Total mixed irrigation.	1,419,28

Note.—Assuming that 8 acres of cereal crops can be grown for 1 of pere... ther

II.

Projects in the Deccan, arranged in order of Excellence.

Area to which perennial must be reduced in worst years.	Gross Revenue.			Working Expenses.			Revenue of the existing works to be deducted.	Net revenue expected.	Rough estimate of works proposed.	Percentage of net revenue on capital.
	Monsoon, Rabi and eight months to 3 rupee base = average Rs. 4 per acre.	Perennial Rs. 30 per acre.	Total.	Monsoon, Rabi and eight months—average Re. 1 per acre.	Perennial, Rs. 6 per acre.	Total.				
13	14	15	16	17	18	19	20	21	22	23
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Lakhs of Rs.	
No reduction necessary.	10,35,000	12,75,000	23,10,000	2,58,750	2,55,000	5,13,750	1,99,412	15,96,878	310	5·15
No reduction.	4,32,000	7,20,000	11,52,000	1,08,000	1,44,000	2,52,000	48,000	8,52,000	179	4·75
8,000 ?	8,56,360	5,14,800	13,71,160	2,14,090	1,02,960	3,17,050	*Nil.*	10,54,110	221?	4·76
13,440	4,06,800	7,52,400	11,59,200	1,01,700	1,50,480	2,52,180	1,50,400	7,56,620	175	† 4·32
10,000	4,50,000	7,50,000	12,00,000	1,12,500	1,50,000	2,62,500	*Nil.*	9,37,500	180	5·21
No reduction.	4,32,000	6,00,000	10,32,000	1,08,000	1,20,000	2,28,000	*Nil.*	8,04,000	175	4·59
No reduction.	11,70,000	1,50,000	13,20,000	2,92,500	30,000	3,22,500	*Nil.*	9,97,500	311	3·20
10,000	1,80,000	6,00,000	7,80,000	45,000	1,20,000	1,65,000	*Nil.*	6,15,000	120 Not estimated.	5·00

† perennial were grown, it would be possible to irrigate 26,70,460 acres altogether.

General tables of rojects, Tables I and II.

4. In Table I, I have prepared a general statement of all the irrigation works proved possible, arranged in geographical order from north to south of the Presidency. The list is considerably onger than the one given in para. 23 of my report of 1905, and includes all the ivers rising in the Western Ghats. Items numbers 4, 11, 12, 14, 19, 20, 28, nd 29 of the list are the best protective works, and a separate Table II has been repared giving more detailed information regarding them.

Method of calculating irrigation possible.

5. For the purpose of general comparison of these works in Table I, the irrigation possible has been calculated at the rate of 15 acres per million cubic feet of water for which storage is provided. In my previous report the irrigation possible was calculated at the rate of 10 acres per million cubic feet of water, and as the water which can be utilised by a canal during the monsoon rains when the river is flowing is usually about half the quantity for which storage is provided, the two methods give almost precisely the same results.

The method now adopted, or 15 acres per million cubic feet of storage, is, however, more convenient and the more detailed information obtained regarding the discharges of the river since 1905 admits of it being adopted.

The areas of irrigation thus obtained are well within the areas which have been obtained regularly on our Deccan canals, details of the areas possible or the duty of water are given in the Appendix to Part I of my report, but I note here that during the rain or cold weather season of 1908–09, the Commissioner of the Central Division specially requested that all endeavours should be made to give one watering to as many rabi or cold weather cereal crops as possible, for even one watering only would be sufficient to produce a valuable crop, and without this watering the crops would fail completely.

This condition recurs repeatedly in the Deccan and the average duties assumed in this review are far below those possible in these conditions.

Rates adopted in Table I.

6. The rates in Table I are based on the existing rates actually being realised on many canals in the Deccan, namely, Rs. 2 only per acre for monsoon, Rs. 4 for rabi and Rs. 6 for eight months' crops, which last through the above two seasons. This comes to an average of Rs. 4 per acre, but the rate is precisely the same as the Rs. 3 per acre for four months' crops adopted in the report of 1905.

Similarly, the rate for working expenses of Re. 1 per acre for the average of the three classes of irrigation is identical with the rate of As. 12 for working expenses for four months' crops only.

The rates are admittedly low, and in several cases in the Deccan, higher rates are already obtained, and as every increase above that entered means an increase of net profits, it will be at once apparent that an increase of one rupee only or a basis of Rs. 4 per four months' crop, instead of Rs. 3, would make many of these works productive by water rates alone.

Rates adopted in Table II, including perennial rate.

7. The best protective works are dealt with in Table II. The rate adopted in Table II for monsoon, rabi, and eight months' crops are the same as those used for Table I, namely, Rs. 2, 4 & 6, or a basis of Rs. 3 for four months' crops equal to Rs. 4 per average acre irrigated of these three classes, and for perennial crops, the rate actually obtained on the Mutha and Nira canals, Rs. 30 per acre is adopted; it is much below the value of the water and considerably more revenue could be obtained if the water were utilised for cereal crops at the low rate of three rupee basis just quoted, and a higher rate than Rs. 30 might fairly be charged for sugarcane, which is the chief perennial crop in the Deccan. The works in Table II, with the exception of the Kukari, have such excellent supplies of water that some perennial irrigation is necessary in order to utilise it on the areas to which the canals are limited, and the figures given for peren-

The area served by Nira Right Bank Canal extends further to the East than in any other project and includes the very worst famine tracts of the Deccan. Full preliminary surveys have been made and approved by the Government of India and detailed plans and accurate estimates are under preparation.

The Gokak Canal has been generally approved by the Government of India and detailed plans and estimates have been prepared. For the Ghatprabha Right Bank Canal, a very good and thorough preliminary survey and estimate have been made. The Daddi Tank is to be raised to supply the Canal.

* If more storage is required for perennial then it can be obtained at Ajra and given to Gokak Canal and the Ghatprabha can then take all the Daddi storage.

† On account of the favourable position of this work slightly higher rates were taken in the detailed estimate and a net revenue of Rs. 9,68,400 was shown to be practicable.

Preliminary surveys have been made, but no detailed estimates are yet prepared.

Very thorough survey has been carried out, a good deal of detailed estimating made. The discharges of the river have not been observed long enough.

The discharge of the river has not been observed for a sufficiently long enough period to frame suitable designs for this great project.

*If instead of storing 20,000 millions only it be found possible to store 30,000 or 40,000, the project will be greatly improved.

Note.—The area supplied by this project lies more to the west than any of the other in the statement, and is not so much exposed to famine, but still it is within famine limits and the large volume of water available in proportion to area commanded renders high-class perennial irrigation possible as in a productive work. There is no doubt the supply will be equal to the volume stated.

nial irrigation in the Table are the maximum area of perennial that can be safely or conveniently supplied by the canal. On some of the canals, this area must be reduced in the one year in thirty that has the worst supply on record, but the area has been chosen so that this reduction can be made without undue loss to the cultivators.

In the Deccan, sugarcane is grown for two years, and hence, when a canal is of long standing and in working order, about half the cane in the ground is being replaced every year, so that when the one bad year in thirty comes it will merely be necessary to cease planting cane for that year and to limit the irrigation to the half of the usual area.

In working a canal growing sugarcane in the Deccan, it is necessary to provide for the new crop being planted overlapping the old crop being cut, and when working out calculation for a canal in detail, this overlapping is now provided for, but in Table II the detail is not shown, and hence, some of the irrigation shown in column 14 for rabi irrigation will have to be given up to the overlapping of cane.

A water rate is charged for the overlapping period, which is equivalent to the rates for the rabi crops lost, and so the omission to enter into this detail does not affect the revenue in Table II, but it has a slight effect on the area, and the area of irrigation will be less than that shown in the Table by about $\frac{1}{4}$ of the area shown for perennial crops.

Method of calculating area of irrigation, Table II.

8. These areas of irrigation in Table II are calculated after making due allowance for losses on the assumption that the canals will be constructed to distribute the water in the manner recommended by the Government of India and accepted by the Government of Bombay, namely, that the water should be distributed equally over the area to be served and that each cultivator should be allowed to grow what he likes with the water supplied to him.

It follows that any cultivator can grow a crop of sugarcane if he likes for as large an area as the water allotted to him will supply, and as at the commencement of each season the cultivators can be informed of the supply of water in the storage tank and the minimum volume that will be available in the hot weather, there should be no risk in growing sugarcane if in each sugarcane field there is a well to use, if necessary, for a few weeks in the hot weather. It will be entirely the cultivators' fault if larger area of cane are grown than can be supplied.

Method of assessing revenue.

9. The revenue that can be obtained is based on the assumption that cultivators will be allowed to pay for and reserve the right to have the water evenly distributed in the manner recommended by the Governments of India and Bombay. The Government of Bombay are gradually introducing this method into their Deccan works. There are many advocates for a distribution of water with a regular rate called a consolidated rate on the land to include both land and water revenue. The objection to such a consolidated rate is that until the capabilities of the canal both for volume of water and for efficient distribution are proved, the consolidated rate may be unfair and may even be levied on land which has no crop at all.

I have, as Chief Engineer, pointed out that this difficulty can be avoided if rates are charged only on the areas of crops grown and matured.

Wherever one of these great Protective Irrigation Works is introduced into the Deccan, the cultivation on the land supplied by the canals is changed from precarious cultivation dependent on insufficient rain to assured cultivation in which the highest and best methods can be employed with the certainty of a crop being obtained if the cultivator has paid for and reserved the right to a supply of water for the canal. Whether his crop is then grown on canal water only, on canal water and rainfall combined, or on rainfall alone, is a detail that is immaterial; in all years he will have much the same excellence of crop, and hence, the cultivator should pay on the area of crops grown in his land. He will always have a crop wherewith to pay the rate, for it is the basis of the method that rates are paid only on crops matured.

Now this method advocated by me as Chief Engineer is the method in force in Sind.

It involves the annual measurement of the crops grown, and this is objectionable, but I explain that after a sufficient number of years' experience, a consolidated rate can be easily introduced with perfect fairness and accuracy. With the knowledge gained, there will be none of the objections to a consolidated rate that exist when it is proposed for a new canal of unknown capabilities.

When measuring up the crops it will be necessary to divide them into the classes monsoon, rabi, eight months and perennial, and monsoon and rabi may be considered equal units, but an eight-month crop must be considered as two units and a perennial crop must be considered as equal to at least eight units made up of three units for monsoon season, three units for rabi season and two units for the hot weather. A perennial crop in the condition of the Deccan rainfall really replaces far more than 8 units, and 15 units is nearer the actual difference, and so perennial must not be given a less value than 8 units and right should be reserved to increase the proportion.

Period within which revenue may be expected.

10. If the method I have recommended as Chief Engineer be adopted, then, the full final estimate revenue will be obtained on the first year, of deficient rainfall or probably within 5 years of the completion of the canals and their system of distribution; for it is not at all necessary to wait for the development of perennial irrigation to obtain the revenue, but the widespread area of cereal crops will at once bring in the revenue.

On all the existing Deccan canals, in times when crops are failing and withering for want of water, cultivators would gladly enter into agreements of the kind described and the revenue and irrigation will be at once obtained.

Perennial irrigation can then be carried on and extended as the cultivators wish, but each man will then realise that he must give up his own cereal crops for his perennial.

Knowledge of the supply of water.

11. In column 3 of Table II the number of years the water-supply has been under close observation is given and for the four great systems placed at the head of the table, the supplies have been observed from 23 to 34 years, in all cases including the worst famine years known. The best size for these projects can therefore be determined.

For the remaining three projects in Table II, the water-supply for the Mula Canal in Ahmednagar and the Kukari have not been observed for a sufficient number of years, and the years in which the results have been recorded seem to have been ones of very deficient rainfall. And it is desirable to have a longer series before finally fixing the size of the projects, for they serve very bad famine tracts and should provide for as much irrigation as possible. As the projects for which reliable information is available are certainly better than these and will probably be constructed first, there is good reason for delaying the design for these two projects. The last project on the list, the Bhima, is smaller than the others and the supply is known to be ample, though it has not been measured for many years.

Cost per acre.

12. A very convenient method of judging the value of a project is the cost per acre.

The gross cost of the projects, including establishment, tools and plant, and all charges for these works in Table II, is 1,671 lakhs of rupees.

The gross area it is proposed to supply is 37 lakhs of acres. The area of crops that could be irrigated, if perennial were not grown, is 26·70 lakhs of acres, or a little more than two-thirds of the gross area. The area of perennial crops that can be grown is 1·78 lakh or about one acre of perennial for every 20 acres of gross area.

And the area to which irrigation must be reduced if the full amount of perennial practicable is grown is 14 lakhs or 38 per cent. (a little more than one-third) of the gross area. These are practicable and suitable proportions and the value or land would certainly increase by from Rs. 50 to Rs. 100 per acre of gross command, whilst the cost of the work is Rs. 45·2 only per acre of gross command or Rs. 63 per acre irrigable if perennial crops are not grown. When perennial crops are grown to the full extent practicable, there would be one acre of perennial to seven acres of other crops and the cost per acre for such mixed irrigation is less than 120 rupees. The works, therefore, promise to be productive if suitable means be found to enable the canals to obtain a moderate share of the profits they make possible.

Miscellaneous profits not included in estimate of revenue.

13. For the Nira and the Girna, the revenue is estimated in Table II at over 5 per cent., and for all the others, excepting the Kukari, at over 4½ per cent. This is for water rates only at a basis of Rs. 3 per acre only for four months' crops and Rs. 30 for perennial. These rates are low and a slight increase would at once make the works very paying projects. Also, no credit is taken for the reduction in famine expenditure or for the general increase in the returns from other rates and taxes which accompany an increase of prosperity. In particular, no credit is taken for any increase in the profits to the Railways through the great increase in traffic which will occur.

State of preparation of the projects.

14. The plans and estimates for the Gokak Left Bank Canal are prepared and ready for sanction and the plans and estimate in detail for the Nira Canal Project are in preparation.

These two works are the next it is proposed to undertake.

The Mutha Canal Extension is, however, so promising a project and has such high protective value that it may very probably be justifiable to start this as a productive work, and I recommend that detailed plans and estimates for this be also prepared. Preliminary survey and plans and estimates have been made for the Mutha Canal Extension and also for the Ghatprabha Right Bank Canal.

For the Ghatprabha Right Bank Canal, if the Gokak Left Bank Canal be sanctioned, the preparation of detailed plans and estimates might be postponed until the Left Bank Canal has been commenced, but they should certainly be undertaken soon after as the plans will take two or more years to prepare efficiently.

For the Girna project, about two years will also be required for preparation of plans, and they may be taken up in their turn. A rapid preliminary survey of this work has been made.

The most important of the protective works not included in Table II.

15. Of the works not dealt with in Table II., the most important as a famine protective work is the Kadva, with a storage somewhere near the existing Palkhed weir and a canal on the Left Bank of the Godaveri in the Nasik District. The drawback is the high cost of storage and the want of sufficient information of the actual supply available. The latter is being remedied, and it is quite possible a better storage site may be found, but as the Godaveri Canals are already under construction in the neighbourhood, there is no need for taking up fresh investigation for some years.

At present, the Godaveri Canal and the Pravara Project, which together will form a compact system of irrigation commanding 460,000 acres with storage of 17,000 millions, are sanctioned and under construction.

Rivers on which small Productive Works are possible.

16. One of the results of this general survey for protective irrigation works is to show clearly which rivers cannot be utilised for Famine protection, and on these, small productive schemes seem possible, but have not been surveyed as the survey work has been limited to projects for protective irrigation. The most important of the productive works possible are items 22, 21 and 30 of Table I, on the Koyna River at

Helvak for the extension of the present Krishna Canal and for a canal on the Right Bank of the Koyna, for the Krishna at Dhom to irrigate the Krishna valley between Wai and Satara, and on the Malprabha at Asoka to irrigate the Right Bank of the Malprabha and probably a portion of Dharwar District.

These seem the best of the productive works and they are all sufficiently near to the famine districts to make the influence of irrigation and prosperity under them felt in the famine districts. No schemes have been worked out in detail.

Item 23. The Warna on the Borders of Kolhapur and Satara is an important river on which a productive work seems possible.

Items 15, 16, 17 and 18. The Ghat streams in the Poona District, namely, the Bhama, Indrayani, Pauna and Mula of Poona District, have all abundant supplies of water and small productive works are probably possible on all and from their geographical positions near Poona and the G. I. P. line to Bombay they are important.

Items 24, 25, 26 and 27. The streams between the Warna and the Ghatprahbha of the Krishna catchment are mainly in Kolhapur territory; productive works are possible on them, but the benefits will be almost entirely in Kolhapur State. The Dudganga and Vedganga, however, might be used to serve part of the British District of Belgaum in the Chikodi Taluka.

None of the waters of these streams can be conveyed by a canal on to the Famine lands, and hence, no projects have been worked up for them, but now that the Irrigation Survey has been completed and it is realised that these waters cannot be conducted to the Famine lands, there is no objection to the preparation of projects for high-class irrigation which would be productive.

The storage will be large in proportion to the areas commanded, the canals short and the proportion of perennial to gross area as high as practicable, probably one-third of the area.

No small project should be allowed to interfere with the great Protective projects.

17. If small perennial canals are desired, they should therefore be constructed on some of these streams, but no small project should be undertaken on any of the great protective works entered in Table II.

It is of the utmost importance to the Deccan that the whole of the water available in normal years for these projects should be utilized and no action should be allowed which will interfere with, or prevent, this being accomplished. In each case the best project must be devised, and when works are started they must be on the lines of the best project.

It is universally admitted that the rates now charged in the Deccan are low, it is certain that the demand for irrigation will increase, and that the great improvement in agriculture that is being developed by the Agricultural Department will render higher water rates practicable, and these works of Table II will be most productive to Government and will bring great increase of prosperity to the tract they serve, and as these tracts are situated in the hearts of the Famine districts of the Deccan, the work will be of wide-spread service in the prevention and mitigation of famine.

18. The works investigated on the Tapti River are of a different class to any of the works on the Ghat stream of the Deccan, for they depend on a river with a great catchment area. It has been proved that a large storage is possible at Hatnur, Item 2 of Table I. But the damage to property and villages seems excessive, and the preliminary work done has not determined the cost of the damage, nor has it settled that Hatnur is the best place for storage. It has, however, been ascertained that storage and command of 180,000 acres on the right bank is possible, and that if the demand for perennial irrigation justifies payment for the damage caused, an unusually large area of perennial could be supplied.

The survey, however, indicates that an 8 month canal would probably be more successful.

The Girna Project in this district is, however, so very much more promising that it is included in Table II as one of the best works, and for the present it will be sufficient to measure and record supplies of water available on the Tapti.

18 (*a*). The results of the complete Irrigation Survey of the Deccan far surpass the anticipations of the Irrigation Commission.

The successful results are due to Mr. Beale.

The success of the operation is almost entirely due to the skill and labour of Mr. Beale, who organized these surveys and collected and trained the staff who executed them under his supervision.

A clear understanding of the irrigation facilities of the whole of the Deccan is now possible. The Irrigation Commission estimated for an area of 5 lakhs of acres of irrigation giving a return of Rs. 2 or Rs. 3 per acre at a cost of Rs. 200 per acre, but it has been demonstrated as explained in Table II and para. 12 that instead of 5 lakhs no less than 26¾ lakhs of the same quality of irrigation can be irrigated at a cost of Rs. 63 per acre on works which promise to be productive at once and that further works at higher cost are possible.

Mr. Beale's reports are printed at page 64.

APPENDIX

to the Review on the Survey for Protective Irrigation Works, Part I.

DUTY OF WATER.

For the proper estimation of the area that can be irrigated by a canal in the Deccan, it is necessary to make a suitable deduction for the loss of water in transit along the main canal and so calculate the discharge available at distributary heads, and then to multiply the discharge at distributary heads by some constant, called "The Duty of Water," which represents the area which can be irrigated by a cubic foot per second.

The variations due to the different lengths of the main canals are thus eliminated.

For Table II and for the estimate of irrigation projects now made, the deduction for losses on the main canal is taken at 8 cusecs per million square foot of wetted perimeter, on the advice of the Inspector-General of Irrigation. For canals of the size dealt with in the review, this amounts very approximately to one-fifth of the discharge at the head. Experiments in the Deccan indicate that the actual loss is considerably less than this, and hence, estimates are on the safe side.

For the duty of water, Mr. Beale, the Superintending Engineer, who carried out these Protective Surveys took a general duty for all kinds of crops deduced from areas irrigated as shown in the Irrigation Administration Reports; but for the proper estimation of the area which can be irrigated, it is essential to separate the perennial irrigation from irrigation of ordinary crops. Also, when using the tables of the Administration Report it must be remembered that the areas of 8 months' crops and perennial are entered in one season only, but are irrigated in both.

Now, during the hot weather in the Deccan, irrigation is almost entirely confined to perennial crops and it is known that the duty of water at the head of the Nira Canal is very approximately 50 acres of perennial for each cubic foot per second at the head of the canal. If, therefore, the area of perennial irrigation be divided by 50, then the result is the discharge used by perennial crop; and if this discharge be deducted from the discharge in the Rabi season, the result is the discharge available for irrigation of ordinary crops; and then, if this deduced discharge be divided into (the area of rabi irrigation, plus the area of 8 months' irrigation), the true area of ordinary crops irrigated by a cusec in the rabi season is obtained.

A statement has been prepared in this manner for the Nira Canal for the ten years ending 1908-09 and is attached. It will be seen that the duty for the last three years of deficient rain was 187 to 200 acres per cusec. In the previous years, less care was taken in the distribution, but the average for the whole 10 years is a duty of 165 acres at the head of the canal. If allowance be made for losses, this average is well over 180 at distributary heads. As duties of 187 and 200 have actually been obtained at the head of the Nira Canal in years of very deficient rainfall, I have thought it quite safe to take 180 as the duty for rabi crops and 60 as the duty for perennial crops at the heads of distributaries.

For the monsoon irrigation, the duties for ordinary crops are considerably higher, as there is more rainfall during the monsoon season, and the air is damper and evaporation less. I have however taken 180 as the duty for ordinary crops in the monsoon season also. The rainfall in the Deccan previous to the Rabi season wets the ground and the rainfall during the Rabi season helps the growth of the crops, and though nearly always insufficient, nevertheless, materially diminishes the supply of water it is necessary to provide by irrigation, and hence, the duty of water for ordinary crops in the Deccan is very much higher than in Sind, where there is practically no rain.

I am therefore adopting for my estimates of irrigation these duties at distributary head:—

For perennial crops 60 acres per cusec.

For ordinary crops in the rabi season, 15th Oct. to 14th February...180 acres per cusec;

For ordinary crops in the Monsoon season, 15th June to 14th October, 180 acres per cusec;

and I recommend that they be generally adopted for all projects in the Deccan. In a year of intense drought, the duties may be a little less, but on the average, they are exceeded.

They show clearly how very much more water is required for perennial crops than for ordinary crops and that nine times the actual volume of water required for an ordinary 4 months' crop is used up by a perennial crop. In addition, the losses due to storing water for the hot weather months must be met, so that a perennial crop actually requires the provision of ten times the water an ordinary 4 months' crop wants.

Moreover, whenever rain falls, the rain merely reduces the watering required for the perennial crops; it is not possible to expand the area of perennial, because, the rabi rains are favourable, whilst in such seasons, the area of ordinary rabi crops can be greatly extended.

Perennial irrigation therefore requires more than ten times the water of ordinary crops on the average, and hence, a water rate ten times that for ordinary crop is not excessive, and the rate of Rs. 30 paid on the Nira Canal is not more in proportion than the 3 rupee per acre average for 4 months' crops—admittedly a low and insufficient rate. In the estimate of Revenue in Table II, Rs. 30 has therefore been taken for perennial irrigation and Rs. 2 for monsoon and Rs. 4 for Rabi and Rs. 6 for eight months' crops.

I hope this paragraph on the duties of water will also make it clear that none of these proposed canals depend on the rate of Rs. 30 for perennial irrigation. If perennial irrigation goes out of fashion, the water can be used for ordinary crops, and an equally large, if not larger, revenue obtained.

The rates are those actually obtained with ease on many of the canals in the Deccan and are actually lower than those obtained on the Gokak Canal, where Rs. 2 for monsoon and Rs. 5 for rabi crops or a basis of Rs. 3-8, are obtained; and the proportion of area irrigated to area commanded is very high.

The areas of irrigation in Table II are therefore calculated on duties less than those now obtained and the estimates of revenue are based on rates less than those now obtained and the canals promise to be productive on this basis alone; but in addition, some share of all the profits which accrue to Government through the prosperity of a district and increased traffic on Railways should be added. These additions would be sufficient to make the project profitable works. The value of irrigation is yearly becoming more evident.

The price of grain has greatly increased in recent years with a corresponding increase to the value of the crops, but with as yet no increase in the amount of the water rates levied, and such increase is perfectly justifiable now, and will doubtless be levied shortly, carefully and without haste. Every increase will be so much increase to the net profit on the projects.

These Protective Projects named in Table II are therefore possible sources of immense benefit to the Deccan and of large profits to Government, and may safely be undertaken as sound business enterprises as well as beneficial Protective Works.

There is no reason to consider or treat them as charitable works.

Statement showing duties of water for ordinary crops on the Nira Canal, in the Rabi season, for the 10 years ended 1908-1909.

Year.	Area Irrigated in the Rabi Season.				Average Discharge at head of Canal.	Discharge Required for Perennial.	Balance available for Ordinary Crops.	Duty in Acres per Cusec for Ordinary Crops.	Rainfall Inches.			Total.	Remarks.
	Perennial.	*Ordinary Crops.*							October.	November.	December.		
		Rabi.	8 Months.	Total.									
1899-1900	3,525	14,392	1,753	16,145	188	71	117	138	0·10	.....	.....	0·10	
1900-01	2,978	30,126	3,202	33,328	303	60	243	137	0·18	0·09	.....	0·27	
1901-02	5,514	25,836	7,246	33,082	332	110	222	149	1·47	0·33	.....	1·80	
1902-03	6,237	15,348	2,794	18,142	208	125	83	219*	2·33	1·97	4·20	8·50	*The duty is high as the rainfall in the Rabi Season was exceptionally good.
1903-04	6,541	14,633	3,579	18,212	267	131	136	134	1·06	0·36	.....	4·42	
1904-05	2,645	28,395	5,064	33,459	275	53	222	151	4·74	.....	.....	4·74	
1905-06	5,095	17,829	6,072	23,901	261	102	159	150	3·96	0·34	.....	4·30	
1906-07	6,200	17,320	7,958	25,278	259	124	135	187	0·98	2·09	0·75	3·82	
1907-08	6,500	15,317	9,685	25,002	264	130	134	187	0·15	.....	.....	0·15	
1908-09	6,000	18,914	10,303	29,217	266	120	146	200	0·92	.....	.....	0·92	
								Average165					

During the last three years of the statement, special care was taken to economise the distribution of the Rabi water.

A.

Statement showing duty of water for ordinary crops obtained on Distributary No. XXIX, Nira Canal, in the Monsoon and Rabi Seasons for 1908-09.

Period.		Areas Irrigated.				Discharge at Head of Distributary.			Duty of water for ordinary crops or Col. 6/Col. 9	Remarks.
From	To	Perennial crops.	Ordinary Crops.			Total discharge.	Discharge required for perennial.	Balance available for ordinary crops.		
			Eight months.	Monsoon.	Total.					
1	2	3	4	5	6	7	8	9	10	11
		Acres.	Acres.	Acres.	Acres.	Cusecs.	Cusecs.	Cusecs.	Acres per cusec.	
16th June 1908	15th Oct. 1908	11*	100	334	434	1·64	·14	1·50	289	
16th Oct. 1908	15th Feb. 1909	184	100	308	408	3·66	2·36	1·30	314	For perennial crops, a duty of 78 acres per cusec or 20% higher than 65 acres the duty in the hot weather is assumed with a view to make due allowance for rain.

* In the monsoon season the watering of sugarcane was, as a rule, not done along with that of ordinary crops.

Special experiments were made on the 29th Distributary of the Nira Canal on the duty of water, the quantity issued from the canal being very carefully measured at the Head of the Distributary. The results are given in the statement attached. A duty of 65 acres per cusec was obtained for perennial crops in the hot weather and duties of 289 in the monsoon and 314 in the rabi were obtained for ordinary crops on the assumption that in these seasons the duty for perennial was 78 acres per cusec. If the duty for perennial were less, then it follows that for ordinary crops it will be higher than the figures given.

The duties assumed by me for estimating revenue are 60 for perennial and 180 for ordinary crops in the monsoon and rabi seasons at distributary head and are much below those in the Statement A.

PART II.

1. The following portion of my review deals with the results of the Irrigation Survey of the various river valleys and the comments are arranged in the same order as the geographical position of the rivers from north to south.

With the exception of the Notes on the Tapti Valley, the comments on the various minor streams of each of the great river valleys are also arranged in the geographical order from north to south.

I have endeavoured to describe briefly the physical characteristics of the valleys and the projects which the survey has shown to be possible and to indicate how the survey should be resumed when the time comes to undertake the preparation of detailed plans for any work. I have also named the leading and most important plans which should be printed as an accompaniment to this report, and attach a list* stating where the bulk of the plans and records of the survey of each valley are recorded.

I hope that this review and arrangement will prevent the loss of anything important of the results of this very valuable and laborious survey extending over 7 years and also that it will at the same time help officers hereafter to pick up the leading points of the survey of each valley and save them from repeating work already done or undertaking survey in directions found to be wrong and not the best to adopt.

These notes in Part II will also show the relation of any particular project to the neighbouring ones. No project can be properly considered alone, but its effect on the adjacent projects possible must also be carefully considered. For instance, a small work might be made on the Ghod River which would spoil entirely the great Kukari Project, and would after all merely irrigate land that can be equally well served by the Bhima.

Again, a small project might be made on the Mutha Canal Extension which would prevent the waters of the Mutha being taken on to the Famine lands and would destroy the possibilities of the great and valuable project.

And, again, the water of the Nira may be taken down the Nira Left Bank Canal and money spent on enlarging the Left Bank Canal to irrigate lands that can be equally or better served by the Mutha Canal Extension and all the water of the Nira is required for the Right Bank.

Both these dangers on the Mutha and Nira are real, and have been proposed but now that the Irrigation Survey of the whole of the Deccan is completed, it is possible to see and understand the relative position and value of the works, and where their water should be used for irrigation. And these notes of mine in Part II will, I hope, be useful for illustrating the relation of one work to another. The Bhima Valley is the most complicated and intricate in this respect, and attention is invited to paras. 33—44*g* dealing with the Bhima Valley, for the works are amongst the greatest and most important of all.

THE TAPTI VALLEY.

Description of Tapti Valley.

2. The Tapti river rises in Central India, and unlike the great rivers of the Deccan, which rise in the Ghats and flow east to the Bay of Bengal, the Tapti flows west into the Arabian Sea and cuts through the line of the Western Ghats in the Khandesh District of the Bombay Presidency. The unfailing Ghat rainfall, on which reliance is placed for Protective Irrigation Works in Bombay, ends where the Tapti stream cuts through the Ghats.

* Printed at page 63.

On the south bank of the Tapti, however, there are a number of streams which rise on the Ghats and flow at first towards the east like all Deccan streams from the Ghats, and then curve round and discharge into the Tapti. The Girna is the principal and the most southern of these, and is a true Ghat-fed river with reliable rainfall, though somewhat less heavy than in the Ghat streams further south.

Survey—Preliminary, only.

3. The survey of the Tapti Valley was the last undertaken by the staff on Protective Irrigation Surveys, and under the instructions of the Government of India it was closed down earlier than the Bombay Government wished, but as the staff of Surveyors at work were men trained through the preceding years of survey in the Deccan, they were able to accomplish a rapid survey which has given quite sufficient information for a preliminary report, and has revealed that in the Girna Valley exists a very important and promising Protective Irrigation Project.

THE GIRNA (Tributary of the Tapti).

Selection of site of Storage.

4. A weir has been constructed on the Girna River for the Jamda Canals, and is one of the early irrigation works of Bombay, and for this, as for all similar weirs, the rabi or cold weather supply was deficient. The Government of India have repeatedly asked for means of supplementing this supply and the Girna Valley has been frequently examined for storage tanks, and the Chankapur Tank was one selected and constructed on the upper waters of the Girna. This, however, is a small tank holding 1,624 million cubic feet only, though the dam is a very high one of masonry. During these earlier examinations of the Girna, officers were looking for a moderate-sized tank with a limited catchment area, and the suggestion that the whole water of the Girna should be stored in one great tank was not before them.

The work they had done had indicated that if a good tank site existed on the Girna, it must be below Malegaon, and below the newly constructed little Girna Left Bank Canal to be supplied from Chankapur tank. The skilled Protective Duty Surveyors were, therefore, ordered first to examine this portion of the Girna River and were at once able to select a site for a good storage tank.

The first tank site examined was at Saigaon, a little to the west of the boundary between Nasik and Khandesh, the foundations were good and the storage large, but the length of the dam was long. The surveys of the contours for the storage showed that a much better site was available at Panjhan, a few miles higher up the river, provided that rock was at a practicable depth in the river-bed.

A dam less than 3,000 feet long, and storing water to 125 feet above the sand of the river-bed, will hold 26,000 million cubic feet, and the few villages drowned are not important or valuable.

Nature of foundations.

5. Trial borings were made in the river, and indicated, as was expected, that good rock existed, the deepest hole found being less than 50 feet below river-bed.

The borings indicate deposits remarkably like those found at the Chankapur dam, the borings, after passing through sand and clay, meeting what is described as soft rock, and after passing through about 3′-6″ of this soft rock, again meeting clay, below which sound rock is found. The layer of so-called soft rock is probably a layer of boulders, for, at Chankapur, boulders were found overlying the clay, and the foundations had to be taken out for 40 feet depth below water-level. This Panjhan site is very similar, and apparently the excavation will have to be carried down to 50 or 60 feet below water-level, but for a short length only. As this kind of work was successfully carried out at Chankapur, it can be done again at the Panjhan site, but a liberal provision should be made in the estimate for pumping. At Chankapur the actual pumping did not cost a lakh of rupees, though the excess due to the larger volume of masonry, owing to the foundations being so much deeper than expected, was considerably over a lakh of rupees.

In the Panjhan case, however, the cost of the masonry has been estimated, and I think that a provision of 2½ lakhs of rupees for pumping will be sufficient, and should be provided when estimating finally for this work. In the rough estimate made and referred to in paragraphs 14—24 of the report printed with this, sufficient allowance has been made in the general rate for the item of pumping, and it is not necessary to increase the figure of that rough estimate; on the contrary, my impression is that they will be found ample when detailed examination is made.

Supply available.

6. The depth of water passing over the weir at the head of the Jamda Canals has been observed for 34 years, or since 1871, with three exceptions, which are known not to have been bad years. The discharge has been calculated and for 20 years out of the 34 it was over 32,000 millions and for 21 years in succession, including 1880, amounted to over 24,000 million cubic feet. In 1899, which is far the worst year on record for famine, the supply amounted to 10,700 million cubic feet, the year before it was 71,940 millions and the year after, when famine was at its height, was 21,656 millions.

Similarly, the year before the great famine of 1877, the supply was 27,446 millions and the year after, 75,174 millions, and during the famine year itself, 18,835 million cubic feet.

The discharges for the 34 years are given in paragraph 16 of the report attached, and details of the monthly discharges are given in a statement at the end of the report.

The works, therefore, may be designed for a normal supply of 25,000 million cubic feet.

Canal alignment.

7. The surveys for the canal are most satisfactory, for, it has been proved that a canal line can be taken across the dividing ridge between the Girna and the Bori River Valleys at a point about 23 miles by canal measurement from the Panjhan site, and a further extension of 25 miles would take the main canal through the hills by Dhulia, so that the whole of the area between Panjhra River and the Girna below the G. I. P. Railway Branch from Chalisgaon to Dhulia, excepting the tops of the hills, is commanded. This area is 430,000 acres.

This is more than is required, and it will be better to limit the command to about 300,000 acres, or to the area between the Bori and Girna Rivers.

The rough estimate prepared indicates that a return of about 4 per cent. may be expected at present approved water rates, and a very slight increase in these rates would make the project very productive, and I have shown below that by restricting the area served to 300,000 acres the work will probably be productive.

Instructions for guidance when further survey is ordered.

8. When this project is taken up again and finally surveyed, the Panjhan site should be chosen. Borings 10 feet into hard rock should be taken at intervals of 50 feet along the dam line. For the waste weir the proposals to use a saddle on the left bank and to allow the waste water to flow across the canal line are not convenient, as they entail the provision of a second waste weir for maintenance of the canal where the floods cross it. Instead, it will be much better, and cheaper, to throw back the weir upstream on the right bank of the river. The dam should terminate at 500 feet distance from the F. S. L. contour on the right bank, the waste weir should be thrown back upstream for a distance of 2,500 feet nearly along a contour line, and the discharge over the 2,500 feet of waste weir can freely flow through the 500 feet gap between the end of the dam and the side of the hill, as the depth is more than sufficient, and indeed a subsidiary weir along part of the 500 feet length to reduce the overfall to 40 feet will be advisable.

The canal survey should follow the trial line to the crossing of the ridge between the Girna and Bori Valleys at 23 miles, and then branches and minors should be surveyed along the main ridges as far as the Tapti.

There should be no undersluices in the dam, but as silting will occur, provision should be made for raising the dam another 5 feet hereafter if required.

Main features of the project recommended.

9. The main features of the project, as recommended, are storage 25,000 millions, and the balance of a good year to be held up for next.

Maximum height of dam above foundations, 180 feet.

Above river-bed, 120 feet.

Canal, 1,000 cusecs.

Length of main canal, 23 miles only.

Two main branches of about 70 miles each and minor branches.

Area of command about 300,000 acres.

Probable cost Rs. 180 lakhs, including all charges.

Probable irrigation and revenue.

10. This project has been given No. 23 on the Index map.

In ordinary years the supply would be sufficient to run a canal with a discharge of 1,000 cusecs full until end of February, and with 500 cusecs for the hot-weather months.

The irrigation that might be expected would be—

	Water Rate.	Gross Revenue.
	Rs.	Rs.
25,000 acres of sugarcane ...	32	8,00,000
112,500 acres equal areas of Monsoon, Rs. 2, 8 months ,, 6, Rabi ,, 4	mean 4	4,50,000
		12,50,000

Working Expenses.

Acres.	Rs.		Rs.	
25,000 at	6	=	1,50,000	
112,500 at	mean 1	=	1,12,500	
				2,62,500
The Net Revenue			=	9,87,500
Or 5 per cent. on Capital Expenditure of Rs.				1,97,50,000

In years of intense famine like the worst known in 1877 and 1899, the sugarcane area would have to be reduced, and this could be arranged without loss to the crops.

In 1877 the reduction need not have been more than half the area.

In 1899 the area would have had to be reduced to one-fourth.

If the water were not locked up in sugarcane, 90,000 acres of cereal crops could have been irrigated in 1899 and nearly double this in 1877.

THE PANJHRA (Tributary of the Tapti).

No satisfactory project found.

11. The next important tributary of the Tapti north of the Girna is the Panjhra River, but the catchment area of this river has not reliable rainfall in years of weak rain. In good years it is abundant, and there is a very fine system of Bandharas, or small weirs with little canals from them, along the stream and survey has been frequently directed to the examination of the Panjhra River with the object of finding an economical storage site for supplementing the supply to these Bandharas.

The information collected has been referred to in the report on the Panjhra.

No good site has been found, but the river had not been thoroughly examined before the Government of India closed down the survey.

None of the sites can be recommended at present.

TAPTI (Main Stream).

Main river Tapti examined.

12. The main river of the Tapti was also examined and sites with good rock foundations in the river and suitable for a weir or dam to store water were found at Hatnur, 10 miles east of Bhusawal and 5 miles below the junction of the Tapti and Pauna Rivers, and at Susti a few miles higher up the Tapti and above the junction of the Pauna.

Hatnur site for storage and perennial crops.

13. The Hatnur site was the one chosen by the surveyors and examined at first, and a fine storage basin of 25,000 millions capacity for a dam 100 feet high above the rock in the river-bed was found.

The small town of Edalabad would be drowned and also a number of small villages and the damage to property would be extensive. A canal line was surveyed and a command of 74,368 acres obtained in a length of 50 miles and 193,568 acres is reported to be the probable command for a canal 87 miles long.

The storage of 25,000 millions with the assistance of the flow in the Tapti would be sufficient to supply a perennial canal with a discharge of 1,200 cusecs throughout the year. This would irrigate 60,000 acres of sugarcane or 1 in 3 of the area commanded on the right bank, and at a water-rate of Rs. 32 for sugarcane, and deducting Rs. 6 per acre for working expenses, the net revenue would be 15·6 lakhs, and the working expenses 3·6 lakhs. Along the rich well-drained soil of the banks of the Tapti, a proportion of sugarcane equal to one-third of the gross area is quite possible and an expenditure of Rs. 300 lakhs would be justifiable if perennial crops were grown to that extent. In spite of the cost of compensation for moving Edalabad and the small villages, there seems reason to suppose that a storage project here would pay.

Susti site for an 8-month canal.

14. The time was not sufficient for a thorough examination of the site at Susti, but there is good rock in the river-bed and a weir to utilize some of the monsoon and all the cold weather flow of the Tapti could be readily constructed and apparently without submerging any important villages. A canal discharging 1,200 cusecs could easily be supplied throughout the monsoon and could protect the whole of the culturable area of the 190,000 acres commanded. Additional storage sufficient to supplement the river discharge during the cold weather or rabi season could be obtained with a comparatively low dam. The work done indicates that the villages submerged would be much less valuable than on the Hatnur site, and for a canal to supply water for 8 months only, the Susti site seems much better than the Hatnur one. An increased rate of Rs. 4 per acre for such protection to 150,000 acres would give 6 lakhs of rupees, and deducting 12 annas per acre for working expenses or Rs. 1,12,500, a net revenue of Rs. 4,87,500 would be obtained, sufficient to justify a capital expenditure of Rs. 96 lakhs. No estimate has been made, but the sum would probably be sufficient for the works.

If, therefore, a strong demand for monsoon and cold weather irrigation on the north bank of the Tapti springs up, the Susti site should be thoroughly examined and a project prepared for a weir with large undersluices (Stoney's pattern) to keep down the floods and to give a small storage.

If, on the other hand, a demand for high-class perennial crops occurs, then Susti site should be examined and compared with the Hatnur site for a large storage tank of some 25,000 million cubic feet storage.

The brief and rapid survey executed has shown that there are considerable possibilities of irrigation on the Tapti, but that the command in Khandesh is not great.

The best way to use the Tapti water below Khandesh boundaries has not been examined.

THE ANER (Tributary of the Tapti).

Aner River.

15. The remaining survey that has been done in the Tapti valley is connected with the Aner River.

This river rises in the Satpura range to the north of Khandesh and its catchment area is mainly outside and to the north of Bombay territory. It cuts through the Satpuras and runs into the Tapti about the centre of the northern boundary of Khandesh, and is admirably situated for commanding the lands between the Satpuras and the Tapti.

The rainfall and supply, however, appear to be very unreliable. In most years the supply would be abundant, but in years of weak rainfall or of famine, the supply seems to fail almost entirely.

With the much more abundant and assured supply in the main river of the Tapti available, it seems better to spend money on a work on the Tapti rather than on the Aner, which does not at present seem reliable enough for a large irrigation work.

The discharge of the Aner, however, should be measured regularly and more information obtained about the discharge.

GENERAL REMARKS ON TAPTI VALLEY.

General results of survey of Tapti Valley.

16. The rapid survey of the Tapti Valley has therefore shown—

That the best project is for a storage tank on the Girna at Panjhan to store 25,000 million cubic feet and to command from 300,000 to 420,000 acres, probable cost Rs. 180 to 200 lakhs.

That a practicable project for monsoon and rabi irrigation with a command of about 200,000 acres is possible with a weir at Susti on the Tapti River, and this project would not do much damage to property. Cost not ascertained.

That a project for storing 25,000 million cubic feet and a canal to irrgiate 60,000 acres perennial crops is possible with a dam at Hatnur on the Tapti, but considerable damage to villages, including the submersion of Edalabad, would result. Cost not ascertained.

The report which should be printed as an accompaniment to this review is "The Report on the Tapti Valley Surveys."

Plans to be printed.

17. The plans which should be printed are:—

TAPTI VALLEY (Tapti Storage).

Proposed dam site at Susti. Section and Plan.

Proposed dam site at Hatnur. Section and Plan.

(NOTE.—The tank site has been contoured and village maps with contours shown on them are available.)

1″ map showing the tank sites and first portion of the canal, 25 miles.

GIRNA PROJECT.

Dam site at Panjhan. Section and Plan.

(NOTE.—The tank site has been contoured and village maps with contours shown on them are available.)

Portion* of 1″ map showing canal line as far as the ridge and on to the Bori River.

The section across ridge between Londha and Sitana with probable canal level shown.

General.—The map scale 8 miles to the inch with the land commanded indicated by a red mark into a deeper red border. The rainfall contours 150, 100 and 50 inches to be shown.

* NOTE.—The 1″ maps to be actual printed maps cut up to suit area to be shown.

THE GODAVERI VALLEY.

Good command obtained in the Godaveri Valley and Godaveri Canals are sanctioned.

18. The Godaveri is the most northern of the great rivers which rise in the Western Ghauts and flow across India into the Bay of Bengal. The surveys for Protective Irrigation Works in this valley have been very successful, the waters of the river can readily be conducted on to the lands of the famine districts and it has been proved practicable to utilise all the normal supplies of the streams, and the whole valley is British territory, so that storage works, canals and irrigation will all be in British Territory. The Secretary of State has already sanctioned the two best projects, namely, the Godaveri Canals and the Pravara River Project, and these are under construction. The headworks of the Godaveri Canals are formed by the Nandur-Madmeshwar weir, which is situated in the Nasik District on the main stream of the Godaveri below the junction of all the Ghat tributaries forming the fan-like system of streams at the sources of the Godaveri. Water for a storage work on any one of these streams could be let down the stream concerned to the Nandur-Madmeshwar weir, and hence there are abundant facilities for increasing the supply to the Godaveri Canals when the expense will be remunerative. The best storage site was on the Darna River at Nandgaon and was selected for the Godaveri Canals Project and is under construction. The best means, indicated by the recent very extensive survey, of using the remaining waters of the Godaveri tributaries are now considered.

All the projects practicable are required for irrigation in British territory.

19. The Government of India, when the project for the Godaveri Canals was submitted, were impressed by the facilities for irrigation afforded by the Nandur-Madmeshwar weir and requested that the extension of the Left Bank Canal into the Hyderabad Dominions should be considered. The possibility of forming a large storage tank at the Nandur-Madmeshwar weir was therefore investigated, and it was proved that whilst the Engineering works to store the very large volume of water available were practicable, the damage caused by drowning 19 large villages with a population of 17,000, and 27,000 acres of valuable lands in British Territory which could be irrigated, rendered the proposal financially impracticable, and it

was further shown that all the water available in a normal year could be utilised in British territory with less expense and less destruction to property than the one great storage tank at Nandur-Madmeshwar for the use of Hyderabad.

The Palkhed Project.

20. The most northern of the main tributaries above the Nandur-Madmeshwar weir is the Kadva, which again sub-divides into three main valleys,—the Unanda, the Kadva and the Kolvan—and below the junction of these three streams, a weir has been constructed at Palkhed for the headworks of the small Palkhed canal, and a small storage tank was constructed at Waghad on the upper part of the Kolvan.

The Superintending Engineer, in his paras. 1 to 20, has described the various storage sites investigated ; trial pits have shown that the rivers have been filling up the valleys in the rock in which they run and that though rock may be visible in the bed and on one bank of the river, on the opposite bank there are large deposits of soft material.

None of the sites investigated have provided cheap storage; the cost per million cubic feet of all is very high, but a storage site has been found a little below the existing Palkhed weir, where the normal supply of all the tributaries of the Kadva can be intercepted, and stored and then conducted by a canal on to the famine lands of Nasik in the Niphad and Yeola talukas. A command of 234,000 acres has been proved. The Palkhed site is, therefore, a very important one and when further irrigation works are to be constructed for this district, it is this site that must be the centre of investigation. The existing weir at Palkhed provides a means of accurately measuring the supply available and records of over 10 years are available. During the period of the greatest famine known, when the rains failed in 1899 and distress continued throughout the following year, the supply in the Kadva fell to 5,000 million cubic feet during 1899, but in the year preceding, was 25,000 millions and in the year following, when distress was at its height, was 39,000 millions.

The volume of storage in the tank for which preliminary surveys were made was about 9,000 millions only. The catchment area has not such a great rainfall as the ghat streams further south, for, the hills on the edge of the ghats are lower, but the years 1904 and 1905 were of very weak rainfall in this district and large remissions were granted to the numerous small patches of irrigation in the "bandhara" irrigation of this district. Yet 9,000 million cubic feet were obtained in these years.

Further observation of the discharge seems desirable and is being made, and it seems probable that a storage of 15,000 to 20,000 millions may be found possible in the majority of years.

The site at Palkhed could store this without drowning the Taluka Headquarter village of Dindori. The guiding factors for future survey will, therefore, be to avoid drowning Dindori and to store the whole of the normal supply of the Kadva, but whether this storage can be best effected by one long dam at or below Palkhed or by two dams—one on the Unanda and the other below the junction of the Kadva and Kolvan, has yet to be decided.

The site investigated below Palkhed is 15,000 feet long and has good rock foundations at no great depth, but the great length renders the dam expensive and the cost is estimated at Rs. 113 lakhs for Works only to store 9,000 millions. A larger storage at this site, though costing more, would reduce the rate per million cubic feet.

The rough estimate for storage and canal and distribution works amounts to Rs. 196 lakhs for all charges and the return at present rates is estimated at 1·57 per cent. The high cost is due to the expensive storage. If a good dam site could be found, this work could probably be a good protective work even at present rates, and when irrigation is more valued and slightly higher rates than are at present charged are levied, then a profitable work is possible here ; for, 9,000 million cubic feet of water will ensure cereal crops on 100,000 acres and 20,000 millions on double that area.

The Nasik storage at Gangapur.

21. The next important ghat tributary to the south is the head stream of the Godaveri, and on this, the important town of Nasik is situated. Nasik is a holy city and a place of pilgrimage and large numbers of people assemble there. The best site for a tank is at Gangapur above the town of Nasik, and if part of the storage were sent down the river to be picked up at the Nandur-Madmeshwar weir, the flushing of the river-bed at Nasik would be a valuable sanitary result. Water-supply could also be provided for the town. A small canal for high cultivation is practicable on the left bank of the Godaveri, and as vineyards and gardens are highly cultivated in the neighbourhood of Nasik, high rates will be practicable. The cost of storage works and canal is roughly estimated at Rs. 82½ lakhs for all charges, including establishment, and the revenue at 2 per cent. on this, with present rates for irrigation. Doubling the rates would give over 4 per cent., and also one rupee per pilgrim would probably give over 2 lakhs of rupees annually, so that some Productive Project may eventually be developed at this site.

For the present, there are better projects available elsewhere and it has not been worked out in detail.

The Aundh storage.

22. There are a few small tributaries between the Godaveri head stream and the Aundh River, but the Aundh River is the next important ghat tributary of the Godaveri. Two sites have been surveyed on this stream, the lower site at Mukne to store 4,500 millions seems the best, but further observation of the discharge is advisable before deciding on the size of this tank. Only five years' results are at present available and there are indications that a storage of 7,000 millions may be more suitable than 4,500.

There is not much command under this tank, but the water can be let down the river to the Nandur-Madmeshwar weir and used by the Godaveri Canals, and the site is reserved for this. No details have yet been worked out. The Superintending Engineer describes the work done in paras. 32-35 of his report

The Darna Dam under construction.

23. The next ghat tributary to the south is the Darna River, and on this, the Darna dam at Nandgaon is being constructed for the storage for the Godaveri Canal Project, which has been sanctioned.

The supply is good and the storage cheap, but the full normal supply cannot be stored as the Railway (G. I. P.) would be drowned by a higher dam.

The volume stored is 8,800 million cubic feet.

The Darna Right Bank Canal Project

24. The next tributary to the south forms the last of the fan-shaped system of ghat tributaries of the Godaveri meeting above the Nandur-Madmeshwar weir in Nasik and is called the Karva. This name is very similar to the Kadva River forming the northern branch of the Godaveri and dealt with in preceding paras, and to avoid confusion with this northern branch, the project for the stream is called the Darna Right Bank Canal Project as it commands the right bank of the Darna River. It is a small river rising on the slopes of Kalsubai, the highest hill in the Western Ghats just over 5,000 feet in height and has a reliable supply, though not quite equal to a genuine ghat catchment as the valley is on the side of Kalsubai sheltered from the monsoon.

The supply available is estimated at 3,000 million cubic feet and the canal proposed would be a small one irrigating the right bank of the Darna above the Godaveri Canal, and even at present rates for irrigation, the return is estimated at 2·6 per cent. on a total cost of Rs. 36½ lakhs for all charges, including establishment.

As the area is liable to famine, an irrigation work will probably be constructed hereafter on the stream, but for the present there are better projects possible.

25. The next ghat tributary to the Godaveri is the Pravara River rising in Ahmednagar District in the ghats and for this the Pravara River Project has been sanctioned and is under construction, but the funds available are barely sufficient for the needs of the Godaveri Canals and work cannot be pushed on vigorously on the Pravara. It is a very excellent project, storing 8,600 millions and the canals commanding 228,720 acres on both banks of the Pravara, the irrigation on the left bank meeting the irrigation of the Godaveri Canals and on the Right Bank being bounded by the Mula River. The canals take off from an existing weir at Ojhar in the Pravara and the discharge over this weir has been observed for 30 years. The cost is estimated at Rs. 86,44,841 and the revenue expected from rates which have been already approved on Deccan works is 3·9 per cent.

The Pravara Project.

26. The next ghat-fed tributary of the Godaveri is the Mula River of Ahmednagar, and this must not be confused with the Mula River of Poona District.

The Mula Project of Ahmednagar.

27. The Mula River of Ahmednagar has a good ghat catchment and a supply of water that has exceeded 30,000 million cubic feet in 6 of the 7 years that it has been measured, and on the 6th, in 1905, a year of very deficient rainfall in this area, exceeded 19,000 million cubic feet. A command of from 250,000 to 300,000 acres is obtained of most excellent land situated in the very worst famine district of Ahmednagar along the Dhond and Manmad Railway, and hence this Mula Project of Ahmednagar is a very important famine protective work. A very great deal of excellent survey work has been done. There are very good storage sites available in the valley and good sites are so numerous that choice of the best is confusing.

Commands excellent land.

28. The difficult part of this project lies in getting the water out of the river-bed on to the area to be irrigated. The hills on both sides keep close to the river as far down as Rahuri, and Nandur, a few miles above Rahuri, would be the proper site for the headworks of the canal if the foundations were good, but the river-bed is of sand and there is rock 45 to 50 feet below the river-bed. The gorge is narrow and proposals to use this site for a pick-up weir and also as a storage site were made, but trial pits and borings showed that the sides of the present river-bed were formed of old river gravels and the rocks continued at the low depth, so that a masonry dam or weir founded on rocks would be costly, and any work not carried down to rock would lose a great deal of water by leakage through the old river gravels. It has been proved by the careful survey and estimates that it will be cheaper to place the headworks about 15 miles further upstream at Tas and to carry the canal along the difficult ground on the left bank of the river and cross the river by a siphon near Banjarwadi. This alignment is cheaper than a canal on the left bank without a siphon as large nullas join the Mula on the left bank in this length. This length has been surveyed and estimated very carefully, and a command of 271,000 acres is obtained in the short length of canal of 59 miles only, including the portion on the left bank. This large command in so short a length is very favourable. The survey has shown that it is important to start off the canal at a level high enough to get through the ridge at Deogaon, and the level of the outlet at the Tas headworks and the length and delivery outlet of the siphon must be kept high enough to allow the canal to successfully cross the ridge at Deogaon on the right bank.

Key to the whole work of the Project.

29. A great deal of survey work and estimating has been executed for this project and a separate report on it has been written by the Superintending Engineer and is printed. The projects, roughly estimated, provide for a storage of 15,000 million cubic feet, in two storage tanks at Chas and Mandvi, with headworks and pick-up weir at Tas and for a canal 59 miles long to command 271,000 acres. The command could be extended to 301,000 acres if desired. The total cost is estimated at Rs. 162½ lakhs, including establishment and all charges. The net revenue at present rates is estimated at 3·33 per cent.

Description of Mula project.

The project is therefore a very excellent one, and should the results of gauging the river show that a normal supply of more than 15,000 millions may be reckoned on, the prospects will be still further improved. The results up to date indicate that 30,000 millions may be reckoned on in a normal year.

Storage sites.

30. The Chas site is a very excellent one for a high masonry dam and full advantage should be taken of this site when the project is undertaken, and, I think, the dam should be made high enough to store the whole normal supply of the river. The Mandvi site, lower down, is not nearly so good, and I think it probable that better sites than Mandvi can be found, if required.

Best arrangement for works.

31. For this Mula project, therefore, the best arrangement seems a storage tank at Chas to hold from 20,000 to 30,000 millions, pick-up weir and headworks at Tas, with canal on the left bank of the river as far as Banjarwadi, and crossing the river there by a siphon, the level of outlet at Tas and of the delivery of the siphon to be kept high enough to command the ridge near Deogaon or at about 46 miles of the canal.

The reports which should be printed as accompaniments are :—

The report on the Godaveri Valley Surveys.

The report on the Mula Valley Surveys.

Plans to be printed.

32. The plans to be printed are :—

FOR THE KADVA RIVER.

The 1st map of the Palkhed site and a portion of canal.

The lower dam site at Palkhed.

THE GODAVERI (NASIK STORAGE).

The Gangapur dam site.

THE AUNDH STORAGE.

The Lower site at Mukne.

THE KARVA STORAGE SITE.

For Darna Canal.

THE MULA PROJECT.

The 1" map of the Storage sites.

The headworks at Tas.

The Dam line at Mandvi.

The Dam line at Chas.

BHIMA VALLEY.

Physical features of the Bhima Valley.

33. The Bhima River is the great northern branch of the Krishna River and is one of the largest rivers in the Bombay Presidency. The main stream runs through the Sholapur District and is supplied by a fan-shaped system of tributary streams rising in the Western Ghauts. The broad end of the fan-shaped system, if the Nira River which is a tributary of the Bhima be included, is 175 miles long, but the Nira River is of sufficient size and importance to be considered by itself, and excluding the Nira Catchment the length north and south of the Ghat range of hills along which the tributaries rise is about 125 miles. Along this 125 miles, the heavy and never-failing rain on the summits of the Ghat mountains which catch the full force of the South-West monsoon gives an assured supply to the rivers, in some years greater than others, but in all years considerable even in the worst famine years known. The narrow end of the fan-shaped system of tributaries, excluding the Nira as above explained, is at about 125 miles from

the edge of the Ghauts where the Ghod River joins the Bhima. It has long been desired to intercept these never-failing waters and to turn them on to the famine-stricken lands of the Bombay Deccan, but the main stream of the Bhima lies at a low level and has but a slight fall, whilst the lands on the river bank slope down from a high range of hills forming the watershed between the Godaveri and Bhima valleys, and are at a comparatively high level, and it is impossible to divert the water direct from the main stream on to the famine lands. Attention was therefore directed to the tributary streams, and at first, owing to the difficult nature of the country, it seemed impracticable to get even the water of a tributary on to the worst famine lands, but the systematic survey undertaken has shown how it is possible to utilise the waters of the tributaries on the flank of the fan-shaped system of tributaries, though it is still impracticable to obtain the waters of the central streams.

THE KUKADI PROJECT.

34. The Kukadi River is the most northern of the fan-shaped system of tributaries with ghat catchment, and the surveys have proved that for a canal to be practicable it must start off as high up the Kukadi River as the village of Pimpalwandi on the Poona-Nasik road, and at a reduced level of 2060, and that with a fall of 6⅜ inches per mile, such a canal would reach the ridge line in 120 miles, and have a command, which, by extending the canal to 271 miles length, might reach 1,600,000 acres. The water-supply of the Kukadi River was not nearly sufficient for this, and the best means of obtaining the water of other tributaries were investigated. At first, the most obvious method seemed to be to lower the whole alignment of the canal so that the headworks might be below the junction of the Ghod, Mina and Kukadi Rivers, instead of high up the River Kukadi at Pimpalwandi; there was a very much larger area of land commanded than could be irrigated, and after the canal has reached the ridge line, the canal water must fall some 50 feet. A trial line was therefore started as far down the Kukadi Canal alignment as 174 miles and surveyed back or up to the river at the very low bedfall of 6 inches a mile, with the disappointing result that the low-level alignment had to cross both the Kukadi and Mina Rivers, and extended to a length of 311 miles before the Ghod River was reached. This very great length even with a low bedfall shows clearly the difficulties which baffled the early surveyors, and the correctness of the statement made above that the key to the problem of the alignment of the Kukadi Canal is to keep the canal as high up as possible, and at a level of not less than 2060 at Pimpalwandi where the Poona-Nasik road crosses the Kukadi.

Key to the survey work of Kukadi Canal.

35. There is no difficulty in getting the water of the next stream, the Mina, into the Kukadi Canal at the level as the bed of the Mina is high, but the Mina is not a large river, and more water is wanted, and the supply from the next or third tributary, the Ghod, must be obtained if possible.

Mina water easily delivered into Kukadi.

36. There are two means of obtaining the Ghod waters; one by taking a canal down the right bank of the Ghod and crossing the river valley by a siphon and delivering the water into the Kukadi Canal below the junction of the Kukadi and Ghod Rivers at about 37 miles of the Kukadi Canal; the other by taking a canal down the left bank of the Ghod River and crossing both the Mina and Kukadi valleys, and this latter has been proved to be the cheaper alternative and to be practicable. A canal line was run from the left bank of the Kukadi site at Pimpalwandi across the Mina valley and into the Ghod valley, and in a length of about 24 miles reached a practicable site for a dam in the Ghod valley at Sakora. The water of three tributary streams can thus be delivered into the Kukadi Canal, but it proved quite impracticable to obtain the water of the fourth stream, which is the head of the Bhima itself, as the bed of the river is actually lower than the Ghod and the canal

Ghod water can also be obtained.

round the intervening spur long and difficult. A good tank, however, is possible on the Bhima and a canal which could reach the ridge between the Bhima and Ghod Rivers at about the same level that a canal from the Ghod could reach the same place, and hence the Ghod waters need only be taken down the right bank of the Ghod as far as Sirur, and the remainder of the land commanded between the Bhima and Ghod may be left to be served by the Bhima. The area down to Sirur is small, and hence almost the whole of the supply of the Ghod, Mina and Kukadi Rivers are available for the Kukadi Canal.

Records of discharge insufficient.

37. There is no long series of records of the discharges of these rivers, but they are now being measured and the annual discharges are being regularly entered in Statement V of the annual report on the supplies of water available for irrigation works. The results obtained so far indicate that the discharge for 1904 and 1907 were twice as much as those for 1905 and 1906, the volume being 36,000 million cubic feet for 1906 and 76,800 million, for 1907. Now, 1905-1906 were years of very deficient rainfall and the large supply of 36,000 millions would have been most valuable, but the large area of land commanded could have used it all, and more, if available, and hence before designing final plans for a great project on the Kukadi, a series of some 15 years' discharges seems desirable. The area to be served is one where rabi or cold-weather crops are the predominant crops and where these crops frequently fail for want of one or two waterings after they have started well, and hence the supply in normal years will be very valuable for rabi or cold-weather crops, though not reliable enough for perennial.

Main features of the Kukadi Canal system practicable.

38. The main features of a project to give an eight-month supply to the lower part of the canal and a perennial supply to the upper portion have been surveyed and approximately estimated.

They are a canal down the left bank of the Kukadi commanding the lands it is desired to irrigate, a weir and small storage at Pimpalwandi on the Kukadi to give a constant supply to this canal during the monsoon season when the rivers are flowing, a feeder canal from this weir to the Ghod valley to conduct the Ghod waters into the Kukadi Canal and a storage reservoir on the Ghod River to store the water for the cold season. These works command 580,750 acres gross command.

Separate projects for Ghod, Mina and Kukadi Rivers prepared before importance of Kukadi command was realised.

39. The Superintending Engineer has described the survey work accomplished. Before the importance of conducting the water-supply of the Ghod into the Kukadi Left Bank Canal was realised projects were prepared for each of the Ghod, Mina and Kukadi valleys separately, and estimates were taken out for these separate projects which used only a portion of the water-supply available. The great importance of the Kukadi Left Bank Canal and the necessity of conducting the Ghod waters to that canal was clearly shown by these preliminary projects and the scheme, which has been just described above, was worked out, and in estimating the cost, use has been made of the work done on these three separate projects. For the perennial irrigation at the head of the system it is proposed to make a canal on the right bank of the Ghod River to be supplied by the storage tank on the Ghod, and to construct a storage tank on the Mina to irrigate the land between the Ghod and the Mina, which is extremely well-fitted for irrigation and garden crops.

Mina Project, approximate cost.

39. A. The separate project at first prepared for the Mina can be considered by itself and quite independently of the great Kukadi Rabi Canal. The storage site on the Mina examined is very expensive, the supply available for this river is small and the project does not promise a high return as at present designed. There are many much better paying perennial schemes possible. The Superintending Engineer, Mr. Beale, has given the approximate cost, revenue, and the financial aspect of the work, and in paragraphs 67 and 68 he gives the separate cost of the Mina project at Rs. 73,89,164, including all charges and estimates the revenue at 1·92 per cent. 74 lakhs, is a very

large sum to spend on so small a supply of water as the Mina provides, averaging 5,000 to 7,000 million cubic feet only. The plans and estimates for the Mina have been prepared in detail and should be recorded.

Approximate cost of Kukadi Project.

40. In para. 52 he gives the approximate cost of the works for eight-month canal for the Kukadi and for the perennial Right Bank Canal under the Ghod at Rs. 3,11,27,798, including all charges, and in para. 55 estimates a possible revenue of 3·11 per cent. without allowing anything for the benefits of protection from famine.

These estimates are not mere guesses, as the canal lines have all been surveyed and plotted, and the tank sites contoured, and they indicate that this Kukadi is one of the great irrigation schemes possible in the Deccan, but that it is inferior to the Nira Right Bank, the Mutha Extension, the Gokak, and possibly to the Ghatprahha Right Bank Canal, unless the water-supply is larger than we now suppose.

The advantages of the Kukadi are that it is entirely in British territory, and that the lands to be served in the Ahmednager and Sholapur Districts are very liable to famine and to failure of crops. These surveys have proved that it is possible to conduct the waters of the Ghod, Mina and Kukadi on to these lands, and the water should be reserved for the time when such a project will pay, and not be used up for small perennial schemes not extending into the Famine districts, for, there are numerous streams where such perennial irrigation is possible and where the waters cannot be taken on to the famine lands.

Recommendation for preparation of a project when further observations of discharges are available.

41. The results of the surveys should, I think, be now carefully recorded for use hereafter when the project will be surveyed in detail, and the discharge of the rivers is being regularly measured and the project can be elaborated when the supply is better known. When it is finally taken up, I think search should be made on the Kukadi River for storage site above the proposed weir at Pimpalwandi on one or both of the branches which rise in the ghats, as such storage would decidedly improve the project. The site for the storage in the Ghod River has been very approximately found. It must be somewhere about Sakora to be high enough to run the supplies by the feeder canal into the Kukadi headworks, but whether this can best be obtained by storage tanks above the town of Ghod or by building a high masonry dam below Sakora and drawing off the upper part of the tank only, is a question to be settled.

The Ghod valley affords better foundations and better storage sites and a better supply than the Kukadi, and the chief storage should be in that valley and not in the Kukadi.

The alignment of the feeder canal admits of improvement, though it is quite practicable as it is. Its exact position will depend on the site finally selected for the storage tank on the Ghod.

The alignment chosen for the Kukadi Left Bank Canal must be closely followed, but it will be for consideration whether it is not possible to place the outlet at the Kukadi weir some 10 or 15 feet higher and increase the fall of the canal from 6⅜ inches to 8 inches a mile. Apparently, the higher the Kukadi Left Bank Canal can be placed, the better.

42. In the first project for a separate canal for the Kukadi valley without utilising the Ghod water, a high dam was proposed at Pimpalwandi. The foundations in the river-bed are, however, certainly deep and are somewhat uncertain, and the land drowned was good and extensive, whilst the supply of water seems inferior to that in the Ghod. For these reasons, I have recommended that the main storage work be on the Ghod River, where very good foundations are available, and that at Pimpalwandi on the Kukadi, a weir be built instead of a high dam. The right bank of the Kukadi affords good rock for the overfall of the

weir, and at the deep part of the foundation the crest of the weir can be raised to prevent overfall, so that the length will be a masonry dam of very much less height than at first proposed, and the difficulty with the foundations will be much lessened. Also, with the weir placed in this position, it is practicable for the feeder canal to discharge into the pool above the weir or into a channel constructed along the upper part of the weir and the great difficulty of carrying this feeder canal across the discharge of the Kukadi River is thus arranged for.

The weir at the same time acts as a regulating tank and provides for the large Kukadi Canal being kept full during the monsoon months, and thus utilises about half the normal discharge of the Kukadi. I have suggested above that it will probably be desirable to search on the upper part of the Kukadi stream a site for a storage tank, but this tank need be only half the size of that originally proposed for Pimpalwandi, as the weir provides for the use of about half the normal supply of this river.

Reports to be printed as accompaniment.

42A. The Report which has been printed is that relating to the Bhima Valley Surveys containing the general description by the Superintending Engineer, Mr. Beale.

Plans to be printed for the Kukadi Project.

42B. The plans which should be printed are—

(1) The map 4 miles to the inch showing the storage sites and alignment of the canals and also the character of the land commanded under the Kukadi Canal.

This map will also show the Bhima Project, the Mutha Canal Extension, the Nira Left Bank Canal and the commencement of the Nira Right Bank Canal.

(2) The plan and section of the site of the weir across the Kukadi at Pimpalwandi.

(3) The plan and section of the proposed dam at Sakora on the Ghod River.

(4) Topographical maps Nos. 196 and 230, to the scale of 1" to the mile with the sites of the storage tanks and canal alignments marked to be bound in one piece.

I do not think it is necessary to print the numerous sheets of the longitudinal section of the canal. It is sufficient to place on record that the ruling gradient for the canal surveyed was 6⅜ ins. per mile for 70 miles, and after that from 8 ins. to 1 foot per mile until the ridge was gained. Greater fall was given when cuts were necessary through the ridges.

The survey work that has been done is very valuable and very successful and has cleared away the difficulties which surrounded this project and pointed out the right way to proceed with the preparation of plans for the Kukadi Left Bank Canal; but the plans can certainly be much improved and it is sufficient in these records to indicate the main points which must guide the men who finally undertake the work.

THE BHIMA PROJECT.

Bhima project; general description.

43. In the preceding paragraphs, the possibilities of a great canal on the Left Bank of the Kukadi to utilise the water-supply of the Ghod, Mina and Kukadi Rivers have been described, and it was explained that this canal on the extreme left flank of the ghat tributaries of the Bhima commanded much more land than it could irrigate even

in years of normal supply and that it was advisable to use the supply available mainly for monsoon and rabi irrigation in order that as large an area as possible of the famine district might be served and that water ordinarily available but not reliable enough for perennial irrigation might be used.

The river, or Ghat tributary, now being considered is the upper stream of the Bhima itself and is the next tributary to the Ghod. The water of this Bhima tributary cannot be diverted into the Ghod valley at a level high enough to serve the feeder canal to the Kukadi Canal, because the Bhima valley is lower than the Ghod and a canal round the intervening spur is long and difficult. The waters must therefore be used up in the Bhima valley and in the tract of land between the Bhima and Ghod Rivers, near their junction. A canal line has been surveyed and levelled and a command of over 170,000 acres has been proved. Good sites for a tank have been found at Karda and Kaman, and the river is being gauged and the results recorded in Statement V of the annual return of supplies of water available. For the year of very deficient rainfall, 1906, a discharge of over 9,000 million cubic feet was available, and for 1907, the discharge was 18,000 million cubic feet.

Now these 170,000 acres commanded, though not in the area of intense famine, are still within famine limits and the project may fairly be included amongst Protective Irrigation works, but it is one of quite opposite character to the Kukadi, for, there is abundance of water for the area commanded, and perennial irrigation may be carried out along the whole length of canal. The Superintending Engineer, in his report, paras. 70—82, has described the information collected for this project, and has suggested a scheme with a storage of 5,000 million cubic feet only at first to be raised to 9,000 millions later. The canal line to be limited to 60 miles length with a command of 80,000 acres. The cost—probably about Rs. 47½ lakhs.

The discharge returns of the river, however, indicate that a supply of 9,000 millions can be relied upon in bad years and 18,000 million cubic feet in normal years, and considerably more on the average, and the project suggested by the Superintending Engineer would not utilise to the full the great advantages of this river.

A storage tank for 15,000 million cubic feet or over is required and then a system of distribution of perennial and rabi irrigation for over half the culturable area could be arranged, and if the cultivator preferred to grow cereal for perennial every culturable acre included in the 170,000 acres of gross command could be irrigated, the length of canal being about 115 miles. The area of perennial crops that can be grown without loss from deficient supply in last years seems well over 15,000 acres, and there seems every probability of a project being designed for this valley which would be a productive work and, at the same time, serve part of the famine area. As the tract served lies to the west of the line of intense famine, the scheme has not yet been worked up in detail and its position renders it inferior as a famine work to others and in particular to the Mutha Canal Extension, but it is one of the important projects of the Deccan.

Recommendation for survey when again undertaken.

44. When this project is finally surveyed, I think the Surveying Officers will find it best to keep the canal line at as high a level as possible and that any expenditure difficulties in the upper part of the canal will be more than compensated by avoiding difficulties on the lower part and by the increased command obtained.

The officer who surveyed and investigated the Bhima suggested that a pick-up weir should be constructed at Tulapur some miles below the dam site, and that a canal should be made on the Right Bank below the weir. The Ghat streams south of the Bhima have abundance of water, and the water for the irrigation of this area should come from the stream south of the Bhima, and all the Bhima supply should be reserved for the Left Bank Canal.

Bhima Tributaries that cannot be used for Protective Irrigation.

44*a*. The streams in the centre of the fan-shaped system of Ghat tributaries of the Bhima and which lie between the Bhima tributary on the north and the Mutha tributary on the south cannot be used for protective irrigation and their supplies of water cannot be delivered on to the famine area. These streams are in consecutive order from north to south.

The Bhama.

The Indrayani.

The Pauna.

The Mula.

Small Productive Projects seem possible.

44*b*. Small schemes for productive works with canals of comparatively small command and a large proportion of perennial irrigation are probably possible as the supplies of water, if stored, are abundant, but as the water cannot be conducted by gravity to the famine area, no schemes have been surveyed for these rivers. There is thus a great volume of water from these central streams that cannot be diverted on to the famine lands by means of canals and which will run down the main stream of the Bhima through Sholapur, one of the districts where famine is most intense. To raise the water from the main stream of the Bhima, pumping will be necessary. At present, pumping on a large scale would not be remunerative for the high lifts necessary to command the lands, but hereafter, the value of irrigation may increase to such an extent that pumping may be possible.

THE MUTHA (Tributary of Bhima).

The Mutha Canal Extension.

Mutha Supply well-known for 33 years.

44*c*. The next stream to the south is the Mutha river on which is the existing Mutha Canal System with its fine Storage Reservoir at Lake Fife and a small canal given over to perennial irrigation. The canal also provides a water-supply for Poona. The existing works have been in operation for over 33 years, and the water-supply available from this fine ghat catchment has been under observation for the whole of this period and the normal supply is known to be four times as much as the present work utilises. The whole of the water stored is used up in a comparatively small area on perennial irrigation where the cultivation is very excellent, and proposals have constantly been made for increasing the storage and enlarging the canal, and Mr. Visveswaraya prepared a project for the construction of two additional reservoirs above Lake Fife, and for using about half the normal supply of water in the limited area commanded by the present canal.

Great protective advantage only recently ascertained.

44*d*. It is only recently that the great protective value of this Mutha River has been realised, for, the existing canal had been given a steep gradient or bed fall, and at its present termination near Patas came down on the side slopes of spurs running down to the river, and any extension of the canal would have to wind round these spurs, and be long and difficult with but small increase of command. Recently, however, the same principle which solved the difficulties of the Kukadi Canal Survey has been applied to the Mutha, and the error of giving a steep fall to the canal has been avoided. A trial line for a canal has been surveyed from Poona with a fall of 8 inches a mile, and a practicable alignment has been obtained, which crosses the necks of the spurs instead of having to wind around them, and with a length of about 150 miles can command 340,000 acres and deliver water as far as Indapur and the junction of Nira River with the Bhima, or into the heart of the area of intense famine and as far to the east as the great Kukadi Canal is able to deliver water. A fall of 6 inches a mile will render the canal alignment easier and give greater command.

Proposals for storage.

44*e*. It is proposed to build a higher dam below the existing dam at Lake Fife, and thus utilise the existing expanse of water in Lake Fife as an area on which to store additional water, and the area of culturable land submerged is limited to the additional area drowned around the edges of the lake, and is much less in proportion than would be the case if an entirely new storage tank was formed. There are no important villages drowned and the damage caused is comparatively small. The river discharges have been observed for over 33 years and their character and supply is known and assured.

Reference to details.

44*f*. Details of this project are given in the attached report by the Chief Engineer for irrigation and a preliminary report has been submitted to the Government of India with a recommendation that final plans be prepared; a copy of this report is attached as an accompaniment. It seems probable that the work can be made a productive work; for, the water-supply is abundant, and large area of perennial irrigation can be grown. The Mutha is thus one of the most important of the projects possible for the irrigation of the area of intense famine in the Eastern Deccan.

Mutha extension can relieve tail of Nira Left Bank Canal.

44*g*. The Nira Right Bank Canal with the existing Nira Left Bank Canal is the greatest and most important of all the Protective Irrigation works, and is on the southernmost tributary of the Bhima, and the water from the Nira can be delivered into the very heart of the area of intense famine and much further east than any other tributary of the Bhima, and hence all the supply of the Nira is required for lands to the south of the Nira, and the Mutha waters should be taken as far into the Nira Valley as practicable to relieve the Nira of the work of supplying more than is necessary on the Left Bank. The Mutha holds the same position to the Nira Right Bank Canal that the Bhima Project described in paras 43-44 above does to the great Kukadi Project, and as the Bhima sets free some of the Ghod waters for use on the Left or North Bank of the Kukadi, so the Mutha should set free as much of the Nira water as possible for use on the Right or South Bank of the Nira. The Mutha Project is, however, able to deliver water much further east than the Bhima, and indeed, as far east as the great Kukadi Project itself can efficiently supply. The area served is entirely in British territory. The storage tank is mainly in British territory, but would drown about 4,200 acres in the State of Bhor.

Report on the Mutha Extension Project referred to in para. 44*f* of the Chief Engineer Irrigation's Review of the results of the Irrigation Survey of the Deccan.

No. W. I.—763 of 1909.

PUBLIC WORKS DEPARTMENT,
Bombay Castle, 18th March 1909.

FROM

C. N. CLIFTON, ESQUIRE, C.E.,
OFFG. JOINT SECRETARY TO THE GOVERNMENT OF BOMBAY;

To

THE SECRETARY TO THE GOVERNMENT OF INDIA,
PUBLIC WORKS DEPARTMENT.

Irrigation (Works).

SIR,

I am directed to submit for the approval of the Government of India, preliminary plans and estimates for the extension of the Mutha Canals.

The project is intended to take the place of the one submitted with No. A. I.—1602 of 18th June 1907 of the Government of Bombay for two additional storage Reservoirs at Panset and Warasgaon situated entirely in the territory of the State of Bhor to provide

water for the irrigation of an additional 7,500 acres of sugarcane. The Government of India returned that project with their letter No. 1576-I of 12th September 1907, of which the concluding paragraph 7 reads as follows:—

> "I am now to request that when the question of the proposed acquisition of land in the Bhor State has been definitely settled, revised forecast statements of financial results, based on the actuals of the three years ending 1905-1906, as estimated in paragraph 4 of this letter, may be prepared and submitted for transmission to the Secretary of State, in place of those now appended to the report on the project."

Meanwhile, the Government of India in dealing with the Godaveri Irrigation project had impressed on the Government of Bombay the great importance of using the whole of the water available from the streams of the Bombay Ghats and the valuable results of the extensive surveys for Protective Works in the Deccan had shown prominently that the Mutha River was one of the best catchment areas on the Ghats and was situated so that the waters could be delivered on to the Famine Districts in the East of Poona between the Bhima and Nira Rivers. The main stream of the great Bhima River has been proved to be at too low a level to irrigate lands in the Deccan and the Bhima divides up into a number of tributary streams rising in the Bombay Ghats. Hence, although there is abundance of water in these tributary streams, only the water from the tributary on the extreme flanks can be conveyed on to the lands on the banks of the Bhima in the Famine District of the Deccan. The Mutha is the tributary on the extreme right or southern flank of the Bhima, and hence is one of the most important means of Irrigation in the Deccan. The project first sent up for the two Reservoirs at Panset and Warasgaon provided for the storage of an additional 4,666 million cubic feet, making with the 3,955 of the existing Lake Fife, a total storage of only 8,621. The reliable supply of the Mutha is, however, very much larger than this and during the 30 years this tank has been constructed, there has been only one year when the discharge was less than 22,000 millions and the supply of that year is estimated at 14,500 millions. Consideration was, therefore, given to the possibility of utilising more of this valuable water and the preliminary project now submitted is the result.

2. In place of two reservoirs in Bhor State territory, it is proposed to build a higher dam at the site of the existing dam at Lake Fife. The maximum height of the dam will be 160 feet above bed level and the storage will be 22,000 million cubic feet including the existing storage.

The full supply level will be 60 feet above the present full supply level and there will be 60 feet depth of storage over the existing water surface of Lake Fife and the loss in lands submerged will be confined to the sides and ends of the existing lake. The result is that the 22,000 millions of storage can be obtained with the submersion of an additional 4,200 acres only, whilst in the previous project for the two Reservoirs of Panset and Warasgaon 3,200 acres were submerged for an additional storage of only 4,666. Further, in the case of the enlarged Lake Fife, the land submerged is mainly on hill sides and comparatively poor, whilst the two new Reservoirs covered the rich rice-fields lying at the bottom of the valleys; and again whilst the two Reservoirs, Panset and Warasgaon, submerged 3,200 acres in Bhor State, the larger Reservoir at Lake Fife submerges about 1,800 acres only in Bhor State.

In the matter of lands submerged, the enlarged Lake Fife is, therefore, very favourably situated.

3. The losses direct from the lake by evaporation are also proportionately much less in the case of a deep lake than in the case of shallow ones, as the depth lost is the same, about 5 feet in each case, and 5 feet is $\frac{1}{5}$th of 25 feet, the present available depth, but is only $\frac{1}{19}$th of 95 feet—the proposed available depth.

The net result is that the available storage will, for the proposed enlarged Lake Fife, be seven times the available storage of the existing Lake.

4. As the city of Poona is upon the banks of the Mutha River about eleven miles below the site of the existing dam, it is deemed desirable to construct an entirely separate dam for the enlarged Reservoir, for, although the risk of preparing new foundation at the toe of the present dam may be small, still, it is a case where no avoidable risks should be taken, and hence, an entirely new masonry dam is proposed.

5. The existing canal as far as Poona will be utilised and enlarged and the short tunnels at Poona enlarged to carry 1,000 cusecs discharge; but from the exit of these tunnels or at 13 miles from the head of the canal, an entirely new line of canal will be excavated in order to gain command which has been sacrificed by the steep fall in the present canal.

The tunnels and canal to Poona can be enlarged during the hot and cold weather when the supply in the existing canal is low, but if the Panset and Warasgaon small storage tanks were first constructed and the present canal run full, then there would be very considerable difficulties in enlarging the tunnels and an entirely new canal at much greater expense would be required.

The preliminary surveys have shown that with the useful fall of 8″ a mile, the ridges which were impassable for the extension of the existing canal are crossed with ease, two short tunnels only being required, and that with an amended line and fall of 6 inches a mile, the tunnel can be dispensed with. The command obtained is 340,000 acres and most of it in the heart of the famine district of the Deccan.

The water-supply is so abundant that it is sufficient to irrigate annually every acre commanded if cereal crops only were grown, and if the demand were limited to cereals the supply would be much in excess of requirements; but in the Deccan, and more especially in the precise area to be served by this canal, there is a demand for water for perennial crops, chiefly sugarcane, far larger than can be supplied. The present storage on the Mutha canals is entirely given up to sugarcane, the storage on Matoba Tank is not nearly sufficient for the demands for sugarcane, and on the Shirsuphal and Bhadalwadi Tanks in the centre of the area served by the canal, there is a keen demand for sugarcane water which cannot be met because of the precarious supply to these tanks and lastly, at the tail of the proposed canal under Shetpal Tank, which is filled by the Nira Canal, there is a demand for perennial water which cannot be met. All the small tanks named above are commanded by the proposed canal and can be filled by it in the monsoon at the sacrifice of monsoon irrigation. Hence, it is estimated that at least 25,000 acres of sugarcane will be grown, and include the total of over 100,000 acres of mixed crops irrigated or about ⅓rd of the gross area commanded

The proportion of perennial crops, 25,000 acres to 340,000, or 1 in 13½ is very much less than the proportion on the existing Mutha Canal where it is less than 1 in 5.

6. The rates proposed are already current in the Deccan with the exception of the monsoon rate, and are 32 for sugarcane, 8 for eight months, 5 for rabi, and 3 for monsoon, and the return anticipated is 5½ per cent. on the additional capital expenditure of 175 lakhs. This capital expenditure, however, includes a provision of 32 lakhs for establishment charges, and if the works be pushed on vigorously and constructed expeditiously, as all irrigation works ought to be, the cost of establishment will be much less than this.

7. The estimate for revenue makes no account of the areas of perennial crops that can be irrigated from wells. It has been proved in the Deccan, that wherever there is sugarcane cultivation there is a very large increase in the subsoil water, and this increase is not utilised so long as canal water can be given by flow. When the flow for the canal is exhausted, then it may be expected that irrigation from well will be taken up. No allowance, however, has been made for this in the estimate of revenue.

8. Again, no allowance has been made for the gain from immunity from famine to the area. At present it is the worst part of the Poona District, is in the centre of the Eastern Deccan, and is specially liable to failure of rain. The cultivation of an additional 20,000 acres of cane, in the famine area, would give a very great source of work to labour. The District Officers of Poona are unanimous on the far-reaching effect of sugarcane cultivation in mitigating distress in famine. Further, the water-supply is so abundant that all ordinary crops could be grown, in addition to the sugarcane, in 29 of the 30 known years, and in the 30th, the sugarcane could have been continued without any loss to cultivators, all cane being maintained and all first year's crop preserved for the second year's crop, the only change being a reduction in area of newly-planted crop for that year only.

The project will therefore, be most efficient as a Famine Protective Work.

9. Further, no credit is taken for the increase in Railway traffic, and increase in general taxes, owing to general prosperity. The 5½ per cent. expected is from water-rates only, and the Bombay Government recommend the project as a productive work.

10. The revenue that may be expected has also been calculated on the method recommended in paragraph 4 of Letter No. 1576-I of 12th September 1907 of the Government of India. This method gives a larger area of sugarcane and a larger gross revenue than the detailed calculations adopted for the preliminary report, but the working expenses are also larger and are excessive amounting under the method to 4¼ lakhs, whilst for the proper maintenance and management 2½ lakhs should be ample in

addition to charge for Poona Water-supply. Two forecast statements of financial results are therefore prepared, one with the revenue calculated on the method recommended by the Government of India showing a net revenue of 8·05 lakhs or 4·60 per cent. marked A, and the other, on the method of details of crops showing a net revenue of 9·50 lakhs marked B, or nearly 5½ per cent.

11. I am to request the approval of the Government of India to the project and to ask for sanction for the preparation now of final plans and estimates for the tank, canal, and all masonry work, ready for the commencement of the work as soon as the sanction of the Secretary of State is obtained.

I have the honour to be,
Sir,
Your most obedient servant,
C. N. CLIFTON,
Offg. Joint Secretary to Government.

STATEMENT OF FINANCIAL RESULTS.

LAKE FIFE EXTENDED PROJECT.

STATEMENT A.

Year.	Direct Capital outlay during the year.	Direct Capital outlay to end of the year.	Simple Interest at 3¾ per cent. on Capital outlay to end of previous year *plus* half outlay during year.	Net Revenue due to extension.	Simple Interest less net revenue.	Net Revenue less simple Interest.
1	2	3	4	5	6	7
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
First ...	5,00,000	5,00,000	9,375	.....	9,375	.....
Second ...	12,00,000	17,00,000	41,250	.....	41,250	.....
Third ...	17,00,000	34,00,000	95,625	.....	95,625	.....
Fourth ...	17,00,000	51,00,000	1,59,375	.....	1,59,375	.....
Fifth ...	17,00,000	68,00,000	2,23,125	.....	2,23,125	.....
Sixth ...	17,00,000	85,00,000	2,86,875	1,00,000	1,86,875	.....
Seventh ...	17,00,000	1,02,00,000	3,50,625	2,00,000	1,50,625	.....
Eighth ...	17,00,000	1,19,00,000	4,14,375	2,50,000	1,64,375	.....
Ninth ...	17,00,000	1,36,00,000	4,78,125	3,00,000	1,78,125	.....
Tenth ...	17,00,000	1,53,00,000	5,41,875	3,50,000	1,91,875	.....
Eleventh ...	17,00,000	1,70,00,000	6,05,625	4,00,000	2,05,625	.....
Twelfth ...	5,00,000	1,75,00,000	6,46,875	4,50,000	1,96,875	.....
Thirteenth ...	.....	1,75,00,000	6,56,250	5,00,000	1,56,250	.....
Fourteenth ...	.....	1,75,00,000	6,56,250	6,00,000	56,250	.....
Fifteenth ...	.....	1,75,00,000	6,56,250	7,00,000	.....	43,750
Sixteenth ...	.....	1,75,00,000	6,56,250	8,00,000	.....	1,43,750
Seventeenth ..	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Eighteenth ...	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Nineteenth ..	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Twentieth ...	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Twenty-first ...	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Twenty-second ...	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Twenty-third ...	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Twenty-fourth ...	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Twenty-fifth ...	.....	1,75,00,000	6,56,250	8,05,000	.....	1,48,750
Total ...	1,75,00,000	.....	1,23,84,375	1,18,95,000	20,15,625	15,26,250

STATEMENT OF FINANCIAL RESULTS.

LAKE FIFE EXTENDED PROJECT.

STATEMENT B.

Year.	Direct Capital outlay during the year.	Direct Capital outlay to end of the year.	Simple Interest at 3¾ per cent. on Capital outlay to end of previous year *plus* half outlay during year.	Net Revenue due to extension.	Simple Interest less net Revenue.	Net Revenue less simple Interest.
1	2	3	4	5	6	7
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
First ...	5,00,000	5,00,000	9,375	.....	9,375	.....
Second ...	12,00,000	17,00,000	41,250	.....	41,250	.....
Third ...	17,00,000	34,00,000	95,625	.....	95,625	.....
Fourth ...	17,00,000	51,00,000	1,59,375	.....	1,59,375	.....
Fifth ...	17,00,000	68,00,000	2,23,125	.....	2,23,125	.....
Sixth ...	17,00,000	85,00,000	2,86,875	1,00,000	1,86,875	.....
Seventh ...	17,00,000	1,02,00,000	3,50,625	2,00,000	1,50,625	.....
Eighth ...	17,00,000	1,19,00,000	4,14,375	2,50,000	1,64,375	.....
Ninth ...	17,00,000	1,36,00,000	4,78,125	3,00,000	1,78,125	.....
Tenth ...	17,00,000	1,53,00,000	5,41,875	3,50,000	1,91,875	.....
Eleventh ...	17,00,000	1,70,00,000	6,05,625	4,00,000	2,05,625	.....
Twelfth ...	5,00,000	1,75,00,000	6,46,875	4,50,000	1,96,875	.....
Thirteenth ...	.....	1,75,00,000	6,56,250	5,00,000	1,56,250	.....
Fourteenth ...	.....	1,75,00,000	6,56,250	6,00,000	56,250	.....
Fifteenth ...	.....	1,75,00,000	6,56,250	7,00,000	.....	43,750
Sixteenth ...	.....	1,75,00,000	6,56,250	8,00,000	.....	1,43,750
Seventeenth ...	.....	1,75,00,000	6,56,250	9,00,000	.....	2,43,750
Eighteenth ...	.....	1,75,00,000	6,56,250	9,50,000	.....	2,93,750
Nineteeth ...	.....	1,75,00,000	6,56,250	9,50,000	.....	2,93,750
Twentieth ...	.....	1,75,00,000	6,56,250	9,50,000	.....	2,93,750
Twenty-first ...	.....	1,75,00,000	6,56,250	9,50,000	.....	2,93,750
Twenty-second ...	.....	1,75,00,000	6,56,250	9,50,000	.....	2,93,750
Twenty-third ...	.....	1,75,00,000	6,56,250	9,50,000	.....	2,93,750
Twenty-fourth ...	.....	1,75,00,000	6,56,250	9,50,000	.....	2,93,750
Twenty-fifth ...	.....	1,75,00,000	6,56,250	9,50,000	.....	2,93,750
Total ...	1,75,00,000	.....	1,23,84,375	1,31,50,000	20,15,625	27,81,250

(Accompaniments to Letter to the Government of India, No. 763, dated 18th March 1909.)

INDEX TO CHIEF ENGINEER'S LETTER, No. C. E. I.-16, DATED 11TH JANUARY 1909.

N. of Para.	Contents.
1.	Area commanded 340,000 acres.
2.	Length. 150 to 160 miles. | Rough estimate of cost. 175 to 184 lakhs.
3.	Volume of storage.
4.	Probable return at different rates.
5.	Tanks to be filled.
6.	Size of canal.
7.	Distribution of supply.
8.	Areas of irrigation, Rates and Revenue expected.
9.	Overlapping of sugarcane.
10.	Area to be irrigated by tanks.
11.	Total irrigation expected.
12.	Proportion of sugarcane to total area.
13.	Maintenance of sugarcane during the worst year.
14.	Revenue calculated in the manner suggested by the Government of India.
15.	Improvements possible in design of project.
16.	Value of the canal.
17.	Note on the cost of the masonry dam.
18.	Area likely to be irrigated, and duty of water.
19.	Classed as next to Nira Right Bank Canal.

No. C. E. I.—16 OF 1909.

PUBLIC WORKS DEPARTMENT,
Bombay Castle, 11th January 1909.

FROM

A. HILL, Esq., C.I.E.,
CHIEF ENGINEER FOR IRRIGATION;

To

THE SECRETARY TO GOVERNMENT,
PUBLIC WORKS DEPARTMENT,
IRRIGATION.

SIR,

I have the honour to submit the report of the preliminary survey and rough estimate for the extension of the Mutha Right Bank Canal called for in Government Resolution No. 1655 of 12th June 1908. The preliminary survey has shown that the land around Indapur is commanded and that without encroaching on the area at present served by the Nira Canal, a gross area of 340,000 acres is commanded, of which 270,000 are estimated as culturable. The canal, where it meets the tail of the Nira Canal, is at a higher level than the Nira Canal and water could be sent into Shetphal Tank if required, but as the command is so large, the water can be all used up without including Shetphal.

2. The length of the canal as surveyed is 147 miles from the aqueduct at the Empress Gardens, Poona, which is 11 miles from Lake Fife, so that the total length as surveyed would be 158 miles. The only unusual difficulties along this preliminary line are two short tunnels about 1,100 and 1,400 feet long respectively, and I have shown how these can be converted into open cuts it the work is approved and improved detailed surveys and plans made. The rough estimate of cost amounts to 184 lakhs including all charges; of this, 33 lakhs are for establishment alone and all this will not be required. I think the estimate is not only ample but capable of reduction and also that the length of canal can be shortened; the canal will be less than 150 miles total length and cost less than 175 lakhs, and I have taken 175 lakhs as the basis of my estimates.

3. The storage provided for is 22,000 million cubic feet. The storage is more than the total storage for Godaveri, Pravara and present Mutha Canal systems combined. Also, it is more than 4 times the volume of the present storage at Lake Whiting for the Nira Canals and 5½ times the volume at present stored at Lake Fife for the Mutha Canals. Further, the loss by evaporation in the tank is very much less than 5½ times the present loss on Lake Fife, because the loss is 5 feet depth on the mean area; the available depth of Lake Fife is to be increased from 25 to 95 feet and 5 feet is $\frac{1}{5}$th of 25 feet, but only $\frac{1}{19}$th of 95 feet. Hence the water available for issue at canal head is about 20,500 million or a little more than 7 times that now available at Lake Fife.

4. I have estimated the returns of revenue that may be expected and the gross returns amount to a little more than 7 times the present gross return, and deducting ample working expenses, the net revenue would give a return of 5·5 per cent. on the additional capital expenditure excluding interest during construction, if the water rates are Rs. 32 for sugarcane and Rs. 5 for rabi. The return would be 3·72 per cent. if the water rates are 24 for sugarcane and 4 for rabi.

5. The canal also commands the following existing tanks:—

	Contents in million cubic feet.
Matoba	229
Kasurdi	14
Shirsuphal	365
Bhadalwadi	222
Total ...	830

They must be filled and this would require a discharge of 315 cusecs for a month or 105 cusecs for 3 months and the canal should be made large enough to supply this in addition to monsoon requirements. The Victoria Tank at Warwand and the Khamgaon Tank, commenced as Famine Relief works and not yet completed, are also commanded.

6. The contents of the enlarged tank at Lake Fife for R. L. 315 F.S.L. 160 feet height of dam are 21,911 million cubic feet. Deducting 5 feet depth on the mean area of 276 millions square feet or a deduction of 1,380 million cubic feet for losses by evaporation for the tank, the net quantity available for issue is 20,531 million cubic feet. It will be convenient to reduce this to cusecs per month. The volume is sufficient for a continuous discharge of 640 cusecs for 12 months = 7,680 cusecs for one month. Now, in all normal years, the monsoon discharge will be able to supply the canal for 3 months, and hence, the storage is available for 9 months. The rabi season and the period when sugarcane is being replanted is when most water is required and the size of the canal must be made to suit this season. The losses along the canal due to leakage and absorption and calculated at the rate of 8 cusecs per million square feet of wetted perimeter amount to about 264 cusecs. The experiments and observations made on our Deccan canals indicate that for perennial canals the loss is considerably less than this, and hence 250 cusecs is ample allowance. The actual size of canal suitable is one with 1,000 cusecs discharge at the head and the share of water for each crop is calculated and detailed in paragraph 9 below under the head overlapping of sugarcane.

7. The total discharge required during the rabi season and for planting sugarcane is 998 cusecs. The discharge allotted to rabi is 130 cusecs and for overlapping 98 cusecs, and hence, during the monsoon, this discharge, totalling 228 cusecs, will be available for monsoon irrigation and for filling the tanks. About 120 cusecs are required for filling the tanks and hence, over 100 cusecs are available for the monsoon irrigation. The calculations further show that there will be a supply of about 90 cusecs for the hot weather over and above the quantity required for sugarcane. It will be convenient to have this reserve in case the replanting season takes longer than expected or to allow for excessive dryness in a hot weather season. It could not be utilized for sugarcane without increasing the size of the canal or diminishing the rabi and 8 months crops and hence it is estimated as available for hot weather crops.

8. The areas, rates, gross revenue and working expenses and net revenue, are worked out in table below. The rate for sugarcane, however, is taken at Rs. 32 only per acre instead of Rs. 40 as for the Panset Warasgaon Project:—

Total Area, Revenue and Working Expenses for canal and tanks combined.

	Acres.	Water rate.	Gross Revenue.	Working Expenses.	
				Rate per acre.	Total.
				Rs. a. p.	Rs.
Sugarcane or perennial	25,080	32	802,560	6 0 0	150,480
Overlapping of sugarcane ...	12,540	8	100,320	1 8 0	18,810
Eight months	25,080	8	200,640	1 8 0	37,620
Rabi	25,080	5	125,400	0 12 0	18,810
Monsoon	21,000	3	63,000	0 12 0	15,750
Hot weather	5,400	6	32,400	0 12 0	4,050
Total, excluding overlapping ...	101,640	...	13,24,320		2,45,520
Add—Extra for 5,000 acres of sugarcane near Poona at Rs. 40 instead of 32=5,000×8 ...	...	...	40,000		
			13,64,320		
Deduct—Working expenses ...	...	...	2,45,520		
Net Revenue	...	...	11,18,800		
Deduct—Previous net revenue including Tanks	...	...	1,50,400		
Increased net Revenue due to additions	...	...	9,68,400 =5½ per	cent. on 175	lakhs.

The above figures are on the basis of water rates of Rs. 32 for sugarcane, 5 for rabi and 3 for monsoon or a Rs. 4 basis for cereal crops. If these are reduced to 24 for sugarcane, 4 for rabi and 2 for monsoon or to a Rs. 3 basis for cereal crops, then the net revenue will be reduced by Rs. 3,21,960* and the percentage reduced to 3·72 per cent. In the Panset and Warasgaon Project Rs. 40 was taken as the water rate for sugarcane. The present net revenue on the Mutha Canal and the 4 tanks is calculated, excluding the revenue from water-supply and miscellaneous which would not be affected by the extension of the canal, and then deducted from the expected net revenue and the balance amounts to Rs 9,68,400 or 5½ per cent. on the outside estimate of 175 lakhs of rupees, including 32 lakhs for establishment.

25,080 × 8 = 2,00,640
12,540 × 2 = 25,080
25,080 × 2 = 50,160
25,080 × 1 = 25,080
21,000 × 1 = 21,000
3,21,960

9. *Overlapping of sugarcane.*—The sugarcane plantation lasts for two years, the second year's crop called Katoons growing from the roots of the old. New crops are planted during the three months, January to March inclusive, and for the overlapping of the old crops being cut, by the new crops being planted, an allowance of 1½ months' time is required, and hence during these three months water must be provided for ¼ more sugarcane than the annual area. To grow equal areas of sugarcane (duty 60) and 8 months and rabi crops (duty 180) the discharge 1,000 cusecs must be divided up as follows during the period January to March when 8 months and rabi are being grown:—

	Cusecs.		Cusecs for 1 month.
For sugarcane	390 for 9 months	=	3,510
For overlapping	98 for 3 do.	=	294
8 months	130 for 5 do.	=	650
Rabi	130 for 4 do.	=	520
Losses	250 for 9 do.	=	2,250
Total discharge the canal must supply ...	998		7,224
The storage available is			7,680

Balance=456 cusecs for one month = 114 for the 4 months hot weather, of this 25 cusecs will be wanted for sugarcane grown under tanks.

10. The area which can be irrigated by the tanks can be calculated in the same manner. The total contents of the 4 tanks = 830 millions or equal to 318 cusecs for one month. Deducting $\frac{1}{5}$th for losses, net available = 255 for one month. Now, as there is a balance of 114 cusecs for the hot weather in the canal, the tanks may share some of it for their sugarcane and it may be arranged to use up all the water in the tanks during the 5 months comprising the last month of monsoon and 4 months rabi. The proportion will be—

	Cusecs.	Months.	Cusecs for one month.
Sugarcane	28	× 5	= 140
Overlapping	7	× 4	= 28
8 months	$9\frac{1}{3}$	× 5	= $46\frac{2}{3}$
Rabi	$9\frac{1}{3}$	× 4	= $37\frac{1}{3}$
		Balance	252

The extra area irrigable with the assistance of the tanks is therefore—

	Discharge.	Duty.	Acres.
Sugarcane	28	× 60	= 1,680
Overlapping...	$\frac{1}{2}$ of above		= 840
8 months	$9\frac{1}{3}$	× 180	= 1,680
Rabi	$9\frac{1}{3}$	× 180	= 1,680

The tanks will be run dry by the end of the cold weather and the hot weather water for sugarcane be supplied from the canal. The deduction for losses made in these calculations for tanks is put at $\frac{1}{5}$th, but, as the tanks are to be run dry by end of February, the losses will be less than this and there should be some water to spare.

11. *Total Irrigation under Canal and under Tanks :—*

	Under Canal. Acres.		Under Tanks. Acres.
Sugarcane	390×60	= 23,400	1,680
Overlapping	2×$\frac{1}{4}$ of above	= { 5,850 / 5,850 } 11,700	840
8 months	130×180	= 23,400	1,630
Rabi		= 23,400	1,680
Monsoon	100×180	= 18,000	800
Hot weather	90×60	= 5,400	

12. This area agrees closely with the proportion the committee calculated as irrigable when considering the proposals for the preliminary survey. They assumed that the command would be 200,000 acres gross, of which the culturable area would be about 160,000 acres and the area irrigated 64,000, of which 15,000 will be sugarcane. The actual area commanded is 340,000 acres, the culturable area 270,000. If the sugarcane and irrigated area increased in proportion to the gross command the figures would be 25,500 sugarcane and 113,800 total irrigation, whilst my figures are 24,600 sugarcane and 109,800 total irrigation and I include the 4 tanks, 3 of which the committee did not know would be filled. The areas for sugarcane and also the gross Revenue are less than those obtained by calculations in the manner recommended in paragraph 4 of letter No. 1576-I of 12th September 1907 of the Government of India. The working expenses, however, are less, as the very high rate of Rs. 6 per acre at present ruling is due mainly to the large proportion of sugarcane to the total and also to the small total area of crops under the canal. The working expenses I have allowed, $2\frac{1}{2}$ lakhs, are ample for the proper management of the canal. The water-supply of Poona is excluded from these calculations and the revenue and expenses for that would continue as at present.

13. *On the maintenance of the sugarcane crop during the worst year.*—The year's storage is calculated to last until the 1st of July. The sugarcane is planted in January, February and March, and hence, the full crop of 25,080 acres would be in the ground when the monsoon of the worst year arrived. The supply of the worst year is estimated at a gross storage of 14,000 millions and deducting 1,200 millions for losses direct from the tank, 12,800 million cubic feet would be available for issue or sufficient for 410 cusecs for 12 months=4,920 for one month. Now to irrigate the 25,080 acres of sugarcane of a full crop, 418 cusecs delivered at outlets are required, and allowing $\frac{1}{4}$ loss in canal = 522 cusecs for 6 months = 3,132 cusecs for one month. The sugarcane could, therefore, be all irrigated up to the 31st December and the balance available for next year's crop=4,920—3,132=1,788 cusecs for 1 month=298 for 6 months; deducting $\frac{1}{4}$=74 for losses in canal, the balance available for

issue at distributary heads=224 cusecs=sufficient for $224 \times 60 = 13,440$ acres of cane or more than half the full crop, *viz.*, $\frac{25080}{2} = 12,540$. In the very worst year, therefore, not only could the whole of the usual ratoons or second year's crop be maintained, but 900 acres of new cane could also be planted. In working the tank it will, therefore, be sufficient precaution to wait until 14,000 millions are stored in the tank before issuing water to crops other than sugarcane. As a general rule, more than this quantity will be stored during July or in the first fortnight of monsoon rain and there will be no danger of any sugarcane crop being lost or damaged for want of water.

14. If the return of revenue be calculated on the method described in paragraph 4 of letter No. 1576-I of 12th September 1907 of the Government of India, the figures would work out as shown below :—

Effective storage of existing work = 2,758 million c. ft.
Effective storage of proposed work= 20,531 do.
Proportion = $\frac{1}{7\cdot4}$
Probable annual irrigation = 9,107 × 7·4 = 67,392 acres.
Probable sugarcane ... ... 4,369 × 7·4 = 32,331 do.
Annual gross Revenue for water rate... ... ... 185,337 × 7·4 = 13·71 lakhs.
Deduct working expenses ... 71,035 Acres at 6 = 4·26 lakhs.
Net Revenue ... = 9·45 lakhs.
Deduct previous net revenue for water, &c. ... 1·40 do.
8·05 do.
= 4·6 per cent. on 175 lakhs.

15. *Notes on the preliminary survey and estimate for the canal.*—The estimate provides for a canal to discharge the full 904 cusecs from the Empress Gardens and makes no allowance for the existing canal; this can carry 250 cusecs and the size of the new canal need not be more than 750 cusecs capacity reducing the estimate to 605 at 60 miles. The preliminary survey was made with a bedfall of 8 inches a mile for 80 miles and increased fall beyond this. At all cuts increased fall was given to narrow the cut and reduce the cost. Excepting at the cuts, I recommend that the bedfall be reduced to 6 inches a mile. The reduction in the depth of the cuts and of the tunnels is shown in the following table :—

No. of cut.	Mileage.	Reduction in depth.	Original depth.	Revised depth.	Length above 20 feet depth.
No. 1	47	7·83′	32·27′	24·44′	1,500
„ 2	63	10·50′	45·88′	35·38′	
„ 3	71	11·83′	30′	18·17′	
„ 4	109	20·25′	48′	27·75′	700
„ 5	123	24·83′	37′	12·17′	*Nil.*
„ 6	126	25·50′	52′	26·50′	800
Tunnel No. 1	74	12·33′	63′	50·67′	1,400
„ „ 2	86	14·10′	69′	54′	2,800

The result is that cuts 3, 4, 5 and 6 almost entirely disappear or are insignificant and Nos. 1 and 2 are of moderate depth. The depth at the tunnel is also so much reduced that open cuts may be substituted in place of tunnels unless the rock is specially favourable for tunnelling.

16. The area commanded will also be considerably increased; the preliminary trial line as actually levelled was 7 feet above the tail of the Nira Canal at 100 miles of that canal and the change of gradient to the 6″ a mile recommended by me will raise the canal 35 feet higher at this point. I expect that over 50,000 acres additional command will be obtained and that the gross area commanded will be close on 400,000 acres. The canal is, therefore, one of the most important that have been discovered by the Protective Surveys and I should place it next to the great Nira Right Bank Canal in importance and value. The Kukari Canal, it has been proved, cannot deliver water so far East as this canal and the revenue would be much less. The Gokak Left Bank Canal is about the same size and the Ghatprabha Left Bank Canal is larger, but both of these do far more damage by submersion of

valuable lands than the Mutha Right Bank Canal which is very exceptional in causing so little damage; 4,200 acres only are submerged, whilst over 100,000 additional acres are irrigable, of which 20,000 are additional sugarcane. Further, in the land commanded is a considerable area amounting to over 20,000 acres of good land which was reserved for forest after some of the early famines, but has been unable to grow trees for want of rain and all this forest failure can be converted into excellent irrigated lands. No credit has been taken for this conversion of forest to irrigated land but the increase in value of the land will be over 20 lakhs of rupees.

17. The Executive Engineer's estimates in detail were for masonry dams of 150 and 170 feet height. The height I have chosen is 160 feet. The additional cost is calculated as follows:—

Approximate figures for additional cost of Masonry Dam and Waste Weir for 160 feet height at Lake Fife.

The extra masonry = ...		45 lakhs cubic feet over that for a dam of 150 feet height.
If the existing dam is not to be used		50·60 lakhs.
Quantity		95·6 lakhs.
Cost at Rs. 20 per 100 cubic feet	Rs.	19·1 lakhs.
Add 5 per cent.	Rs.	·9 lakhs.
Extra cost	Rs.	20·0 lakhs.
Savings which can be made by reducing cost of Dam Masonry from 22 to 20 : 17,393,787 at 2=	Rs.	3,47,875
Parapet and turbines		40,000
Undersluices		2,00,000
Waste Weir.		
Excavation not required		1,50,000
822,100 Rubble Masonry at 2 = ...		16,442
22,583 Arch work at 50 = ...		11,294
		7,65,611
	5 per cent.	38,280
		8,03,891

Thus—

20 lakhs Extra.

Deduct—8 lakhs Savings.

12 lakhs Extra.

3 lakhs ¼ Establishment and Tools and Plant.

15 lakhs Net Extra.

So that total cost of a dam 160 feet high as per usual estimate would be 69 lakhs+15 lakhs=84 lakhs. The amount of establishment is, however, excessive. If the 84 lakhs were substituted for the 75 lakhs of the Executive Engineer's estimate and the 3 lakhs for bridges added also, the total would be 184 lakhs, but I think the canal estimate is excessive and that with the reduction of cutting made by the change of gradient from 8″ to 6″ a mile, 175 lakhs will be ample.

18. Regarding the proportion of the culturable area likely to be irrigated and the duties to be obtained from water, the Bhadalwadi Tank in the centre of the area to be irrigated is a good illustration. The culturable area under this tank is 2,400 acres and in 1906-07 no less than 1,929 acres were irrigated. Shirsuphal and Matoba Tanks also within the area and Shetphal at the end of the command used up all the water available. Matoba and Shetphal serve sugarcane and so the duties are determined by that crop, but Bhadalwadi

and Shirsuphal cannot reserve water for perennial crops and the duties for these tanks are instructive and are given in Table subjoined below:—

Bhadalwadi.

		1905-06.	1906-07.	1907-08.
Rainfall		15·25	24·43	12·32
Total culturable area under command	Acres	2,400	2,400	2,400
Area irrigated	„	1,047	1,929	1,115
Duty per c. ft. { Kharif	„	202	452	237
Duty per c. ft. { Rabi	„	289	260	233

In 1906-07, large supply was in tank and all rabi was irrigated.

Shirsuphal.

Duty .. { Kharif	Acres	338	500	175
Duty .. { Rabi	„	647	282	121

In 1906-07 large supply was in tank and all rabi was irrigated.

It will be seen that they much exceed in the average the duty of 180 taken for water issued at heads of distributaries in the present estimate. For sugarcane, careful measurements on the experimental distributary at Baramati give a duty of 63 acres per cusec at the head of the distributary. Duties on the Nira and Mutha at the heads of the canals are about 50 acres per cusec and if the allowance of loss in canal be made in the same way as in the calculations for the proposed canal, the duty is about 66. In the present calculation a duty of 60 only at distributary heads has been taken. The duties for cereal crop on the Nira Canal, after deducting the water required for sugarcane, are as follows, but they are on the discharge at the head of the canal and will be about ¼ greater at distributary heads:—

Nira Canal.

Year.	Kharif.			Rabi.			
						Rainfall.	
	Acres, excluding perennial.	Duty.	Rainfall 15th June to 15th October.	Acres, excluding perennial.	Duty.	15th August to 21st October.	22nd October to 2nd December.
1900-01	18,163	251	11·61	33,328	142	0·98	0·18
1901-02	1,928	191	6·27	33,082	154	6·36	0·66
1902-03	12,276	367	2·46	13,142	310	7·85	6·00
1903-04	7,418	184	6·91	18,212	172	10·19	Nil
1904-05	16,257	196	...	26,809	153	...	...
1906-07	1,754	331	...	29,932	253	...	...

The duties of 180 for cereal and 60 for perennial taken in paragraph 10 are therefore, moderate. Further, there are about 90 cusecs available over and above the estimated requirements of sugarcane and perennial crops during the hot weather and which are allotted to hot weather crops, but can be used for perennial in the hot weather if found necessary.

19. I recommend the work as one of the most promising in the Deccan. It will be a most efficient Protective work in times of Famine and if the rate of Rupees 32 for sugarcane is approved will be Productive. I should class it next to the Nira Right Bank Canal in order of merit.

A. HILL,

Chief Engineer for Irrigation.

THE NIRA RIVER.

The Proposed Nira Right Bank Canal and the Existing Nira Left Bank Canal.

Magnitude and importance of the Nira Project.

44*h*. The Nira River is the extreme southern tributary of the fan-shaped system of ghat tributaries of the Bhima and, as noted in the first paragraph dealing with the Bhima Valley, is of sufficient importance to be considered by itself. It has a catchment area of 600 square miles above the existing weir at Vir forming the headworks of the Nira Left Bank Canal, and has three ghat tributaries—the Gunjowni, Yelwandi and Nira Rivers—rising along a length of 20 miles north and south of the strip of country with heavy and assured rainfall on the edge of the ghats. The discharges have been observed for 30 years, and the normal supply is accurately known. Preliminary reports on the project have been sent to the Government of India and its value has been recognised, and detailed surveys and the preparation of accurate plans and estimates for the project are sanctioned and are in energetic progress. The main features of the project are as follows. The Right Bank Canal could command, and the water available is sufficient to supply eight-month irrigation to, a larger area in the tract of intense famine than an y other Irrigation Project in the Deccan.

Two other schemes only are of similar magnitude, namely, the Kukadi Left Bank Canal and the Gokak and Ghatprabha Right Bank Canal. The Kukadi, however, has not so good a supply as the Nira, a d though the Gokak and Ghatprabha Right Bank Canal have an even better supply than the Nira, still the area supplied does not suffer so intensely from famine as the Malsiras taluka of Sholapur and the surrounding districts which can be irrigated from the Nira Right Bank Canal.

Length of Nira Right Bank Canal to be limited to 150 miles.

45. The length of canal necessary to irrigate the whole area commanded has been proved to be over 240 miles, and it has been decided by the Government of India that this is too great a length and that the canal is to be limited to a length of about 150 miles with a command of from 650,000 to 800,000 acres according to the length and cost of the canal now being finally surveyed.

Storage at Bhatgarh—Lake Whiting.

46. To supply this canal, the storage of the existing Bhatgarh Reservoir or Lake Whiting on the Yelwandi, the central valley of the three ghat tributaries of the Nira, is to be increased from 5,000 millions to 25,000 millions or over by raising the height of the dam from 100 to 160 feet. This plan will, as explained from the case of Lake Whiting for the Mutha Extension Project, utilise the whole of the water surface of the existing lake for the storage of 60 feet depth of water, and the area of land drowned will be the extra area submerged around the edges of the lake, and will be much less than if entirely new reservoirs were constructed. Several additional reservoirs were surveyed, and it has been shown that to store the same volume of water two dams 160 feet high, one in the Nira and one in the Gunjowni Valley, would be required, and that the area submerged by each of these reservoirs would exceed the area round the edge of Lake Whiting, and that the lands would be mostly rice-lands in the bottoms of the valleys and much more valuable than the rough hill-side fields forming the greater portion of the area submerged by the raised Lake Whiting. The water-supply of the Yelwandi or river from the Lake Whiting catchment is equal to the two other rivers combined. The storage reservoir is therefore to be Lake Whiting raised from 100 feet to 160 feet depth and to store 25,000 to 30,000 million cubic feet.

Storage at Vir Basin.

47. To utilise the waters of the other two streams, the existing weir at the Vir headworks of the existing Nira Left Bank Canal is to be raised from 50 feet to about 100 feet, so that a storage of about 9,000 million cubic feet is obtained, and this large tank will act as a regulating tank during the monsoon and keep the large canals constantly supplied during the monsoon, and in most years will also be full at the end of the monsoon.

48. The supply of water is thus abundant for the area to which the command is to be limited, and it seems probable that the Nira Right Bank Canal may be productive from its irrigation revenue alone, without reckoning on the benefits derived by protection of this area from famine.

Probably a productive work.

The first 75,000 acres commanded are in Native State of Phaltan, but the remainder is nearly all in British territory. The lands of the storage tanks submerged are, however, mainly in the Native State of Bhor.

49. General Abstract of Projects in the Bhima Valley.

Name.	Storage.	Command.	Rough Estimate of cost in lakhs.
The Kukadi Canal	20,000	5,80,000	310
The Bhima	15,000	1,70,000	120
The Bhama	5,000	Not surveyed.	50
The Indrayani	5,000		50
The Pauna	5,000		50
The Mula	5,000		50
The Mutha	22,000	3,40,000	175
The Nira Right Bank Canal and Left Bank Canal.	35,000	7,00,000 3,00,000	310

50. In addition to the report and plans mentioned in paras. 42A and 42B for Kukadi Project, there should be printed —

Mina Storage.

The Dam Line at Wadgaon.

Bhima Project.

The Dam Line at Karda.

The Dam Line at Kaman.

For the Mutha Canal Extension it does not seem necessary to print any plans as the storage site is at the existing Kadakvasla Dam and the special report indicates the canal line. Similarly, for the Nira Right Bank Canal, detailed plans and estimates are under preparation and it is not necessary to record any in his report.

THE KRISHNA VALLEY.

51. It has not been found practicable to conduct the water of the Krishna River by gravity on to the famine lands of the Deccan. The rainfall on the sources of the Krishna is very heavy and the catchment area of the ghat tributaries of this river lies well within the zone of heavy rainfall and the water-supply is most abundant and great efforts were made to find some means of using the waters for irrigation for protection from famine. The main results of these surveys are now recorded with the object of saving further fruitless survey in the same direction and of indicating how the water may possibly be utilised hereafter for Protective irrigation, if the value of irrigated lands increases and justifies the expense, or for Productive irrigation.

The abundant supply of water cannot be conveyed on to the famine lands.

52. The physical features of the country rendering a protective canal impracticable are the long high spurs and ridges which run from the water-shed between the Bhima Valley and the Krishna down to the banks of the Krishna. The streams in the valleys between these ridges have Deccan catchments without reliable rainfall and provide no supply of water during famine. To indicate clearly the character of the ground on the left bank of the Krishna, the contour line at 2,000 feet level has been plotted on the maps and

Physical features of the valley.

shows that the town of Bijapur itself is at the same level as the bed of the Krishna and Koyna Rivers within the zone of ghat rainfall and that the length of contours connecting them is over 775 miles.

The ghat tributary keeping the name of the Krishna River is on the extreme left, or northern flank of the system of ghat streams feeding the Krishna, and an endeavour was made to find an alignment for a canal at a higher level than R.L. 2,000. which might be shorter than the great length of the 2,000 feet contours. A trial line was run from the lowest point in the ridge separating the Krishna Valley from the large Deccan tributary of the Yerla, but the levels were found to be higher than the bed of the Krishna at its source and the contours of impracticable length. The principal levels and the line tried have been shown on maps.

No canal of ordinary design can take the Krishna waters on to the famine lands of Bijapur.

The possibility of reducing the length by siphons across the valleys, and tunnels through the hills was also considered, but is financially quite impracticable.

Pumping necessary to get water on to famine lands.

53. If the abundant waters of the Krishna are to be delivered into Bijapur then it will be necessary to pump from the river up to the high ground to be supplied. The cost of pumping would at present be prohibitive, but hereafter, the value of water for irrigation may so largely increase that pumping would be justifiable, and the best position for pumping from the Krishna River into a canal which would command Bijapur has been noted on the map. It is situated on the Krishna River about due south of the large village of Savalgi, and by pumping the water up a height of 416 feet, water could then be run by gravity to command Bijapur town itself and about 2½ million acres of Bijapur eastern districts.

The Superintending Engineer in his comments has stated that the shortest length of pipe line would be 8½ miles and this pipe line has been marked on the maps, but if instead of raising the water the whole 416 feet by one continuous lift, several lower lifts be adopted, for instance, 9 lifts of 50 feet, then, by carefully aligning channels along the sides of the hill from one lifting station to another, the length of piping could be reduced to very small limits, probably to about 200 feet length at each station.

This position near Savalgi is the best for pumping to Bijapur town and to the eastern parts of Bijapur District, but there are numerous other places along the Krishna, where high ground comes near to the river, and a good command can be obtained by a series of pumping stations close together and, in my opinion, the surveys recently undertaken have proved that the best method of utilising the Krishna water for protection of famine lands is by pumping, and not by one continuous lift, but by a number of lifts at various points along the river, and in various steps or stages of lift with a series of small canals at different levels. The time is not yet ripe for such a project on a great scale for ordinary cereal crops with monsoon supply only, but small projects might possibly pay and show the way for larger developments.

Head-waters cannot conveniently be taken into Nira Valley.

54. Survey was also directed to ascertain whether the head-waters of the Krishna River could be taken by means of a tunnel into the next valley, which is the Nira tributary of the Bhima, and used to add to the supply to the great Nira Right Bank Canal. A tunnel is possible, but the length at the levels investigated would be 8½ miles and the cost considerably more than could be justified. This tunnel line started from the tank site near Dhom above Wai, and is indicated on the map.

Productive Works of small command possible.

55. The Krishna River is therefore of very little help for Protective Irrigation, but it is quite possible that Productive Irrigation works of small command with large proportion of perennial or valuable crops may be made to pay. No such scheme has been worked out, but the survey for

protective works has indicated schemes which would probably be suitable if carefully designed, and the Superintending Engineer has described in his reports the survey work suitable for such projects.

Best Productive work would have storage at Helvak on Koyna.

56. The most promising work seems the extension of the present Krishna Canal. An extension was actually surveyed for a great length of canal in the hope of commanding the famine lands and a site was surveyed for a storage tank at Kamargaon, near Helvak, on the Koyna. From this tank the water was to be let down the Koyna River and picked up by a weir at Nisra, from which it would be conducted by a canal on the left bank to the headworks of the existing Krishna Canal which are at the Khodsi weir on the Krishna River, a little above the junction of the Krishna.

The Superintending Engineer has described the project in paras. 25 to 42, and suggests that the existing Krishna Canal should be increased from 35 miles, its present length, to 105 miles, an increase of 70 miles, obtaining a command of 108,000 acres gross command. Much of this land commanded is flooded when the Krishna runs in great floods, and excellent crops are grown on the area flooded, but the floods are not sufficient for perennial irrigation. At the same time they are not harmful, and in the Mudhol State on the Ghatprabha, in the Kolhapur State on the Bhogava, and in British territory on the Ghatprabha and also on this very Krishna River, sugarcane is grown by means of lift water on the banks of the rivers, and is completely submerged by the floods with the result that the crops are much benefited. The very fertile belt of soils along the banks of the rivers is therefore peculiarly well suited for the cultivation of sugarcane or other perennial crops. The Superintending Engineer has adopted for this special case the usual proportion of equal areas of perennial, eight-month, rabi and monsoon crops and has estimated for $\frac{1}{4}$ of 37,000 acres or 9,250 acres of perennial irrigation, or less than one-tenth of the gross area commanded. Now, the supply of the Koyna is most abundant and storage facilities good, and it will be possible to irrigate perennially a great deal more than one-tenth of the gross area commanded, and under similar conditions near Poona, over one-fourth of the gross command has been irrigated under perennial crops. The banks of the Krishna River and the land close to the bank, though subject to floods, are some 40 to 50 feet above the cold weather level of the river, and so are exceptionally well-drained and well-suited to intense irrigation and 25,000 acres of perennial irrigation could be efficiently cultivated in the area of 108,000 acres commanded by the extended Krishna Canal.

Further, the Superintending Engineer has not made any allowance for a canal on the right bank from the proposed pick-up weir. The town of Karad would form the centre of irrigation for such a right bank canal and perennial irrigation is practised around Karad wherever water can be economically raised by lift. The command to be obtained on the right bank of the Koyna and Krishna is less than on the existing Krishna Canal, but an additional 5,000 acres of perennial at least could be obtained, so that an area of at least 30,000 acres of sugarcane may be expected. At a rate of Rs. 30 per acre, with working expenses at Rs. 6 per acre, it would be practicable to obtain a gross revenue of Rs. 9 lakhs, working expenses 1·8 lakhs, and net revenue 7·2 lakhs ; and making allowance for a little ordinary irrigation in addition to perennial, an expenditure of Rs. 150 lakhs would be productive, and pay 5 per cent. on the capital cost.

The Superintending Engineer's rough estimate of the work, he suggests, amounted to Rs. 82 lakhs with a probable return of 3 per cent., and it seems quite practicable to gain the increased storage required and the increased canal for less than Rs. 70 lakhs additional expenditure.

I therefore report that a project for a storage tank on the Koyna, tributary of the Krishna, near Helwak and canals on both banks of the Krishna will probably be a remunerative productive work, and deserves close investigation and preparation

of detailed plans, and that it will be necessary to investigate whether it will not be better to dispense with the pick-up weir at Khodsi and take off canals direct from the dam at Kamargaon. The difficult work in the first few miles of the canals will probably be well repaid by the extra command obtained. A siphon to cross the river will probably be necessary to get over the difficulty of crossing the waste weir channel and to save a second canal on bad ground. The storage provided should be not less than 15,000 millions with power to increase it if the area of perennial becomes larger than estimated. The supply is far in excess of this storage, exceeding 100,000 million cubic feet in a bad year.

Storage at Dhom on Krishna would probably suit a Productive work.

57. Another storage tank has been investigated, the site for the dam being at Dhom on the Krishna River, about 5 miles above the town of Wai. It was from this tank site that a trial line for a tunnel into the Nira valley was surveyed. The Superintending Engineer has dealt with this Dhom storage reservoir and its probable uses in paras. 43-53 of his report, and suggests that the best way to use it would be to let the water down the river and use it at the existing Krishna Canal, picking up the water at the existing headworks at the Khodsi weir on the Krishna. The Koyna River waters can, however, be delivered into the Krishna Canal as explained above, and the best way to use the water would be for perennial irrigation in the Krishna valley itself between the town of Wai and the Khodsi weir. No detailed survey has been made, but the general survey dealt with in this note has shown that though the valley is narrow there are 50,000 acres of command below the 2,000 feet contour, whilst the level of outlet of the tank would be over 2,300. The large town of Satara is in the centre of the length to be supplied and the S. M. Railway runs through the southern part of it. An area of 15,000 acres of perennial seems quite practicable and an expenditure of Rs. 72 lakhs justifiable.

This site is therefore another which deserves careful investigation for a productive irrigation work. A storage of 10,000 millions seems desirable, and the water-supply is abundant.

Tributaries in Kolhapur State.

58. The ghat tributaries of the Krishna which lie south of the Koyna and north of the tributary of the Ghatprabha are a numerous set of streams with a great rainfall over the catchment and a very excellent supply of water, but they all join the main stream of the Krishna, west of the Belgaum-Poona branch of the Southern Mahratta Railway, and their waters cannot be delivered on to the famine lands to the east and the next effective river for Famine Protective Irrigation is the Ghatprabha River which commands the land between the Krishna and Ghatprabha River east of the Railway, and for this tract, the Gokak Canal Project is prepared and ready. These streams have therefore not yet been surveyed as their waters are not available for Famine Protective Works, but projects for Productive Works, with a limited command, abundant supply of water and large proportion of perennial irrrigation in hot weather cultivation of a high class, will be found practicable.

The valleys of these streams are mainly in the Kolhapur State. The largest of these numerous streams are the Warna, Kasari, Bhogava, Dudgunga and Vedgunga. The Warna is the boundary line between British territory and the Kolhapur State, and the valleys of the remaining streams are almost entirely in Kolhapur territory, but the upper waters of the Dudgunga and Vedgunga would command a small portion of Chikodi Taluka of the Belgaum District in British territory. The Maharajah of Kolhapur has commenced a project on the Bhogava for a fine masonry dam and canal to utilise some 6,000 million cubic feet of water in the growth of sugarcane along the fertile banks of the river; a command of over 50,000 acres can be obtained, if necessary, and the project promises to be a very productive one for the State. Similar projects could be designed for the other streams.

59. The projects that seem possible, without pumping in the Krishna valley, are therefore all Productive works and the probable volumes of storage that can be utilized are roughly given in the following Table :—

Statement of projects possible.

	Millions Cubic Feet.		Rough estimate of cost, including all charges, Lakh.
On the Krishna at Dhom	10,000 to 15,000	...	... 75
On the Koyna at Kamargaon, near Helwak.	20,000 to 30,000	...	... 150
On the Warna ...	... 15,000	... ...	... 75
Kasari	... 10,000	... ...	... 50
Bhogava ...	... 6,000	Under construction by Kolhapur.	
Dudganga / Vedganga	... 10,000	... ...	... 50

60. The reports and plans which should be printed as an accompaniment are :—

Reports.

The Report on the Krishna Valley Surveys in full.

Plans.

The Kamargaon Dam Site } Koyna River.
The Pick-up Weir at Nisra }

The Dam Site at Dhom, Krishna River.

The Index map showing classification of soil.

The work on the portion of 1" map included in sheets 202, 203 and 237 (=58).

Also a map to the scale 4 miles to the inch, on which should be shown the soil map of the Krishna Canal and all the information given in the set of 1" map amongst the plans. (Maps Nos. 201 {327/328} 202, 203 {327/328} 328, 329, 351, 40. 352, 301, 302, 327, 238, 270, 271, 272.)

THE GHATPRABHA VALLEY.

61. The Ghatprabha is a fine river to the south of the Krishna into which it flows near Bagalkot and just above the place where the Gadag, Hotgi and Bijapur branch of the Southern Maratha Railway crosses the Krishna River.

The whole of the supply can be utilised.

The valley has been thoroughly surveyed and it has been proved possible to utilise for irrigation the whole of the normal supply of this fine river amounting to 100,000 million cubic feet in normal years.

62. The principal features of the valley are the fine falls of the Ghatprabha a little above Gokak; they are 200 feet in height, allowing for the rapids above the falls, and a weir has been constructed a short way above them, and supplies a small canal on the Left Bank and also provides water for power at the Gokak Mills which have been made at the falls.

The Gokak canal on the Left Bank.

This weir is situated above and within a few feet of the S. M. Railway Poona-Belgaum Branch, where it crosses the Ghatprabha.

Irrigation is much appreciated and the water in the little existing Gokak Canal is keenly sought after, and as much as 14,000 acres have been irrigated out of a gross command of 19,000 acres, although little or no perennial water is available.

The fine commanding position of this weir above the great falls renders a Left Bank Canal easy. In the older surveys, excessive fall was given to the canal lines proposed, but Mr. Beale, the Officer on the Protective Survey, when re-designing this canal, adopted a fall of 8 inches a mile suitable and ample for the larger size of canal proposed, and thus made it possible to keep the canal line at a higher level and to get through the ridge forming the water-shed between the Ghatprabha and Krishna Rivers, and to command all the land between these rivers, excepting the tops of the hills.

The storage site selected for this work is at Daddi, some 25 miles above the Gokak weir and on the Ghatprabha or southern of the two main ghat streams which join above the Gokak weir. The other or northern Ghatfed stream is the Harankashi.

Detailed plans ready for sanction.

63. Plans and estimates for the canal to start from the Gokak weir and serve the land between the Ghatprabha and the Krishna have been prepared in accurate details, have been approved by the Government of India as a sound irrigation work, but are not yet sanctioned. They are not printed, as the project has been prepared in detail.

They include a tank at Daddi to store 18,000 million cubic feet out of the normal supply of 60,000 million ordinarily available at the site, and a canal to discharge 1,100 cubic feet a second, starting from the existing Gokak weir and commanding 497,000 acres, and a return of 4·75 per cent. is expected at existing irrigation rates. The land commanded is very subject to famine, and hence the project with its super-abundant water-supply is one of the most important in the Deccan.

GHATPRABHA RIGHT BANK PROJECT.

The Ghatprabha Right Bank Canal.
A canal can be taken through the hills by Gokak and command 825,000 acres.

64. On the right bank of the Ghatprabha immediately below the site of the weir, there are high hills of quartzite and no practicable way could be found round or through these hills for a canal taking off from the existing Gokak weir. When, however, the Daddi site had been found and selected for the storage for the Gokak Left Bank Canal, and the unusually large storage possible there was known, then it was suggested that if a canal were commenced from the site of the dam of the Daddi tank, instead of 25 miles further down the river at the existing Gokak weir near the Railway, the gain in command obtained would make it practicable to get through the hills to the south of Gokak which had hitherto blocked all projects for a right bank canal. A trial line has therefore been made for such a canal with results far exceeding those anticipated. A very thorough preliminary survey and preliminary estimate has been carried out and it has been proved that the right bank canal can command 825,000 acres of land subject to severe famine and where the people are keenly desirous of water for irrigation. A line has been selected and levelled and estimated roughly, and the difficulties which appeared so formidable are overcome by 5 miles of canal in sidelong ground, two siphons—one 3,000 feet long and one 1,100 feet long—and a cut 2 miles long with a depth not exceeding 52 feet, and a short cut of half a mile with a depth less than 30 feet. The works are quite practicable, not unduly costly, and amply justified by the command of 825,000 acres obtained.

Ghatprabha can use storage for Gokak and additional storage for Gokak can be obtained at Ajra.

65. The water-supply at Daddi which was so much in excess of the needs of the Gokak Left Bank Canal can all be used up. The rough estimate of the preliminary report has been framed on the supposition that the Daddi Tank will continue to supply the Gokak Left Bank Canal, but the Gokak Left Bank Canal can, if necessary, be supplied by storage on the Harankashi, a northern branch of the Ghatprabha above the Gokak weir. A site has been selected for a dam at Ajra and the discharge of the river is being gauged at Ajra, and during the five years the discharge has been

measured there it has varied from 24,000 to 42,000 millions. The discharge at the Gokak weir for the same year varied from 53,000 to 153,000 millions, but the year 1904 of 53,000 millions is the very worst on record, and the normal supply at the Gokak weir is over 100,000 millions and was exceeded in 12 years out of 19.

The Markandya supply could be used.

66. The Right Bank Canal could also intercept the supply of the Markandya River by means of a small storage tank to be used as a Regulating Tank, and the normal supply of this river is about 5,000 millions.

These two canals, the Gokak Canal on the Left Bank commanding 497,000 acres and the Right Bank Canal commanding over 825,000 acres, together command an area of 1,322,000 acres, or a probable culturable area of over a million acres. The water-supply available in normal years is over 100,000 millions and is more than sufficient to irrigate the whole culturable area with cereal crops. The minimum supply on record is over 53,000 millions or sufficient for 80,000 acres of perennial crops or 640,000 of cereal crops.

The system is therefore the greatest in the Deccan, even exceeding the Nira Right Bank Canal in area commanded and in volume of water-supply. The one drawback is that the lands drowned are valuable and a large number of villages and people will be submerged. Details are given fully in the report on the project, but this drawback is more than compensated by the greatness of the benefits obtained.

66A. The report on the project and the Chief Engineer's comments and the opinion of Revenue Officers are attached.

67. The reports, plans and estimates which should be printed are :—

All the corrrespondence with Chief Engineer's report.

The Ghatprabha Right Bank Canal Report, Book I.

The Ghatprabha Right Bank Canal Report, Daddi Storage, Book II.

These books with reports, estimates and statements had better be printed in full, as they contain valuable preliminary information.

The plans to be printed for the Ghatprabha Valley are :—

The map 4 miles to the inch of the Ghatprabha Right Bank Canal and the Sheet 274, Scale one mile to the inch, which are in the portfolio of Index Plans of the Ghatprabha Right Bank Canal.

REPORT REFERRED TO IN PARA. 66A OF CHIEF ENGINEER'S REVIEW

Note by the Chief Engineer for Irrigation on the Preliminary Report on the Ghatprabha Right Bank Canal.

Best line for the canal.

1. The best line for the Canal is the one surveyed round the Vantmur ridge, then across the Markandya River by a siphon to the Madval cut, then by the second siphon across the Hira Nalla to the Yergatti Cut, from Yergatti by the south side of the ridge to the Saleli gap, and thence by the north side of the ridge to the saddle where it is proposed to end the main canal. This gives a total length of canal of about 141 miles with a command of 560,000 acres, which may be increased to 800,000 by extending the canal along the ridge if desired; all the land between the Ghatprabha and Malprabha Rivers from Yergatti to this junction is commanded, excepting the tops of hills.

The difficulties which appeared so formidable before the survey was undertaken have been reduced to 5 miles of canal in sidelong ground, a siphon 3,000 feet long across the Markandya, a cut 11,000 feet long and 52 feet maximum depth at Madval. A siphon 1,100 feet long with 105 feet head at the Hira Nalla and a cut 2,790 feet long and 30 feet deep at 70 miles.

Sidelong ground by river. Leakage utilised.

2. The Executive Engineer expects heavy leakage along this sidelong length near the river, but as the water of the river is used for the Gokak Left Bank Canal, leakage into the river will not be lost or wasted, and it is also desirable that as much land as possible near the head of the Canal should be supplied with perennial irrigation for the employment of the cultivators whose lands are drowned by the tank.

Siphon.

3. I think the diameter of the siphon must be somewhat larger than the Executive Engineer has estimated, probably 16 feet diameter instead of 14, but it is not necessary to place them on masonry aqueducts at the river crossing. The expense of these aqueducts may be saved, and I think the total provision for the siphon sufficient for built-up steel pipe siphons cased in concrete.

Sidelong ground—Estimate sufficient.

4. In Statement 5 the Executive Engineer has given details of the sidelong ground, and shows that there will be $1\frac{1}{8}$ miles with side slope $2\frac{1}{2}$ to one, where the canal will require a side wall of masonry;

$1\frac{2}{3}$ miles with side slopes $2\frac{1}{2}$ to $3\frac{1}{2}$ to one, where the canal bank will require a core wall of masonry and special construction of the downstream slope of the bank with the rock debris which is abundant at the place;

$2\frac{1}{4}$ miles of side slopes $3\frac{1}{2}$ to 5 to one where it is desirable to narrow the channel by giving increased fall and greater velocity but where the downstream bank may be of ordinary construction, the canal face being pitched with the plentiful rock debris. For all these cases, the Executive Engineer has provided a good fall of $2\frac{1}{2}$ to $3\frac{1}{2}$ feet per mile giving a velocity of 4 to 5 feet per second and so reducing the section to be excavated in the hill side.

In Statement 18 he has estimated for the special section and his rate of Rs. 15 per running foot for the core wall and Rs. 45 per running foot for the side wall in the steepest ground are sufficient as stone is available at the site. His rates for the excavation and bank are good. The estimated provision for sidelong ground seems sufficient.

Estimates for drainage works require slight increase.

5. In Statement 6 the cost of cross drainage works is given. The rates per square mile are somewhat variable. On the whole, the estimate seems a fairly approximate one, but I expect that the amount of 13 lakhs mentioned as the cost of these works in paragraph 56 will probably have to be increased to 15 lakhs, an excess of 2 lakhs.

Earthwork sufficient.

6. The estimates for earthwork in bank cutting and in typical miles are satisfactory.

For distributaries provision is liberal even for difficult ground.

7. For the branches and distributaries, as the ground is steeper than usual in the Deccan, reliance has not been made on average rates of other works but the branches and distributaries for a typical area were actually surveyed and estimated.

The area selected was the Yadvad Branch and the most difficult piece of country under the canal. So that, the rate obtained is not likely to be exceeded. Further, the Executive Engineer has estimated for distributaries of a size suitable for intermittent working instead of constant.

The type of vertical fall estimated for is expensive.

Hence, the rate adopted, Rs. 4-8-0 per acre for distributaries and watercourses, is ample.

For 560,000 acres, 25,20,000 Rupees are provided to distribute 1,500 cusecs=Rs. 1,700 per cusec nearly.

Full supply level of tank.

8. The full supply level of the Daddi Tank has been fixed partly by the quantity of water available, partly by the value of property submerged and partly by the low gap on the Ghat ridge at Kalasgad. The full supply level proposed is less than 2 feet above the lowest point of this low gap and the ridge is wide and the bank would not be dangerous as it could be made of ample width, say 100 feet. I think, however, that the small nulla on the outside should be diverted into the Daddi Tank as it will then be less likely to affect the bank by scour. The remainder of the nulla between the proposed embankment and the precipice to be terraced to prevent scour.

Foundation of dam sound.

9. For the masonry dam of the Daddi Tank the foundations of the dam are sound and the proposals for the Waste Weir are good.

Undersluices not required.

Provision is made for 15 undersluices, but as it is proposed to use nearly all the water of a normal year it is not advisable to allow any to run to waste and the undersluices should be omitted.

Belgaum-Vengurla Road.

10. For the diversion of the Belgaum-Vengurla Road a provision of Rs. 2,80,000 has been made for 28 miles at Rs. 10,000 per mile. It will probably be better to bridge a narrow part of the lake near the existing road and to avoid having so long a diversion.

Compensation for villages.

11. It is in the villages that the real difficulty for this work is met and 34 more than for the Gokak Left Bank Canal Project or 74 villages in all, are affected; of these, 41 are wholly submerged and 33 partially and 35,000 acres of land are submerged or 13,000 more than for the smaller tank for Gokak Left Bank Canal, but the total provision made for this is Rs. 50,00,000. The compensation for the land seems sufficient but for the houses seems hardly adequate. The population affected numbers 22,000, but they will all be required on the irrigated lands under the canals and the best way to compensate them seems to me to be to purchase land for them under the canals and start them again on good holdings that can be irrigated; and with this object, a short canal is proposed on the Left Bank immediately below the Daddi Tank. The canal will have to start off on the Right Bank and cross the river by a siphon but obtains a command of 25,000 acres in 14 miles and the main canal, in the length 37½ miles to the Markandeya River, commands over 43,000 acres so that there will be 68,000 acres of land in a tract like the country at the Reservoir and adapted to perennial and rice cultivation. In addition, there is all the command under the Gokak Left Bank Canal and proposed Ghatprabha Right Bank Canal. If, therefore, the canals or part of them be made and the distributaries and water courses provided ready for irrigation before the dam is finally completed and the land drowned, it should be practicable to give employment to the people driven out from the bed of the tank.

In a succeeding para, it has been shown that 16,000 acres of sugarcane could be grown in addition to running the canal full during the Monsoon and Rabi. This is a greater area than the 13,000 extra acres submerged by increasing the storage tank above the size required for the Gokak Left Bank Canal. Now, if one acre in 5 of the gross area commanded in the upper part of the canal were sugarcane, 13,000 acres of cane could be grown in the 68,000 acres explained above to be in the immediate neighbourhood of the tank and it may be practicable to arrange for the people displaced by the tank to undertake this cultivation.

Estimated proportion of cost of Daddi Tank for Ghatprabha L. B., is excessive.

11A. In his estimate of the share of the cost of Daddi Tank to be charged to the Ghatprabha Left Bank Canal, the Executive Engineer has calculated the proportionate cost of the storage allotted to this canal and takes Rs. 59¼ lakhs as the charge to be made. He has not, however, given any credit to the Gokak Left Bank Canal for reduction in the share to be charged to that canal. The

cost of the tank as estimated for Gokak Left Bank Canal is 71 lakhs and of the enlarged tank of the Ghatprabha Right Bank 103½ lakhs, so that the charge for Ghatprabha Right Bank Canal should be 33 lakhs instead of 59 and the total estimate would be reduced from 224 lakhs to under 200 lakhs.

Supply of water and areas irrigable.

12. The deduction made by the Executive Engineer for losses in the tank 4 feet on the mean area in 3,116 is probably sufficient for a tank in this district, and if most of the supply is used for Rabi it will be ample. The balance available for issue to the Right Bank Canal, after deducting volume required for Gokak Left Bank Canal is 23,318 million cubic feet.

It will be convenient to reduce this to cusecs per month and then calculate the distribution and areas.

The supply is = 752 cusecs for 12 months.

„ = 9,024 for one month.

This is sufficient for 1,500 cusecs for 5 months = 7,500

381 for 4 months = 1,524

9,024

As the monsoon river supply will be sufficient for 3 months the canal can be run full during the monsoon and rabi and 381 cusecs will be available for the hot weather. This must be used up in the upper part of the canal or else combined with the supply to the Gokak Left Bank Canal. I instructed the Executive Engineer to take a duty of 175 at the outlets for cereals, but this may be raised to 180 for the average, and 60 is a low duty for sugarcane at outlets. Hence, the supply available could be used as follows :—

In the hot weather, 381 cusecs are available, and deducting ¼ for loss, 286 are available for issue at the outlets.

During the Rabi season, when overlapping sugarcane has to be supplied, the distribution would be :—

	Cusecs.	Duty.	Acres.	Water rate.	Gross Revenue.	Working Expenses.	
						Rate.	Total.
					Rs.	Rs. a.	Rs.
Sugarcane	286	60	17,160	32	5,49,120	6 0	1,02,960
Overlapping	71	.....	8,580	8	68,640	0 12	6,435
Rabi	398	180	71,640	5	3,58,200	0 12	53,730
Eight months... ...	398	180	71,640	8	5,73,120	1 8	1,07,460
Losses...	345	.....	.....	.....	.....	.....	.....
Total discharge ...	1,498	.....	.....	.....	.....	.....	.....
Monsoon	469	180	84,420	3	2,53,260	0 12	63,315
Total acres, irrigation...			2,53,440	.....	18,02,340	.....	3,33,900
					3,33,900		
					14,68,440		

or 6·0 per cent. on 224 lakhs.
or 7·34 per cent. on 200 lakhs.

Additional Storage possible on more expensive sites.

13. The estimates are based on the storage of the water of the Ghatprabha River only. If irrigation develops so much that more expensive storage is justifiable, then, it will be possible to make storage works on the Harankashi for the supply of the Gokak Left Bank Canal and thus to set free for the Ghatprabha Left Bank Canal most of the 18,000 million reserved in Daddi Tank and to extend perennial irrigation ; also the supply from the Markandeya River could be stored.

This preliminary survey has, therefore, shown that the whole of the waters of the Ghatprabha River can be stored and diverted on to the Famine lands of Belgaum and Bijapur and that a good return of interest may be expected with rates that have already been levied in the Deccan for water.

Provided these rates are approved and water issued only on long leases with the stipulation that payment is made on the crops matured, whether water is taken or not, there seems good justification for constructing the works.

The difficulty is the disturbance of the large population in the fertile valley to be submerged by the storage tank ; but all their labour will be wanted on the canal, and if holdings can be purchased and laid out for them under the canal they also should benefit.

14. The canal is a large one and the supplies of the Ghatprabha have been observed at the Dhupdal weir for a long series of years, and comparing these with the measurements at Hadlag and Rajgoli a good estimate can be formed of the water likely to be available, and during the 18 years from 1891 to 1908 there were only 2 years when the tank would not have completely filled, and in these years, it would have been more than half full.

Supplies observed for a long period.

A. HILL,
Chief Engineer, Irrigation.

PUBLIC WORKS DEPARTMENT,
Bombay Castle, 12th January 1909.

FROM

A. HILL, ESQUIRE, C.I.E.,
CHIEF ENGINEER, IRRIGATION.

To

THE JOINT SECRETARY TO GOVERNMENT FOR IRRIGATION.

SIR,

I have the honour to forward the Preliminary Report, plans and rough estimates for the Ghatprabha Right Bank Canal which have been prepared by Mr. Natesaiyer and a note of mine on the same. The Superintending Engineer, Southern Division, when forwarding the project has commented on this, but during the period Mr. Natesaiyer was carrying out this survey, the Special Duty Sub-Division was broken up, and also the Superintending Engineers of the Southern Division have been changed and most of the instructions for the execution of the Survey have been given by me as Chief Engineer.

2. I do not think it desirable to adopt the suggestion of the Superintending Engineer that the full area 825,000 acres should be supplied and the cost of the works increased by 33 lakhs of rupees. Also, I do not think it necessary to provide for further raising of Daddi Dam and I think that on the whole, the Executive Engineer's estimate is a fair one.

3. The Executive Engineer, in estimating the cost of the project, has calculated the whole cost of the enlarged Daddi Tank and then takes the proportionate cost of the storage allotted to the Ghatprabha Right Bank Canal, which he makes 59,22,186.

Now the total cost of the enlarged tank for Works and compensation amount to Rs. 1,03,63,824, but the estimated amount for Daddi Tank for the Gokak Left Bank Canal for Works and compensation is Rs. 70,96,537, so that the extra cost for increasing the storage as proposed is under 33 lakhs only instead of over 59 as estimated by the Executive Engineer. The total of the estimate should, therefore,

be reduced by 25 lakhs and the corresponding indirect charges, so that the estimate of 224 lakhs will be reduced to less than 200, and the estimated return would be 5 per cent. instead of 4·5 as calculated by the Executive Engineer in paragraph 57, and if the higher rates recommended by me in para. 12 of my note are accepted, then a return of 7 per cent. may be expected.

4. It is necessary, however, to group the Ghatprabha Left Bank Canal and the Gokak Left Bank Canal together to get a proper view of the project as follows :—

	Total cost Lakhs.	Total Command.	Mixed Irrigation.
The Gokak Canal ...	179	4,97,000	1,20,000
The Ghatprabha ...	200*	5,60,000	2,53,000
Combined	379	10,57,000	3,73,000

Or about Rupees 36 per acre of land commanded, the command being at the same time limited to an area which could not use the water if cereal crops only were grown but requires mixed crops to use the water.

I think, therefore, that this Ghatprabha Right Bank Canal Project, combined with the Gokak Left Bank Canal having a command of over one million acres and ample water for all probable requirements, is most important for the benefit of the Southern Deccan. They are much superior to the Kukari Project and in extent of command and volume of water they equal the Nira Right Bank Canal, but on account of the damage to the land and property by the Reservoir and to the difficulties of the canal, I should place them after the Nira Right Bank Canal and after the Mutha Canal Extension.

5. I think the preliminary project should be sent up to the Government of India for information along with the Gokak Left Bank Canal Project when that is resubmitted.

I do not think it is necessary to undertake any more survey work immediately, but when the Nira Right Bank Canal has been sanctioned and started, then, this great and valuable canal should be surveyed in detail.

If the Native States under the Gokak Canal do not elect to share in that canal, then, it will be possible to use all the water in the Ghatprabha and it will be a matter for consideration how best to curtail the Gokak Canal and how the Ghatprabha Right Bank should be modified if Native States do not join in the project.

The areas of Native States commanded by the Ghatprabha Right Bank are given in paragraph 3 of the Executive Engineer's reports.

6. Mr. Natesaiyer has carried out this survey very well indeed. The difficulties at first appeared almost prohibitive, but he has found a practicable way through them all. He has not limited his report to the one practicable line found, but has given alternative alignments at critical places and presented them in a concise form.

The amount of survey work done has been limited to requirements, plans prepared are sufficient and clear without over elaboration and generally the very difficult survey has been carried out and reported on in an able and prompt manner without unnecessary expense.

I commend this piece of work of Mr. Natesaiyer to the notice of Government.

* The 24 lakhs are deducted as they are included in the 179 of Gokak Left Bank Canal.

7. I have written to the Commissioner, Southern Division, for his opinion on the Revenue prospects of the work, but as I am going on leave and his reply has not been received, I send up my report to Government now.

I have the honour to be,
Sir,
Your most obedient servant,
A. HILL,
Chief Engineer for Irrigation.

January 12th, 1909.

No. 9496 OF 1908.

FROM

B. A. BRENDON, ESQUIRE, I.C.S.,
COLLECTOR OF BELGAUM.

To

THE COMMISSIONER,
SOUTHERN DIVISION, BELGAUM.

Camp Shindogi, 30th November 1908.

SIR,

In reply to your No. 5110, dated 11th instant, I have the honour to report that I have questioned a number of village officers of the villages which the proposed canal will traverse, and that they are unanimous in assuring me that the rayats will eagerly take the water for the same rates as are charged on the Gokak Canal. Those rates are approximately the same as rates calculated on a 3 rupee basis as described in para. 5 of the Chief Engineer's report (not printed). I do not think that rates materially higher than those charged on the Gokak Canal should be charged, more especially as rates on a 3 rupee basis are calculated to yield a return of 4 per cent. This, on a protective work, seems sufficient.

2. It is, of course, impossible to say what area will be brought under perennial irrigation. I am inclined to think water will chiefly be taken for monsoon and rabi crops. But I have no doubt whatever that the water will be taken freely.

I have the honour to be,
Sir,
Your most obedient servant,
B. A. BRENDON,
Collector of Belgaum.

No. 1045 OF 1909.

FROM

W. C. SHEPHERD, ESQUIRE, B.A., I.C.S.,
COLLECTOR OF BIJAPUR.

To

THE COMMISSIONER,
SOUTHERN DIVISION, BELGAUM.

Bijapur, 26th February 1909.

SIR,

In returning the papers received with the Belgaum Collector's No. 9321 of 14th December last, below your No. 5110 of 11th ultimo, I have the honour to report that I think it probable that in the part of my district concerned, the available area would all be irrigated, though, perhaps not immediately, at the lower

rates given in Mr. Hill's para. 5, and very possibly at the higher rates. Badami is, on the whole, a poor Taluka, and the soil is, generally speaking, so light that the Rayats suffer heavily in a year of defective rainfall. I am informed that they would gladly avail themselves of opportunities of irrigating their lands.

I have the honour to be,
Sir,
Your most obedient servant,
W. C. SHEPHERD,
Collector of Bijapur.

No. 791 OF 1909.

FROM

M. C. GIBB, ESQUIRE, LL.B., I.C.S.,
COMMISSIONER, SOUTHERN DIVISION.

TO

THE CHIEF ENGINEER FOR IRRIGATION.

Camp Bellikeri, 10th March 1909.

SIR,

Your No. C.E.I. 373 of 5th November 1908. I forward reports from the Collectors of Belgaum and Bijapur. There appears to be no doubt that water, if made available, will be eagerly taken.

Gokak Canal Extension. Ghatprabha Right Bank.

2. From G. R. No. W. I. 154 of 23rd January 1907, I gather that the intention is to begin by extending the canal (left bank) without adding to the storage, that some 41 miles of canal can be constructed and supplied with water during the monsoon without the storage being added to, and that it is expected that in addition to areas now taking water from the existing canal some 42,700 acres in British Territory or 84,000 acres in British Territory and Native States, would take the monsoon water from the new canal out of 230,000 acres being brought under command.

3. I gather that the larger scheme for additional storage by construction of a lake at Daddi must have been altered considerably since the above G. R. was passed. The G. R. para. 6 speaks of 22,333 acres, 33 villages as being submerged and a population of 17,217 as having to be moved. You (para. 4) give the figures at 35,000 acres and 64 villages. I gather from the G. R. that the idea is to add gradually to the storage so as to provide gradually for the removal, it being hoped that the addition to the demand for labour in the country brought under irrigation will of itself provide some remedy for the submersion of the villages and lands by the tank.

4. I mention the subject because it seems improbable that the eastern country will completely absorb the evicted population. Enquiries were made a few years ago as to where the population could be moved to. I believe the answers generally were that there was no good waste land available in suitable places in large contiguous areas—whether it would be possible to provide considerable contiguous areas of fair quality by disforestment I am not in a position to say, but it may be regarded as certain that the evicted people would be very reluctant to go to Kanara—the district where it is least unlikely that land could be found.

I have the honour to be,
Sir,
Your most obedient servant,
M. C. GIBB,
Commissioner, S. D.

THE MALPRABHA VALLEY.

Physical features of the Malprabha Valley.

68. The survey of this valley is incomplete, but a great deal has been ascertained of the irrigation possibilities of rivers and valley.

The richness of the land in the bed of the valley, the assured rainfall, the thick population and large villages, some of which may be classed as small towns, make it most unadvisable to drown the valley by a dam at the famous Peacock Gorge above Manoli.

The survey of the Ghatprahbha valley has shown that the land between the Ghatprabha and Malprabha Rivers can be protected by a canal from Daddi Tank on the Ghatprabha, and the sacrifice of the rich Malprabha Valley is not necessary for the protection of this area.

The land that could be commanded on the right bank from this gorge in Dharwar District is not subject to severe famine, and so the benefits to be gained by storing 100,000 million cubic feet at the Peacock Gorge above Manoli are not likely to exceed the damages which would be caused so far as can be foreseen at present.

The surveys have shown that 20,000 million cubic feet can be stored at a dam site near Asoka, a little above the point where the Southern Maratha Railway crosses the Malprabha.

The gauging of the river at Asoka shows a discharge of about 22,000 millions and about 25,000 at Khanapur or at the Railway crossing.

If this be compared with the discharge of 60,000 to 175,000 millions at Gurl-Hosur, just above the Peacock Gorge, it will at once be evident that a great portion of the Malprabha supplies is derived from the valley below Khanapur and that it must have good rainfall, and hence the reason for the valuable cultivation and thick population of the valley is apparent.

Command of Canal on the Right Bank (South).

69. The rainfall, however, is not sufficient for perennial cultivation, and it has been proved by the old surveys of 1878 and earlier, that a command of 65,000 acres can be obtained on the right bank by a canal 115 miles long.

The canal, as aligned by these old surveys, had a bed fall of 1½ feet per mile, and the length to the ridge at Karikatti, the narrowest place between the Malprabha and the valley of Benihalli, in the Dharwar District, was 90 miles. The canal line did not command the ridge, but the report says the ridge cutting would be heavy.

Now, if the canal line were given a fall of 8 inches a mile instead of 18, there would be a gain of 75 feet on the 90 miles, and the canal could probably be taken into the Dharwar District and a command larger than the water can supply could then be obtained with ease.

When survey is again commenced in the Malprabha Valley, the work should start at the Karikatti ridge; the level at which this ridge is to be crossed should be fixed and a canal line surveyed with a rise of 8 inches a mile up the valley to the dam site, and the site of the dam and position of outlet should be arranged to suit this alignment.

The surveyors should take great pains to shorten the canal and avoid loss of fall as much as practicable until the Karikatti ridge is crossed.

(Hence, for the Malprabha Valley it appears that the normal supply of the river or probably 20,000 million cubic feet can be stored by a dam site near Asoka, and that it can be utilised for perennial irrigation in the Malprabha Valley.)

If, however, the crossing of the ridge at Karikatti is practicable, then it will require careful consideration whether the canal should not be constructed to use up the normal supply in 8 months, monsoon and rabi irrigation, as this Malprabha is the only ghat-fed river from which water can be diverted on to the North of Dharwar District.

	Length of canal.	Command. Acres.	Cost.	*Prospects.*
Storage in million cub. ft., 20,000.	90	60,000	Not estimated.	Might very possibly be productive.
	150	200,000		

As rock is reported at numerous places in the river-bed and the actual section levelled at Asoka does not seem the best, it will be sufficient to print the position of the tank and the approximate canal lines from it as far as Gurl-Hosur on the 1 inch map. The Karikatti ridge to be marked.

The report on the Malprabha surveys to be printed.

THE TUNGABHADRA VALLEY.

70. The Malprabha is the most southern of the great tributaries of the Krishna in the Bombay Presidency and the next river available for irrigation is the Wardha, a tributary of the Tungabhadra running through the southern corner of the Dharwar District.

Northern tributaries not reliable.

The high hills of the Western Ghauts which form the reliable water-gathering grounds of the more northern streams are much less pronounced in the Dharwar District, and the watershed line lies more to the east, so that the rivers rising in the area of reliable rain in the Dharwar District run to the west through Kanara, where there is abundant rainfall and canals are not wanted. The rivers which flow to the east through the famine district have "Deccan" catchments and the river supply fails when rain fails in the eastern district.

71. The Wardha River, however, is south of this break or interruption to the range of ghats and rises well within the area of reliable rainfall and has an assured supply.

The Wardha is the first reliable stream.

No project has yet been surveyed in detail on this river, but the upper part of the river has been visited and it is known that good storage sites can be obtained on it. The catchment is generally thick forest with fine trees on it.

No survey yet made.

The levels on the topographical map show that the river bed lies low, compared with the centre of the Dharwar District, and no large Famine Protective work seems practicable, but there are indications that a work for productive irrigation might be successful as the land commanded is amongst the area thickly studded by tanks in the Dharwar District and rabi and perennial water are much sought after.

The river discharge is being gauged at a site suitable for a storage tank.

72. The most southern irrigation project of all in the Bombay Presidency is the Madag Tank on the Kumudvati River.

Madag tank on the Kumudvati.

The Madag Tank existing in the bottom of a very large tank which was formed by a huge earthen embankment put up by the Vijianuggur Empire.

The embankment was breached for want of proper provision for a waste weir, but the breach occurred at a ridge and the scouring ceased when rock level was reached, so that a small portion of the bottom of the once great tank now remains,

The works that were constructed by the Vijianuggur Empire so long ago for the storage of water at Madag are larger and more extensive than any designed for the Protective Irrigation Works proposed by the British Government and discussed in this report. The contents of the original tank are not exactly known, but they probably exceeded even the great storage proposed at Daddi Tank for the Gokak and Ghatprabha Left Bank Canal, and the volume of earthwork in the embankment and the massive pitching are far more costly than any of the masonry dams proposed for the more modern works.

73. The remains of the tank as they exist are utilised for a small canal and an extension of this small canal is proposed for the small area of land between the Kumudvati and the Tungabhadra River, but without addition to the storage of the tank.

Best command on the left or northern bank.

On the left bank of the Kumudvati, a fair-sized canal is possible. A short length has been surveyed and indicates that a command of 150,000 to 200,000 acres is probable.

The discharge of the Kumudvati at Madag Tank has been measured for a long series of 25 years, including the bad famine years of 1877, and reliable information of the rainfall is available.

The discharge seems to vary more than the discharges of the northern river, but there is only one year with less than 5,000 million cubic feet, and there seems a possibility of a productive work being constructed. The embankment of Madag Tank is the boundary between British and Mysore Territory, and the fact that the area which would be submerged by a larger tank lies in Mysore Territory, and that the land commanded are in British and not very liable to famine, have up to the present blocked the construction of an irrigation project here. There are other places where the money is more urgently wanted, though expenditure here would probably be productive.

NOTE.—No report and plans need be printed.

GUJERAT.

74. This record of Protective Irrigation Survey in the Bombay Presidency would be incomplete without some reference to Gujerat, but very little information can be given as the Government of India were satisfied that the Irrigation works proved possible in the Deccan were better than those practicable in Gujerat and decided not to undertake the Irrigation Survey of Gujerat for the present.

Information scanty.

This is much to be regretted as it renders the treatment of current small schemes much more difficult than would be the case if the general character of the country were clearly shown by Irrigation Surveys.

75. The little survey work it has been possible to carry out has shown that the Mahi River offers the best means of irrigating Gujerat, and that good rock foundations exist for a weir at Pali on the Mahi. It has been proved that from a weir here, water might be conducted to the greater part of the low-lying tract between the Mahi and Sabarmati Rivers. The discharge of the Mahi does not seem reliable enough for perennial irrigation, but seems very suitable for rice cultivation during the monsoon, a form of irrigation which is very valuable in Gujerat.

The Mahi River.

The lands commanded are comparatively flat and low-lying, and it may be possible to fill a very large number of small storage tanks from the Mahi River to supply rice and to grow rabi crops on the beds of these tanks as the water is used up for rice.

When the Irrigation Survey of Gujerat is again taken up, this Pali site on the Mahi is the principal one to examine, and a contour survey of the low-lying ground is essential for the study of the problem for distribution of the water.

76. Another river that may be useful is the Sabarmati, but it has a much smaller catchment area than the Mahi at Pali. A reservoir has been suggested at Dharoi on the Sabarmati and a little survey work done. The supply of the Sabarmati is very variable, but here also a canal to supply rice cultivation seems the best way to use the water available.

The Sabarmati River.

77. Between the Sabarmati and the Mahi there are a number of small streams with local catchments the supply of which fails in a famine year, but where, in seasons of irregular rainfall, small storage works would be very useful. They would not be Protective irrigation works, but ordinary irrigation works only.

Smaller streams.

78. The land near the mouth of these Gujerat rivers for a considerable distance from the sea is reported to resemble deltaic formation and demands for drainage channels conflict with demands for irrigation works, and for the study of this country a good contour survey is necessary.

A contour survey of the low lands of Gujerat is required.

The first work to undertake in Gujerat is, therefore, a contour survey, and until this is available it seems probable that any work constructed on the meagre information now available will be unsuitable and a source of trouble, hereafter. The records and papers of the little work done are with the Executive Engineer for Irrigation, Gujerat.

No reports and plans need be printed.

GENERAL.

79. The Index map, 8 miles to the inch, to be corrected to agree with this report.

A. HILL,

Chief Engineer for Irrigation.

List, showing in which Executive Engineer's Office are recorded the field book plans and papers of various Irrigation Projects and Surveys prepared for the Irrigation Survey of the Deccan for Protective Irrigation Works.

Name of the Project.	Despatched for record to.
I.—Tapti Valley Surveys.	
Tapti storage and R. B. Canal	Office of the Executive Engineer, West Khandesh.
Girna storage and L. B. Canal	
Panjra storage and Canal	
II.—Godaveri Valley Surveys.	
Unanda storage at Wajarkhed	Office of the Executive Engineer, Nasik and Ahmednagar Irrigation District.
Kadwa storage at Karanjawan	
Kadwa storage at Palkhed and L. B. Canal	
Aundh storage at Mukne	
Darna storage at Nandgaon (Pick-up weir at Nandur-Madhmeshwar R. & L. B. Canal)	
Karwa storage at Pimpalgaon (Darna R. B. Canal) ...	
Godaveri storage at Gangapur and L. B. Canal ...	
III.—Mula River Surveys.	
Mula storage at Chas	Office of the Executive Engineer, Nasik and Ahmednagar Irrigation District.
Mula storage at Kotulor-Mandvi and R. B. Canal ...	
IV.—Bhima Valley Surveys.	
Kukari storage at Pimpalwandi and L. B. Canal ...	Office of the Executive Engineer, Poona Irrigation District.
Mina storage at Vadgaon and R. and L. B. Canals ...	
Ghod storage at Nirgudsar and R. B. Canal	
Ghod storage at Sakora and Junction canal	
Bhima at Kaman and L. and R. B. Canals	
Indrayani storage at Moshi	
V.—Nira River Survey.	
Gunjawni storage at Umbra	Office of the Executive Engineer, Poona Irrigation District.
Yelwandi storage at Bhatghar	
Nira storage at Natambi	
Nira storage at Vir	
Nira Right Bank Canal	
VI.—Krishna Valley Survey.	
Krishna storage at Dhom	Office of the Executive Engineer, Satara.
Krishna L. B. Canal and contour survey	
Koyna storage at Kamargaon	
VII.—Ghatprabha Valley Survey.	
Harankashi storage at Ajra	Office of the Executive Engineer, Belgaum District.
Ghatprabha storage at Hadlag and R. B. Canal ...	
Tamraparni storage at Rajgoli	
Ghatprabha storage at Daddi	
Gokak Canal Project	
VIII.—Malprabha Valley Survey.	
Malprabha storage at Assoga	Office of the Executive Engineer, Belgaum District.
Malprabha R. and L. B. Canals	

INDEX TO GENERAL REMARKS
ON
PROTECTIVE IRRIGATION WORKS.

By Mr. H. F. Beale, Superintending Engineer.

History—

Para.

1. Order to carry out hydrographical and hydrological survey.
2. Some schemes were mentioned by the Indian Irrigation Commission.
3. Three schemes submitted to the Government of India.
4. This report will describe remaining projects.

Guiding Principles—

Para.

5. Extent of country to be examined.
6. Selection of best schemes first to avoid delay in submission of results.
7. Uniformity of design, and avoiding novel departures open to criticism.
8. Relying on improvements to design after preliminary sanction was received to scheme as a whole.

Productive System of Irrigation—

Para.

9. Government decided upon taking a more favourable view of future irrigation.
10. Productive system of irrigation to be encouraged.

Rain and River Gauges—

Para.

11. River gauges at Dam and Weir sites.
12. Rain gauges in catchment areas.
13. Rain gauges in the area to be irrigated.

Water-Supply—

Para.

14. Determination of water-supply available.

Subsoil Water Level—

Para.

15. Well observations in the area to be irrigated.
16. Method of tabulating results.

Soil Maps—

Para.

17. Variation of soil in the Deccan.
18. Classification adopted.
19. How this was transferred to the maps.
20. Soil Map and Famine Map indicate value of irrigation.

Staff—

Para.

21. Some officers and subordinates selected for mention.

GENERAL REMARKS

ON

PROTECTIVE IRRIGATION PROJECTS,

By Mr. H. F. BEALE, Superintending Engineer.

History.

1. In consequence of the recommendations made by the Indian Irrigation Commission early in 1902, the Government of Bombay directed the Superintending Engineer on Special Duty to make a hydrographical and hydrological survey of a certain portion of the Bombay Presidency, in which an unfailing supply of water could be counted on and where also this water could be used for the irrigation of lands liable to a very fluctuating rainfall and to occasional droughts. The area referred to extends from the Tapti River in the North to the Tungabhadra in the South, the ridge of the Ghats forms its Western boundary and the limits of the Presidency its Eastern boundary.

2. The directions given included the elaboration of a number of schemes for Protective Irrigation Works. The Commission indicated some of these in what appeared at that time to be their proper order of importance. Two in particular were called for early, so that the Commission might be able to make more definite proposals when preparing their report for the Government of India in 1903.

3. These two, the Nira Right Bank Canal and Gokak Canal Extension Projects, were submitted in the first year. They have since been revised and submitted, with all the information, drawings and forecast statements required, to the Government of India. Another scheme, which has also been submitted to the Government of India and which is now under construction, is the Godaveri Canals Project.

4. In the present final report on the Protective Irrigation Works, it will not be necessary to give any details concerning the above 3 projects. It is proposed only to give a short account of the numerous other schemes investigated some of which will in course of time develop, it is hoped, into useful and profitable projects.

Guiding Principles.

5. In commencing a work of such magnitude as the investigation of a country 470 miles long by 120 miles broad, containing at least 9 large stream lines and numerous important tributaries, all taking their rise in the hilly country of the Western Ghats, it was important to avoid waste of time in either having too large or comprehensive a programme, or elaborating too many details.

6. To avoid the first error it was evidently necessary to decide upon a few of the best schemes for immediate elaboration. These had to be schemes which would give a very large and reliable water-supply and from which a correspondingly large command could be profitably irrigated.

7. The error of excessive detail was avoided by aiming at uniformity of design.

The location and designs for the dams, the method of canal alignment, the design for the canal sections and for the masonry works, were all carefully considered and received the preliminary approval of the Chief Engineer for Irrigation. In preparing the designs and forecasts of irrigation it was felt that the submission of schemes based on ideals, more than on the record of many years' experience, would necessarily meet with opposition when reviewed, and long delays might thus ensue. The crop proportions and water-supply required were, therefore based upon past experience.

8. The canal sections were larger of course, but similar in design to those of other non-silting canals in the Deccan and a sufficient discharging power was given to cope with periods of pressure and extra irrigation in years of drought. The sections, though liberal, were not of excessive size, and the probable loss of water in transit down the canal was thus reduced to a minimum.

It was intended that the details of design for masonry works should be discussed after the projects had received the general approval of the Governments of Bombay and of India, and therefore the ordinary types were adopted with only a few modifications.

Productive System.

9. After the investigations had progressed for some years, the Government of Bombay decided to take a more favourable view of the future of irrigation in this province, and in many respects the designs of the works and the forecast of their efficiency were altered, giving in the opinion of the Superintending Engineer on Special Duty more favourable results than can be looked for in the near future, but not by any means beyond the bounds of possibility.

10. What is now called the productive system of irrrigation is much the same as the quadrennial system of rotation, in the ancient projects. The administrative experience and methods of the department have improved, and it should be possible now to work more closely to the productive system of irrigation than heretofore. The description of the unelaborated schemes will all be based on the more favourable figures recently adopted.

Rain and River Gauges.

11. When a good tank site was discovered it was customary to erect near the place where the dam was to be constructed a gauge to measure the discharge of the river. At all dam sites it was necessary to gauge the monsoon discharge and the flow, if appreciable, up to the end of December. For pick-up weirs it was only necessary to measure discharges under 2,000 cusecs. This would show for how many months in each year the normal river discharge could feed the canal, and from the information thus obtained it was possible to decide upon what storage was necessary to supply the canal for the remaining months.

12. Rain gauges were also put up in the catchment areas of proposed tanks, and from these it was possible to deduce roughly what would have been the discharge in other years by comparison with the rainfall recorded for a long series of years at some other station in the vicinity. In this manner *50 river* gauges and 17 new rain-gauge stations were erected. But the Inspector-General of Irrigation was not satisfied with the number of rainfall stations adopted, so under direction from him, 27 new stations were put up in 1907.

13. There are numerous rain-gauge stations, as a rule, in most valleys, at Taluka headquarters and Irrigation Bungalows, etc., so no fresh stations were erected in the area to be irrigated.

Water-supply.

14. It was, of course, necessary in the earlier years to guess at the probable figure of river discharge without many data to go upon, and as a rule the assumptions were reasonably accurate. Now, however, the records give 5 or 6 years of discharge and the proper supply to be depended on can be determined more satisfactorily. A supply of about 50% more than what may be called the minimum is a fair quantity to be counted on.

Subsoil water level.

15. The level of the subsoil water in the area to be irrigated is one of the items to be mentioned in the reports on irrigation projects. As soon as the canal alignment had been carefully located the observations were commenced. First a well register was prepared. In this, a table number of wells were noted and details given as to position, ownership, level of fixed point from which measurement should be taken, etc.

Wells were chosen in belts, *(a)* on the upstream side within ½ mile of the canal, *(b)* on the downstream side within ½ mile, 2 miles and 4 miles of the canal.

16. The observations were then taken once a month, the depth of water below the fixed point measured, and if the well was being used for irrigation this would be noted. If the well was deepened at any time this would be reported and the register altered accordingly.

The results would be examined in the head office and the average water level for different sections of the canal would be calculated for each month. The resulting statement formed a very satisfactory record of the fluctuations in the subsoil water level during the year.

These observations have now been discontinued by the orders of Government.

17. The nature of the soil is very unequal in the Deccan. Generally, near the large rivers, there is a deposit of black soil, and on high ground as a rule the absence of trees has allowed of the good earth being washed away and the ground has become barren or capable only of light cultivation. But there are exceptions to these rules. A general written description is not easy to follow, so the Superintending Engineer, Special Duty, decided to prepare maps showing the nature of the soil in the commanded area of each project.

Soil Maps.

18. After consulting Mr. Lushington, who was at that time Superintendent of Land Records in the Southern Division and had a long experience of classifying land in the previous Revenue Survey Department, the Superintending Engineer decided to make use of the land registers and to divide the soils according to their anna classification. The divisions adopted were:—

CLASSIFICATION OF SOIL.

Anna valuation per acre.	Colour.	Description of soil.
A.—Over 10 As. to 16 As.	Dark Sepia.	The best fertile soil, some of which may possibly be unsuitable for heavy irrigation.
B.—Over 5 As. to 10 As.	Light Sepia.	Good soil, probably the most suitable for irrigation.
C.—up to 5 As.	Burnt Sienna.	Light soil, which will be improved by irrigation.
D.—*Nil.*	Yellow Ochre.	Barren soil, uncultivable waste or forest reserve.

Small areas outlined in red show the portions called "Kharab" (bad) in village numbers.

19. The information was extracted from the records in the Collectors' offices. Each field on the village map was marked A, B, C or D by special clerks appointed for this purpose. The maps were coloured in the head office and the information was then very carefully reduced to the 1 mile to 1 inch scale and entered on tracings of the topographical sheets.

Soil maps have not been prepared for some of the newer projects nor for the less promising ones among the older schemes.

20. The information gained from the soil maps and the extent of famine liability as shown by the Statistical Atlas, combine to show the value of irrigation in the areas for which projects have been proposed.

21. The number of officers and subordinates who have been appointed at one time or another on Special Duty has been very great and the half-yearly qualification reports to Government have testified to the work each man has done. But in this final report the Superintending Engineer desires to mention the names of some who have been particularly helpful owing to their long connection with the Special Duty Division and the excellence of their work :—

Staff.

OFFICERS.

Mr. B. KRISHNARAO, Executive Engineer.

Mr. HANSOTI, Assistant Engineer and Executive Engineer.

Mr. V. GRIFFITHS, Assistant Engineer.

Mr. NATESAIYER, Assistant Engineer and Executive Engineer.

and especially

Mr. HANCKEL, Assistant Engineer.

Mr. BOWERS, Assistant Engineer.

SUBORDINATES.

Mr. SHAIKH EBRAHIM, Sub-Engineer.

Mr. R. G. APTE, Sub-Engineer.

Mr. GOGHARI, Supervisor.

Mr. LOURENCO, Surveyor.

Mr. BRAGANZA, Overseer.

Mr. H. B. JOSHI, Surveyor.

Mr. S. V. GORE, Surveyor.

Mr. R. R. KHANOLKAR, Sub-Overseer.

Mr. R. G. LIKHTE, Surveyor and Draftsman.

Mr. BIBIKAR, Draftsman.

H. F. BEALE,

Superintending Engineer.

REPORT ON TAPTI VALLEY SURVEYS.

CONTENTS.

		PAGE.
1.	Report on the Tapti Valley Surveys	73 to 80
2.	Preliminary Report on the Panjhra Project, October 1908 ...	80 to 84
3.	Discharge of the Girna at the Jamdha Weir	86 & 87

TAPTI VALLEY SURVEYS.

List of Drawings and Tracings accompanying the Report.

NOTE.—The Office in which these plans are recorded is named in the list at page 63 following the Chief Engineer's Review.

No. of Drawing.	Title.	No of Sheets.	Scale.
	Tapti Project.		
1	Index map showing storages and canals for Tapti, Girna and Panjhra projects.	1	8 miles=1"
2	Index map showing storages and canals for Tapti, Girna and Panjhra.	1	4 miles=1"
3/1 to 3/3	Plan and longitudinal section of Hatnur dam line.	3	{H—400' V—20'} =1"
4/1 to 4/5	Tracings of village maps showing contours for Tapti storage at Hatnur.	5	660'=1"
	Girna Project.		
5	Plan and longitudinal section of dam line at Panjan.	1	{H—400 V—20'} =1"
6	Plan and longitudinal section	1	{H—400' V—20'} =1"
6-A	Tracing of village map showing waste weir site.	1	660'=1"
	Panjhra Project.		
7	Plan and longitudinal section of dam line on Panjhra storage at Ner.	1	{H—1,000' V—50'} =1"
8	Tracings of village maps showing contours for Panjhra storage at Ner.	1	660'=1"
9	Plan and longitudinal section of dam line on Panjhra storage at Pankheda.	1	{H—1,000' V—50'} =1"
10	Tracings of village maps showing contours for Panjhra storage at Pankheda.	1	660'=1"

TOPO SHEETS.

Nos. 223, 253, 254, 255, 256, 257, 285, 286, 287, 288, 314, 315 and 340.

TAPTI VALLEY SURVEYS.

List of Drawings and Tracings for Tapti, Girna and Panjhra Projects not referred to in the Report on Tapti Valley Surveys:—

No. of Drawing.	Title.	No. of Sheets.	Scale.
	Tapti Project.		
1	Index map tracing showing contours for Tapti storage at Hatnur.	1	1 mile=1″
2	Plan of Hatnur dam line showing trial lines, one drawing and one tracing.	2	1000′=1″
3	Sections of trial dam lines for do. do.	1	H—1000′ V—50′ =1″
4	Plan and longitudinal section of Hatnur dam line tracings ...	3	H—400′ V—20′ =1″
5	Plan of Susti dam line, one drawing and one tracing ...	2	1000′=1″
6	Plan and sections of Susti dam line including trial dam lines, 5 drawings and 6 tracings.	11	H—400′ V—20′ =1″
7	Rough tracings of village maps showing Tapti Right Bank Canal contour.	28	660′=1″
	Girna Project.		
8	Index map progress tracings showing storages and canal (rough).	5	1 mile=1″
9	Plan and longitudinal section of Panjan dam line (rough) ...	1	H—400′ V—20′ =1″
10	Longitudinal sections of dam lines at Saigaon, Panjan, Issapur and Tamaswadi.	1	H—1000′ V—50′ =1″
11	Plan and longitudinal section of dam line at Saigaon, including trial lines.	2	1000′=1″
12	Sections of trial pits on Saigaon dam line	1	10′=1″
13	Plan and longitudinal section of dam line at Tamaswadi ...	1	H—400′ V—20′ =1″
14	Plan and longitudinal section of dam line at Issapur ...	1	H—400′ V—20′ =1″
15	Tracings of village maps showing contours for Girna storage at Saigaon.	9	660′=1″
16	Longitudinal section of cut on Girna Left Bank Canal near Loudha.	1	H—400′ V—20′ =1″
17	Rough tracings of village maps showing Girna Left Bank Canal contour from Saigaon dam line.	36	660′=1″
	Panjhra Project.		
18	Tracings of Index map showing dam lines and storages on Panjhra River.	2	1 mile=1″
19	Plan and longitudinal section (rough) of dam line near Ner.	1	H—1000′ V—50′ =1
20	Plan and longitudinal section (rough) of dam line at Akalpara.	1	H—1000′ V—50′ =1″
21	Plan and longitudinal section (rough) of dam line at Datarti.	1	H—1000′ V—50′ =1″
22	Plan and longitudinal section (rough) of dam line at Senpur.	1	H—1000′ V—50′ =1″
23	Sections of trial pits on Senpur dam line	1	5′=1″
24	Tracing of village maps showing contours for Panjhra storage at Senpur.	1	660′=1″

INDEX TO REPORT ON THE TAPTI VALLEY SURVEYS.

Para.	Subject.
1	Position.
2	History.
	Scope of the Special Duty Surveys.
3	Only preliminary investigation possible.
	Investigation of the Tapti river.
4	Storage works surveys.
5	Canal survey.
6	Volume required for irrigation on the productive system.
7	River discharge.
8	Volume required for irrigation on the 8 months' system.
9	Comparison of the above two systems and permissible cost of the project.
10	Possibility of constructing the project for the above amount.
11	The Aner River, a possible source of supply.
12	River discharge.
13	Purpose of the project.
	Investigation of the Girna River.
14	Storage works surveys.
15	Canal surveys.
	Rough details of the project.
16	Dam at Panjan.
17	Proposed canal-lines.
18	Extent of the command.
19	Statement showing the length, command, discharge and cost of the proposed canals and branches.
20	Distributaries.
21	Purpose of the storage and canals.
22	Financial Prospects.
23	Net Revenue.
24	Rain and river gauges.
	Investigation of the Panjhra Valley.
25	Surveys for storage tanks.
26	The Pankheda site.
27	Cost and main details.
28	Previous report.

REPORT ON THE TAPTI VALLEY SURVEYS

IN THE

KHANDESH AND NASIK DISTRICT.

Position.

1. The Tapti River has its source in the Central Provinces, and flows westwards, entering the Bombay Presidency 32 miles east of Bhusaval in the East Khandesh District.

It then flows close to the foot of the Satpura Hills, the northern boundary of the Khandesh District and finally enters the sea at Surat.

On its passage through Khandesh, the Tapti is joined by the following important tributaries:—

From the south, the Purna River rising in the Behar State, the Girna River rising in the Nasik District and the Panjhra rising in the Ghats in the west of the Khandesh District; and from the north, by the Aner, Arunavati, and Gomi Rivers, rising in the Satpuras.

The recent Special Duty Surveys only dealt with the Tapti itself, and the Girna and Panjhra Rivers.

On the Purna, no surveys were made, as from its position no storage works and canals would be constructed in the Bombay Presidency on a large enough scale, to bring them under the heading of Protective Work Surveys.

The Aner River has already been investigated in 1881, and the Arunavati and Gomi Rivers from their position are not available for any important project.

History.

2. Until the Special Duty Surveys commenced in 1908 no scheme had been put forward for a storage work on the Tapti. On the Girna and its tributary streams there are numerous bandharas, the most important being the Weir at Jamdha with its Right and Left Bank Canals, which irrigate 5,000 acres. A small storage work is being constructed at Chankapur in the Nasik District, to supplement the supply to the bandharas and to provide water for the Girna Left Bank Canal. On the Panjhra and its tributaries there are numerous bandharas, from which 9,036 acres are irrigated annually. Several schemes have been put forward for storage works on the upper reaches of the river, to assure a perennial supply of water to these bandharas. For the Aner, a small project has been prepared for a storage work and canal, but this has been held in abeyance for some years.

Scope of the Special Duty Surveys.

Only preliminary investigation possible.

3. The time at the disposal of the Special Duty staff did not permit of the preparation of any detailed and complete project, as has been done in other valleys. All that could be done was to select and survey dam sites, and to run canal contours to show the possible command obtainable, and from the results of these surveys, to indicate on broad general lines what appears to be the best method of utilizing the possible storages of the various rivers.

Investigation of the Tapti River.

Storage works surveys.

4. Sites were selected at Hatnur and Susti, and cross-sections of the river were taken. On comparison, the Hatnur site appeared the more favourable, and it was selected for the project. The site is 10 miles east of Bhusaval and 5 miles below the junction of the Tapti and Purna Rivers.

Contours were taken at R. Ls. 665, 685, 705, 715 and 725 above M. S. L., and from these the capacity of the tank has been worked out. The river bed level is R. L. 625.

R. L. of contour.	Area in million square feet.	Area in acres.	Volume up to contour in million cubic feet.
665	36·24	832	483
685*	176·75	4,058	2,390
695	**296·00**	**6,795**	**4,730**
705	422·92	9,709	8,208
715	844·72	19,392	14,403
725	1,269·86	29,152	24,579

* Outlet level of the canal.

N. B.—Calculated areas and volumes in black.

Good rock is exposed throughout the river bed and in places on the left bank, but on the right bank no rock is to be seen, and it is possible that the foundations will be deep.

The town of Edalabad, on the left bank of the Purna River, stands rather low, and would be submerged if the level of water in the tank is over R. L. 695.

Canal survey.

5. A contour with a fall of 6 inches per mile was run on the right bank of the river for 50 miles, starting from the Hatnur site at R. L. 685. The command obtained in this length is 74,368 acres, and a further length of 37 miles up to the Arunavati River would probably yield a total of 193,568 acres.

Volume required for irrigation on the Productive System.

6. On what is called the Productive System of irrigation, 207·4 million cubic feet are required per 1,000 acres of irrigation. Taking the usual proportion of irrigable area to gross area, 51,618 acres would be irrigable out of the above gross command, and the volume required would be 10,700 million cubic feet. This volume

is roughly 900 million cubic feet per month, and judging from the result of the Tapti Gauge for 1908, the only year during which the river has been gauged, no storage would be required for the first 5 months of the season, and only two hundred million cubic feet for the next two months.

River discharge.

7. Discharge of the Tapti, 1908. Gauge at Kathora.

Month.	Discharge in million cubic feet.
June	3,965
July	33,653
August	45,004
September	23,702
October	1,596
November	829
December	767
Total ...	109,516 million cubic feet.

The discharge for the remaining months has not yet been given, but it is improbable that the actual storage required for the area commanded will be more than 5 months supply or 4,500 million cubic feet.

The storage above the canal outlet up to R. L. 695 is only 2,340 million cubic feet, so that to obtain the required storage the town of Edalabad would have to be submerged.

Volume required for irrigation on the 8 months' system.

8. The volume required for irrigation on the 8 Months' System is 93·28 million cubic feet per 1,000 acres. As in the Kukadi Left Bank Canal Project, the irrigable area for the 8 Months' System may be taken at 50 per cent. of the gross command or 96,784 acres. The volume required is therefore 9,029 million cubic feet, or 1,127 million cubic feet per month. Apparently about 2 months storage will be required for this system, which is obtainable with a weir, with F. S. L. at R. L. 695.

Comparison of the above two systems and permissible cost of the Project.

9. The following table gives a rough comparison of the main features of the two systems, and the permissible cost of the project, the net revenue being taken at 3½ per cent. on the total cost in each case.

	Area irrigated in acres.	Storage required in million cubic feet.	Crest level of weir to give required storage. R. L.	Net Revenue per acre irrigated.	Total net Revenue.	Permissible cost, *i.e.*, capital required to produce net revenue at 3½ per cent.
Productive system.	51,618	4,500	702	6·75	3,48,420	99,54,900
8 Months' system.	96,784	2,254	695	3	2,90,352	82,96,000

There is thus a difference of 16·5 lakhs in favour of the Productive System to cover the difference in cost between a dam with F. S. L. at R. L. 702 and one with F. S. L. at R. L. 695 or a difference of 7 feet in height.

Possibility of constructing the project for the above amount.

10. The total permissible cost is Rs. 99,54,900. Deducting the amount required for all other charges, except Works, *viz.*:—Rs. 21,78,000, the amount to be expended on Works is Rs. 77,76,900. This may be divided as follows:—

Distribution at 4/8 per acre of gross command	Rs. 8,71,056
87 miles of canal at 40,000 per mile	„ 34,80,000
Dam at Hatnur 77 feet above the river bed including land and village compensation	„ 34,25,844
Total works ...	Rs. 77,76,900

As the gross volume stored at Hatnur will be 6,890 million cubic feet, the permissible cost of the dam represents a cost of Rs. 500 per million cubic feet stored.

Taking into consideration the provision which will have to be made to pass the floods from the catchment area of 13,102 square miles above Hatnur, and the cost of submerging the town of Edalabad, it is very improbable that the required storage can be provided at the above rate.

The Aner River, a possible source of supply.

11. It is however possible, to irrigate a large part of the area commanded on the right bank of the Tapti from a storage work on the Aner River.

This river, which has a catchment area of 502 square miles, should be able to supply the required volume, but the gauge returns for the last four years show such extraordinary results, that until the average discharge has been properly arrived at, no project for this river can be put forward. It may, however, be noted that, as ascertained from levels given on the topo sheet, the command from a pick-up weir at Sikawal would be 52,160 acres up to the Arunavati River on the right bank, with a canal 20 miles long, and 67,040 acres upto the Gul Nala beyond Chopda on the left bank, with a canal 17 miles long; or a total command of 119,200 acres for a canal mileage of 37 miles, which appears to be very favourable.

River discharge.

12. Catchment area, 502 square miles. Gauge at Ganpur.

Year.	Discharge in million cubic feet.	Run-off inches.
1905	49,145	42·00
1906	16,592	14·28
1907	3,787 (Standard).	3·29
1908	4,806 „	4·12

The catchment area of this river lies wholly in the Satpura hills, and unfortunately there are no gauges on other rivers in the same catchment, which would give some idea of what run-off may reasonably be expected.

Purpose of the project.

13. The above project, if constructed, would serve to irrigate land in the Chopda Taluka of East Khandesh and the Shirapur Taluka of West Khandesh, both of which were badly affected by the last big famine. The land commanded is very fertile and produces excellent crops when the monsoon is favourable, but in the opinion of most of the Revenue Authorities personally consulted, there is no immediate call for irrigation on the right bank of the Tapti.

Investigation of the Girna River.

Storage works surveys.

14. Two sites were selected at Saigaon and Panjan, and both were fully investigated. This was done, because, though as regards length of dam and waste weir facilities, the Panjan site appears the better, there was some doubt about the foundations, which it was difficult to clear up during the monsoon. The foundations at Saigaon on the other hand were obviously favourable. After the monsoon, borings were taken at the Panjan site, and when it was proved that good rock occurred at a reasonable depth, this site was adopted for the project.

Contours were taken at R. Ls:—1143·78, 1173·78, 1203·78, 1223·78, 1233·78 at Saigaon. Three of these extend upstream beyond Panjan, and from these and a contour at R. L. 1303·78, taken at Panjan before the work was stopped, the capacity of the tank has been worked out.

The waste weir site at Panjan is in a separate saddle on the left bank. The tail channel will have to be crossed by the canal, but this could not be avoided.

15. A canal contour was run from the Saigaon Dam site, on the left bank for a distance of 29 miles, to the other side of the ridge between the Girna and the Bori Rivers. From this point two lines were taken, one running west crossing the Bori River 5 miles above Borkund, and reaching the top of the ridge between the Bori and the Panjhra Rivers, and the Dhulia Chalisgaon Road in a length of 24½ miles. The other line runs east along the main ridge for a distance of 43 miles, ending 5 miles south-east of Parola.

Canal surveys.

These lines served to show the extent of the command, and the uncommanded areas along the ridge lines. From the information given by these, lines have been marked in blue on the topo sheets which indicate the position the canal lines should take, when the project is properly worked up.

Rough details of the proposed project.

16. Catchment area 1,826 square miles. River Gauge at the Jamdha Weir. Catchment area 2,389 square miles. Discharge of the river:—

Dam at Panjan.

Year.	Discharge in million cubic feet.	Run off.
1871	26,001	
1872-3	not recorded.	
1874	45,441	
1875	52,766	
1876	27,446	
1877	18,835	
1878	75,174	
1879	52,194	
1880	not recorded.	
1881	24,763	
1882	77,752	
1883	95,424	
1884	64,313	
1885	32,079	
1886	48,932	
1887	47,166	
1888	24,818	
1889	24,706	
1890	24,526	
1891	29,007	
1892	72,889	
1893	48,582	
1894	56,735	
1895	40,359	
1896	51,754	
1897	64,689	
1898	71,940	
1899	10,715	
1900	21,656	
1901	14,320	
1902	19,902	
1903	42,099	
1904	32,730	
1905	25,491	
1906	32,113	
1907	16,918	

The average for the 34 years recorded is 41,595 million cubic feet.

The average since 1900 is 25,653 million cubic feet.
" " 1890-1899 is 47,119 " "
" " 1880-1889 is 48,884 " "
" " 1871-1879 is 42,551 " "

Although the average discharge is 41,595 million cubic feet, the average for the last 8 years shows such a marked falling off that it is only thought safe to estimate for 26,000 million cubic feet storage.

The maximum flood discharge is taken at ¼ inch per hour or 294,589 cusecs.

River bed-level	... R. L. 1186·78 above M. S. L.
Proposed F. S. L. and H. F. L. ...	... R. L. 1311·78 „ „
Proposed outlet-level	... R. L. 1223·78 „ „
Length of dam	... 2,866 feet.
Length of waste weir	... 2,569 „
Calculated discharge over waste weir	... 295,966 cusecs.
Depth of flood over sill of waste weir	... 14 feet.
Number of gates, 14′ × 10′	... 183
Storage above sill of outlet	... 25,691 million cubic feet.
Deduct for evaporation, absorption, etc.	... 1,865 „ „
Net storage	... 23,826 „ „
Area of land submerged	... 16,552 acres.
Number of villages submerged ...	... 10
Cost of dam and waste weir	Rs. 75,38,496
Cost of land and village compensation.	„ 6,50,000
Total ...	Rs. 81,88,496

Cost per million cubic feet stored = Rs. 319

None of the villages submerged are at all important.

The proposed canal lines.

17. The canal surveys showed that practically all the land between the Girna and Panjhra Rivers, east of the Dhulia-Chalisgaon Road, would be under command, with the exception of the ridge lines. The existence of these ridges and the difficulties of making canals on them, makes it necessary to run canals or branches into each valley from the main canal.

Lines showing the approximate position of such canals are shown in blue on the 4 miles to the inch map, and on the topo sheets. They have been carefully drawn from the surveyed levels and levels given on the topo sheets, to give the required command with the shortest possible canal mileage.

Extent of the command.

18. On the Productive System of irrigation, 207·4 million cubic feet are required for every 1,000 acres irrigated. The irrigable command may, therefore, be $\frac{23826}{207·4} \times 1000 = 1,14,880$ acres.

The culturable command at three times the irrigable = 3,44,640 „

The gross command at 1·25 the culturable ... ... = 4,30,800 „

19. Statement showing the length, command, discharge, and cost of the proposed canals and branches.

Name of canal or branch.	Length in miles.	Command in acres, beginning and end of section.	Discharge at head and tail in cusecs.	Cost per mile.	Cost of each canal or branch.	Remarks.
				Rs.	Rs.	
Main canal...	0 to 22¾	4,30,800—4,12,848	1,150—1,101	75,000	17,06,250	The Dhulia and Parola canals take off here.
Do. ...	22¾ to 64¾	2,47,680—1,52,915	661—408	50,000	21,00,000	The Banbhori minor takes off here.
Do. ...	64¾ to 79¾	1,19,238—69,760	318—186	30,000	4,50,000	
Branch. ...	**4**	**69,760—64,000**	**186—171**	**15,000**	**60,000**	The Chansar minor takes off here.
Dhulia canal.	24	92,499—65,210	247—174	30,000	7,20,000	The Badharpur minor takes off here.
Branch ...	**1**	**38,387**	**103**	**10,000**	**10,000**	The Narwala and Garutar minors take off here.
Parola canal.	3¾	72,669—67,840	194—181	30,000	1,12,500	
Branch. ...	**22**	**67,840—37,500**	**181—100**	**15,000**	**3,30,000**	The Parola minor takes off here.

Canals 107½ miles. Branches 27 miles. Total cost Rs. 54,88,750.

Distributaries.

20. The cost of distribution may be taken at Rs. 4/8 per acre of gross command, amounting to Rs. 19,38,600 on the gross command of 4,30,800 acres.

Purpose of the storage and canals.

21. The works described above would serve to bring a large area, chiefly in the East Khandesh District, under irrigation. The soil generally seems fit for producing valuable crops with an assured supply of water.

The transport facilities are excellent, the Chalisgaon-Dhulia Line runs through the commanded area, and the G. I. P. Main Line and the Tapti Valley Railways lie just outside.

Financial prospects.

22. The cost of the project may be:

	Rs.
Dam and waste weir, including land and village compensation	81,88,496
Canals and branches	54,88,750
Distributaries	19,38,600
Total Works...	1,56,15,846
Add—28% for all other charges ...	43,72,424
Grand Total ...	1,99,88,270

Net Revenue.

23. The net revenue is taken at 6·75 per acre irrigated on the Productive System, amounting to Rs. 7,75,440 on an irrigable area of 1,14,880 acres, or 3·88% on the total cost.

The project at this stage appears to be a very favourable one. The figures given for the cost of the canal are rough, and it is quite possible that they may be considerably reduced when the project is worked up, as there will be few important masonry works.

Rain and River Gauges.

24. Rain Gauges have been erected at Hatgad and Mulher in the catchment area.

The discharge of the Girna has been gauged at the Jamdha weir since 1871.

Investigation of the Panjhra Valley.

Surveys for storage tanks.

25. An inspection of the levels on topo sheets Nos. 254 and 255 shows that if a storage site could be found on the Panjhra River somewhere near Ner, it would be an easy matter to make a Left Bank Canal which would reach the ridge line between the Buray and Panjhra Rivers at a point a little north of Songir, and then irrigate a large area of land in the Sindkheda Taluka of West Khandesh, where a scheme of this sort is badly wanted.

For this purpose the Panjhra Valley was very carefully investigated, and sites were selected at Ner, Akalpar and Datarti, below the junction of the Panjhra and Kan Rivers, and at Senpur above the junction.

The Pankheda site.

26. When it was found that none of these sites were at all satisfactory the Executive Engineer on Special Duty directed that a site should be investigated near Pankheda, on the upper reaches of the river, for a small storage tank to provide perennial water for the Panjhra Bandharas.

This was done and 3 contours at R. L. S. 50, 75 and 100 (arbitrary datum) were taken from which the capacity of the tank was worked out.

Trial pits were commenced, but the Special Duty Surveys were closed before any definite results were obtained.

It is not, however, anticipated that the foundations will be deep, as there are indications of rock in many places along the line.

27. A rough estimate for the cost of this dam has been worked out, and amounts to Rs. 23,15,059.

Cost and main details.

The depth of water above river bed will be 90 feet and the storage 1,500 million cubic feet.

The length of masonry dam across the river is 2,532 feet, the flank earthen dam is 3,004 feet long, and the waste weir 427 feet, to pass a flood of 37,429 cusecs or 1 inch per hour from the catchment area of 58 square miles.

28. A report on the Panjhra Project, discussing the best method of using the water from the river, was sent to the Executive Engineer on Special Duty in October 1908.

Previous report.

A copy of this, slightly modified to show the work done since then on the lower storage sites, is attached.

P. L. BOWERS, A. M. I. C. E.,
Assistant Engineer.

REPORT ON THE SURVEYS FOR STORAGE SITE ON THE PANJHRA RIVER.

1. A reference to the rainfall contours on the Presidency map shows that the catchment area of this river lies almost entirely in the area where the annual rainfall is 50″ or less; a small portion of the catchment area of the main stream receiving up to 100″ a year. This being the case, a very much smaller run-off can be expected from this river, than from the other large streams previously investigated in the Deccan.

Situation.

2. The rainfall from the Ghat catchment drains into 3 main streams:—The Panjhra on the south, the Jam-khari in the centre, joining the Panjhra at Mhasdi, and the Kan on the north, joining the Panjhra at Sakri. Of these, the Panjhra has the best catchment, being about half of the total Ghat catchment of the whole system, and situated in the area of largest rainfall.

Site for large storage tank.

It is obvious that the places to look for a site for a large storage work are: (1) below the junction of the three streams, (2) below the junction of the Panjhra and Jam-khari.

Three sites have been investigated in the first portion and one in the second; these will be described later in this report.

Another point to be considered in selecting a site for a large storage tank is the fact that there is already a large area of land irrigated by small canals taking off from frequent bandharas along the course of these streams. The site selected should submerge as little as possible of this irrigated land.

3. River Gauge stations situated on the Panjhra and Kan Rivers have been in existence for some years in connection with various schemes for improving the supply of water to the existing irrigated area, but these observations appear to have been made spasmodically, and may not be very reliable.

Discharge of the river.

Kan at Dahival:—

Year.	Discharge in million cubic feet.	Catchment area, square miles.	Average rainfall at two stations, inches.	Run-off, inches.
1894	947·71	44·48	47·70	9·17
1895	224·37		15·69	2·18
1896	1,751·99		26·39	16·95

Kan at Khandbara.

Year.	Discharge in million cubic feet.	Catchment area, square miles.	Average rain fall, two stations, inches.	Run-off, inches.
1906	834·73	34	29·14	10·56
1907	1,710·66		32·25	21·66

Panjhra at Pankheda.

* Year.	Discharge in million cubic feet.	Catchment area, square miles	Average rain-fall, inches.	Run-off, inches.
1905	927	58	No station in the catchment area.	7·67
1906	874			7·23
1907	2,303			19·00

Panjhra at Dhulia 1907.

Discharge, million cubic feet.	Catchment area.	Average rainfall at 5 stations, inches.	Run-off, inches.
14,945·09	680 square miles.	21·71	9·16

Panjhra at Nahalod 1907.

Discharge, million cubic feet.	Catchment area, square miles.	Average rainfall, 6 stations, inches.	Run-off, inches.
15,203·80	768	20·52	8·54

* Mukti Nala at Mukti Tank.

Year.	Discharge, million cubic feet.	Catchment area, square miles.	Rainfall, inches.	Run-off in inches.	Proportion of rainfall.
1882	326·90	34·20	22·43	4· 5	1/5
1883	173·70		9·46	2·36	1/4
1884	114·13		9·23	1·32	1/7
1885	209·22		13·84	2·77	1/5
1886	494·27		23·92	6·00	1/4
1887	170·86		20·39	2·10	1/14
1888	.....		13·10	...	...
1889	163·12		13·56	1·94	1/7
1890	305·17		12·71	3·81	3/10
1891	302·76		19·95	3·99	1/5
1892	242·43		20·30	2·90	1/7
1893	84·42		8 88	1·11	1 8
1894	177·00		18·47	2·31	1/8
1895	208·61		18·29	2·61	1/7
1896	277·71		10·79	3·59	1/3
1897	227·08		9·40	2·82	3/10
1898	153·22		21·03	2·10	1/10
1899	10·76		4·27	0·13	1/33
1900	206·03		15·27	3·05	1/5
1901	161·71		17·74	2·22	1/8
1902	308·62		22·41	5·60	1/4
1903	235·47		23·94	2·99	1/8
1904	311·91		14·84	3·71	1/4
1905	130·46		14·86	1·86	1/8
1906	254·71		15·66	4·00	1/4
1907	145·93		14·70	1·85	1/8

* This is a nala in the catchment area above Dhulia and serves as a useful guide to the proportion of run-off to rainfall, in the non-ghat portion of the catchment area.

From the Mukti Tank figures it appears that an average annual discharge of $\frac{228}{34 \cdot 2} = 6 \cdot 7$ million cubic feet per square mile may be expected from the non-ghat portion of the catchment area. From the ghat portion the discharge per square mile varies from 22 million cubic feet for the period 1894-1895 to 40 million cubic feet for 1906-1907 for the Kan, the discharge per square mile from the Panjhra catchment being 23·6 million cubic feet.

The figures for the Kan for 1894-1896 are not much use for calculation as they contain one very bad year 1895. Neglecting this, the discharge would be 30 million cubic feet per square mile.

A safe average discharge per square mile from the Ghat portion of the catchment, *i.e.*, a line drawn between Pankheda and Dahival would appear to be about 30 million cubic feet, the catchment area over which this figure applies being about 150 square miles.

This average discharge will gradually reduce from the Ghats towards Dhulia, where, as shown by the Mukti Tank records, it is 6·7 million cubic feet or roughly 7 million cubic feet.

The next 100 square miles nearest the Ghat catchment may be taken as giving a discharge of 20 million cubic feet per square mile. The next 100 square miles, 15 million cubic feet per square mile; the next 100 square miles, 10 million cubic feet; and east of this only 7 million cubic feet per square mile may be expected.

Best method of using the water stored.

4. The question whether it is better to store water so as to improve the already existing system of irrigation or whether a new canal should be constructed and fresh land brought under irrigation must now be considered. As before mentioned, there are a considerable number of bandharas on the Panjhra and its tributaries, which have supplied water to small canals for many years. Owing to the gradual sinking of the water level in the country, the after monsoon flow in the river has decreased to an alarming extent, so that, whereas formerly nearly all the bandharas used to supply water for perennial irrigation, now only a few in the upper reaches of the river do so, and now these are liable to fail.

On the Panjhra River and its tributaries there are 57 bandharas which supply water for 9,035¾ acres of irrigation, yielding a total assessment of Rs. 83,096 or about Rs. 9 per acre.

Of this assessment, the Government share is divided into :—

	Rs.
Water rates	66,387
Land rates	12,470

and the Inamdars share is—

Water rates	3,472
Land rates	767

Hence, the amount charged for water averages about Rs. 7 per acre irrigated.

Of the 57 bandharas on the Panjhra and its tributaries, 31 are on the Panjhra itself, 14 are on the Kan River, and 12 on Nalas ; the latter could not be improved by storage works on the Panjhra or Kan Rivers.

There are no Bandharas on the Jam-khari nala.

The areas and assessments are as follows :—

River.	No. of bandharas.	Area irrigated.	Assessment.	Water share.	Government or Inamdars' land share.
		Acres.	Rs.	Rs.	Rs.
Panjhra	31	6,429¾	67,650	56,997	10,652
Kan	14	1,786¾	12,721	10,686	2,035
Other nalas	12	819¼	2,725	2,176	549

In order to improve the irrigation under these bandharas the storage sites should be as far up the valley as possible.

On the Panjhra, a site has been investigated by the Executive Engineer, West Khandesh, at Pankheda, which will have all the Bandharas on the Panjhra River under command. The catchment area above the site is 58 square miles so from the figures given in para. 3 the storage can amount to 58 × 30 million cubic feet=1,740 million cubic feet.

This will be sufficient for 1,740 × 4·5=7,830 acres of irrigation on the productive system, so that even neglecting the supply to the Panjhra below this tank site, water could be given throughout the year to the 31 Bandharas on the Panjhra and an additional area of 1,400 acres irrigated by lengthening some of the canals.

The only site available on the Kan is at Khandbara. This has been fully investigated by the Executive Engineer, West Khandesh. A tank at this site would command 11 out of the Kan Bandharas irrigating a total of 1,562 acres.

The storage at Khandbara could be 30 × 34 square miles=1,020 million cubic feet, sufficient for 4,590 acres on the productive system, without any further supply being received by the river between the tank and the bandharas. This allows for an increased area of irrigation amounting to 3,028 acres.

The storage of water to improve existing irrigation on the above lines would insure the present water revenue on 8,217 acres × Rs. 7=Rs. 57,519 against further loss, caused by the short supply of water in the rivers, and produce a further revenue of 4,428 acres × Rs. 7=Rs. 30,996 from the additional area irrigated.

This could probably be accomplished at a cost of 1,740 + 1,020 million cubic feet at say 1,500 per million cubic feet, as an outside cost, which comes to Rs. 41,40,000.

The question of a large storage tank with new canals appears to be negatived by the following considerations:—

(*a*) The danger of the old bandharas above such a site gradually falling out of use owing to the lack of after-monsoon flow in the river, thus causing a loss of revenue.

(*b*) The difficulty of obtaining a good and economical site.

(*c*) Unavoidable submersion of a certain area of land at present under irrigation.

(*d*) The just claims of the present holders of irrigated land, who all feel that Government should do something, to ensure a perennial supply of water for existing irrigation, and ensure them against loss owing to failure of the after-monsoon flow in the river.

Sites investigated for a large Storage Work.

(*a*)—At Ner on the Panjhra.

5. Catchment area, 472 square miles. Storage possible:—

Miles.		Million cubic feet.		
150	×	30	=	4,500 million cubic feet.
100	×	20	=	2,000 „
100	×	15	=	1,500 „
100	×	10	=	1,000 „
22	×	7	=	154 „
Total storage			=	9,154 million cubic feet.

Three contours were taken at R. Ls. :—1233, 1213, and 1193, and from these the following capacities have been worked out:—

River bed R. L. 1153 above M. S. L.

Contour.	Area in million square feet.	Volume in million cubic feet up to contour level.
1193	28·77	383·61
1213	68·76	1330·42
1233	140·85	3384·00

The section and foundations on the left bank are promising, but on the right bank there is probably deep black soil and shadu, and the ground rises very slowly. No trial pits, however, have been taken. The dam would be a very expensive one compared with the storage possible.

(*b*)—At Akalpara.

Catchment area, 448 square miles. Storage possible, $150 \times 30 + 100 \times 20 + 100 \times 15 + 98 \times 10 = 8,980$ million cubic feet.

It has been calculated that a dam 100 feet high at this site would store about 4,500 million cubic feet. The foundations appear to be better than those at Ner and the dam to store an equal volume of water would be more expensive.

(*c*)—At Datarti.

Catchment area, 402 square miles. Storage possible, $150 \times 30 + 100 \times 20 + 100 \times 15 + 52 \times 10 = 8,520$ million cubic feet.

This section is as unfavourable as the other two.

(*d*)—At Senpur.

Catchment area, 188 square miles. Storage possible, * $\frac{2}{3} \times 150 \times 30 + \frac{2}{3} \times 100 \times 20 + 22 \times 15 = 4,650$ million cubic feet.

Three contours were taken and the capacity worked out.

River bed R. L. 1520.

Contour.	Area, million square feet.	Volume million cubic feet.
1570	9·3	155
1595	28·15	602
1620	74·7	1841

Trial pits were taken but the results were not satisfactory.

The storage would do considerable damage to lands at present under irrigation.

Conclusion.

6. On the whole, therefore, it appears better first, to use the water from the Panjhra, to improve existing irrigation and to increase the area irrigated, by means of two small storage tanks, situated, one on the Panjhra near Pankheda and the other on the Kan at Khandbara.

Afterwards if it is found that further storage is required for irrigation on the left bank of Panjhra and in the Buray Valley, the site at Ner should be fully investigated for a storage of about 5,000 million cubic feet. This site is the best in the valley for a large storage work, as no irrigated land would be submerged and the construction of a canal from this site into the Buray Valley would be a comparatively easy matter.

P. L. BOWERS, A.M.I.C.E.,
Assistant Engineer.

* As the catchment above Senpur contains about $\frac{2}{3}$rd Ghat area of whole catchment of the Panjhra and Kan Rivers combin

GIRNA DISCHARGE AT THE JAMDA WEIR.

GIRNA DISCHARGE AT THE JAMDA

Year.	January.	February.	March.	April.	May.	June.	July.
1871...	.....	.....	.....	.....	.....	1,770·10	164·05
1872...	.....	66·94	37·07	596·62	24·00	.....	.....
1873...	.....	.....	.....	.....	.....	.....	.....
1874...	384·53	227·34	166·89	128·92	413·79	16,987·18	8,117·88
1875...	290·70	270·93	217·38	156·67	136·17	1,740·08	8,921·32
1876...	726·43	509·49	432·63	294·40	227·50	4,046·90	6,080·80
1877...	776·05	331·96	259·65	143·62	211·18	9,559·51	1,113·47
1878...	75·67	43·31	153·35	5·53	15·37	2,725·22	15,464·15
1879...	310·40	214·22	153·46	125·24	1,373·77	9,551·08	8,993·66
1880...	.....	.....	.....	.....	.....	.....	.....
1881...	223·65	154·31	103·07	89·44	334·74	904·16	6,063·31
1882...	124·70	72·40	49·10	13·94	9·47	13,346·83	20,597·87
1883...	487·50	290·36	151·26	99·53	70·99	2,273·04	30,387·35
1884...	1,374·91	856·13	602·11	348·90	423·68	1,556·18	13,906·77
1885...	1,262·55	532·54	425·87	245·74	368·80	410·40	2,204·85
1886...	407·11	196·66	217·97	130·80	168·68	8,992·69	8,364·84
1887...	451·61	306·23	232·18	184·74	195·07	2,670·36	13,130·36
1888...	1,584·61	619·66	475·06	375·16	74·46	2,092·69	4,022·32
1889...	173·70	110·79	107·49	82·13	42·85	96·48	7,285·37
1890...	77·51	45·15	33·50	19·90	4·56	.....	6,315·03
1891...	90·14	47·57	20·21	13·77	0·78	.....	9,210·33
1892...	131·86	50·47	35·39	16·95	17·58	6,529·61	5,061·58
1893...	431·09	242·21	226·11	129·72	2,457·72	14,226·83	10,712·71
1894...	388·86	249·79	21·13	135·04	88·10	2,639·64	18,443·71
1895...	1,056·60	495·69	324·78	163·00	153·38	6,083·68	5,146·06
1896...	282·08	174·63	154·66	98·15	125·20	8,207·08	20,924·68
1897...	299·53	194·57	157·93	116·21	54·42	655·01	4,111·42
1898..	218·05	163·34	119·56	69·80	52·62	3,989·11	11,328·33
1899...	300·08	211·70	166·00	146·66	174·75	5,232·15	1,251·73
1900...	44·63	33·34	18·30	1·29	.....	3,302·54	6,843·16
1901...	183·53	43·06	21·56	33·11	171·69	3,774·01	916·67
1902...	82·34	2·48	.....	.....	.....	2,260·55	5,005·45
1903...	122·43	10·27	0·91	.....	3,836·24	3,084·44	8,401·54
1904...	65·85	25·42	16·16	3·48	31·52	1,063·82	3,130·01
1905...	45·10	16·97	7·86	2·09	0·51	1,982·31	16,185·95
1906...	47·78	7·86	1·22	.....	.....	3,174·12	6,930·34
1907...	38·92	20·27	16·72	15·77	16·39	919·16	3,892·96

WEIR, IN MILLION CUBIC FEET.

August.	September.	October.	November.	December.	Total.	Year.	Remarks.
14,993·91	7,536·05	1,027·20	510·46	.....	26,001·77	1871	Not recorded for 6 months.
.....	.....	.....	.....	.....	724·63	1872	Do.—8.
.....	.....	2,034·29	1,634·97	.....	3,719·26	1873	Do.—10.
11,771·67	5,770·09	751·68	391·69	330·21	45,441·87	1874	
10,251·18	27,002·45	1,571·34	1,000·36	1,208·03	52,766·41	1875	
7,810·64	4,954·88	807·72	306·57	248·07	27,446·03	1876	
1,472·78	2,718·81	1,935·24	154·30	159·02	18,835·59	1877	
22,494·45	26,591·68	6,366·51	771·55	467·96	75,174·75	1878	
15,463·03	7,855·34	6,354·16	1,799·78	.....	52,194·14	1879	
.....	.....	.....	.....	.....	.....	1880	Not recorded.
6,152·71	4,584·19	4,746·87	270·77	136·67	24,763·89	1881	
6,904·63	32,288·14	2,605·32	1,002·77	737·78	77,752·95	1882	
9,782·13	20,275·19	26,592·89	3·397·01	1,615·72	95,424·97	1883	
10,652·47	18,170·43	8,105·13	3,599·38	4,717·74	64,313 83	1884	
10,148·99	7,115·56	6,802·09	1,694·80	866·97	32,079·16	1885	
10,799·82	9,499·92	8,030·19	1,482·82	640·87	48,932·37	1886	
11,144·49	9,013·90	3,787·69	4,711·97	1,337·48	47,166·08	1887	
10,433·41	3,614·07	878·26	375·00	224·12	24,818·82	1888	
5,252·80	7,695·96	3,551·14	193·86	113·55	24,706·12	1889	
10,158·91	5,249·70	2,252·73	210·18	159·79	24,526·96	1890	
7,501·62	8,523·90	3,162·65	258·26	178·37	29,007·60	1891	
14,426·75	38,772·17	5,315·24	1,929·97	602·34	72,889·91	1892	
9,014·52	7,300·45	2,419·17	960·76	461·05	48,582·34	1893	
5,947·49	19,782·22	5,519·00	2,383·82	1,137·16	56,735·96	1894	
5,909·73	16,955·43	3,025·62	661·80	383·33	40,359·10	1895	
17,489·03	2,805·46	819·96	349·13	324·34	51,754·40	1896	
11,466·69	20,277·39	6,375·14	678·83	302·04	64,689·18	1897	
27,020·37	23,657·25	4,573·95	448·01	300·14	71,940·53	1898	
467·14	2,596·07	62·87	56·05	50·35	10,715·55	1899	
7,622·12	2,580·59	951·62	143·69	115·45	21,656·73	1900	
3,718·18	2,881·88	2,406·69	125·14	45·25	14,320·77	1901	
3,575·48	7,037·45	1,040·73	716·02	181·99	19,902·49	1902	
7,683·72	14,042·37	4,162·58	525·91	229·20	42,099·61	1903	
4,143·93	20,105·86	3,589·57	473·15	76·72	32,730·49	1904	
4,307·36	2,333·32	331·31	42·12	36·59	25,491·52	1905	
15,049·66	5,888·59	879·30	85·06	49·89	32,113·82	1906	
10,476·25	1,144·80	304·12	46·06	27·05	16,918·47	1907	

REPORT ON GODAVERI VALLEY SURVEYS.

CONTENTS.

		Pages.
1.	Report on Godaveri Valley Surveys	93 to 100
2.	Rain and River Gauge Statements	101 to 103
3.	Preliminary Report on the Kadva Storage at Palkhed and Left Bank Canal	103 to 111
4.	Preliminary Report on the Darna Right Bank Canal Project prepared March 1908	111

INDEX TO

Godaveri Valley Report.

Para.	Subject.
	A—Investigation of the Kadva River and its tributaries.
	1.—Unanda River Surveys.
1	Phopsi Dam Site.
2	Wajarkhed Dam Site.
3	Trial pits and description of Dam Site.
4	Details of the project, Areas and volumes.
5	Available supply.
6	Catchment area, Land and village submersion, Cost.
7	Purpose of the Storage.
8	Rain and River Gauges.
	2.—Kadva River Surveys.
9	Dam sites.
10	Site 2½ miles above Karanjawan.
11	The Karanjawan-Pimparkhed Ridge Site.
12	Site at Ozah.
13	Site 2¾ miles below Ozah.
14	Details of the Karanjawan-Pimparkhed Dam — Bed-level, Outlet, Net capacity, Available supply, Catchment area, Land and village submersion, Cost.
15	Purpose of the Storage.
16	Rain and River Gauges.
17	Palkhed site.
18	Surveys for dam.
19	Surveys for canal.
20	Details of the project.
	B—Investigation of the Godaveri River and its Southern tributaries.
	3.—Nasik Left Bank Canal Project.
21	Surveys.
22	Dam sites above Nasik.
23	Gangapur Dam Site Survey.
24	Canal survey.
25	Details of the project.
26	Details of the Gangapur Tank, Net capacity, Supply available, Catchment area, Land and village submersion, Cost.
27	Details of Left Bank Canal, Alignment, Nature of command, Irrigation, Cost.
28	Purpose of the Storage.
29	Water-supply to Nasik.
30	Rain and River Gauges.
	4.—The Godaveri Canals Project.
31	Description.
32	Additional storage on the Aundh-Nalla-Surveys, The Kavnai and Mukne Dam Sites.
33	Details of the project—Lower dam site, F. S. L., Outlet level, Net capacity, Available supply, Land and village submersion, Cost.
34	Purpose of the Storage.
35	Rain and River Gauges.
	5.—The Darna Right Bank Project.
36	Surveys.
37	Pimpalgaon-Dokra Dam Site.
38	Canal lines.
39	Details of the project.
40	Rain and River Gauges.

GODAVERI VALLEY SURVEYS.

List of Drawings and Tracings accompanying the Report :—

NOTE.—The office in which these plans are recorded is named in the list printed at page 63 following the Chief Engineer's Review.

No. of Drawing.	Title.	No. of sheets.	Scale.
	Unanda Storage.		
1	Longitudinal section of dam line at Wajarkhed...	1	H—400′ V— 20′ =1″
2/1 to 2/2	Plan of ditto ...	2	400′=1″
3/1 to 3/2	Contour plans of ditto ...	2	
	Kadva Storage.		
4	Longitudinal section of dam line Karanjwan-Pimparkhed Ridge	1	H—400′ V— 20′ =1″
5	Plan of longitudinal section of dam line Karanjwan-Pimparkhed Ridge	1	400′=1″
6/1 to 6/17	Contour plans of Kad va Storage at Karanjwan-Pimparkhed Ridge	17	400′=1″
7	Plan and cross section of dam line at Palkhed ...	1	H–1000′ V— 20′ =1″
8/1 to 8/10	Cross sections of Kadva storage at Palkhed ...	10	H—400′ V— 20′ =1″
9/1 to 9/10	Contour plans of ditto ...	10	400′=1″
	Nasik Storage.		
10	Plan and longitudinal section of dam line at Gangapur	1	H—400′ V— 20′ =1″
11/1 to 11/10	Cross sections of Nasik Storage at Gangapur ...	10	Do.
12/1 to 12/10	Contour plans of ditto	10	400′=1″
	Aundha Storage.		
13	Longitudinal section of dam line at Mukna ...	1	H—400′ V— 20′ =1″
14	Plan of ditto ...	1	400′=4″
15/1 to 15/7	Cross sections of ditto ...	7	H—400′ V— 20′ =1″
16/1 to 16/11	Contour plans of ditto ...	11	400′=1″
	Karwa Storage.		
17	Plan and longitudinal section of dam line at Pimpalgaon Dukra (Ninavi)	1	H—400′ V— 20′ =1″
18 to 18/4	Cross sections of ditto ...	4	Do.
19/1 to 19/5	Contour plans of ditto ...	5	400′=1″
20/1 to 20/35	Plan and longitudinal section of Darna Right Bank Canal	35	H—400′ V— 20′ =1″

List of Topo Sheets for Godaveri Project.

Topo sheets Nos :—191, 192, 193, 194, 225, 226, 227, 258, 259 and 260.

Index map showing Storages and Canals—Scale 8 miles to 1 inch.

A.—INVESTIGATION OF THE KADVA RIVER AND ITS TRIBUTARIES.

I.—UNANDA RIVER SURVEYS.

1. Before the Wajarkhed dam site was decided on, the valley was carefully examined. A site near Phopsi was levelled over, but it was rejected because it gave too high a dam for the probable capacity, and it was preferable to have a greater catchment area.

Phopsi Dam site.

The position of this site is shown on the topo sheet No. 191, and on the contur survey plan (Unanda Project) drawing No. 2.

2. For the Wajarkhed dam 3 sites were examined, the middle one lying just above the village proved the most suitable. This was fully investigated; see tracting No. 1 and drawing No. 2.

Wajarkhed Dam site.

For the contour survey of the tank, lines were run at R. Ls. 2061·56, 2091·56 and 2,121·56 and from these the area and volume up to R. L. 2,141·56 were calculated.

3. The foundations for the dam are very favourable on the Right Bank of the river gorge, but the rock dips rapidly in the river bed, and it is 50 feet below ground level on the left bank of the river. The dam would be only 2,600 feet long in this gorge, but the ridge on the right between the Unanda and the Kadva Valleys is comparatively low, and will have to be closed in 3 places, as follows :—

Trial pits and description of dam site.

Length. Feet.	Deepest part. R. L.
1,600	2126·16
6,100	2116·36
900	2136·16

In the first of these it is proposed to place the waste weir. The foundations are favourable. The flood will discharge into the Kadva Valley but there is no objection to this. The ground is steep and little damage will be done.

4. The river bed at the dam site is at R. L. 2,027·86 feet above Mean Sea Level.

Details of the project.

The proposed F. S. L. is R. L. 2,141·56 and the statement of areas and volumes is as follows :—

Areas and volumes.

R. L.	Area of contour.	Volumes between contours, Million cubic feet.
2,061·56	3,700,800	43·2
2,091·56	28,113,600	448·3
2,121·56	72,174,400	1,453·20
2,141·56	110,340,800	1,811·70
	Total ...	3,756·40

The proposed outlet level is at R. L. 2,046·56 and assuming 10·4 million cubic feet to be the volume below outlet the designed net storage would be 3,746 million cubic feet.

5. The discharge of the river has been gauged for 5 years and it yielded :—

Available supply.

Year.	Discharge, million cubic feet.	Run-off, inches.
1903	2,709	17
1904	1,895	12
1905	1,781	11·3
1906	2,010 (standard)	12·7
1907	3,167 „	20
1908	2,014 „	12·75

It follows from this that the designed storage is probably rather in excess of requirements, but the tank should store more than 2,000 million cubic feet.

6. The catchment area is 68 square miles. The land to be submerged at R. L. 2,141·56 would be 2,530 acres, and two small villages would be drowned, *viz.*, Waglud and Krishnagaon. About 2½ miles of the Dindori-Wani road fall into the tank area, but this could easily be diverted over the dam.

Catchment area, Land and Village submersion.

The dam would necessarily be a very expensive one, probably costing 1,200 rupees per million cubic feet, and its construction cannot possibly be contemplated in the near future.

Cost.

7. If the dam were made it would supply water for the existing Kadva River Works, which start from the pick-up weir at Palkhed. Any water passing this point would continue to flow down the river and be picked up at Nandur-Madhmeshwar for the new Godaveri Canals.

Purpose of the Storage.

8. Two rain gauges were erected in this catchment in 1907, at Achla Fort and at Wajarkhed.

Rain and River Gauges.

A river gauge was put up quite close to the dam site in 1903. The observations are detailed in the accompanying statement.

2.—KADVA RIVER SURVEYS.

9. Four dam sites were examined west of the Nasik-Dindori Road.

Dam sites.

The site near Karanjawan was, on the whole, the most favourable. A fifth site was also investigated recently at Palkhed, 1½ miles below the existing weir. (See topo sheet No. 191.)

10. (*a*) Site 2½ miles above Karanjawan.—On the left bank a high spur comes right up to the river, and there is rock in the river bed ; but the right bank is very unfavourable, as if the line is taken right across the valley to the high ground beyond, the length is very great ; or if the dam is made to turn up-stream and join the high ground close to the river, the capacity of the tank is much curtailed. Besides this the trial pits show that the rock is very low down on the right bank.

Site 2½ miles above Karanjawan.

11. (*b*) Karanjawan-Pimparkhed Ridge site 1 mile above Ozah.—This is the least unfavourable site. The spur on the right bank is very high, and there is a hillock on the left bank. Beyond this, however, there is dip containing rich cultivable soil of great depth. The dam may either branch somewhat up-stream to high ground, or down-stream to the village which is at the end of a spur. The former is the better alignment. This site has been fully investigated. At the deepest part of the foundation rock is 81 feet below ground level, which makes the construction of a masonry dam almost prohibitive. But a heavy earthen dam might be made here, as there is ample material for a liberal section to be adopted.

The Karanjawan-Pimparkhed Ridge site.

The waste weir would be on the high ground on the right bank.

A river gauge was erected, the observations at which are given in a separate statement. Four contour lines were run at R. Ls. 2040, 2060, 2100, and 2140·04 and cross sections were taken up the valley at each mile. The capacity of the tank was worked out from the former.

The contour was continued down-stream as far as the other two sites.

Site of Ozah.

12. (*c*) Site at Ozah.—This is very short distance below the Karanjawan site, and as the trial pits proved unfavourable, it was rejected.

Site 2¾ miles below Ozah.

13. Site 2¾ miles below Ozah.—One advantage of this site is that if it were constructed in combination with the Unanda Project, there would be no necessity for a protective work on the right flank of the Unanda tank at Wajarkhed. All the superfluous water from the Unanda could be allowed to flow over the spur into the Kadva Valley, and it would help to fill the Kadva Tank. But in other respects, *viz.*, trial pit results and size of the dam, this site is less favourable than the Karanjawan one. Figures are, therefore, given for the latter only.

Details of the Project for the Karanjawan-Pimparkhed Dam.

Bed Level.

14. The river-bed at dam site is R. L. 2021·43 above M. S. L. A tank to store 6,886 million cubic feet would have its full supply level at R. L. 2,140·04.

The statement of areas and volumes is as follows:—

River bed R. L. 2021·43 above M. S. L.

R. L.	Area of contour in mill. square feet.	Volumes up to each contour in mill. cubic feet.
2,030·04	1·41	9·44
2,060·04	8·65	99·90
2,100 04	71·82	1,505·24
2,140·04	209·14	6,885·53

Outlet, net capacity.

The proposed outlet level is R. L. 2,080 and assuming 377 million cubic feet to be the volume below outlet level, the designed net storage would be 6,500 million cubic feet.

Available supply.

The discharge of the river has been gauged for 6 years and it yielded:—

Year.	Million cubic feet.	Run-off in inches.
1902	7,197	32·3
1903	7,805	35
1904	6,001	26·9
1905	4,430	1·9
1906	4,668 (standard) ...	20·9
1907	10,011 „ ...	44·9
1908	8,359 „ ...	37·5

The capacity of the tank, 6,886 million cubic feet, was selected in the early days before the actual discharge of the river was definitely known, but the figure is a good one.

Catchment area.

The catchment area is 96 square miles and the run-off required to fill the tank would be about 31 inches.

The land in the vicinity of Karanjawan is excellent soil, and this is one reason for choosing the upper alignment on the left wing. The compensation, excepting for this portion should not be very high, and no villages would be submerged. The accumulation of silt, however, in this tank, is a matter which would require consideration. The area to be submerged is 4,800 acres.

Land and village submersion.

The cost of the dam would necessarily be high, because of the great depth of the foundations on the left flank, it would not be less than 70 lakhs rupees, *viz.*, over 1,000 rupees per million cubic feet.

Cost.

15. The first intention when examining this scheme was to secure a water supply for the Godaveri Canals, and also to add to the supply of the existing Kadva River Works. Since then a better storage has been found for the Godaveri Canal Project on the Darna River, and no work is required on the Kadva. If the Karanjawan dam were ever constructed, it would probably be required for a fresh canal from the Palkhed weir, or for an additional supply to the existing Kadva River Works.

Purpose of the Storage.

16. The first rain gauge in the catchment was put up at Charose in 1902, and another was erected in 1907 at Kosemba under orders from the Government of India. There are also rainfall statements for—

Rain and River Gauges.

Waghad Bungalow	...	...	...	1898-1907.
Chachadgaon Store	...	...	...	1893-1907.
Waghad Tank ...	...	...	...	1877-1907.

A river gauge was fixed below the dam site at Karanjawan in 1902. The observations are detailed in the accompanying statements.

Site near Palkhed.

17. This is the fifth site on the Kadva River, and was examined by request of the Chief Engineer for Irrigation, the purpose being to ascertain whether a greater command could not be gained on the left bank of the Godaveri.

Palkhed site.

Surveys.

18. The project has been investigated and a separate report on it is attached. The dam site is, on the whole, unfavourable. It would be about 3 miles long, to hold up 113 feet of water, and the cost for works alone would be 112 lakhs rupees. The proposed capacity is about 8,910 million cubic feet. The cost per million of this scheme is as great as of the others referred to in this valley, but it has the advantage of a storage lying further downstream and, therefore, getting a better supply of water. The land to be submerged is fertile, and 4 villages will be drowned and 2 villages partially drowned. The Nasik-Dindori road would be submerged for a distance of $\frac{1}{4}$ mile. The existing Palkhed weir and about 2 miles of the Palkhed Canal would be submerged.

Surveys for dam.

19. The new canal contour line has been surveyed with a fall of 1 foot per mile and its possible command for 88 miles length is 2,34,000 acres. As, however, the water supply is only enough for 1,71,500 acres gross, the canal need not be more than 60 miles long, when properly laid out.

Surveys for canal.

20. The project is described in a separate report attached, (*quo vide*). This scheme has the same discharge as the Nira L. B. Canal nearly double the present storage at Bhatghar, and is designed to irrigate 45,720 acres on the quadrennial rotation system, and will probably cost 200 lakhs including indirect charges. The direct return could reach $1\frac{1}{2}$ per cent. on the capital but will generally be much less.

Details of the project.

B.—INVESTIGATION OF THE GODAVERI RIVER AND ITS SOUTHERN TRIBUTARIES.

3.—NASIK LEFT BANK CANAL PROJECT.

Surveys.

21. The pick up weir for the Godaveri Canal Project is at the junction of the Kadva and Godaveri Rivers.

There is no site for a storage reservoir between this point and Nasik.

Dam sites above Nasik.

22. Above Nasik seven dam sites are marked on the topo sheet No. 192. Of these, the first at Anandwali, 3 miles from Nasik, is impracticable, because of the length of dam required, and the great expense of fertile ground and orchards which would be submerged. The two sites on the Godaveri above Sawargaon and the site at Uzarkhere on the Wokti are all unfavourable as regards foundations and restricted basin area.

The country at Sawargaon is rather flat, and the dam site at the junction of the Wokti and the Godaveri is a bad one. The next line about 1 mile lower down may repay investigation, but the site at Gangapur looked at first sight to be the most promising of all.

Dam Site at Gangapur.

Gangapur Dam site survey.

23. This has been investigated in the usual manner. Trial pits have been taken. On the right the rock is not deep, it is visible in the river bed, but on the left bank, 1,400 feet from the river, the rock dips and is 90 feet below ground level. Further on the left, the foundations are again favourable. A little below the dam site there is a fall in the river bed of about 25 feet.

Besides the usual cross sections at one mile apart, up the valley, one contour has been run at R. L. 1971, 80 feet above river bed at dam site.

Canal survey.

24. A canal line has been surveyed on the left bank, 24 miles in length, running from the dam to the Banganga River. This is only a trial line to ascertain the area to be commanded, and to see if there would be any difficulties.

Details of the project.

25. The Nasik Project will consist of a tank formed by a dam near Gangapur and a left bank canal. A right bank canal would have no appreciable command, because the Darna River joins the Godaveri not far from Nasik, and there is another scheme for irrigating the land on the right bank beyond this junction.

(*a*).—The Gangapur Tank.

Details of the Gangapur Tank.

26. The river bed at the dam site is R. L. 1890·86 (above M. S. L.). If the full supply level in the tank were R. L. 1971, the volume stored would be about 7,000 million cubic feet. The area of the 1971 contour is 168·13 million cubic feet. The outlet level may be at R. L. 1911. The rise in the river bed is only 15 feet for the first 2½ miles (to dam site above Savargaon), but it is much steeper in the two branches, the head of the tank being reached about 5 miles in each case above the junction.

Net capacity. Available supply.

A net capacity of 7,000 million cubic feet is not unreasonable, seeing that the river discharge for the last 4 years has been :—

Year.	Million cubic feet.	Run-off in inches.
1905	6,313	19
1906	5,531*	16
1907	14,590*	43
1908	9,893*	29

* Standard.

Catchment area.

The catchment area is 145 square miles and the run-off required to fill the tank would be about 21 inches.

Land and village submersion.

The land to be submerged is not particularly rich, and the compensation will not be heavy, but several villages will be drowned, *viz.*, Savargaon, Braman-Wada and Dehulware, at the junction of the streams, and Pimpalgaon. The road from Nasik to Wagira and Harsul will be drowned for 3½ miles, a diversion along the track *vid* Pimpalgaon to Nasalgaon, about 10 miles from Nasik, would present little difficulty, except at the crossing of the tank at Pimpalgaon where a ferry would have to be arranged for.

Cost.

The dam will be 80 feet high, and nearly 9,000 feet long, so with the great depth of foundations on one bank, the cost would probably be about 60 lakhs rupees.

(*b*).—The Left Bank Canal.

Details of the Left Bank Canal, Alignment.

27. The alignment, at 2½ feet fall per mile, gives a command of 22,240 acres for a length of 24 miles. There is no particular difficulty about the alignment, but there are very many nalas to cross. The command is very small up to the 8th mile, opposite Nasik, but beyond that it improves rapidly.

Nature of command.

The land under command is excellent fertile soil. It is safe to count upon the highest class of irrigated cultivation for this part, lying, as it does, quite close to Nasik at first, and after that all along the G. I. P. Railway lines as far as the Banganga River.

Irrigation.

With 50 per cent. sugarcane and 25 per cent. each of 8 months and of 4 months crops, about 3 acres could be irrigated by each million cubic feet of water supplied from the tank. Not more than 16,000 acres of irrigation would be counted on, requiring 5,333 million cubic feet or say 6,000 million, including losses in the tank.

Cost.

The cost of the canal may be taken at 5 lakhs rupees, making a total with the dam of 65 lakhs rupees. Add 27 per cent. for other charges and the total direct and indirect charges would be 82½ lakhs rupees. The revenue from the canal would be 1,63,000 rupees, and the return on capital expenditure is therefore 2 per cent.

Purpose of the Storage.

28. In addition to the canal supply it would be possible to supply water to Nasik town.

The population, including the Civil Station, was 21,490 in 1901. A 10 per cent. increase would raise this figure to nearly 24,000.

Water-supply to Nasik.

29. At 15 gallons a head (2½ cubic feet) the supply required is 60,000 cubic feet per diem and 22 million per annum.

Nasik is a holy city in India, and provision must be made for pilgrims, say 200,000 for 4 months in the year equivalent to 70,000 increase to the population for 12 months. The requirements would then be 66 millions more, or 88 million cubic feet altogether. The tank would hold 7,000 million cubic feet, of which 6,000 million cubic feet are wanted for irrigation and less than 100 million cubic feet for the water-supply.

A smaller tank would suffice, and the revenue from the water-supply would further improve the prospects of the project.

Rain and River Gauges.

30. A rain gauge was erected at Trimbak in 1901, and in accordance with instructions from the Government of India two more gauges were put up in 1907 at Wagira and Girnara.

The river discharge has been gauged at the proposed dam site since 1905. The results of the river and rain gauges is shown in the statement attached.

4.—THE GODAVERI CANALS PROJECT.

31. This project has been sanctioned by the Secretary of State and a detailed description of it is therefore not required. It consists of a storage tank on the Darna River, a pick-up weir and basin above Nandur Madhmeshwar on the Godaveri and R. B. and L. B. Canals.

Additional storage is available on the Aundh Nala.

Additional Storage on the Aundh Nala—Surveys.

32. The Aundh River is a tributary to the Darna from the north. Two dam sites were examined, the upper site near Kavnai and the lower near Mukne (see topo sheet, No. 193).

The Kavnai and Mukne Dam sites.

The foundations of the latter are less favourable than the former, but the rock level is very deep in either case. Two contours were run at R. Ls. 1897·54 and 1937·54 and from these the capacity of the tank was calculated.

The volumes from outlet at R. L. 1887·54 to top contour level at R. L. 1937·54 were found to be—

(*a*) *Lower site*—4,514 million cubic feet for a tank 67½ feet deep.

(*b*) *Upper site*—2,811 million cubic feet for a tank 51½ feet deep.

Details of the Project—Lower Dam Site.

F. S. L.

33. The river bed at the dam site is at R. L. 1869·91 above mean sea level. The proposed F. S. L is R. L. 1937·54.

Outlet level.

The proposed outlet level is at R. L. 1887·54. The volume below outlet level is 85·2 million cubic feet, leaving a net storage above outlet of 4,514 million cubic feet.

Net capacity.

The catchment area is 52 square miles.

Available supply.

The discharge of the river has been gauged for 4 years, and it yielded :—

Year.	Discharge, million cubic feet.	Run-off, inches.
1904	3,568	29·5
1905	3,424	28·3
1906	6,786 (standard) ...	56
1907	10,898 „ ...	90
1908	5,315 „ ...	43·98

So this tank is a suitable size, and might even be made somewhat larger.

Land and village submersion.

The land to be submerged at R.L. 1937·54 is 5,334 acres. It is good culturable soil, growing, as a rule, rice and other monsoon crops. No villages would be drowned as they are all on high ground.

Cost.

The dam will be rather expensive, say 1,000 rupees per million cubic feet, but it will not be constructed until the Godaveri Canal system runs very short of water; this is not likely to occur for very many years.

34. The water stored at Mukne could be let down the river, and would run into Godaveri basin above Nandur-Madhmeshwar.

Purpose of the Storage.

Rain and River Gauges.

35. The rain gauge at Kusegaon has only recently been put up (1907), under orders from the Government of India.

A river gauge was erected at Mukne in 1904.

The results of the observations are shown in the accompanying statement.

5.—THE DARNA RIGHT BANK PROJECT.

36. Complete surveys were made for this Project. A dam site was chosen on the Karwa River, a tributary from the south to the Darna River, because the waters of the Darna were already taken for the Godaveri Canals, and because the Karwa was a suitable stream, with its source near the Ghats, giving a storage with outlet level 67 feet higher than the Darna and thus allowing of a good command on the Right Bank.

Surveys.

37. Trial pits were taken at the dam site above Pimpalgaon Dokra giving favourable rock foundations, but the length of the dam and weir will be 4,770 feet for a storage above sill level of 3233·5 million cubic feet. The site chosen is the best in the valley for a dam.

Pimpalgaon Dokra Dam site.

Besides the usual cross sections at 1 mile apart up the valley, four contour lines were run at R.L. 1867, 1942, 1957, and 1965 allowing of a very accurate estimate of contents.

38. A canal line was first roughly surveyed for 86 miles, then more carefully aligned, but not finally examined, with a fall of 1 foot per mile for 68 miles. There were considerable difficulties to be overcome in the first 20 to 25 miles. After that the line was easy, but there are some very large nalas to be crossed after mile 43.

Canal line.

The canal line is below the Bundhara area in the Sinnar Taluka.

39. A separate report is attached giving details of this scheme. This shows that the original storage figure assumed, was too high, and that the catchment is less favourable than a real Ghat catchment. The 1904 discharge was incompletely gauged. 1905 and 1906 can be taken as about average years, so about 21 inches run-off or 3,250 million cubic feet may be counted on usually.

Details of the project.

The report starts on this basis and shows that the length of the canal will be under 50 miles for the required gross command of 53,000 acres. In this the proportions of crops and irrigable area are, of course, different from those originally adopted.

A very rough estimate gives the probable cost at 36⅓ lakhs rupees, including indirect charges. With a net revenue of rupees 95,400, the return is 2·6 per cent. The area to be commanded lies above the land under the Godaveri Project, and is liable to famine.

40. A river gauge was erected at the dam site in 1903 and gave some difficulty in observation, because of a rocky barrier downstream. But the gauging has been done satisfactorily since 1904.

Rain and River Gauges.

Rain gauge stations were put up at Takhed and Indore in 1907.

H. F. BEALE,
Superintending Engineer.

DARNA STORAGE.

Statement showing the yearly rainfall at Igatpuri.

Year.	Rainfall in inches.
1875	148
1876	115
1877	68
1878	161
1879	133
1880	124
1881	127
1882	162
1883	133
1884	154
1885	123
1886	131
1887	170
1888	157
1889	119
1890	146
1891	119
1892	137
1893	152
1894	161
1895	133
1896	163
1897	124
1898	140
1899	65
1900	156
1901	122
1902	113
1903	112
1904	96
1905	83
Average fall	= 130·55

Abstract Statement of Discharges of the River Unanda at Wajarkhed.

Months.	1903.	1904.	1905.	1906.	1907.	1908.
June	.....	.....	.....	64	6	.....
July	652	119	1,438	841	118	530
August	768	404	224	710	2,875	1,177
September	690	1,319	95	347	107	229
October	567	42	15	38	61	66
November	27	8	5	6	.....	7
December	5	3	4	4	.....	5
Total	2,709	1,895	1,781	2,010	3,167	2,014

Catchment area, 68 square miles.

Equivalent run-off in inches.	17·00	12·00	11·30	12·70	20·00	12·75

68×2·323=157·96 per inch run-off.

Note.—Black figures are Standard Discharges.

Comparative statement of the discharges of the river Kadwa at Karanjawan.

Months.	1902.	1903.	1904.	1905.	1906.	1907.	1908.
January	.....	25	12	.....	.....	.....	.....
February	.....	40	7	.....	.....	.....	.....
March	.....	8	2	.....	.....	.....	.....
June	.....	.....	13	.....	220	92	27
July	3,750	1,885	1,540	3,158	2,180	882	4,337
August	1,478	2,458	1,310	701	1,388	8,763	3,087
September	1,830	1,479	3,036	431	765	214	820
October	103	1,854	54	118	94	42	61
November	23	36	12	16	15	11	18
December	13	20	15	6	6	7	9
	7,197	7,805	6,001	4,430	4,668	10,011	8,359
Catchment Area 96 square miles.					96×2·323=223·00.		
Equivalent run-off in inches	32·3	35	26·9	19·9	20·93	44·9	37·48

Abstract of net discharges in million cubic feet at Palkhed (Nasik District) Catchment area, 338·00 square miles.

Year.	January. Million cubic feet.	February. Million cubic feet.	March. Million cubic feet.	April. Million cubic feet.	May. Million cubic feet.	June. Million cubic feet.	July. Million cubic feet.	August. Million cubic feet.	September. Million cubic feet.	October. Million cubic feet.	November. Million cubic feet.	December. Million cubic feet.	Total Discharges. Million cubic feet.	Run-off in inches.
1895	...	...	...	...	...	...	11	5,036	5,400	1,230	74	52	11,803	15·0
1896	41	36	30	43	40	7	24,786	9,008	1,323	205	81	54	35,644	45·4
1897	23	8	9	...	10	1,122	1,428	4,093	16,788	1,511	67	41	25,100	32·0
1898	34	21	6	...	...	173	11,688	9,033	4,083	207	73	47	25,865	33·0
1899	26	24	8	6	...	2,798	867	1,023	554	12	...	...	5,318	6·8
1900	15	...	...	1	...	1,306	1,360	26,857	8,946	1,098	58	64	39,705	50·6
1901	21	17	12	6	...	...	2,537	7,499	1,030	90	26	74	11,312	14·4
1902	8	...	...	...	6	...	5,735	3,357	4,547	307	32	13	14,005	17.8
1903	3	...	...	...	...	...	2,625	5,022	4,141	5,944	71	42	17,848	22.7
1904	10	...	5	...	...	...	2,802	2,625	3,164	688	38	93	9,425	12·0
1905	...	...	...	...	...	5	5,558	2,239	1,136	40	...	...	8,978	11·4
1906	...	...	...	...	...	365	4,523	4,477	2,224	85	...	6	11,691	14·9
1907	7	1	12	12	...	...	...	...	..	...	...	...	...	...

Abstract Statement of Discharges of the River Godaveri at Gangapur.

Months.	1905.	1906.	1907.	1908.	Remarks.
June	.....	54	14	27	
July	4,872	3,233	2,676	5,211	
August	981	1,386	11,567	4,138	
September ...	395	760	192	368	
October	36	58	85	73	
November	17	24	38	48	
December ...	12	16	18	28	
Total ...	6,313	5,531	14,590	9,893	
Catchment areas:—145 square miles.					
Equivalent run-off in inches ...	18·61	*16*	*43*	*29·37*	

146×2·323 = 339·16 per inch run-off.

Abstract Statement of Discharges of the River Aundha at Mukne.

Months.	1904.	1905.	1906.	1907.	1908.
June	52	3	**401**	61	.....
July	1,239	2,402	**3,813**	3,266	**2,492**
August	1,315	692	**1,765**	7,255	**2,319**
September	724	268	**754**	242	**436**
October	232	56	**51**	66	**59**
November	5	2	**2**	4	**4**
December	1	1	.....	3	**3**
Total ...	3,568	3,424	6,786	10,897	5,313
Catchment area, 52 square miles.	52×2·323 = 120·796 per inch run-off.—				
Equivalent run-off in inches ...	29″	28″	**56″**	**90.28″**	**43.98″**

Note.—Black figures are Standard Discharges.

Abstract Statement showing discharge of the River Karwa at Pimpalgaon for the Years 1904, 1905, 1906, and 1907.

Catchment area 67 square miles.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total discharge in million cubic feet	Run-off in inches.
1904						73	564	433	360	525	31	5	1,991	12·75
1905						...	2,572	562	110	23	4	3	3,274	21·04
1906						**137**	**1,359**	**1,129**	**554**	**24**	**7**	**4**	**3,214**	**20·65**
1907						**50**	**690**	**3,761**	**254**	**115**	**6**	**4**	**4,880**	**31·28**
1908						**25**	**2,346**	**1,973**	**498**	**75**	**23**	**2**	**4,945**	**31·77**

Note.—Black figures are Standard ones.

REPORT ON THE SURVEYS MADE ON THE KADVA RIVER AND ITS TRIBUTARY THE UNANDA RIVER.

A preliminary report on these surveys was submitted by Mr. Visvesvaraya, Superintending Engineer on Special Duty (Protective Works) with his No. C-152, of November 2nd, 1907.

Since this report the Canal contour on the left bank of the Kadva, has been surveyed upto 88 miles with a command of 233,845 acres. As mentioned in the report above referred to, 11,000 million cubic feet can be taken as the average discharge of the river at Palkhed.

Of this, 8,991·04 million cubic feet gross will be stored in the tank or 7,474·45 million cubic feet net, and the remaining 2,008·96 million cubic feet will be drawn off during the monsoon discharge of the river giving a total of 9,483·41 million cubic feet available for irrigation. This volume will irrigate on the Productive System (at 207·4 million cubic feet per 1,000 acres irrigated).

cubic feet acres.

$$\frac{9,483.41}{207.4} \times 1,000 = 45,720 \text{ Irrigable,}$$

or $45,720 \times 3 = 1,37,160$ culturable,

or $137,160 \times \frac{10}{8} = 1,71,450$ gross.

This area will be commanded by 72 miles contour length. This distance will probably be reduced to $72 \times \frac{4}{5} = 58$ miles by canal alignment.

The discharge of the canal at the head will be 458 cusecs.

In order to obtain a figure for a rough estimate of the cost of the canal a comparison with another canal line which has been fully estimated is required. The Ghod Right Bank Canal with a discharge of 352 to 118 cusecs was estimated to cost Rs. 39,000 per mile, including distribution of water.

The country through which the Kadwa Left Bank Canal will run is much easier than that traversed by the Ghod Canal. The distributary lengths for this canal will, however, be greater, and the new Type Masonry Works will also cost more than those used for the Ghod.

Taking these points into consideration, a fair rate for the canal will be Rs. 45,000 per mile, including distribution.

The cost of the dam as given in the preliminary report before referred to was Rs. 1,11,17,958 without land and village compensation. For this item Rs. 15,00,000 may be added.

Rough estimate of cost of Kadva Left Bank Canal Project.

I.—Works—		Rs.	
(1) Head works		...1,26,17,958	
(2) Canal (3) Distributaries, etc. } ...	miles Rs. ...58 × 45,000 =	26,10,000	Rs.
			1,52,27,958
(2) Establishment @ 23 per cent. on Works			35,02,417
(3) Tools and Plant @ 1½ per cent. on Works... ...			2,28,419
Total Direct Charges... ...			1,89,58,794
Leave and Pension Allowances @ 14 per cent. on Establishment		4,90,336	
Abatement of Land Revenue @ 1 per cent. on Works		1,52,279	
Total Indirect Charges...			6,42,615
Total Direct and Indirect Charges...			1,96,01,409

The probable final net revenue for this project will be—

acres 45,720 × Rs. 6·75 = Rs. 3,08,610.

This is equivalent to a percentage of 1·57 on the estimated expenditure.

The unfavourable result of this project as a productive work is due to the cost of the storage works.

None of the dam sites investigated are satisfactory, though the canal is favourable and would have a great protective value. However, as every other project reported on shows a better result, it is unlikely that this project will ever be required.

P. L. BOWERS, A.M. I.C.E.,
Assistant Engineer.

REPORT ON THE KADWA PROJECT
with dam at Palkhed.

History.

1. In 1898, Mr. Strange (then Executive Engineer, Nasik) recommended that, an Upper Kadwa Canal should start from the proposed Karanjawan Tank (on the Kadwa River) which might be supplemented from the proposed Unanda Tank (at Wajarkhed) to the north of it, and Mr. Strange judged that it would be able to run above the proposed

Odal and Pimpled Tanks, and tail into the Khirdi Sathe Tank, north of Yeola, and thus command the whole area of land down to the Godaveri River. It was afterwards proved, however, that a canal cannot be run as proposed, as with a fall of 1 foot a mile from Karanjawan, the canal would cross the Odal Nalla 40 feet below the Odal Tank outlet, and the Naradi Nalla 10 feet below the outlet of the Khirdi Sathe Tank.

Surveys for the Karanjawan and Wajarkhed Tanks were carried out by Mr. Hansoti, Executive Engineer on Special Duty, in 1902, 1903 and 1904 in connection with the Godaveri Project, the proposal being that these tanks should supply water to the Godaveri Right and Left Bank Canals, starting from Nandur-Madhmeshwar.

The sites were finally abandoned as being too expensive, it being estimated that 6,886 million cubic feet at Karanjawan would cost from Rs. 1,000 to Rs. 1,200 per million to store, and that 3,746 million cubic feet at Wajarkhed would cost about the same amount.

In 1906, surveys were started below the junction of the Kadva and Unanda Rivers to discover a tank site, from which a Left Bank Canal could be taken off; this would have a much greater command in the Yeola Taluka than at the present proposed Godaveri Left Bank Canal. A site was discovered a little below the present Palkhed pick-up weir, and the object of this report is to show the principal features and discuss the possibility of this project.

Position.

2. The dam line is situated on the Kadva River about 5 miles E. S. E. of Dindori, and 1½ miles below the present Palkhed Weir.

The site is not a very favourable one as the ground on both sides of the river is very flat, causing the dam to be of great length. The foundations on the left bank are bad, and the dam will be a very expensive one.

The basin above the dam is a good one, and will give a large spread of deep water. The land submerged is fertile, and lies wholly in British Territory. Only four village sites will be totally submerged, *viz.*, Palkhed, Jopal, Rajapur and Pimpalgaon; and two partially, Parmori and Aondkhair. The present Palkhed Weir and about 2 miles of the Palkhed Canal will also be submerged.

Water available.

3. The discharge over the weir at Palkhed has been taken since 1895, and varies between 5,318 million cubic feet in 1899 and 39,705 million cubic feet in 1900.

From examination of the Table of Discharge, a safe figure to take for the amount available for irrigation appears to be 11,000 million cubic feet.

Abstract of Discharges in million cubic feet at Palkhed Weir.

Year.	June.	July.	August.	September.	October.	Rest of year.	Total.	Run-off catchment area, 338 square miles.
1895 ...	.....	11	5,036	5,400	1,230	126	11,803	15·0
1896 ...	7	24,786	9,008	1,323	205	325	35,654	45·4
1897 ...	1,122	1,428	4,093	16,788	1,511	158	25,100	32·0
1898 ...	173	11,688	9,033	4,083	707	181	25,865	33·0
1899 ...	2,798	867	1,023	554	12	64	5,318	6·8
1900 ...	1,306	1,360	26,857	8,946	1,098	138	39,705	50·6
1901 ...	.....	2,537	7,499	1,030	90	156	11,312	14·4
1902 ...	.....	5,735	3,357	4,547	307	59	14,005	17·8
1903 ...	.....	2,625	5,022	4,141	5,944	116	17,848	22·7
1904 ...	.....	2,802	2,625	3,161	688	146	9,422	12·0
1905 ...	5	5,558	2,239	1,136	40	.....	8,978	11·4
1906 ...	365	4,523	4,477	2,224	85	17	11,691	14·9

It will not, however, be necessary to store the whole 11,000 million cubic feet, as the examination of the monthly discharge during the monsoon will show that the river can be depended on to give the required discharge during 3 months in the monsoon season.

Area which can be irrigated by 11,000 million cubic feet and required storage.

4. Under the Productive System of irrigation, 4·5 acres can be irrigated per million cubic feet.

	Acres.
The irrigable area will therefore be	49,500
The culturable area @ 3 times the irrigable will be ...	148,500
And the gross area @ $\frac{5}{4}$ths the culturable area will be ...	185,625

For the 3 monsoon months, for which the river is to be relied on to provide, the discharge will be—

Crop.	Percentage.	Area.	Duty.	Discharge.
Perennial	25 per cent.	12,375	60	206
8 months	25 „	12,375	120	103
Monsoon	25 „	12,375	120	103
				412 cusecs.

This equals 1,068 million cubic feet for 1 month, or 3,204 million cubic feet for 3 months. The net amount required to be stored will be 11,000 - 3,104=7,896 million cubic feet, or allowing for evaporation and loss, say 9,000 million cubic feet.

Height of Dam required.

River Bed Level, 1862·00.

R. L.	Area, million square feet.	Volume, million cubic feet.	Volume above Sill Level, million cubic feet.	Remarks.
1,902	6·03	80·51	.....	Sill Level.
1,922	34·59	447·75	367·24	
1,942	114·23	1,859·01	1,778·50	
1,962	245·26	5,371·00	5,290·49	
1,975	**313·10**	**8,991·04**	**8,910·53**	**F. S. L.**
1,977	**324·28**	**9,628·40**	**9 547·89**	
1,982	425·34	11,994·38	11,913·87	

Roman figures show surveyed areas and volumes,
Black figures show calculated areas and volumes.

5.—General Features of the Dam.

Catchment area square miles	338 square miles.
Average rainfall at Charosa (4 years) ... ... inches	50·51
Worst year's rainfall at Charosa ... ... „	45·53
Run-off assumed average year ... ... „	14·4
Run-off assumed worst year ... ... „	6·8
Run-off required to fill the tank to F. S. L.	11·4 or to give total required for irrigation 14·1.
Fall in river-bed above dam site ... ... feet per mile	10·88
Length of structure of dam proper ... ... feet	15,886
Ditto of Waste Weir ... ... „	1,639
Maximum depth of water above river-bed, R.L. 1862. feet.	113

5.—General Features of the Dam.—*contd.*

Depth from F. S. L. R. L. 1975 to sill of outlet R.L. 1902. feet	73
Ditto ditto to sill of undersluices R.L. 1881 „	94
Width of dam at top ... ... „	12· 5
Width of weir crest ... ... „	19
Construction of dam and weir	Coursed rubble masonry face work, with concrete hearting. When pressure exceeds 60 lbs. per square inch, uncoursed rubble masonry hearting. Weir to contain cisterns for counterweights and have piers on the crest. Roadway over the whole.
H. F. L. and F. S. L., R. L. 1975	.....
Height of parapet of dam above H. F. L. ... ... feet	4·25
Top of roadway between parapets above H. F. L. „	0·75
Height of masonry on weir over weir crest ... „	14·5
Length of weir between abutments ... ... „	1,629
Estimated maximum flood discharge, inches per hour ...	0·40
Ditto ditto in cusecs	87,249
Calculated discharge over weir ... ... cusecs	87,373
Description of weir	125 gates 8′×10′
Outlet sluices sill	R. L. 1902
Under sluices sill	R. L. 1881
Area of tank at F. S. L., R. L. 1975 in million square feet ...	313·10
Ditto ditto at outlet R. L. 1902 ditto ...	6·03
Total gross capacity of tank million cubic feet	8991·04
Capacity over sill of outlet, million cubic feet	8910·53
Depth allowed for evaporation and absorbtion on mean of F. S. L. and outlet areas ... ... feet	4·5
Loss ... ... million cubic „	1436·08
Net available for discharge through sluices ... ... „ „ „	7474·45
Cost of dam complete...	Rs. 1,11,17,958
Village compensation	Not yet determined.
Land compensation	Ditto.

Canal.

The contour from this with a fall of 1 foot per mile, has been run for 35 miles and has a command in this length of 57,971 acres, or a little over ¼ the total gross area required.

The country through which it has run so far is favourable for canal construction.

After passing the ridge near Vinchur, the line will turn north-east, and will gain command rapidly. The ground here is not so favourable, as several large nallas will have to be crossed.

The country through which the canal will pass is very liable to scarcity, and the value of a canal as a protective work will be great.

Materials.

Rock of good quality is found in the river-bed, at and above the dam site.

Field Lime is plentiful.

Wood is scarce.

Sand is plentiful but is much mixed with mud.

Alternative.

As an alternative to this scheme, a dam might be constructed at Karanjawan on the most favourable of the sites investigated there, and the water let down to the present Palkhed Weir from which the canal would start. The same amount of water could not be obtained, and it would be necessary to restrict Productive Irrigation to the first 40 miles or so of the canal, and open the lower reaches as a Protective Canal only. This alternative would probably not pay so well, but it would be a valuable protective work.

P. L. BOWERS, A.M.I.C.E.,

Assistant Engineer.

Kadwa Storage at Palkhed Dam.

Figures for Estimate F. S. L. 1975·00.

Chainage, feet.	Height of dam from 7·5 feet below rock.	Area of dam founded 7·5 feet below rock, square feet.	Mean area, square feet.	Corresponding height in feet.	Corresponding bed-width.	Depth of foundations.	Nature of excavation. H. R=Hard Rock. S. R=Soft Rock. M=Acreage Murum. S=Soil.	Remarks.
9,485	20	270	451·5	29	21	22· 5	1 Soil, 7 M., 7·0 R., 7·5 H. R.	
8,598	37· 5	633						
7,485	·66	1,565	1099	54	33	24·50	1·5 Soil, 6·5 M., 9 S. R., 7·5 H. R.	
4,970	·78	2,100	1832·5	872	44· 5	28·00	8 Soil, 5·5 M., 7 S. R., 7·5 H.R.	
3,085	104	3,638	2869	92	59	38·00	19 Soil, 5 M., 6·5 S. R., 7·5 H. R.	
2,685	124	5,177	4407·5	114	76· 5	60·50	39 Soil, 4 M., 10 S. R., 7·5 H. R.	
1,580	109	3,999	4588	117	78	39·50	27 Soil, 5 S. R., 7·5 H. R.	
1,060	132	5,895	4947	121	80· 5	38·50	25·5 Soil, 5·5 S. R., 7·5 H. R.	
610	112	4,222	5058	123	82	52·00	38·5 Soil, 6 S. R., 7·5 H. R.	
0	121	4,993	4572·5	117	78	21·00	13 Soil, 0·5 S. R., 7·5 H. R.	
940	110	4,072	4497·5	116	77	23·50	1·5 Soil, 3·5 M. 11 S. R., 7·5 H. R.	
2,540	71	1,780	2926	93	59· 5	35·00	3 Soil, 7·5 M. 17 S. R. 7·5 H. R.	
5,040	49	954	1367	61	35· 5	25·00	3 Soil, 4·5 M., 10 S. R., 7·5 H.R.	
5,853	40	690	822	45	29	20	3 Soil, 5 S. M., 4·5 S. R, 7·5 H. R.	

Kadwa Storage at Palkhed Weir.

Figures for Estimate up to Crest level of weir, F. S. L. 1975·00

Chainage feet.	Height of weir from 10 feet below rock.	Area of weir founded 10 feet below rock, square feet.	Mean area, square feet.	Corresponding height, in feet.	Corresponding bed-width.	Nature of excavation.	Remarks.
5,853	34·5	830	634	28	27	1 Soil, 6 M. 8 S. R., 10 H. R.	
7,492	20	438					

Darna Right Bank Canal Project.

Report.

It is proposed to construct a dam at Pimpalgaon Dokra on the Karwa River, a tributary of the Darna River, to impound water for a Right Bank Canal, taking off direct from the tank. Surveys have been made for a dam and for a canal 68 miles long, to command 82,138 acres. This was done on the assumption that the crops would have definite proportions which have since been rejected for the old form of quadrennial rotation adopted in General Fife's time.

Water-supply available.

2. The catchment area of the Karwa River is 67 square miles and the yearly discharge, for the period the river has been gauged, is as follows :—

Year.	Discharge, million cubic feet.	Run-off, inches.
1904	1,991	12·75
1905	3,274	21·04
1906	3,214, Standard.	20·65
1907	4,880 „	31·28
1908	4,945 „	31·77

From these figures it will be seen that not more than 3,250 million cubic feet can be relied on from the catchment.

From Statement B attached, it is seen that a dam with F. S. L. 99·19 feet above river bed or 69 feet above sill level of the canal will be required to store 3,275 million cubic feet. The losses by evaporation, etc., are shown to be 245 million cubic feet, leaving 2,915 million cubic feet available for irrigation purposes.

Area commanded.

3. Assuming that the productive system of irrigation will be adopted, 207·4 million cubic feet will irrigate 1,000 acres. The irrigable command will therefore be :—

$\frac{2915}{207·4} \times 1{,}000 = 14{,}130$ acres irrigable command or $3 \times 14{,}130 =$ 42,390 acres culturable command or $42{,}390 \times 10/8 = 52{,}990$ acres gross command.

This area will be commanded by a canal 47½ miles long. The discharge required at the head of the canal will be 141 cusecs, and the section at the head will be :—

Bed width	18 feet.
Depth	3·5 „
Fall per mile	1·5 „

The original survey was made on the assumption that the river had a bigger discharge, and that a larger area would be commanded, and hence the bed-fall given was one foot per mile.

If this canal is constructed it will be necessary to make a completely new alignment starting with a bed-fall of 1½ feet per mile.

Tank site.

4. The site selected for the dam is a fair one, the rock level being nowhere at any great depth below the ground level.

The total length of the dam and waste weir up to the F. S. L. proposed, *viz.*, R. L. 1946, is 4,770 feet of which 483 feet is waste weir (see Statement A). There is a good site for the waste weir in the saddle on the right bank.

Numerous trial pits have been taken and their result is favourable.

The bed-fall of the river in the proposed tank is 16 feet per mile.

The catchment area is 67 miles and a run-off of 21 inches is required to fill the tank.

The results of rain-gauging at two stations in the catchment area, fixed before the monsoon of 1907, are attached.

The land to be submerged is of good quality.

One village site will be submerged, namely, Bharvihir B.

The usual building materials are found in the vicinity, though lime will have to be obtained from quarries.

The construction of the Nandgaon Dam on the Darna will probably have some effect on the rates as it is only 6 miles away, and the work will have taken a large quantity of wood and lime which otherwise would have been available for this project.

Canal.

5. The country through which the canal passes is not difficult, though the Nala and Hill Torrent Works in the first 12 miles may give some trouble, on account of the depth of the Nala beds below ground level.

Note for the preparation of the estimate of the cost of the project.

6. No canals having such a small discharge as this have been estimated by the Special Duty Division.

The Nira Right Bank Canal, mile 320—382, discharging from 300 to 113 cusecs, was estimated to cost Rs. 35,000.

A fair sum for this project whose maximum discharge at head is 141 cusecs seems to be about Rs. 15,000 a mile. The distribution of water may be taken as costing ⅕th of this sum per canal mile, Rs. 3,000.

The dam which is high in comparison with the volume stored may be taken as costing Rs. 600 per million cubic feet stored.

Time.

7. The time required for the construction of the project will probably be about 4 years.

8. Rough estimate of direct and indirect charges :—

		Rs.
I.—Works—		
(1) Headworks, 3,275 × 600	=	19,65,000
(2) Canal, 47½ × 15,000	=	7,12,500
(3) Distributaries, 47½ × 3,000	=	1,42,500
		28,20,000
II.—Establishment—		
Say 23 per cent. on Works		6,48,600
III.—Tools and Plant—		
At 1½ per cent. on Works		42,300
Direct Charges...		35,10,900
Leave and Pension Allowances—		
14 per cent. on Establishment.		90,804
Capitalised abatement of Land Revenue—		
Say 2 per cent. on Works		56,400
Indirect Charges...		1,47,204
Total Direct and Indirect Charges...		36,58,104

Probable final net revenue

9. Taking 6·75 as the net revenue per acre irrigated, the total net revenue amounts to 14,130 × 6·75 = Rs. 95,377, which is equivalent to 2·6 per cent. on the estimated expenditure.

H. F. BEALE,
Superintending Engineer.

A.—DARNA RIGHT BANK CANAL PROJECT, KARWA STORAGE, WASTE WEIR CALCULATIONS.

Catchment area ... = 67 square miles.

Run-off ... ... = 1 inch per mile, or 43,235 cusecs.

The formula adopted for calculating the discharge with clear over fall, through the waste weir sluices when the automatic gates are fully open is:—

$$Q = \frac{2}{3} c \sqrt{2g} B H^{\frac{3}{2}}$$

with c = 0·577.

Width of opening ... ... B = 10 feet.

Depth of water ... ... H = 12 feet.

$$Q = \frac{2}{3} \times 0{\cdot}577 \times 8{\cdot}02 \times 10 \times 12^{\frac{3}{2}} = 1{,}289{\cdot}4.$$

Number of openings required: $\frac{43{,}235}{1{,}289{\cdot}4} = 34.$

Discharging capacity = 43,839 cusecs.

Length of weir—

34 openings × 10	=	340 feet.
33 Piers × 4	=	132 „
2 Abutments 5·5 × 2		11 „
		483 feet.

B.—Darna Right Bank Canal Project.

Statement showing areas and volumes of the tank on the Karwa at Pimpalgaon Dokra.

R. L. of Contour.	Height above river bed, feet.	Area of contour, million sq. feet.	Area of contour, acres.	Volume between contours, million cubic feet.	Total volumes, million cubic feet.	Volume above outlet level, million cubic feet.	Remarks.
1,836·81	...	.....	.....	.....	.....	.....	Bed Level.
1,867·0	30·19	4·160	95	41·85	41·85	.....	
1,877	**40·19**	**11·00**	252	**73**	**114·85**	.....	**Sill Level.**
1,942	105·19	91·04	2,090	2,783	2897·85	2,785	
1,946	**109·19**	**97·8**	2,245	**377·5**	**3,275·35**	**3,160·5**	**Proposed F. S. L.**
1,957	120	119·04	2,733	1,203·67	4,479·02	4,364·17	
1,965	128	135·23	3,105	1,016·35	5,495·37	5,380·52	

Note.—Surveyed figures in Roman types. Calculated in Black type.

Loss by evaporation 5 feet on mean area = $\frac{11+97{\cdot}8}{2} \times 4{\cdot}5 = 245$ million cubic feet.

Net storage available for irrigation purposes = 3,160·5 − 245 = 2,915 million cubic feet.

REPORT ON MULA VALLEY SURVEYS.

CONTENTS.

		Pages.
1.	Report on Mula Valley Surveys	116 to 123
2.	Rain and River Gauge Statements	124 to 126
3.	Recapitulation of estimates and estimate of direct and indirect charges.	127 & 128

INDEX TO

The Mula Valley Survey Report.

Para.	Subject.
1	Position.
2	History.
	Scope of the Special Duty Surveys.
3	Preliminary investigations.
4	First project.
5	Further investigations ordered by the Chief Engineer for Irrigation.
6	Second project.
7	Second project condemned by the Chief Engineer for Irrigation.
8	Further surveys.
9	Third project.
10	Third project returned by the Chief Engineer for Irrigation.
	Storage Works Surveys.
11	The Digras site.
12	The Chas site.
13	The Kotul site.
14	The Mandvi site.
15	The Tas site
	Canal Headworks Surveys.
16	The Nandur sites.
17	The Tas site.
	Canal Surveys.
18	Preliminary contour.
19	First project canal line.
20	Second project canal line.
21	Third project canal line.
22	Final alignment.
	Details of the Final Project.
23	The Chas Tank—Maximum flood discharge—Details of the storage work—Cost.
24	Mandvi Tank—Details of the storage work—Cost.
25	Tas Pick-up Weir—Details of weir.
26	Details of canal.
27	Storage required.
28	Purpose of the storage and canal.
29	Financial prospects.
30	Net Revenue.
31	Rain and River Gauges,

MULA VALLEY SURVEYS.

List of Drawings and Tracings accompanying the Report.

Note:—The office in which these plans are recorded is named in the list at page 63, following the Chief Engineer's Review.

No. of Drawings.	Title.	No. of Sheets.	Scale.
1	Index map showing storages and canal	1	4 miles=1".
2/1 to 2/4	Do. do. classification of soil under Mula Right Bank Canal.	4	1 mile=1".
3	Plan and longitudinal section of Chas Dam line.	1	H-200' V-20' =1"
4/1 to 4/10	Contour plans of Chas storage	10	200'=1"
5/1 to 5/2	Plan and longitudinal section of Mandvi Dam...	2	H-200' V-20' =1"
6	Detailed sections of trial pits	1	4'=1"
7	General plan of Mandvi dam site	1	400'=1"
8/1 to 8/5	Contour plans of Mandvi storage	5	400'=1"
9/1 to 9/2	Cross sections of Mula storage at Mandvi ...	2	H-400' V-20' =1"
10	Plan and longitudinal section of pick-up weir at Tas.	1	H-50' V-20' =1"
11/1 to 11/2.	Plan and longitudinal section of Headworks at Tas.	2	8'=1"
12/1 to 12/2	Contour plans of Tas Weir	2	50'=1"
13/1 to 13/9	Plan and longitudinal section of Mula Left Bank Canal.	9	H-400' V-20' =1"
14/1 to 14/2	Plan and longitudinal section and details of syphon under Mula River.	2	H-100' V-10' =1"
15/1 to 15/25	Plan and longitudinal section of Mula Right Bank Canal from mile 15 to mile 58 1304 feet.	25	H-400' V-20' =1"

TOPO SHEETS.

Topo sheets Nos. 195, 229, 261, 290, 291.

REPORT ON THE MULA VALLEY SURVEYS.

Position.

1. The Mula River is the most southern Ghat-fed tributary of the Godaveri. It has its source on the Western Ghats near Harischandragad and joins the Godaveri at Pravara Sangam, after being joined by the Pravara River at Manipur, It is situated entirely in the Ahmednagar District. About 171 square miles of its catchment area may be regarded as Ghat catchment from which the run-off is very heavy.

History.

2. In 1862 the river was carefully examined from Nandur to Mandvi, and several dam sites were selected, but these did not turn out satisfactory. In 1866 and 1877 further surveys were made, but without any definite result. The discharge of the river was gauged from 1882 to 1892, and Mr. Whiting reported on a scheme in 1899, which was not adopted. In 1901 the Executive Engineer of Ahmednagar commenced a survey of the valley for a storage site and a Right Bank Canal under the direction of the Superintending Engineer on Special Duty.

Scope of the Special Duty Surveys.

Preliminary investigations.

3. In 1901 and 1902 the Mula Valley was carefully examined, and a site for a storage tank was selected at Digras (3 miles above Rahuri), but afterwards rejected in favour of the Chas site. See topo sheets Nos. 229 and 261.

A preliminary canal contour was also run from Nandur (5 miles above Rahuri) on the right bank of the river to show the command. After further surveys and correspondence on the subject, a project was prepared and submitted to Government in February 1905.

First project.

4. The features of this project were :—

(i) A storage tank at Chas with a capacity at 138·5 feet above the river bed of 7,161 million cubic feet, of which 6,760 million cubic feet were available for irrigation purposes.

(ii) A pick-up weir at Nandur with a crest 36 feet above the river bed from which

(iii) A Right Bank Canal, 109 miles long, took off.

The area commanded was 307,200 acres, of which 61,440 acres were to be irrigated.

The estimated cost was 89·45 lakhs of rupees, and the ultimate net revenue showed a return of 2·35 per cent. This would be increased to 3·60 per cent. on what is called the productive system of irrigation.

Further investigations ordered by the Chief Engineer for Irrigation.

5. This project, which is now deposited in the office of the Executive Engineer, Nasik and Nagar Irrigation, for reference, was returned by Mr. Cameron, then Chief Engineer for Irrigation, for further investigation, as he considered a larger storage tank was necessary.

Second project.

6. Further surveys were made for this purpose, and in December 1905, the Superintending Engineer on Special Duty submitted a second report, the main features of which were :—

(*i*) A storage tank at Chas with a capacity, at 154 feet above the river bed, of 10,905 million cubic feet.

(*ii*) A tank at Kotul to store 4,400 million cubic feet, and

(*iii*) An earthen dam 95 feet high at the Canal Headworks at Nandur to store 9,584 million cubic feet above the river bed, or 5,857 above the canal sluices.

The Right Bank Canal starting level was raised 34 feet, and the gross command increased to 403,000 acres, of which 107,520 acres were to be irrigated.

The estimated cost of this project was 170 lakhs of rupees, and the net revenue 4 lakhs of rupees, or 2·3 per cent. on the capital expenditure. This would be increased to 4·26 per cent. on the productive system.

Second project condemned by the Chief Engineer for Irrigation.

7. This project, which is now deposited with the Executive Engineer, Nasik and Nagar Irrigation, was condemned by Mr. Hill, Chief Engineer for Irrigation, who considered that the loss of water in the lower tank would be excessive, both because of its foundation not being in rock, and because of the considerable area and depth of the tank at outlet level. He also did not approve of the increased command, and directed that further surveys for the canal headworks should be made, and personally inspected the valley.

8. During 1906, further surveys were carried out in the Mula Valley. The Nandur Site for the canal headworks was abandoned, and a new site selected at Tas, 15 miles further upstream. A fresh site for the second storage work was investigated at Mandvi, which proved more satisfactory than the one at Kotul.

Further surveys.

A canal line was surveyed for 15 miles from Tas in very difficult ground on the left bank of the river, crossing by a syphon on to the right bank at Banjarwadi, and joining the original Right Bank Canal line. This was done to avoid the still more difficult sidelong rugged ground, intersected by wide deep valleys on the right bank of the river between Tas and Banjarwadi. The last nalla to be crossed on the right bank would have been the Kapri, which is a very large one.

9. In May 1907, a third project was submitted to Government, the main features of which were :—

Third project.

(*i*) A Storage Tank at Chas, capacity 10,728 million cubic feet with F. S. L. 154 feet above the river bed.

(*ii*) A Storage Tank at Mandvi with a capacity, at 113·5 feet above the river bed, of 7,131 million cubic feet.

(*iii*) A pick-up weir at Tas, with its crest 33 feet above the river bed.

(*iv*) A left bank canal, discharging 610 cusecs at head, from Tas to Banjarwadi, 15 miles.

(*v*) A syphon across the river at Banjarwadi, and

(*vi*) A right bank canal, 30 miles long.

This last was not completely surveyed, and the estimate for it was rough. The gross command was 228,750 acres, of which 66,000 acres were taken as being irrigable.

The cost of this project was worked out to be Rs. 1,45,33,868 and the net revenue to Rs. 4,45,500 or 3 per cent. on the total expenditure, on the productive system of irrigation.

10. In June 1907, this project was returned by Mr. Hill, Chief Engineer for Irrigation, who directed that the canal line on the right bank should be completely surveyed, and that further investigations of the Tas pick-up weir site should be made to determine whether it would be possible to substitute a storage at this site for the one at Mandvi.

Third project returned by the Chief Engineer for Irrigation.

These new surveys were carried out, and are embodied in the new or fourth project described in this report.

Storage Works Surveys.

11. Previous to the selection of the storage site at Chas, a site was surveyed at Digras, a village between Rahuri and Nadur, see topographical sheet No. 261.

The Digras site.

Five trial pits were dug, but the foundations proved unsatisfactory ; the dam would have been a long one, and the waste weir arrangements were bad.

12. The Chas site was then surveyed and contours were run up the valley at R. Ls. 2111, 2141, 2171, 2201 and 2226, from which the capacity of the tank was worked out. The foundations proved to be very favourable, the rock, which is sound Trap, being found close to the surface throughout the line. The site for a waste weir is a good one.

The Chas site.

13. When it was found that a greater storage was required, a site was surveyed at Kotul, 10 miles above Chas. Trial pits do not appear to have been taken, but an F. S. L. contour at R. L. 2361 was surveyed for this site, which was included in the second project. See paragraph 6 above.

The Kotul site

14. For the third project a new site was selected at Mandvi, about 30 miles below Chas, where, as the catchment area is much larger, an assured supply for the storage tank is more certain.

The Mandvi site.

Contours were taken at R.Ls. 1881, 1961, and 1951, from which the capacity of the tank was worked out. The foundations as proved by the trial pits taken are very satisfactory.

15. In returning the third project, the Chief Engineer directed that surveys should be made to determine whether it is possible to make a storage tank at Tas, to replace the Mandvi Storage, and Tas Pick-up Weir. The Executive Engineer, Ahmednagar, reports that a cross section of the valley for a dam site, and 3 or 4 cross sections further upstream were taken, and two trial pits were dug on the proposed waste weir site. The drawings of these sections have been lost, but the field books have been sent for, and new drawings will be made which will be forwarded later. It is not anticipated that this will prove to be a cheaper work than the Mandvi storage and the Tas Pick-up Weir combined, but if it does, it will have to be considered when the question of constructing this project is opened.

The Tas site.

Canal Headworks Surveys.

16. Altogether four sites were investigated at or near Nandur, the neighbourhood of this village being indicated as the most natural position for a Pick-up Weir, as just below Nandur the valley opens out considerably, and a canal starting from the headworks there, would run through comparatively easy country from the start.

The Nandur sites.

After investigating these sites, the upper site, just below the junction of the Kapri Nala with the Mula River, was selected for the Pick-up Weir site for the first project, and for the earthen dam for the second project.

Trial pits showed that the rock was to be found 45 to 50 feet below the river bed.

Contours were taken in the valley and from these the capacity of the tank above the weir was calculated.

17. In returning the second project the Chief Engineer for Irrigation condemned the above site, and a new site was selected at Tas, some 15 miles further upstream.

The Tas site.

The foundations at this site are excellent, rock being exposed in the river bed and on the banks ; in fact, the one serious drawback is that the canal will have to be dug in very difficult country for the first 15 miles.

13 cross sections 100 feet apart were taken at the weir site, and from these contours at every 5 feet in the immediate neighbourhood of the weir were drawn.

Canal Surveys.

18. A short preliminary contour was run from the Digras site, see paragraph 11 above, but this was not marked on the village maps, and was only shown roughly on the Topo Sheets.

Preliminary contour.

19. For the first project a line was surveyed from Nandur, with bed level at R. L. 1714. The length of this line was 109 miles, and the command obtained was 307,200 acres.

First project canal line.

20. It was proposed to increase the command for the second project, and a few cross sections were taken which showed that a canal, starting from the Nandur Headworks at R. L. 1750, would command 403,200 acres.

Second project canal line.

21. The change of the proposed Headworks to Tas necessitated the survey of a new canal line from Tas to join the old line from Nandur, and it was found better to run the line on the left bank of the river for the first 15 miles, and to cross the river by syphon near Banjarwadi. This portion of the line was fully surveyed, but the surveys for the continuation of the line on the right bank were only rough.

Third project canal line.

The command of this line was given as 250,000 acres, and the total length of the canal, including the syphon, as 46 miles.

22. As noted in paragraph 10 above, the third project was returned by the Chief Engineer for Irrigation in order that the surveys for the alignment of the canal on the right bank should be carried out.

Final alignment.

This has now been done, and the total length of the canal, including the syphon, is 58¼ miles, of which 42¾ miles, are on the right bank of the river.

The command now obtained is 271,501 acres for the above length.

If more water was available, an increased command could easily be obtained by extending the canal through the ridge at Dedgaon.

Details of the Final Project.

23 Catchment area 171 square miles. River Gauge at Rahuri; catchment area 900 square miles.

The Chas Tank.

Year.	Discharge million cft.	Run-off.
1902	31,619	15·1
1903	37,936	18·1
1904	31,544	15·00
1905	19,919 (Standard)	9·53
1906	32,290 „	15·44
1907	36,879 „	17·64
1908	44,090 „	21·09

The maximum flood discharge is taken at 0·6 inch per hour or 52,632 cusecs at Chas.

Maximum flood discharge.

Details of the storage work.

H. F. L. and F. S. L. ...R. L. 2226 above M. S.L.
Outlet level ... ... R. L. 2111 „
Bed of river ... ... R. L. 2072 „

Depth of water in tank	154	feet.
Depth of water above outlet level	115	,,
Total capacity of tank	10728	mil. C.ft.
Capacity above outlet	10658	,,
Deduct loss by evaporation, etc.	611	,,
Net storage available	10047	,,
Calculated discharge over waste weir	53086	cusecs.
Depth of water over weir crest	8	feet.
Area submerged	4434	acres.
Number of villages submerged	4	

Cost.

Cost of dam and waste weir	Rs.	42,16,397
Land and village compensation	,,	2,08,655
TOTAL	,,	44,25,052
Cost of water stored above sill per million C.ft.	Rs.	415

Mandvi Tank.

24. Catchment area 532 square miles, including 171 square miles above Chas Tank. The maximum flood discharge is taken as 0·6 inch on 171 square miles and 0·45 inch on 361 square miles or 171,042 cusecs altogether.

Details of the storage work.

H. F. L	R. L. 1956	above M. S. L.
F. S. L	R. L. 1951	,,
Outlet level	R. L. 1860	,,
River bed level	R. L. 1837·5	,,
Depth of water in tank	113·5	feet.
Depth of water above outlet	91	feet.
Total capacity of the tank	7131	mil. C.ft.
Capacity over outlet	7098	,,
Deduct loss by evaporation, etc.	628	,,
Net supply available	6,470	,,
Calculated discharge over waste weir	171,042	cusecs.
Depth of water over weir crest	5	feet.
Area submerged	6401	acres.
Number of villages submerged	3	

Cost.

Cost of dam and waste weir	Rs.	26,77,974
Land and village compensation	,,	1,57,773
Total	,,	28,35,747
Cost of water stored per million C. ft.	,,	399·5

Tas pick-up weir.

25. Catchment area 592 square miles. The maximum flood discharge is taken at 171,042 cusecs.

Details of weir.

Length of weir	810	feet.
Depth of water over weir to discharge maximum flood	15	,,
H. F. L.	R. L. 1803	above M. S. L.
Level of crest of weir	R. L. 1788	,,
River bed level	R. L. 1755	,,
Outlet level of canal	R. L. 1780	,,
Depth of water against weir	33	feet.
Depth of water above canal outlet level	8	,,
Depth of water above F. S. L. of canal	7	,,

Area submerged		145 acres.
Villages submerged		Nil.
Cost of weir	Rs.	93,514
Cost of land compensation	„	2,175
Total ...	„	95,689

Total length of canal ... ... 58¼ mile.

Details of canal. 26. Length of left bank portion ... ... 15 miles.

Length of syphon			2,485 feet.
Length of right bank portion			42¾ miles.
Bed level of canal at Headworks ...	R. L.	1780	above M. S. L.
Bed level of canal at commencement of syphon	R. L.	1751	„
Bed level of canal at end of syphon ...	R. L.	1735·45	„
Gross command		2,71,501	acres.
Culturable, 8/10 gross		2,17,201	„
Irrigable, 1/3 culturable		72,400	„

The discharge of the canal at the Headworks was fixed by the Chief Engineer for Irrigation at 1,000 cusecs.

Cost of canal including syphon	Rs.	40,90,740
Cost of branches, minors and distributaries	„	12,14,290
Total	„	53,05,030

The canal is to irrigate the above area on the productive system.

Storage required. 27. For every 1,000 acres irrigated we have :—

Crop acres.	Number of times watered.	Equivalent Rabi acres.
250 Perennial	8 times	2,000
250 Eight months	twice	500
250 Rabi	once	250
250 Monsoon	once	250
	Total... ...	3,000

In each season we have :—

Monsoon or Rabi.	Equivalent Rabi.
250 Acres perennial, watered twice	500
250 Acres 8 months, watered once	250
250 Acres rabi, watered once	250
Total... ...	1,000

At 150 acres per cusec duty, 7 cusecs are required per 1,000 acres of mixed irrigation during the monsoon and rabi seasons, or 18·15 million cubic feet per month.

During the hot weather 250 acres of perennial crop, at 40 acres per cusec duty requires 6 cusecs per 1,000 acres of mixed irrigation, or 15·55 million cubic feet per month. This gives a total of 207·4 million cubic feet per 1,000 acres.

The supply required, therefore, is :—

Monsoon and Rabi Seasons 72·4 × 8 × 18·15	10,512·5
Hot weather 72·4 × 4 × 15·55	4,503·5
Total Mill. C. ft. ...	15,016

The net supply from the two storage tanks is 16,681 leaving a balance of 1,665 mill. c. ft. which is sufficient for $\frac{1665}{207\cdot4} \times 1000 = 8000$ acres of irrigation on the productive system.

The irrigable area thus becomes 80,400 acres and the gross command may be increased to 301,500, if it is found impossible to irrigate the additional area in the present gross command.

Purpose of the Storage and Canal.

28. The works are designed to irrigate a large area in the Rahuri, Nevasa and Shewgaon Talukas of Ahmednagar, which is liable to severe famine.

The Dhond-Manmad Railway runs through the western portion of the command, which is also crossed by the Ahmednagar-Aurangabad, and Ahmednagar-Pyton Roads.

The facilities for transporting the produce are thus fair, and the value of the project, as a means of livelihood to the impoverished ryots in the north-east of the Ahmednagar District, is incalculable.

Financial prospects.

29. The cost of the project is as follows :—

	Rs.
Storage at Chas	44,25,052
„ at Mandvi...	28,35,747
Pick-up weir at Tas	95,689
Canal, including distribution	53,05,030
Total ...	1,26,61,518
Add for all other charges ...	35,97,755
Grand Total ...	1,62,59,273

for a gross command of 271,501 acres (or 301,500 acres if extended). The cost of Rs. 54 per acre of gross command is high.

Net revenue.

30. The net revenue at Rs. 6·75 per acre on 80,400 acres irrigated amounts to Rs. 5,42,700, or 3·33 per cent. on the total cost.

Rain and river gauges.

31. Rain gauges were erected in the catchment area at:—

Harischandragad, Pachnai, Kotul and Chas.

River gauges were fixed at:—

Rahuri, 1902, and Tas, 1907.

These gauges have been observed continuously since the date of their erection.

H. F. BEALE,
Superintending Engineer.

MULA PROJECT.

Yearly Rainfall at Harischandragad.

Month.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	Remarks.
June	16·17	14·69	50·77	5·51	43·59	19·20	24·03	
July	117·72	110·34	117·47	98·92	91·82	75·50	127·67	
August	65·11	58·9	76·7	25·2	54·44	77·7	100·60	
September ...	64·2	31·67	16·40	28·91	44·0	8·2	8·08	
October	2·48	5·65	5·90	2·95	0·65	0·82	1·55	
November ...	3·51	.....	.....	0·63	0·11	.....	0·15	
December ...	3·35	.....	.....	.....	.....	.....	.....	
Total ...	272·36	220·44	266·67	161 94	234·61	180·66	262·08	

Statement showing the Yearly Rainfall at Pachnai.

Month.	1903.	1904.	1905.	1906.	1907.	1908.	Remarks.
June	8·84	.....	4·82	35·59	14·6	19·05	
July	84·1	93·65	88·58	71·87	59·27	113·03	
August	45·51	58 26	23·10	31·27	66·98	96·17	
September	23·12	14·38	28·28	41·74	7·56	6·29	
October	5·80	4·97	2·15	0·26	0·53	0·76	
November	.....	.....	0·56	.....	.....	.....	
December	.....	.....	.....	.....	.....	.....	
Total ...	167·28	171·26	147·49	187·63	148·40	235·30	

Statement showing Yearly Rainfall at Kotul.

Month.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	Remarks.
June	.....	1·8	0·37	1·15	3·33	4·55	1·00	
July	9·10	8·25	4·28	8·68	2·5	9·95	6·25	
August	2·33	2·32	1·5	2·5	1·73	9·72	5·16	
September ...	3·49	1·93	3·71	0·62	0·64	1·90	6·75	
October	2·34	2·60	2·38	0·42	.....	.....	1·23	
November ...	2·40	.....	.....	0·55	0·10	.....	.....	
December	1·88	.....	.....	.....	.....	.....	.....	
Total ...	21·54	16·18	11·79	15·47	7·76	26·12	20·39	

Statement showing the Yearly Rainfall at Chas.

Month.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	Remarks.
June	0·66	1·27	0·22	1·94	6·93	2·12	1·94	
July	10·71	9·10	2·38	4·48	2·20	6·57	3·74	
August	0·82	0·74	0·67	1·35	4·51	5·75	4·73	
September ...	0·92	1·19	1·97	1·10	0·76	2·69	8·06	
October	1·11	4·90	1·98	1·78	0·11	0·32	1·65	
November ...	0·38	.....	.....	0·56	.....	.....	.....	
December ...	1·29	0·12	.....	.....	0·57	.....	.....	
Total ...	15·89	17·32	17·22	11·21	14·90	17·45	20·12	

MULA PROJECT.

Statement showing the Monthly Discharge of the Mula River at Rahuri.

Catchment area 900 square miles.

Month.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	Remarks.
June	.....	974	2,360	626	3,465	969	1,205	
July	14,304	14,054	11,839	13,970	12,682	10,268	15,651	
August	6,849	11,818	8,459	3,958	11,834	24,247	19,107	
September	9,432	7,576	5,725	1,046	4,004	1,223	7,485	
October	324	3,264	2,988	303	222	82	440	
November	334	70	149	13	42	59	134	
December	376	27	24	3	41	31	68	
Total ...	31,619	37,783	31,544	19,919	32,290	36,879	44,090	
Equivalent run-off in inches.	15·1	18·1	15	9·53	15·44	17·64	21·09	

MULA PROJECT.

Statement showing the Monthly Discharge of the Mula River at Tas.

Catchment area 592 square miles.

Month.	1907	1908	Remarks.
June	1,893	1,018	
July	10,388	15,562	
August	25,859	17,454	
September	1,319	4,628	
October	56	1,413	
November	26	94	
December	28	45	
Total	39,569*	40,214	
Equivalent run-off in inches ...	28·80	29·24	

* This is greater than at Rahuri. One of the results is therefore wrong.

MULA PROJECT.

58¼ Miles.

RECAPITULATION OF ESTIMATES.

I.—WORKS.

ITEMS.	HEAD WORKS.			Main Canal.	Distributary including Branches and Minors.	Total.	REMARKS.
	Chas Storage.	Mandvi Storage.	Tas Weir.				
I.—Works.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
A. Preliminary expenses	9,000	6,000	5,000	10,000	5,966	35,966	
B. Land	2,08,655	1,59,693	3,775	74,130	78,523	5,24,776	
C. Works	41,77,597	26,02,754	57,114	.....	11,28,619	79,66,084	
D. Stopgates and Escapes	.....	.....	.....	19,112	.....	19,112	
F. River and Hill torrent works (including syphon).	.....	.....	.....	12,39,114	.....	12,39,114	
G. Bridges	.....	.....	.....	65,424	.....	65,424	
K. Buildings	7,300	7,300	7,300	51,400	.....	73,300	
L. Earthwork including tunnels	.....	.....	.....	25,94,979	.....	25,94,979	
M. Plantations	.....	.....	.....	4,456	.....	4,456	
O. Miscellaneous	22,500	60,000	22,500	2,125	1,182	1,08,307	
P. Maintenance	.....	.....	.....	30,000	.....	30,000	
TOTAL ...	44,25,052	28,35,747	95,689	40,90,740	12,14,290	1,26,61,518	

MULA PROJECT.

Estimate of Direct and Indirect Charges.

I.—Works.—		Rs.	Rs.
(1) Headworks.			
	(*a*) Dam at Chas	44,25,052	
	(*b*) Dam at Mandvi	28,35,747	
	(*c*) Headworks at Tas ...	95,689	
(2) Main Canal		40,90,740	
(3) Branches, Minors and Distributaries,		12,14,290	
			1,26,61,518

II.—Establishment.—

		Rs.		
(1)	(*a*)	... 42,07,397	Excluding	
	(*b*)	... 26,70,054	(A)	Preliminary expenses.
	(*c*)	... 86,914	(B)	Land compensation.
(2)		... 40,06,610		
(3)		... 11,29,801		
		on 1,21,00,776	at 23 per cent.	27,83,167

III.—Tools and Plant.—

on 1,21,00,776 at 1½ per cent.	1,81,512
Direct charges	1,56,26,197
Indirect charges 5 per cent. on I—Works	6,33,076
Total Direct and Indirect charges ...	1,62,59,273

REPORT ON BHIMA VALLEY SURVEYS.

CONTENTS.

PAGES

1. Report ... ... 134 to 155

2. River Gauge Returns of 5 Stations ... ... 156 & 157

3. Opinion of the Agricultural Department on the Mina Project 158 to 160

Index to Report on Bhima Valley Surveys.

Para.	Subject.
1	Position.
2	Existing irrigation.
3	History.
4	Scope of the recent surveys.
5, 6, 7 and 8	Ghod Right Bank Canal Project.
9, 10 and 11	Mina Left Bank Canal Project.
12	Other schemes.
13	Kukadi Left Bank Canal—Maximum Command.
14	Kukadi supply insufficient.
15 and 16	Supply from other rivers for the Kukadi Canal.
17	Mina supply.
18	Ghod supply.
19	Tank at Nirgudsar not sufficiently high for command.
20	Storage sites near Sirur rejected.
21	Tank at Sakora gives a fair command.
22	Feeder Canal.
23	Preliminary Project for Kukadi Left Bank Canal.
24	Estimated cost and percentage return of the Project.
25	Fresh project proposed by the Chief Engineer for Irrigation.
26, 27 and 28	Bhima Project.
29	Indrayani Project.
	A.—Investigation of the Kukadi Valley—Surveys.
30	Shirapur Site.
31	Higher sites examined.
32	Pimpalwandi Site.
33	Canal Surveys.
	B.—Investigation of the Ghod Valley—Surveys.
34	Dam Sites in the Ghod Valley.
35	Pimpalgaon Site.
36	Katapur and Nirgudsar Sites.
37	Sirur Sites.
38	High level contour at Nirgudsar.
39	Sakora Site.
40	Canal Surveys.
41	Further investigations.
42	Rising contour from Kem.
43	Feeder Canal.
44	Report to Government.
45	Comparison between the Sakora and Pimpalgaon Dam Sites.
	Details of the new Kukadi Left Bank Canal Project.
46	(*i*) Pimpalwandi Dam—Headworks, River Discharges, Maximum flood, Details of the Dam and Waste Weir, Cost.
47	(*ii*) Sakora Dam—Sakora Tank, River Discharges, Maximum flood, Details of the Dam and Waste Weir, Cost.
48	(*iii*) Kukadi Left Bank Canal—Details of the Canal, Discharge required, Volume required for Irrigation, Cost of Canal.
49	(*iv*) Feeder Canal—Details of Feeder Canal, Discharge required, Volume required for Irrigation, Cost.
50	(*v*) Ghod Right Bank Canal—Details of Ghod Right Bank Canal, Discharge required, Volume required for Irrigation, Cost of Canal.
51	Statement showing how the water available for irrigation is to be distributed through the various canals during the year.
52	Financial Aspect. Estimated cost.
53	Net revenue Kukadi Left Bank and Feeder Canals.
54	Net revenue Ghod Right Bank Canal.
55	Total net revenue and percentage return.
56	Purpose of the Storage and Canals.
57	Soil Map, Kukadi Left Bank Canal.

Index to Report on Bhima Valley Surveys.—(*continued.*)

Para.	Subject.
58	Soil Map, Ghod Right Bank Canal.
59	Rain and River Gauges.
	Appendix No. I.
	Appendix No. II.
	Appendix No. III.
	Appendix No. IV.
	Appendix No. V.
	C.—Investigation of the Mina Valley.
60	Wadgaon Dam Site.
61	Waste Weir.
62	Left Bank Canal.
63	Right Bank Branch Canal.
	Details of the Project.
64	Wadgaon Dam—River Discharges, Maximum flood, Details of Dams and Waste Weir, Cost.
65	Mina Left Bank Canal—Details of the Canal, Discharge required, Volume required.
66	Purpose of the Storage and Canals.
67	Financial Aspect. Estimated cost of the Project.
68	Net Revenue.
69	Rain and River Gauges.
	D.—Investigation of the Bhima Valley.
70	Karda and Kaman Sites.
71	Left Bank Canal Contour.
72	Right Bank Canal Contour.
73	Low Level Left Bank Canal Contour.
74	Tulapur Pick-up Weir.
75	Moshi Dam Site.
76	Recommendations for further investigations. Small Project.
77	Financial Aspects.
78	Net Revenue.
79	Possible extensions to small Project.
80	Further extensions on the Right Bank.
81	Purpose of the Storage and Canal.
82	Rain and River Gauges.

BHIMA VALLEY SURVEYS.

List of Drawings and Tracings accompanying the Report.

Note.—The office in which these plans are recorded is named in the list at page 63 following the Chief Engineer's Review.

No. of Drawings.	Title.	No. of Sheets.	Scale.
	A.—Kukari Left Bank Canal Project.		
1	Bombay Presidency map showing Bhima Valley Projects	1	8 miles = 1".
2	Index map folded showing storages, canals, and nature of soil ...	1	4 miles = 1".
3/1 to 3/16	Topo sheets showing storages and canals, etc., Nos. 195, 196, 197, 198, 230, 231, 232, 263, 264, 265, 294, 295, 296, 297, 323, 324..	16	1 mile = 1".
4/1 to 4/8	Index map tracings showing classification of soil	8	1 mile = 1".
5	Plan and longitudinal section of Kukari Storage at Pimpalwandi ...	1	H-400' V- 20' } =1".

No. of Drawings.	Title.	No. of Sheets.	Scale.
	A.—Kukari Left Bank Canal Project—*concluded.*		
6/1 to 6/12	Cross sections of Kukari Storage at Pimpalwandi	12	H-400′ V- 20′ =1″.
7/1 to 7/22	Contour plans for Kukari Storage at Pimpalwandi	22	400′=1″.
8/1 to 8/2	Do. for waste weir	2	400′=1″.
9/1 to 9/7	General longitudinal section of Kukari Left Bank Canal, O to 124 M.	7	H-400′ V- 20′ =1″.
10/1 to 10/63	Plan and longitudinal section of Kukari Left Bank Canal from Pimpalwandi to 124 M, 1666 feet ; tracings.	63	H-400′ V- 20′ =1″.
11	Longitudinal section of Ghod River bed, from Ghoda to the junction of Ghod and Mina Rivers.	1	H-5280′ V- 20 =1″.
12	Plan and longitudinal section of Dam line at Sakora; tracing ...	1	H-400 V- 20′ =1″.
13/1 to 13/5	Cross sections of Ghod Storage at Sakora	5	H-400′ V- 20′ =1″.
14/1 to 14/5	Contour plans for Ghod Storage at Sakora	9	400′=1″.
15	Waste weir contours Do.	1	400 =1″.
16/1 to 16/14	Plan and longitudinal section of junction canal from Sakora to Pimpalwandi.	14	H-400′ V- 20′ =1″.
17	Plan and longitudinal section of Dam line at Pimpalgaon near Ghoda.	1	H-400′ V- 20′ =1″.
18/1 to 18/3	Base line and cross sections for Do. Do.	3	H-400′ V- 20′ =1″
	B.—Mina Project.		
19	General longitudinal section of Mina Left Bank Canal	1	H-4000′ V- 20′ =1″.
20	Plan and longitudinal section of Dam for Mina storage at Wadgaon; Tracing.	1	H-400′ V- 20′ =1.
21/1 to 21/2	Cross sections of Mina Storage at Wadgaon	2	H-400′ V- 20′ =1″.
22/1 to 22/4	Contour plans for Do. do.	4	400 =1″.
23/1 to 23/14	Plan and longitudinal section of Mina Left Bank Canal, O to 28 miles ; tracings.	14	H-400′ V- 20′ =1″.
23 A	Index Map Tracing showing classification of soil	1	1 mile=1″.
	C.—Bhima Project.		
24/1 to 24/3	Plan and longitudinal section of Proposed Dam line on Bhima River at Kaman, (one foolscap paper).	1	H-400′ V- 20′ =1″.
	Longitudinal section of Proposed Dam line on Bhima River at Kaman.	1	H-1000′ V- 50′ =1″.
25/1 to 25/4	Cross sections of Bhima Storage at Kaman	4	H-400′ V- 20′ =1″.
26/1 to 26/2	Plan and longitudinal section of Proposed Dam line on Bhima River at Karda (on foolscap paper).	1	H-400′ V- 20′ =1″.
	Do. do.	1	H-800′ V- 20′ =1″.
27/1 to 27/2	Plan showing levels along the Bhima River bed from Tulapur to 51 miles upstream near Bhorgeri.	2	2000′=1″.
28/1 to 28/2	Longitudinal section of weir on Bhima River at Tulapur, 1 Drawing 1 Tracing.	2	H-400′ V- 20′ =1″.
29	Plan showing levels along Indrayani River bed from Tulapur to 30 miles upstream	1	2000′=1″.
30	Longitudinal section of Dam line on Indrayani River at Moshi ...	1	H-200′ V- 10′ =1″.
31/2 to 31/5	Cross sections of Indrayani River	6	H-400′ V- 20′ =1″.

BHIMA VALLEY SURVEYS.

Position.

1. Under the original title of Ghat Tank Surveys comes the investigation of the various rivers in the Bhima Valley. This is separated from the Godaveri Valley by a high range of hills, running eastward from the Ghats towards Ahmednagar. It is taken to comprise the Ghat Rivers enumerated below: —

The Kukadi, Mina, Ghod, Vel, Bhima, Bhama, Indrayani, Pauna, and Mutha Mula Rivers. Of these, the Kukadi, Mina, Ghod, Bhima, Bhama, and Indrayani Rivers have been investigated for fresh projects. The Bhama has a comparatively small catchment area and the river is unfavourably situated. A dam site at Chandus was roughly examined.

The Vel River is too small and its supply too uncertain to come within the scope of the Special Duty Surveys.

A scheme for a tank on the Pauna has been mooted, but as it is a comparatively small project, and the water could not be delivered to a famine-stricken area, it has not been included in the Special Duty Surveys.

The Nira River is a southern tributary of the Bhima, lying between Poona and Satara. A project for this river has been dealt with separately.

Existing irrigation.

2. The only use made of the water from the Bhima Valley is the irrigation of 9,500 acres (10 years' average), out of a gross command of 49,800 acres, by the Mutha Canals, which take off from Lake Fife, a storage tank on the Mutha River, a southern tributary of the Bhima passing through Poona.

A project has recently been prepared to increase the storage and the area commanded under this system.

There are also a few bandharas which irrigate small areas annually, but they are not of much importance.

History.

3. Old records dating from about 40 years ago show that a great deal has already been done towards the investigation of possible projects on these rivers. The Ghod and Kukadi Rivers were investigated, and a rough scheme seems to have been prepared for a dam on the Ghod at Shinoli (Sinoli), and a pick-up weir at Kalwant (Kalamb). The canal was to have been on the left bank of the river, and it was proposed to cross the Mina River at Ranji (Rajni) and the Kukadi River at Ressori (Renaudi), at which place it was proposed to construct another storage reservoir. From Renaudi, several canal lines were surveyed as far as Kem in the Sholapur District.

Other storage sites were examined at Hewra and Edgaon on the Kukadi River. A line of levels had also been run along the bed of the Ghod River, and levels were run across country from Poona to Talegaon, and over the area between the Bhima and the Ghod Rivers, but in this latter case, no particular scheme seems to have been aimed at. But the work recently done by the Special Duty Staff has covered the whole ground very thoroughly, and the old surveys need not be referred to again. The old records have been made use of as far as possible.

Scope of the recent surveys.

4. The Special Duty Surveys since 1903 have been directed towards discovering in what manner the supply from the rivers in the Bhima Valley could be most advantageously used; and from time to time reports on various projects have been sent to Government.

Ghod Right Bank Canal Project.

5. The first project that was prepared, was for the Ghod Right Bank Canal, with a storage tank at Nirgudsar (see topographical sheets Nos. 196, 230 and 231). The tank site was selected after a careful examination of the Ghod Valley. It is the best and cheapest site from which a canal can be made to reach the fertile plateau to the east of Sirur, between the Ghod and Bhima Rivers.

6. The storage proposed was 10,236 million cubic feet, and the area commanded by the Right Bank Canal in a length of 59 miles was 121,675 acres. It was also proposed to bring under irrigation 43,904 acres by a canal 35 miles long on the left bank, making the total command of the project 165,579 acres. See topographical sheets Nos. 231, 232 and 264, accompanying this report.

7. The estimated cost of this scheme was 94 lakhs of rupees, and the net revenue anticipated was 1·06 per cent. on this.

It should be noted that this is the return which could reasonably be expected. Under the system now adopted of showing the possible return under favourable circumstances, the revenue would amount to 3·20 per cent. of the cost.

8. This project was rejected partly because subsequent surveys showed that the large supply from the Ghod could be more fully employed on the left bank of the Kukadi River, and partly because a Left Bank Canal from the Bhima River could be made to irrigate a large proportion of the land at the tail of the proposed Ghod Right Bank Canal. The original report was returned by Government and is recorded in the office of the Executive Engineer for Irrigation, Poona.

The Mina Left Bank Canal Project.

9. The next scheme prepared was the Mina Left Bank Canal Project. The storage site is at Wadgaon, with a capacity of 4,864 million cubic feet. A Left Bank Canal, 28 miles long, was surveyed, the command being 70,000 acres, and a contour was run for a branch on the right bank to command 9,000 acres. See topo. sheets Nos. 196, 230 and 231.

10. This project was held in abeyance for some years, as there was a question as to how the Mina water could be most profitably employed. The Mina River is the highest in the Bhima Valley, and therefore its water could most easily be diverted for use on the left bank of the Kukadi River.

11. The Chief Engineer for Irrigation has now agreed that it is probably best to use the Mina water to irrigate land in the Mina Valley, and the project is, therefore, described in this report lower down.

Other schemes.

12. While the preparation of the above-named projects was in progress, surveys were also being made on the Kukadi, Bhima and Indrayani Valleys.

Kukadi Left Bank Canal. Maximum command.

13. In the Kukadi Valley an extensive preliminary survey was made, and it was shown that the maximum command of a canal starting from a point west of the Poona-Nasik Road was 1,638,000 acres (with a length of 271 miles), including some of the worst famine lands in the south of the Ahmednagar, and north of the Sholapur Districts.

Kukadi supply insufficient.

14. River gauge observations on Kukadi, which were begun in 1903, proved, however, that its supply fell very far short of the quantity required for so large an area. It was considered important to attempt to irrigate as much of this famine-stricken area as possible, and surveys were then taken in hand to find a way of supplementing the supply of the Kukadi from other rivers.

Supply from other rivers for the Kukadi Canal.

15. Surveys were made for diverting the flood water of all the more important nallas crossed by the Kukadi Canal into the canal. This was to be done by inlets suitably protected by dry stone dams to keep out some of the silt. It was proposed also to use the Hanga River discharge if the Visapur project (Ahmednagar District) was not to be carried out.

The quantity of water to be gained by this means was, however, small and liable to great fluctuation.

16. The existence of a high range of hills between the Ghod and Bhima Valleys makes it impossible to use the water of any stream to the south of the Ghod for this purpose. There only then remain the Mina and Ghod Rivers to be considered.

Mina supply.

17. Of these, the Mina presents no difficulties, as the river-bed level at the proposed storage site at Wadgaon is R. L. 2179 above M.S.L. This is 155 feet above the bed of the Kukadi at the proposed storage site at Pimpalwandi. As the ridge between the two rivers is low, it would be comparatively simple to transfer a large proportion of the Mina supply to the Kukadi Storage Tank and thence to the Left Bank Canal. A dam would have to be constructed on the Mina, and a short cut made through the ridge.

Ghod supply.

18. The supply of water from the Ghod river is, however, a more difficult matter and several alternative schemes were examined.

Tank at Nirgudsar not sufficiently high for command.

19. A low-level rising canal contour was first run from Kem in the Sholapur District to Nirgudsar (see topo sheets Nos. 296, 295, 294, 264, 263, 232, 231 and 230). The length of this contour is 311 miles, while the length of the Kukadi Left Bank Canal alignment from Pimpalwandi to Kem is 174 miles, and the latter has a better command. The low-level canal project being ruled out, it was then shown that to supply the high-level Kukadi Canal from a tank at Nirgudsar would be a very wasteful plan. The F. S. L. of the tank would have to be made so high that 18,432 acres and 18 villages would be submerged, and the volume of water left in the tank below canal bed level would be 24,141 million cubic feet. This represents practically a whole year's supply of the river, so that if it was ever necessary to completely empty the tank, there would be no water available for irrigation until the second monsoon after the tank was emptied, and in ordinary circumstances the loss by evaporation and absorption would be very heavy.

Storage sites near Sirur rejected.

20. The same reasons operated still more forcibly in the rejection of three storage sites, which were examined near Sirur on the Ghod River, below its junction with the Kukadi.

Tank at Sakora gives a fair command.

21. The investigation of the river above Nirgudsar was then commenced and a dam site was selected at Sakora, a village four miles west of the Poona-Nasik Road. The river-bed level at this site is R. L. 2043·50 or 17·5 feet above the bed of the Kukadi at Pimpalwandi.

Feeder canal.

22. A feeder canal 23½ miles long, crossing the Mina River at Rajni, was surveyed from Sakora to Pimpalwandi.

Preliminary project for Kukadi Left Bank Canal.

23. A preliminary project on the following lines was prepared and submitted to Government under the Secretary, Indus River Commission's No.S/1401 of 15th August 1908.

It was proposed to construct a Storage Tank on the Kukadi River at Pimpalwandi, with a capacity at F. S. L., R. L. 2137, of 22,035 million cubic feet above the canal sluices.

From this tank the Kukadi Left Bank Canal was to take off direct at R. L. 2,060; the canal was to be 130 miles long, with a gross command of 653,250 acres.

The system of irrigation was to be perennial, and water was to be drawn off the Pimpalwandi storage during the last 7 months of the year.

A dam was to be constructed at Wadgaon on the Mina, with a storage at F. S. L., R. L. 2249, of 988 million cubic feet. A canal 4½ miles long was to take off from this tank at R. L. 2209 and pass through the ridge between the Mina and Kukadi Rivers. The canal was to discharge 950 cusecs, and therefore be capable of delivering 4,000 million cubic feet during the monsoon into the proposed Pimpalwandi Tank.

An area of 15,620 acres on the left bank of the Mina was also to be irrigated from the storage in the Wadgaon Tank.

A storage tank was to be constructed at Sakora on the Ghod River, with a capacity up to F. S. L, R. L., 2152, of 8.695 million cubic feet. From this tank a feeder canal to Pimpalwandi 23½ miles long was to be dug. The starting level of this canal was to be R. L. 2102, so as to reach the head of the Kukadi Left Bank Canal at R. L. 2060.

The discharging capacity of the canal was to be 1,742 cusecs, and its purpose was to supply water to the Kukadi Left Bank Canal, for the first 5 months of the year, from the monsoon flow of the Ghod River, in addition to the storage of 7,467 million cubic feet above its upper outlet sluices (R. L. 2102).

An area of 32,360 acres was also to be irrigated on the right bank of the Ghod River, by a canal 30 miles long, taking off from Sakora at R. L. 2064.

Estimated cost and percentage return of the project.

24. The estimated cost of the project was 441 lakhs of rupees and the net revenue anticipated was 2·86 per cent. on this amount.

Fresh project proposd by the Chief Engineer for Irrigation.

25. This project was returned by the Chief Engineer for Irrigation for revision on the following lines:—

(i) The Pimpalwandi dam to be replaced by a weir on the same site from which water would be discharged into the Kukadi Left Bank Canal during the monsoon, usually for 3½ months.

The command of the Kukadi Left Bank Canal to be reduced to 525,000 acres and the system of irrigation changed from perennial to 8 months.

(ii) The Mina Project to be adopted as originally proposed, the storage being used for irrigating the land between the Kukadi and Mina Rivers.

(iii) The storage on the Ghod at Sakora to be enlarged, or if this proved too expensive owing to the flooding of the town of Ghoda, a fresh dam site to be selected above Ghoda.

The canal on the right bank of the Ghod to be extended as far as Sirur, increasing the command to 43,251 acres. Also 12,500 acres between the Ghod and Mina Rivers, to be irrigated from the feeder canal between the Sakora Tank and Pimpalwandi weir. This scheme is described in more detail lower down.

Bhima Project.

26. Rough surveys were carried out in the meantime on the Bhima River. Two dam sites were selected and surveyed at Kaman and Karda, and a pick-up weir at Tulapur (see topo. sheet 197).

Canal contours were run from Kaman on the left bank, and from Tulapur at the junction of the Indrayani and Bhima Rivers, on the left and right banks to indicate the possible command of the project.

27. A rough report on this project was submitted to Government, by the Superintending Engineer on Special Duty and returned under the Chief Engineer for Irrigation's No. C. I. E. 210 of 15th October 1907, in order that the levels of this project might be shown in connection with the Ghod Right Bank Canal Project.

28. In the Bhima Project the command on the left bank was given as 80,000 acres, the canal being stopped when it reached the broken ground south-east of Kondhapuri (see topo. sheet No. 232). It is, however, possible to extend the Left Bank Canal, so as to irrigate the land between the Ghod and Bhima Rivers, south-east of Sirur. This area forms part of the command under the original Ghod Right Bank Canal Project, see para. 8 above.

Indrayani Project.

29. On the Indrayani River a site was selected at Moshi, on the Poona-Nasik Road, for a tank to hold roughly 2,000 million cubic feet, but no futher investigation was made. As the junction of the Indrayani and Bhima is only 10 miles from Moshi, a Left Bank Canal from the tank would not be possible, and as the country on the right bank as far as Tulapur is very broken, it would probably be better to let down the water from Moshi to a pick-up weir at Tulapur.

A.—INVESTIGATION OF THE KUKADI VALLEY.

Surveys.

Shirapur Site.

30. The first site examined for a dam was at Shirapur, and from this a low level Left Bank Canal was surveyed. Trial pits were taken all along the line, because although it is not an ideal dam site, it seemed possible that either a dam or a weir would be wanted at this place. It was eventually rejected, however, as it was found that a canal line 80 feet higher than the one from Shirapur would be far more favourable, because a large amount of the broken ground north of Sirur, and between that town and Visapur, could thereby be avoided.

Higher Sites examined.

31. This led to the examination of dam sites higher up the river, and lines at Edgaon, Whiskeri and Pimpalwandi were surveyed and trial pits and borings were taken.

The sites at Edgaon and Whiskeri were found to be unsatisfactory as regards foundations, and that at Pimpalwandi was finally selected as the best.

Pimpalwandi Site.

32. This site has been very fully examined, and numerous trial pits have been taken, both along the dam line and also in the river bed above and below the line.

The general result indicates the existence of sound trap rock at reasonable depths, along the selected line, except at one point on the Right Bank 750 feet from the river, where the rock level descends to R. L. 1981 or 67 feet below the ground level at this point.

Three contours at R. Ls. 2074, 2104, and 2132, have been taken, and from these the capacity of the basin has been calculated.

Canal Surveys.

33. The canal surveys were very extensive commencing with a low level line from Shirapur which had to be stopped when it got into the hilly ground east of river. The next set of levels was run about 80 feet higher with a fall of 9 inches per mile, and when it was proved that this would give a good line through the difficult hilly country between Sirur and the Hanga Valley, the preliminary contour was continued for some 200 miles from the Hanga Valley into the Sholapur District with a fall of 1 to 1½ feet per mile. The total command obtained was 1,638,000 acres.

After this a revised final alignment was run from the Pimpalwandi tank site for 130 miles to command 653,250 acres.

It is thought advisable to irrigate as large a portion of this command as possible, so, in order to provide more water, the Ghod River has to be drawn upon. The supply will be brought from the storage site at Sakora to Pimpalwandi by means of a feeder canal.

B.—INVESTIGATION OF THE GHOD VALLEY.

Surveys.

Dam sites in the Ghod Valley.

34. It was originally intended to use the supply from this valley mainly for irrigation on the Right Bank of the Ghod River. With this end in view, two sites at Katapur and Nirgudsar, were fully investigated, and a third dam line was surveyed at Pimpalgaon 4 miles west of Ghoda. (See topo sheet Nos. 196, 230 and 231.)

35. Of these, the Pimpalgaon site was rejected, on account of the very difficult land on the Right Bank of the river, through which it would be necessary to cut the first part of the canal without giving much additional command in the lower reaches, and because, though no trial pits were taken, it appeared likely that the foundations for the dam on the Left Bank would prove very unsatisfactory; and finally because the valley is steep and narrow and would not form a satisfactory tank basin.

Pimpalgaon Site.

36. The Nirgudsar site was finally selected as providing the best storage work for the project. It has a good basin and is far more favourable as regards length of dam and nature of foundations than the Katapur site. Four contours were taken in the valley at R. Ls. 1971, 1996, 2036, and 2051, and from these the capacity of the tank was worked out.

Katapur and Nirgudsar Sites.

37. Three dam sites were surveyed near Sirur below the junction of the Ghod and Kukadi Rivers, with a view to constructing one large storage work for the project, but this scheme was rejected for the reasons given in para 20 above.

Sirur Sites.

38. Fresh contours at R. Ls. 2066, 2081, and 2101 were then run at Nirgudsar to see whether the required supply could be obtained from this site. But for the reasons given in para. 19 above, the plan was deemed wasteful and was rejected in favour of a tank further upstream.

High level contour at Nirgudsar.

39. The Sakora dam site 4 miles west of the Poona-Nasik Road (See topo sheet, No. 196) was then investigated, and numerous trial pits were taken, which proved that the foundations were very favourable, sound trap rock being found at reasonable depths below ground throughout the line. Contours were taken at R. Ls. 2102, 2132, and 2152 and from these the capacity of the tank was calculated.

Sakora Site.

40. A canal contour was run from the Katapur site towards Sirur, but when it was proved that the Nirgudsar site was the better, the contour was extended upstream to that site, and eastward on to the table-land below Sirur. A final alignment was surveyed from Nirgudsar for 59 miles, giving a gross command of 121,675 acres. A canal contour was run on the Left Bank from Katapur to connect with the Shirapur Site and several cuts across the ridge between the Ghod and Kukadi Rivers were surveyed.

Canal Surveys.

Another contour was afterwards surveyed from Nirgudsar for a Left Bank Canal but no final alignment was made, although figures for this canal were included in the estimate for the Ghod Right Bank Canal Project. The command was found to be 43,940 acres for a length, up to the hills north of Sirur, of about 35 miles.

41. When it was found that the Ghod supply could be more advantageously used on the Left Bank of the Kukadi, further surveys were made, to determine the best method of conveying the water to the Kukadi Left Bank Canal.

Further investigations.

42. The Kukadi Left Bank high level canal alignment gains the ridge line of the country between the Bhima and Seena Rivers, near Karmala in the Sholapur District. The preliminary contour, which was run on as far as Ashti, showed that just north of Kem on the G. I. P. Railway, there was a drop of 50 feet in the ridge line.

Rising contour from Kem.

The Chief Engineer for Irrigation ordered that a rising contour should be run from the foot of this drop back to Nirgudsar, to determine whether it would be possible to start a canal direct from that site, but as mentioned in para. 19, this line proved so very much inferior to the Kukadi Left Bank Canal alignment, that it only served to confirm the opinion already formed, that any canal on the Left Bank of the Kukadi at a lower level than that already aligned, must necessarily be more expensive and unsatisfactory.

43. The line for the feeder canal from Sakora to Pimpalwandi was surveyed, the distance being 23½ miles. The line generally was easy, except where crossing the ridges between the Ghod, Mina and Kukadi Rivers, and the Mina River itself.

Feeder Canal.

44. The above work is fully described in the report sent to Government by the Superintending Engineer, Indus River Commission, with his No. 1401 of 15th August 1908. This report was returned for certain modifications, mentioned in para. 24 and has now been sent to the office of the Executive Engineer, Poona Irrigation, for record.

Report to Government.

45. The modifications involve, either the raising of the proposed dam at Sakora to such a height that the large town of Ghoda would be flooded, or if this proved too expensive, the selection of some other site above Ghoda.

Comparison between the Sakora and Pimpalgaon Dam Sites.

As there was no time for further surveys, and as the investigations of the Pimpalgaon site, the only one above Ghoda which had been surveyed, were not sufficiently advanced to permit estimates to be made, to give a fair comparison between this site and the one at Sakora, the latter has been adopted for the revised project, subject to its proving on further investigation at a later date, better than any possible site above Ghoda.

The cost of storage per million cubic feet at Sakora amounts to Rs. 466.

The Chief Engineer for Irrigation, however, directed that the new dam site above Ghoda may be assumed to give the required storage for a cost of Rs. 475 per million cubic feet.

This estimate is probably far too low. The cost should not, it is thought, be taken at less than 600 rupees per million cubic feet because of the unfavourable foundations on the Left Bank and the very narrow and steep valley in which the tank would be formed.

DETAILS OF THE NEW KUKADI LEFT BANK CANAL PROJECT.

(*i*)—Pimpalwandi Dam.

Headworks.

46. Catchment area = 288 Square miles.

River discharge; gauge at Edgaon.

River Discharges.

Year.	Discharges, Million cubic feet.	Run-off inches.
1904	24,697	40·10
1905	12,078	19·62
1906	11,171	18·14
1907	29,007	47·12
1908	24,742	40·19

Maximum flood.

The maximum flood discharge is taken at ½ inch per hour or 92,926 cusecs.

The greatest observed flood discharge was 75,109 cusecs on July 25th 1907.

Details of Dam and Waste Weir.

Bed level at dam site	...	R. L. 2,026·14.	above M. S. L.
Proposed F. S. L.	...	R. L. 2,080·14	„ „ „
Proposed H. F. L.	...	R. L. 2,085·39	„ „ „
Proposed outlet level	...	R. L. 2,060·14	„ „ „
Depth of water above sill.		20 feet.	

Gross volume stored	2,215 Million cubic feet.
Volume below sill	553 „ „ „
Net storage available	1,562 „ „ „
Monsoon discharge to be used for the canal during the months of ½ June, July, August and September	7,620 „ „ „
Volume of Kukadi water available for irrigation purposes	9,182 „ „ „
Area of land submerged	2,275 acres.
Number of villages submerged	6.
Length of dam	4,475 feet.
Length of waste weir	2,550
Estimated discharge over weir + 3″ spill over dam	93,576 cusecs.

Cost. The cost of the dam and waste weir ... Rs. 21,36,991
Cost of land and village compensation ... „ 7,53,775

TOTAL Rs... 28,90,766

Cost per million cubic feet stored above sill Rs. 1,844
Cost per million cubic feet used for irrigation purposes ... ... Rs. 317

(*ii*)—Sakora Dam.

Sakora Tank.

47. Catchment area = 208 Square miles.
River Discharge ; gauge at Nirgudsar.

Catchment area at Gauge site = 284 square miles.

River Discharge.

Year.	Discharge, Million cubic feet.	Run-off, inches.
1906	19,477	29·0
1907	39,610	59·0
1908	47,852*	72·53

* Figure given by the Executive Engineer on Special Duty. It appears to be abnormally high.

Maximum Flood.

Maximum flood discharge is taken at ½ inch per hour or 66,726 cusecs.

Greatest observed flood discharge was 37,828 cusecs on July 25th 1907.

Details of Dam and Waste weir.

Dam site ... ...R. L. 2,043·50 above M. S. L.
Proposed F. S. L. and H. F. L. ... ...R. L. 2,185 above M. S. L.
Proposed outlet level (feeder canal) ... ...R. L. 2,102 above M. S. L.
Proposed outlet level (Ghod Right Bank Canal) ... ...R. L. 2,064 above M. S. L.
Depth of water above sill of feeder canal ... ... 83 feet.
Depth of water above sill of Ghod Right Bank Canal ... ... 121 feet.

	Mil. cubic feet.
Gross volume stored	20,568
Volume below sill of feeder canal	1,228
Volume below sill of G. R. B. Canal	83
Loss by evaporation, etc., on volume above feeder canal sluice till middle of February, say 1′ 6″ on mean area	404

	Mil. cubic feet.
Loss by evaporation, etc., on volume between feeder canal sluice, from middle of February, to middle of June, say 3′ 6″ on mean area	121
Net volume available for irrigation purposes till middle of February	18,936
Net volume available for irrigation purposes after middle of February	1,024
Area of land submerged	14,465 acres.
Number of villages submerged	18

Cost.

Cost of Dam and waste weir	Rs.	78,57,665
Land and village compensation	,,	17,00,000
TOTAL ...	Rs.	95,57,665

Cost per million cubic feet stored above sill of G. R. B. Canal... Rs. 466

(*iii*)—Kukadi Left Bank Canal.

Details of the Canal.

48. Length	135 miles.
Gross command	525,000 acres.
Irrigable command	262,500 ,,

(This proportion is given by the Chief Engineer for Irrigation for an 8—month canal.)

Discharge required.

Discharge required, 8 months irrigation.

For every 1,000 acres of irrigation we have :—

Crop.	Acres.	Equivalent Rabi Irrigated acres.
8 months	333 acres watered twice a month ...	666
Rabi	333 ,, ,, once ,, ...	333
Monsoon	333 ,, ,, once ,, ...	333
	Total ...	1,332

The discharge required in each season is :—

Monsoon or Rabi.	Equivalent 4 months.
333 acres 8 months...	333 acres
333 acres Rabi or monsoon	333 acres
Total ...	666 acres

which at 150 acres duty per cusec=4·5 cusecs.

Therefore, the discharge required per 1,000 acres during the monsoon or Rabi seasons would be 11·66 million cubic feet per month.

Volume required for Irrigation.

The volumes required are, June 16th to September 30th:—

	Mil. cubic feet.
From Pimpalwandi $225 \times 11{\cdot}66 \times 3{\cdot}5$ ... ... =	9,182
From Sakora $37{\cdot}5 \times 11{\cdot}66 \times 3{\cdot}5$ ... ... =	1,542
October 1st to February 14th, $262{\cdot}5 \times 11{\cdot}66 \times 4{\cdot}5$ ... ... =	13,773
TOTAL ...	24,497

The irrigable command being 262,500 acres, the discharge required per month is 3,061 million cubic feet, or 1,143 cusecs at the head of the canal.

Cost of Canal. The cost of the canal has been proportionately reduced from the cost of the canal in the old project (the discharge of which was 1,742 cusecs) and now amounts to Rs. 76,52,400.

The cost of distribution has been recalculated and is Rs. 16,65,483, giving a total of Rs. 93,17,883 for the canal including distribution.

(*iv*)—Feeder Canal.

Details of Feeder Canal. 49. Length ... ... = 23½ miles.

The canal is required to discharge 1,143 cusecs into the small tank at Pimpalwandi and irrigate on the 8-months system 12,500 acres gross for 6,250 acres irrigable command lying between the Ghod and Mina Rivers.

Discharge required. The required discharging capacity will, therefore, be :—

Discharge at end	1,143 cusecs.
Discharge for irrigation *en route* 11·66 × 6·25 = 72·875 million cubic feet per month or	28 ,,
Add for loss at 6 cusecs per million square feet wetted perimeter	47 ,,
TOTAL ...	1,218 cusecs.

The volume required for irrigation from the feeder canal, between Sakora and Pimpalwandi :—

	Mil. cubic feet.
Volume required for Irrigation. Irrigation of land between Ghod and Mina 11·66 × 6·25 × 8	600
Loss *en route* 16th June to 30th September 18·14 million cubic feet × 3½	63·5
Loss *en route* 1st October to 14th February 126 × 4·5 ...	667
TOTAL ...	1,330·5

Cost. Cost of canal determined proportionately from cost of canal in old project* ... ... Rs. 14,28,714

Cost of distribution ... ... ,, 61,062

TOTAL ... Rs. 14,89,776

* Item for Mina aqueduct omitted, as when the Mina Project is constructed, the whole flow in this river will be stopped. See Report on Mina Left Bank Canal Project.

(*v*)—Ghod Right Bank Canal.

Details of Ghod Right Bank Canal. 50. Approximate length equals 42½ miles. Gross command equals 43,251 acres, Irrigable command, ⅓rd gross taken for a perennial canal = 14,420 acres.

Discharge required. Irrigation on perennial system.

For every 1,000 acres of irrigation we have :—

Crop.	Acres.	Equivalent Rabi Irrigated Acres.
Perennial	250 watered 8 times	2,000
8 months	250 ,, twice	500
Rabi	250 ,, once	250
Monsoon	250 ,, once	250
	TOTAL ...	3,000 acres.

The discharge required in each season is :—

Monsoon or Rabi season.	Equivalent 4 months
250 acres Perennial...	500 acres
250 acres 8 months	250 ,,
250 acres Monsoon or Rabi	250 ,,
TOTAL ...	1,000 acres

which at 150 acres per cusec duty equals 7 cusecs.

In the hot weather, 250 acres perennial at 40 acres per cusec duty equals 6 cusecs.

From the above, the discharge per month during the monsoon and Rabi seasons equals 18·15 million cubic feet per 1,000 acres irrigated, while in the hot weather it is 15·55 million cubic feet.

The canal will draw water from the Sakora tank : first, from the storage above the Feeder Canal Sluice, for 8 months (15th June to 15th February), and then from the storage between the Feeder Canal Sluice and the Ghod Right Bank Canal Sluice levels for the remaining 4 months.

Volumes required for Irrigation.

The volumes required are :—

		Mil. cubic feet.
First 8 months	18·15 × 8 × 14·42 ...	2,096
Remaining 4 months ...	15·55 × 4 × 14·42 ...	896
	TOTAL ...	2,992

The discharge required at the head of the canal on the proportion given by the Chief Engineer for Irrigation, *viz* : 1 cusec for every 300 acres culturable command $= \frac{43,251}{300} =$ 144 cusecs.

Cost of Canal.

The cost of the canal has been roughly calculated from the figures worked out for other canals and is taken to be Rs. 10,62,500 for all works, including distribution.

51. *Statement showing how the water available for irrigation is to be distributed through the various canals during the year.*

Appendix No. 4 shows that the Kukadi River at the Pimpalwandi Dam cannot safely supply 1,000 cusecs or 2,623 million cubic feet per month from the middle of June to the end of September. In July and usually in August, more could be obtained but the canal discharge is only 1,143 cusecs. As 3,061 million cubic feet per month are required for the Kukadi Left Bank Canal, the extra water amounting to 438 million cubic feet a month must be drawn from the Ghod Storage at Sakora, where the storage amounting to the average year's supply of the Ghod River, is sufficient for this extra draw-off.

Canal.	Period.	Source of supply.	Monthly supply.	Total. Mil. cubic feet.
Kukadi Left Bank ...	June 16th to Sept. 30th	Pimpalwandi ...	2,623	9,182
Do. ...	,,	Sakora ...	440	1,542
Do. ...	Oct. 1st to Feb. 14th ...	,, ...	3,061	13,773
Feeder	June 16th to Feb. 14th	,, ...	75	600
Loss in transit in feeder at 7 cusecs	June 16th to Sept. 30th	,, ...	18·14	63·5
Loss in transit in feeder at 47 cusecs	Oct. 1st to Feb. 14th ...	,, ...	126	667
Ghod Right Bank ...	June 16th to Sept. 30th	,, ...	262	2,096
Do.	Oct. 1st to Feb. 14th...	,, ...	224	896
		Total Volume...	... ...	28,819·5

	Million. c. ft.
The total supply required from Pimpalwandi	9,182
The total supply required from Sakora up to February 19th	18,742
The net storage at Sakora above the Feeder Canal Sluice or 194 million cubic feet in excess of the requirements ...	18,936
The total supply required from Sakora from February 15th to June 15th	896
The net storage between Feeder Canal and Ghod Right Bank Canal Sluice	1,024

or 128 million cubic feet in excess of the requirements for this period.

It follows, therefore, that on the Kukadi Left Bank Canal—

$$\frac{1{,}000 \times 194}{93{\cdot}3} = 20{,}000 \text{ acres of mixed 8 months irrigation}$$

while on the Ghod Right Bank Canal—

$$\frac{1{,}000 \times 128}{207{\cdot}4} = 600 \text{ acres of mixed perennial irrigation can be added}$$

to the figures given above.

The gross command has not been altered, it being assumed that a little higher percentage of the gross area will be irrigated.

Financial Aspect.

52. *Estimated Cost.*

		Rs.
(1)	Pimpalwandi weir	28,90,766
(2)	Sakora Dam and waste weir...	95,57,665
(3)	Kukadi Left Bank Canal, 135 miles	93,17,883
(4)	Feeder canal, 23½ miles	14,89,776
(5)	Ghod Right Bank Canal, 42½ miles...	10,62,500
	Total, I—Works ...	2,43,18,590
	Add for all other charges 28% ...	68,09,208
	Grand total, direct and indirect charges ...	3,11,27,798

for a total gross command of 5,80,750 acres.

Net Revenue, Kukadi Left Bank and Feeder Canals.

53. The net revenue per acre irrigated on the Kukadi Left Bank and Feeder Canal will be :—

Crop.	Water rate, per acre.	Revenue, Rs.	Working expenses per acre.	Working expenses.	Net Revenue.
⅓ 8 months ...	6	2	1·5	0·5	1·5
⅓ Rabi ...	3	1	0·75	0·25	0·75
⅓ Monsoon ...	3	1	0·75	0·25	0·75
1 Acre		4·00		1·00	3·00

* 282,500 acres on the Kukadi Left Bank Canal and 6,250 acres on the Feeder Canal or a total of 288,750 acres will be irrigated.

	Rs.
Grosss Revenue	11,55,000
Working expenses	2,88,750
Net Revenue	8,66,250

* 20,000 acres added, see preceding para.

Net Revenue Ghod Right Bank Canal.

54. The net revenue per acre irrigated on the Ghod Right Bank Canal will be:—

Crop.	Water rate per acre.	Revenue, Rs.	Working expenses per acre.	Working expenses.	Net Revenue.
¼ Perennial ...	24	6·00	6·00	1·50	4·50
¼ 8 months ...	6	1·5	1·50	0·375	1·125
¼ Rabi ...	3	0·75	0·75	0·1875	0·562
¼ Monsoon ...	3	0·75	0·75	0·1875	0·562
1 acre ...	.....	9·90	.....	2·25	6·75

The irrigable area being 15,020 acres.

	Rs.
The gross revenue	1,35,180
Working expenses	33,795
The net revenue	1,01,385

Total net revenue and Percentage return.

55. The total net revenue for the whole project equals Rs. 8,66,250 + Rs. 1,01,385 = Rs. 9,67,635 representing a return of 3·11% on the total capital cost, direct and indirect.

Purpose of the Storage and Canals.

56. The storage and other works proposed would serve to protect a large area in the southern portion of the Ahmednagar District (where the rainfall is scarce) from famine, and to enable a small area in the Poona District to be planted with sugarcane and other valuable crops.

Soil Map, Kukadi Left Bank Canal.

57. A reference to the soil maps which accompany this report (scale 4 miles to 1 inch) is very instructive. For the 1st 18 miles, the Kukadi Left Bank Canal passes through an area of 1st class, or black cotton soil of excellent quality; for the next 52 miles up to the Hanga Nalla, the land commanded is evenly divided between 2nd class soil, "good for irrigation," and 3rd class soil "improved by irrigation." From the Hanga Nalla practically up to the border of the Shrigonda Taluka, the land commanded is nearly all 1st and 2nd class land; while from the border of the Shrigonda Taluks up to the Bilowara Nalla, or nearly the whole of the command in the Kurjat Taluka, the land is practically all either 3rd class, or unfit for irrigation. From the Bilowara Nalla up to the end of the command for this project on a line through Wuhal, Umbrad, Undargaon, and Sogaon, the land is nearly all 2nd class.

The protection of the south of the Ahmednagar District is very important and this area will form a large grain-producing district, practically in the centre of the Deccan famine tract. With the already good facilities for transport, grain could be distributed in time of famine, throughout the Deccan, with a comparatively low charge for freight.

Soil Map, Ghod Right Bank Canal.

58. On the Ghod Right Bank Canal the land is nearly all 3rd class, but in the valleys and near the river, there are small strips of 1st and 2nd class land, on which, in former times, were numerous fruit gardens. These, owing to frequent droughts, have disappeared, and their reintroduction would be of great value.

Rain and River Gauges.

59. Rain Gauges have been erected at the following stations:—

Kukadi Valley.

Station.	Date.
Junnar	1875
Malsaj	1907
Otur	1907
Pur	1907

Ghod Valley.

Station.	Date.
Ghoda	1875
Asne	1907
Aupa	1907
Manchar	1907

River gauges were erected at Shirapur on the Kukadi River in ... 1903

Ditto. at Edgaon on the Kukadi River in ... 1904

Ditto. at Nirgudsar on the Ghod River in ... 1904

Observations have been taken at all these gauges yearly since the dates on which they were erected.

River gauge readings were also taken after the monsoon was over, at Katapur on the Ghod, on a hot weather gauge from 1903 till 1907, when they were stopped.

APPENDIX No. I.

Kukadi Left Bank Canal Project.

Cost of Kukadi Left Bank Canal.

The cost of the canal without distributaries, as given in the original project revised by Mr. Beale, was Rs. 1,12,36,988.

The length of the canal was 130 miles and the discharge was 1,742 cusecs.

The length of the canal in the new project is 135 miles and the discharge required is 1,143 cusecs.

The cost of the canal without distributaries will therefore be ... $1,12,36,988 \times \frac{1,143 \times 135}{1,742 \times 130}$ = Rs. 76,52,400

The cost of distributaries has been separately worked out and amounts to ... ... ,, 16,65,483

Total for the new canal ... ... ,, 93,17,883

APPENDIX No. 2.

Kukadi Left Bank Canal Project.

Cost of Feeder Canal.

	Rs.
Cost of canal in original project	32,12,255
Discharge 1,742 cusecs.	
Deduct for Pimpalwandi Waste Weir crossing	9,32,931
Deduct for crossing Pimpalwandi Dam	1,42,212
Deduct for Mina aqueduct, if Mina project is constructed ...	93,676
Total deductions ...	11,68,819
Cost of original canal, less deduction	20,43,436
Discharge of New Canal ... 1,218 cusecs.	
Cost of new Canal ... ... $\frac{1,218}{1,742} \times 20,43,436$ = Rs.	14,28,714
The cost for distributaries has been separately worked out and amounts to ... ... Rs.	61,062
Total ... Rs.	14,89,776

APPENDIX No. 3.

Kukadi Left Bank Canal Project.

Kukadi Storage at Pimpalwandi. Areas and Volumes of the Tank.

Contour.	R. L. of contour.	Area in acres.	Area surveyed million sq. ft.	Contents between contours, million C. ft.	Gross total contents, million C. ft.	Total contents above outlet level, million C. ft.	Remarks.
34	**2060·14**	**1,118**	**48·71**	**552·78**	**552·78**	.....	Outlet level.
48	2074·14	2,232	97·24	1003·22	1556·00	1003·22	
54	**2080·14**	**2,825**	**123·07**	**659·42**	**2215·42**	**1562·64**	F. S. L. for new project.
83	2109·14	9,426	410·60	7596·58	9812·00	9259·22	
106	2132·14	14,900	649·02	9376·00	19188·00	18635·22	
110	**2136·14**	**16,045**	**698·92**	**2695·00**	**21883·00**	**21330·22**	
111	**2137·14**	**16,338**	**711·69**	**705·00**	**22588·00**	**22035·22**	F. S. L. for old project.

Note.—Surveyed areas and volumes in Roman type. Calculated areas and volumes in black type.

Total volume to F. S. L. for new projects = 2215·42 million cubic feet.

Volume below sill of canal sluices = 522·78 million cubic feet.

Volume available for Kukadi Left Bank Canal = 1562·64 million cubic feet.

APPENDIX No. 4.

Kukadi Left Bank Canal Project.

Statement showing that it is possible in most years to depend on the Kukadi River to supply the required volume of 9,182 million cubic feet during the 3½ months, 16th June to 30th September.

Year.	Month.	Discharge, million cubic feet.	Requirements for canal, million cubic feet.	Stored in Dam, million cubic feet.	Discharged over waste weir, million cubic feet.	Remarks.
1904	½ June ...	3,819	1311·5	1562	945·5	Irrigation would have begun on proper date.
	July ...	8,597	2623·5	Tank full ...	5923·5	
	August ...	7,019	2623·5	Tank full ..	4395·5	
	September ...	4,227	2623·5	Tank full ...	1603·5	
	October ...	1,027	2623·5	Tank emptied during the month.	.....	The supply from the river would have been sufficient for October.
1905	½ June ...	92	1311·5	92	.....	No irrigation possible in June.
	July ...	6,757	2623·5	1470	2663·5	
	August ...	3,805	2623·5	Tank full	1181·5	
	September ...	1,173	2623·5	111·5	.....	Tank practically empty at end of September.
1906	½ June ...	645	1311·5	.....	.....	Irrigation could have been started on 21st June.
	July ...	5,223	2623·5	1562	1037·5	
	August ...	2,388	2623·5	1326·5	.....	The supply from the river would have lasted till the middle of October.
	September ...	2,806	2623·5	1509	.....	
1907	½ June ...	208	1311·5	208	.....	No irrigation possible in June.
	July ...	10,685	2623·5	1354	6707·5	
	August ...	16,981	2623·5	Tank full	14357·5	
	September ...	966	2623·5	Tank emptied during the month.	.....	The supply is not quite sufficient to last till end of September.
1908	½ June ...	14	1311·5	14	.....	No irrigation possible in June.
	July ...	9,224	2623·5	1548	5052·5	
	August ...	13,405	2623·5	Tank full	10781·5	
	September ...	1,902	2623·5	834·5	.....	Supply sufficient to last till October 9th.

APPENDIX No 5.

Kukadi Left Bank Canal Project.

Ghod Storage at Sakora. Areas and Volumes of Tank.

Contour.	R. L. of contour.	Area in in acres.	Area as surveyed million. sq. ft.	Contents between contours million C. ft.	Gross total contents million C. ft.	Total contents above outlet level.	REMARKS.
20·5	**2,064**	**172**	**7·5**	**83**	**83**	...	Outlet level for Ghod Right Bank Canal.
58·5	2,102	1,410	61·4	1,145	1,228	...	Outlet for feeder Canal.
88·5	2,132	3,754	163·5	3,249	4,477	3,249	
108·5	2,152	6,187	269·5	4,218	8,695	7,467	
141·5	**2,185**	**10,523**	**458·4**	**12,093**	**20,788**	**19,560**	
Loss	at $1\frac{1}{2}$ ft.	on mean	area to middle of February				
		=	$\frac{61·4+458·4}{2}$		×1·5=390	million C.	ft.
	For Right Bank Canal after water has been drawn off to sill of Feeder Canal Sluice. Volume available for irrigation purposes from middle of February to middle of June.						
20·5	**2,064**	**172**	**7·5**	**83**	**83**	...	
58·5	2,102	1,410	61·4	1,145	1,228	1,145	
Loss	at $3\frac{1}{2}$ ft.	on mean	area from 7·5	middle of $\frac{+61·4}{2}$	February		
		=			× 3·5=121	million C.	ft.

Net volume for use on the Feeder Canal and Ghod Right Bank Canal up to the middle of February = 18,936 million cubic feet and the net volume for use on the Ghod Right Bank Canal after the middle of February = 1,024 million cubic feet.

Note.—Surveyed contours are in Roman type. Calculated contours area in black type.

C.—INVESTIGATION OF THE MINA VALLEY.

Surveys.

60. Only one site suitable for a dam was found on this river at Wadgaon, a small village about 4 miles west of Narayangaon, where a high rocky spur approaches close to the river on the Right Bank. On the Left Bank the ground slopes gradually to the top of the low ridge between the Mina and Kukadi Valleys, topographical sheet No. 196.

Wadgaon Dam Site.

The foundations, as shown by the results of numerous trial pits taken along the dam line, are very favourable, rock in no place being at any great depth below the surface. The rock is the usual Deccan Trap. Five contours were taken at R. Ls. 2209, 2234, 2274, 2289 and 2294, and from these the capacity of the tank has been worked out.

61. A special feature of the project is the waste weir, which from its position on the Left Bank on the ridge between the Mina and Kukadi Rivers, will discharge all the surplus water from the Mina into the Kukadi Valley. It follows that after the construction of this work, the only water which would flow down the Mina would be from the small catchment area on the Right Bank, about 30 square miles, where the average rainfall is small.

Waste Weir.

62. A Left Bank Canal has been aligned for a distance of 28 miles. The country passed through is generally easy, and the canal reaches the ridge line between the Mina and Kukadi Valleys 11 miles from Wadgaon, and therefore there are no important masonry works.

Left Bank Canal.

63. The gross command of this canal is 69,605 acres: the quality of the soil is good, and the project has been favourably reported on by the Revenue and Agricultural authorities. A contour for a small branch canal was run on the right bank of the river from Wadgaon for a length of 10 miles to command 9,000 acres; as the junction canal for the Kukadi project would command 4,100 acres of this area, the length of this branch is now reduced to 8 miles, and the total command of this project is therefore 74,505 acres.

Right Bank Branch Canal.

Details of the Project.

64. (*i*) Wadgaon Dam.

Catchment area, 65 square miles.

River Discharge.

River discharge-gauge at Wadgaon.

Year.	Discharge, million cubic feet.	Run off, inches.
1904	4,998	33·3
1905	4,408	29·4
1906	5,592	37·3
1907	7,162	47·7
1908	2,861	18·95

Maximum Flood.

The maximum flood discharge is valued at 1·00 inch per hour or 41,946 cusecs.

The greatest observed flood discharge was 36,640 cusecs on July 24th, 1906.

Bed Level at Dam Site ... ... R.L. 2179 above M.S.L.

Details of Dam and Waste Weir.

Proposed F.S.L and H F.L. ... R.L. 2294

Proposed outlet level ... ... R.L. 2209

Depth of water above sill	85 feet
Gross volume stored	4,920 million cubic feet.
Volume below sill	56 do. do. do.
Loss by evaporation, etc.	372 do. do. do.
Net volume available	4,492 do. do. do.
Area of land submerged	3,306 acres.
Number of villages submerged ...	5
Length of dam	8,769 feet.
Length of weir	580 do.
Estimated discharge over weir ...	42,812 cusecs.

Cost.

	Rs.
Cost of dam and waste weir ...	43,86,033
Cost of land and village compensation...	9,64,511
Total... Rs.	53,50,544

Cost per million cubic feet stored above sill, Rs. 1,087, which is very high figure indeed, for a Ghat tank.

65. (*ii*) Mina Left Bank Canal.

Length, 28 miles.

Details of the Canal.

Gross command including Right Bank Branch... 74,505 acres.

Culturable command ... ... 59,604 ,,

Irrigable command ... ... 19,868 ,,

Storage required.

For this project the following crop proportions were adopted by the Superintending Engineer, Special Duty, the favourable position of the valley, and the nature of the soil allowing the assumption that a high proportion of 8 months crops would be grown:—

Perennial	... ...	... 25 per cent.
8 months	... ...	... 45 do.
Rabi	... ...	... 15 do.
Monsoon	... ...	... 15 do.

With these proportions for every 1,000 acres irrigated, we have—

Crop.	Acres.	Equivalent Rabi irrigated acres.
Perennial	250 acres, watered eight times ...	2,000
8 months	450 acres, watered twice	900
Rabi	150 acres, watered once	150
Monsoon	150 acres, watered once	150
	Total ...	3,200

Discharge required.

The discharge required for each season is:

Monsoon or Rabi.	Equivalent 4 months.
250 acres perennial	500
450 acres 8 months	450
150 acres Rabi or monsoon	100
	1,050 acres

at 150 acres per cusec duty, the discharge required is 7 cusecs, or 18·15 million cubic feet per 1,000 acres per month.

In the hot weather 250 acres perennial crop at 40 acres per cusec requires 6 cusecs or 15·55 million cubic feet per 1,000 acres per month.

Volume required.

The volume required is, therefore,

	Million cubic feet		Months		1,000 acres.	
Monsoon and Rabi seasons	18·15	×	8	×	19·9=2,890	mil. c. ft.
Hot weather	15·55	×	8	×	19·9=1,238	,,
					4,128	,,

The net storage at Wadgaon would be 4,492 million cubic feet or 364 million cubic feet more than is required.

The discharge required at the head of the canal is 199 cusecs.

Cost. The cost of the canal and distribution is estimated at Rs. 4,44,632.

Purpose of the Storage and Canal.

66. The Storage and Canal would serve to irrigate a very fertile tract of land between the Mina and Kukadi Rivers which, owing to its position at some distance from the high ridge running eastward from the Ghats, is liable to suffer from scanty rainfall.

Whenever possible in this area, garden and other valuable crops are now grown by well irrigation, and it is hoped that water would be eagerly taken for irrigation, once the canal was constructed.

Financial Aspect.

Estimated cost of the Project. 67. Estimated cost.

	Rs.
Wadgaon Tank and Waste weir	53,50,544
Right Bank Branch	24,500
Left Bank Canal and Distributaries	1,44,632
Total ...	58,19,676
Add for all other charges 28 per cent.	15,69,488
Grand total, direct and indirect charges	73,89,164

Net Revenue. 68. The net revenue per acre irrigated will be :—

Crop	Water Rate per acre.	Revenue.	Working expenses per acre.	Working expenses.	Net Revenue.
		Rs.		Rs.	Rs.
Perennial, 0·25 acres...	24	6·00	6-0-0	1·50	4·50
8 months, 0·45 acres ..	6	2·70	1-8-0	·675	2·025
Rabi, 0·15 acres ...	3	0·45	0-12-0	·125	0·325
Monsoon, 0·15 ...	3	0·45	0-12-0	·125	0·325
1 acre	.....	9·60	...	2·425	7·175

Thus the net revenue on 19,868 acres irrigated will be 7·175 × 19,868 = Rs. 1,42,553, which is equivalent to a net return of 1·92 per cent. on the total cost of the project.

Rain and River Gauges.

69. Rain Gauges were erected at—

Shewali 1904
Damankhed 1907

A river gauge was erected at Wadgaon in 1904.

Observations have been made at all these gauges yearly since their erection.

D.—INVESTIGATION OF THE BHIMA VALLEY.

Surveys.

Karda and Kaman Sites.

70. Two storage sites have been partially investigated, one at Kaman, a small village about 7 miles west of the town of Khed, and the other at Karda, 3 miles further upstream. (See topo sheet No. 197.)

A few trial pits were taken out at Kaman, and the foundations appear to be favourable. No trial pits were taken at Karda, but rock is exposed at frequent intervals along the line. The investigations made are not sufficient to enable a definite decision being arrived at, as to which is the better site, but other things being equal, the Karda Site will probably prove the better, as the length of the dam will be considerably shorter there than at Kaman, and the difference in the catchment area is very slight.

Left Bank Canal Contour.

71. A Left Bank Canal Contour was run from Kaman for a length of 105 miles giving a command of 171,610 acres. (See topo sheets Nos. 197, 231 and 232.)

Right Bank Canal Contour.

72. In order to ascertain what area of land could be irrigated between the Bhima and the Mutha-Mula Rivers, a Right Bank Canal Contour was surveyed starting from Tulapur, a gorge at the junction of the Indrayani and Bhima Rivers (see topo sheet No. 232) for a length of 26 miles ; this yielded a command of 34,000 acres.

Low Level Left Bank Canal Contour.

73. A Left Bank Canal low level was also run from Tulapur for a length of 76 miles and the command of this was 53,216 acres.

Tulapur Pick-up Weir.

74. A site for a pick-up weir at Tulapur (see topo sheet No. 232) from which this canal was to start was surveyed and trial pits were dug.

Moshi Dam Site.

75. A dam site was partially investigated at Moshi (see topo sheet No. 232 on the Indrayani River, from which water could be let down to the pick-up weir at Tulapur, for use on the Right Bank Canal, in the event of the Bhima water not being sufficient for both canals.

Recommendations for further investigations. Small Project.

76. If any further investigations are to be made in this valley, it is recommended that a project be prepared for a storage tank at Karda (or Kaman) with a net storage of 4,410 million cubic feet, or gross storage of about 5,000 million cubic feet to irrigate 21,300 acres on the Left Bank. The gross command to give this irrigable area would be 30,000 acres, which is obtained by a canal 61 miles long.

The cost of the storage tank with a capacity of 7,500 million cubic feet, was roughly worked out in the report sent to Government in September 1907, at 18 lakhs rupees, so the cost of the storage proposed above, may be 18 lakhs rupees *i.e.*, Rs. 360 per million cubic feet stored, as the Karda site is a very favourable one. The Left Bank Canal was roughly estimated to cost 19 lakhs rupees.

Financial Aspects.

77. The financial aspects of a project on the lines proposed above are :—

	Rs.
Cost of Dam and waste weir	18,00,000
Cost of Left Bank Canal including Distributaries	19,00,000
TOTAL ...	37,00,000
Add 28 per cent. for all charges	10,36,000
GRAND TOTAL ...	47,36,000

78. The net revenue at Rs. 6·75 per acre irrigated on the production system would amount to 6·75 × 21,300=Rs. 1,43,775 which is equivalent to a net return of a little over 3 per cent. on the total cost.

Net Revenue.

79. If this project was found to pay, the dam at Karda (or Kaman) might then be raised to store 9,000 million cubic feet gross, which is as far as can be at present determined a safe average year's discharge of the Bhima River.

Possible extensions, small Project.

The net storage would be about 8,000 million cubic feet which would allow the Left Bank Canal to be extended for a distance of 54 miles, giving an additional command of 70,000 acres.

The construction of this extension will be very difficult, as from the 65th to the 95th mile, the contour passes through very broken ground (see topo sheet No. 232) and the cost of this portion of the line may prohibit the extension of the project.

It does not seem advisable to use any of the Bhima water for irrigation on the Right Bank of the river.

80. If any project is required for a Right Bank Canal, the Moshi Site on the Indrayani should be fully investigated for a storage tank and further investigations made for the pick-up weir site at Tulapur.

Further extensions on the Right Bank.

A survey should also be made for the Right Bank Canal starting from Moshi, and the cost of this canal from Moshi to Tulapur compared with the cost of the pick-up weir.

Purpose of the Storage and Canal.

81. This project, if constructed, would serve to irrigate the rich lands lying to the north of the Bhima River.

The rainfall in the commanded area is precarious, and the country is liable to suffer from famine.

The commanded area is very favourably situated, as Poona is only 16 miles from the edge of commanded area by the Poona-Ahmednagar Road, and 25 miles by the Poona-Nasik Road.

If the extended project is constructed, a large area of very fertile land lying at the junction of the Bhima and Ghod Rivers will be commanded. This portion of the command is within easy reach of the G. I. P. Railway from Poona to Sholapur *viâ* Khedgaon station.

Rain and River Gauges.

82. Rain Gauges have been erected at Bhimashankar, Wade and Chas, and Wadgaon, Khandala and Lonawle in the Indrayani Valley.

A river gauge was fixed at Kaman in 1906, and the following discharges have been observed:—

Catchment area 140 sq: miles	1906	Discharge	9,176	cusecs, run-off	27·75 in.
	1907	„	18,155	„ „	55·5 „
	1908	„	*24,064	„ „	74 „

No River Gauge has been erected on the Indrayani River.

H. F. BEALE,

27-4-09. *Superintending Engineer.*

* Figure supplied by the Executive Engineer on Special Duty. It appears to be abnormally high.

Abstract Statement of Discharge of the River Kukadi at Edgaon in million cubic feet.

Catchment Area, 265 Square Miles.

Months.	1904.	1905.	1906.	1907.	1908.	Remarks.
January	.....	.....	.....	.....	.....	
February	.....	.....	.....	.....	.....	
March	.....	.....	.....	.....	.....	
April	.....	.....	.....	.....	.....	
May	.....	.....	.....	.....	.....	
June	3,819	92	645	208	14	
July	8,547	6,757	5,223	10,685	9,224	
August	7,019	3,805	2,388	16,981	13,405	
September	4,227	1,173	2,806	966	1,902	
October	1,027	239	103	115	138	
November	43	8	6	31	32	
December	15	4	.....	21	27	
Total ...	24,697	12,078	11,171	29,007	24,742	
Equivalent run-off in inches	40·10	19·62	18·14	47·12	40·90	

Abstract Statement of Discharges of the River Kukadi at Shirapur in million cubic feet.

Catchment Area, 464 Square Miles.

Months.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	Remarks.
January	...	43	...	...	...	2	41	
February	...	9	...	...	...	...	28	
March	...	1	...	...	...	...	16	
April	...	...	...	...	...	...	14	
May	...	...	...	...	...	...	3	
June	...	458	2,984	73	1,235	203	1,136	
July	...	10,663	8,486	7,480	5,335	6,458	10,372	
August	...	7,277	6,567	4,261	3,542	17,191	14,215	
September	...	3,426	3,927	1,427	3,172	2,894	5,092	
October	...	1,301	285	193	166	1,669	1,465	
November	...	62	64	7	12	483	35	
December	...	19	10	...	5	43	39	
Total ...	10	23,259	22,293	13,441	13,467	28,943	32,456	
Equivalent run-off in inches...	...	21·59	20·68	12·47	12·49	26·85	30·11	

The figures for 1904 and for June 1907, appear to be unreliable. See Edgaon Gauge returns.

The high return for September and October 1907 and 1908 at this Gauge, when compared with Edgaon, are due to the North-East monsoon, which often does not reach the Ghat area.

Abstract Statement of the Discharge of the Mina River at Wadgaon in million cubic feet.

Catchment Area 65 Square Miles.

Months.	1904.	1905.	1906.	1907.	1908.	Remarks.
June	490	.....	642	1	.....	
July	1,979	2,274	1,787	3,638	1,081	
August	1,045	1,210	1,649	3,181	1,460	
September	1,247	573	1,209	116	221	
October	237	332	293	188	48	
November	7	10	6	25	35	
December	5	9	6	12	16	
Total...	5,010	4,408	5,592	7,162	2,861	
Equivalent run-off in inches	33·3	29·4	37·3	47·7	18·95	

Abstract Statement of the Discharge of the Ghod River at Sakora in million cubic feet.

Catchment Area 284 Square Miles.

Months.	1906.	1907.	1908.	Remarks.
June	1,026	410	.....	
July	7,810	16,378	12,950	
August	5,673	20,570	24,118	
September	4,267	1,976	8,192	
October	515	189	2,395	
November	178	50	157	
December	8	37	40	
Total...	19,477	39,610	47,852	
Equivalent run-off in inches	29·50	60·04	72·53	

Abstract Statement of the Discharge of the Bhima River at Kaman in million cubic feet.

Catchment Area, 140 Square Miles.

Months.	1906.	1907.	1908.	Remarks.
June	396	114	.....	
July	4,876	6,229	7,616	
August	2,210	10,939	13,812	
September	1,640	735	2,247	
October	61	96	263	
November	29	30	103	
December	5	12	23	
Total...	9,217	18,155	24,064	
Equivalent run-off in inches	28·27	55·82	73·99	

No. 12 of 1906.

From

J. B. KNIGHT, Esq., M.Sc.,

Professor of Agriculture,

Poona.

To

THE DIRECTOR OF AGRICULTURE,

Bombay—Poona.

Kirkee, 5th January 1906.

Sir,

With reference to your No. A-7421, dated 10th October 1905, I have the honour to state that I have inspected the area that will be commanded by the proposed Mina River Canal. I have visited every village, talked with the village officers and principal cultivators and critically observed the whole area.

This project seems to me far better than the Ghod on account of the following reasons:—

1. The land to be irrigated lies near the site of the dam and the water will not have to be carried for so long distance through a rocky and useless tract.

2. The soil is eminently suited to irrigation ranging from the lightest murum to a medium black, but nowhere too deep to interfere with the under-drainage.

3. The land in general is level, not cut up much by hills, but with gentle slopes towards Kukadi on the east and Mina on the west. There are now sufficient waterways to insure thorough drainage, so that water-logging will not occur to any great extent if these be kept open.

4. The whole valley, including that drained by Kukadi, Mina and lower Ghod and extending from the Ghats nearly to Sirur, is a beautiful stretch of level land better adapted to irrigation than any other equal extent of Deccan land which I have seen.

The little tank at Narayangaon and the small area under it has served as an object lesson to surrounding villages as to the great benefits of water from a canal.

Previous to the last seven years there was abundant rainfall and by means of the numerous wells, large areas of cane were formerly grown here, so that its cultivation is well understood.

Vineyards, orchards of oranges, sweet lime and plantains are frequently seen. The soil is evidently extremely well adapted to fruit culture and the people thoroughly understand how to grow it; all that is lacking is water. I was very much surprised to see how highly manure is valued in this region, how carefully it is saved and used. A lesson in this line might well be learned by cultivators from other regions. Indeed, I found the cultivators of this valley a very intelligent class of men, who are educating their children in the schools and trying in every way to improve themselves.

They were all keen to get irrigation and several showed that they were men of means and could immediately get the money to cultivate from 10 to 15 acres each.

There is no reason why, if a canal were opened here, this valley would not soon become a close rival to the Nira Valley in point of production of sugar.

This project should be classed among the productive as well as protective schemes.

With regard to the percentages of various crops, I anticipate that from 50 to 60 per cent. of the irrigation will be used for sugarcane or orchards and vineyards, and of the balance of 15 to 20 per cent. will go to the highly remunerative crops, like chillies, potatoes and groundnuts, the balance being wheat, jowar, grams bajri and the associated pulses.

Much of the land is suitable for irrigated cotton. In fact, any crop that will grow in this part of India will succeed in this beautiful valley if it is given suitable conditions of water.

To take up the points asked for in detail as follows :—

(*a*) *Kharif Season.*

Bajri mixed with math, kulthi or mug and udid sometimes with tur. Jowār mixed with mug, udid and tur. Chillies alone irrigated by wells.

Groundnuts alone irrigated by wells.

Tobacco ,, ,, ,,

Rabi Season.

Wheat, dry crop and irrigated crop.

Gram ,, ,, ,, ,, ,,

Shalu ,, ,, ,, ,, ,,

Fruits :—Grape, plantains, santras, oranges, sweet lime.

Garden :—Sugarcane, brinjal, sweet potato and other vegetables.

(*b*) The soil is ideal for this part of India for irrigation. Large deposits of lime show that the soil is very full of the alkalis which produce the saltness. Therefore, if the present natural drainage canals are not carefully kept open, there will be considerable salt land.

(*c*) Yes. The people are all keen to take water and even now offered the following rates for water :—

	per acre.
For cane, fruit and vegetables ...	Rs. 25
For chillies, groundnuts ...	,, 6
For wheat and gram	,, 2-8 to Rs. 3.
For shalu, bajri, etc.	,, 2

which are high rates for a new scheme so far from Poona.

(*d*) The water is wanted for perennial crops and will certainly be taken regardless of the rainfall.

(*e*) As already mentioned there are many well-to-do cultivators who will immediately cultivate large areas.

(*f*) I observed several forest areas flourishing on land quite suitable for raising sugarcane and one area of 40 acres or so in the village of Katapura which had evidently been thrown out of cultivation.

I have already treated of the per cents. of various crops.

There is one more thing to be mentioned—the young people from the villages of the valley are fast leaving it and going to Bombay for work. This shows that they have enterprize enough to move about rather than sit still and do nothing in hard times. But the sad part of it is that this superior class of young farmers' children are being forced by famine conditions to leave this area of fertile agricultural land which lacks only water. If these young people are not kept within

the valley by some inducement as the prospects of irrigation before they become settled in Bombay, there will be a great loss to this taluka. It is, therefore, imperative that this project be taken up energetically at once and not allowed to drag till too late. It is immeasurably more useful than the Ghod project, and I prophesy that it will pay after the first year, and just here, I wish to bring two things to notice; the first is that for the first year the water should be free so that the cultivator may turn all his money towards purchase of manure, preparation of his field and buying of sugarcane sets; the other is that an agriculturally trained officer, an L. Ag. should be on the Irrigation Engineer staff who should inspect all lands for which irrigation is applied for, and determine whether it is suitable for sugarcane and whether the owner is likely to give the proper cultivation. He should also by advice to the Irrigation Department point out the danger of salt or water-logging in every village and help them to restrict their irrigation properly, also advise them as to quantity of water necessary to the different soils under the different crops, and incidentally be of great use to the cultivators by giving advice. His work should be checked from time to time by an officer from the Agricultural Department.

I have, etc.,

(Sd.) J. B. KNIGHT,

Professor of Agriculture.

No. $\frac{A}{539}$ OF 1906.

Poona, 27th January 1906.

Copy forwarded with compliments to the Superintending Engineer on special duty in continuation of this office No. A-3663 of 24th May last.

The undersigned has the honour to recommend the scheme for early execution.

H. S. LAWRENCE,

Director of Agriculture.

REPORT ON KRISHNA VALLEY SURVEYS.

CONTENTS.

		Pages
1.	Report on the Krishna Valley Surveys	164 to 173
2.	Statements of Rainfall and River Gauges	174 & 175

INDEX TO

Report on the Krishna Valley Surveys.

Para.	Subject.
1	Situation.
2	Existing irrigation.
3	Scope of Special Duty Surveys.
4	Krishna Left Bank Canal Contour.
5 and 6	First project.
7 and 8	Larger scheme mooted. Low bed level of tributaries to Krishna River.
9	Storage Project on the Krishna River. Bijapur too high to be commanded.
10	The contour at R. L. 2000.
11, 12, 13	A project for pumping water from the Krishna.
14 and 15	Another project proposed by the Chief Engineer for Irrigation.
16 and 17	Cost of tunnelling.
18	Best project.
	A.—Investigation of the Koyna Valley.
	Surveys.
19, 20, 21	Kamargaon Tank.
22 and 23	Pick-up weir and feeder.
24	Canal extension.
	Details of the 1907 Project.
25	(i) Kamargaon Dam—River discharges, Maximum flood, Main features of storage work.
26	Cost of dam.
27	(ii) Pick-up Weir at Nisra—Main features of pick-up weir and feeder canal.
28	(iii) Canal—Main features of canal.
29	Command.
30	Discharge required.
31	Storage required.
32	Available supply.
33	Canal discharge.
34	Cost of canal.
35	Purpose of the storage and canal.
36	Disposal of produce.
37 and 38	Rain and River Gauges.
39	Financial Prospects—Capital cost.
40	Revenue.
41	Famine.
42	Soil map.
	B.—Investigation of the Krishna River.
	Surveys.
43 44 and 45	Dhom Tank.
	Details of the Project
46	River discharges, Maximum flood, Main features of storage work.
47	Cost of dam.
48 and 4	Purpose of the storage.
50	Proposed project.
51	Financial Prospects of (No. ii)—Capital cost.
52	Revenue.
53	Rain and River Gauges.

Tracings accompanying the Report on the Krishna Valley Surveys.

Note.—The office in which these plans are recorded is named in the list at page 63 following the Chief Engineer's Review.

No.	Subject.	Scale.
1	Kamargaon Dam Site	400′ to 1′ Horizontal.
	.....	2 to 1′ Vertical.
2	Nisra Pick-up Weir	Ditto.
3	Dhom Dam Site	Ditto.
4	Index Map	4 miles to 1 inch.
5	Soil Map	1 mile to 1 inch.

Topo sheets Nos. 200, 201, 202, 203, 235, 236, 237, 238, 270, 271, 272, 301, 302, 327, 328, 329, 351, 352	1 mile to 1 inch.

The Presidency Map (scale 8 miles to the inch) is prepared to show all the Special Duty Projects, and will be sent in with the last report.

REPORT ON THE KRISHNA VALLEY SURVEYS.

Situation.

1. The Krishna River rises in the Ghats, just north of Mahableshwar. A few small tributaries flow into it from this range of hills, before it is joined at Karad by the large Koyna River, whose source is on the southern slopes of Mahableshwar.

Existing irrigation.

2. The only use made by the P. W. D. of the water flowing from the catchment area of 2,040 square miles, between the Ghats and Karad, is the irrigation of 6,373 acres (10 years' average) out of a gross command of 26,453 acres, by means of the small Krishna Left Bank Canal, which takes off from a weir at Khodsi. There are also a few village bandharas in this tract, and the water-supply for Satara is obtained from the small Kas tank, at the head of the Urmodi valley; but with these exceptions the water of the Krishna flows unused out of the Presidency on the eastern borders of Bijapur.

Scope of Special Duty Surveys.

3. The Special Duty Surveys since 1902 have been directed towards investigating every reasonably possible method of utilizing the enormous volume of water yearly going to waste from the Krishna valley; but the result, as will be shown, has not been satisfactory.

Krishna Left Bank Canal contour.

4. The first point ascertained by a contour line, 298 miles long, in continuation of the existing Krishna Left Bank Canal, was that a canal starting from the Khodsi weir, with a fall of 8″ per mile, could not gain a greater command than 237,350 acres (of which 123,590 acres are subject to annual floods during the monsoon), by reason of the very low fall in the river bed (in this length only 9″ per mile), and the numerous hill-spurs running southward from the high lands of Satara, Bijapur, and the Jath State, which force the canal line towards the river. This survey is

shown in the Presidency map (8 miles to the inch) in dotted red, and on topo sheets Nos. 238, 270, 271, 272, 302, 323, 329, 351, 352, and on the index map 4 miles to 1 inch, Tracing No. 4.

First project.

5. A rough project was prepared and submitted to Government, under No. 897 of 29th May 1907, by the Superintending Engineer on Special Duty, for an extension of the existing canal upto the S. M. Ry. near Ugar, about 80 miles (by contour). The Krishna Canal is now 35 miles long, and the extended canal would probably, when aligned, be 105 miles long (see topo sheets Nos. 237, 238, 270, 271, 272). The total command of this project is only 108,582 acres, of which 63,942 acres are annually liable to be flooded by the river during the monsoon. This is less than half the command under other canals 100 miles long, and is a very low figure; but any further extension would give a still less favourable relation between the area commanded and the length of the canal, when compared with other projects.

6. It was shown that the water required for this canal could be obtained from the Koyna, by a dam above Helwak, and a pick-up weir considerably lower down, connected to the Khodsi weir by a short Left Bank Feeder canal. The cost was estimated at 82 lakhs of rupees, and the ultimate net revenue at about 2 per cent. on this. A more favourable financial forecast can be made, by assuming a greater area of irrigation, see figures given under details of 1907 project and financial prospects below. The net revenue may amount to 3 per cent. on the total cost.

Larger scheme mooted Low-bed level of tributaries to the Krishna river.

7. The next step, taken at the instance of the Chief Engineer for Irrigation, was to ascertain whether the Koyna water could be conveyed by a direct channel at a high level across the Krishna Valley so as to reach the high ground between Rahimatpur and Aundh. But the level of the ridge here is R. L. 2,608 (see topo sheet No. 236), while the bed of the Koyna River quite close to its source is only at R. L. 2,500. On account of the impracticability of tunnelling through the high hills on the left bank of the Koyna River, the only outlet eastward for the Koyna water is from Helwak, where the river bed is at R. L. 1,906 above M. S. L.

8. The other tributaries of the Krisna in British Territory lie to the north of the Koyna, and are comparatively insignificant streams. The levels of the various valleys are marked on the topo sheets Nos. 201, 202, and 203 with red circles round the figures for ready reference, and are as follows :—

Tributary or river.	Distance from source.	Bed level or level in the valley.
		R. L.
Tarla	20 miles	2,016
Urmodi	7 miles	2,236
Vena	12 miles	2,401
Kurali	11 miles	2,359

Storage project on the Krishna River.

9. The Krishna itself is in one of the highest valleys, and is the largest stream. A storage site was therefore selected and investigated on the upper reaches of this river, at a village called Dhom, situated about 16 miles from its source (see topo sheet 201). The river bed level at this site is R. L. 2,301. An examination of the levels given on the topo sheets, shows that a canal starting from this site could not possibly command the high lands of the Bijapur District, nor could it command any considerable area in the Krishna Valley except with an excessive length of canal.

Bijapur too high to be commanded.

10. The Chief Engineer for Irrigation directed that a R. L. 2,000 contour should be shown on the maps, as accurately as possible, from the G. T. S. levels and contours noted on the topo sheets. This has been done commencing from Helwak. It is a very instructive line, and helps to show the hopelessness of attempting to use the Koyna water for a large project for irrigation by ordinary methods. The contour line is over 150 miles long before it reaches the tail of the present Krishna Left Bank Canal. It is forced close to the river by high spurs at Shedbal (350 miles), Athni (500 miles), and Sawalgi (600 miles), and finally reaches the table-land west of Bijapur (775 miles). This contour, in conjunction with the facts already mentioned, proves conclusively that there is no practicable method of irrigating the high land to the east of Bijapur, with water from the Krishna Valley, by means of a direct channel from the valley.

The contour at R. L. 2,000.

11. In addition to the contour at R. L. 2,000, the Chief Engineer asked that a line should be drawn on the maps showing the position of a pumping station on the Krishna River Bank, and a suitable pipe line to deliver water into a canal, starting on the table-land above Bijapur, and high enough to command the land to the east of that town.

A project for pumping water from the Krishna.

12. The shortest length of the pipe line required to deliver water at R. L. 2,100 on the plateau above Bijapur would be 8½ miles, and the lift would be 416 feet. The water would be taken from the point of delivery by a canal 79 miles long, to a point on the eastern extremity of the table-land above Bijapur, whence all the country eastward, up to the boundary of the Nizam's Dominions, would be commanded. The town itself could be supplied with water from this channel. The possible gross command, however, of this scheme is 2,472,000 acres, and the water supply required for irrigation would be Acres $\frac{2,472,000 \times 8/10}{300}$ = 6,592 cusecs.

13. But the hot weather discharge of the Krishna River is very small indeed, and any scheme for irrigation from the river, without storage, would only operate for a few months in each year. A tank in the Ghat area would be required, if pumps are to be continuously employed.

No figures have been worked out for this scheme.

14. One more method of utilizing the Krishna water was suggested by Mr. Hill, Chief Engineer for Irrigation, namely, to construct the dam at Dhom, and carry the water from this tank to the Nira valley by tunnelling through the high dividing ridge between the valleys. The water would then be used to supplement the supply to the Nira Right Bank Canal, and enable it to be extended into the northern part of the Bijapur District.

Another project proposed by the Chief Engineer for Irrigation.

15. The length of the tunnel would be 7½ miles, and it would be 1,400 feet below ground at its deepest point. On reaching the Nira valley the water would find its way into the Nira River below Bhor, and flow down to the Vir weir. The cost of the tunnel would probably amount to 56 lakhs of rupees.

16. To discharge 4,579 million cubic feet from the tank in 5 months, January to June, the discharging section of the tunnel must be 42 square feet, and the velocity through it 10 feet per second. The proposed section of the tunnel would be 7′ wide and 6′ high with a vault-shaped roof. The quantity to be tunnelled = 7½ miles × 6·21 square yards = 82,000 cubic yards.

Cost of tunnelling.

17. The rate per cubic yard on the West of India Portuguese Railway, (commenced in 1882) was Rs. 30 for headings (average for 14 tunnels, aggregating 7,481 feet in length).

The rate per cubic yard on the Bombay (Tansa) Water Works was Rs. 24 for a section 7′ × 7′ 3″.

The rate per cubic yard on the Hong-Kong water works was Rs. 56 on a tunnel 2,428 yards long, 7′ 6″ wide and 7′ high, partially lined.

For the Krishna-Nira tunnel, on account of its length, a rate of Rs. 67·5 per cubic yard (2-8-0 per c.ft.) is adopted and the cost would be 56 lakhs of rupees.

Best project.

18. The best project, as shown below, is to make a tank at Dhom and let down water for the Krishna Canal Extension.

If it be proved that an extension of the high class irrigation can be anticipated on the flooded lands, and that the Miraj and Sangli States will foster such irrigation, then a scheme can be elaborated, which will pay more than 4 per cent. on capital expenditure.

A.—Investigation of the Koyna Valley.

Surveys.

Kamargaon Tank.

19. Before selecting the Kamargaon Dam site, the valley was carefully examined and surveys were made at five sites, see topo sheet No. 203.

20. Of these sites Nos. 1 and 5 were rejected, because they involved the drowning of the important village of Helwak and 6 miles of the Ratnagiri Ghat Road.

Site No. 3 was also rejected without detailed investigation, being obviously less favourable than the remaining two.

At site No. 4 some trial pits were dug, but site No. 2 (plan No 1) was finally adopted, as it proved to be the most favourable of all, as regards its position in the valley and its foundations, which are good sound trap rock, found at moderate depths throughout.

This site is about 4 miles above Helwak, and a little below the village of Kamargaon.

21. No contours were taken in the valley, but cross sections were surveyed at each mile, and the capacity calculated from these.

Pick-up weir and feeder.

22. As the water from this storage has to be delivered into the Krishna Left Bank Canal, which starts from the Khodsi weir on the Krishna above its junction with the Koyna (topo sheet No. 237) a feeder canal is required to convey the water to the Krishna.

For this purpose a pick-up weir is wanted on the Koyna, sufficiently far above its junction with the Krishna to enable a feeder canal starting from it to reach the Khodsi weir at the required level.

23. Three sites were selected for this weir (see topo sheet No. 237). The one marked A (Drawing No. 2) on the topo sheet, although involving the construction of a longer feeder canal than would be necessary from sites B and C, is probably the best, and was adopted for the 1907 Report. Sufficient investigation of the site was not made, as the actual foundation levels on either bank were not ascertained, but sound rock is exposed throughout the river-bed.

Canal extension.

24. The canal contour from the tail of the Krishna Left Bank Canal (referred to earlier in this report, see para. 4) was next surveyed. When it was shown conclusively that the area, which would be commanded by an extension of the existing canal upto the boundary of the Nizam's Dominions, was insignificant in comparison with its length, it was decided to

estimate for an extension of 80 miles only by contour, or probably 70 miles when finally aligned, making the length of the Krishna Left Bank Canal 105 miles (against an existing length of 35 miles). The gross command of this canal would be 108,582 acres, and 63,942 acres of this area are subjected to floods, when the river rises over its banks. This occurs to a certain extent every year.

Details of the 1907 Project.

(I)—Kamargaon Dam.

(Drawing No. 1).

25. Catchment area=346 square miles. River discharge, gauge at Helwak:—

River discharge.

Year.	Discharge in million c. ft.	Run-off in inches.
1902	98,301	122
1903	123,062	153
1904	111,285	139
1905	117,328	146
1906	116,670	145
1907	173,655	216
1908	188,795	234

Maximum flood.

The maximum flood discharge was given at $\frac{1}{2}$ inch per hour or 1,11,631 cusecs.

The greatest observed flood discharge was 104,577 cusecs on July 14th, 1903.

Main features of storage work.

River bed level at dam site ...	R. L. 1,906 above M. S. L.
Proposed F. S. L. and H. F. L.	R. L. 2,015.
Maximum depth of water	109 feet.
Proposed outlet level	R. L. 1,932.
Depth above sill of outlets	83 feet.
Gross volume stored	6,026 mill. cu. ft.
Volume below sill	36 „ „
Loss in tank from evaporation and absorption...	753 „ „
Net storage available	5,237 „ „
Area of land to be submerged	5,888 acres.
Number of villages submerged or partially submerged	17
Length of dam	2,550 feet.
Length of Right Bank waste weir	1,302 „
Length of Left Bank waste weir	325 „
Depth of water over weir crest	8 „

It is proposed to have automatic gates, to hold the water upto H. F. L.

Estimated discharge over waste weir 1,11,862 cusecs.

26. The cost of the dam and waste weir with land and village compensation was estimated at Rs. 21,22,776 or Rs. 354 per million cubic feet stored above the sill of the outlet sluices.

Cost of dam.

(II)— Pick-up Weir at Nisra.

Main features of pick-up weir and feeder canal (Drawing No. 2).

27.

Catchment area	...	541 square miles.
Flood discharge	...	½ inch per hour or 167,575 cusecs.
Length of weir		3,600 feet.
Height of flood over weir		6·12 „
Bed level at weir site		R. L. 1,829·61 above M.S.L.
Crest level of the Krishna Weir at Khodsi ...		R. L. 1859·81
Present F. S. L. in Krishna Canal		R. L. 1867·81
Proposed F. S. L. in Krishna Canal		R. L. 1868·81
Proposed crest level of the Krishna Weir at Khodsi.		R. L. 1871·81
Length of feeder canal		16 miles.
Fall from end to end of feeder canal		16 feet.
F. S. L. of crest of Nisra Weir will therefore be		R. L. 1887·81
Depth from bed level to crest		58 feet.
The feeder canal will be required to discharge...		370 cusecs.

The probable cost of the weir and feeder canal is given in the report as Rs. 21,00,000.

(III)—Canal.

Main features of canal.

28.

Length of existing canal	=	... 35 miles.
Extension	=	... 70 miles.
Total ...		... 105 miles.

29. The total gross command of this 105 miles of canal is 108,582 acres. The river floods its banks every year, and the area thus flooded is well fertilized; if this were to be omitted from the command, it would not be worth while extending the canal. It is, however, possible to grow sugarcane by irrigation on part of this area, which is only flooded occasionally, and for not more than 3 days at a time. Very good crops are ordinarily grown on the area which is regularly flooded without irrigation, and this portion is not likely to be irrigated. Assuming about ¼th of the area subject to floods as never irrigated, say 16,000 acres, the gross command may be taken as 92,080 acres.

Command.

Maximum area irrigable at ½ culturable = 37,000 acres.

Discharge required.

30. The discharge required is calculated as follows:—

For every 1,000 acres of irrigation we have:—

Crop.	Acres.	Equivalent rabi irrigated Acres.
Perennial ...	250 watered 8 times	2,000
8 months ...	250 „ twice	500
Rabi ...	250 „ once	250
Monsoon ...	250 „ „	250
	Total ...	3,000

The discharge required in each season is:—

Monsoon or Rabi Season.	Equivalent 4 months.
250 acres perennial	500 acres.
250 „ 8 months	250 „
250 „ rabi or monsoon	250 „
TOTAL ...	1,000 acres.

which, at 150 acres per cusec duty=7 cusecs for rabi and monsoon. In the hot weather 250 acres of perennial, at 40 acres per cusec duty=6 cusecs.

From the above the discharge per month during the monsoon and rabi seasons=18·15 million cubic feet per 1,000 acres irrigated, while in the hot weather it would be 15·55 million cubic feet.

Storage required.

31. The tank will be drawn off from for 9 months only, or one month monsoon, 4 months rabi, and 4 months hot weather seasons. The storage required will, therefore, be:—

			Mill. cu. ft.
1	Monsoon month	$18{\cdot}15 \times 37$ ...	= 671
4	Rabi months	$\ldots 4 \times 18{\cdot}15 \times 37$ ...	= 2,684
4	Hot weather months ...	$\ldots 4 \times 15{\cdot}55 \times 27$ ...	= 2,300
		Total ...	5,655

Available supply.

32. The net volume available at Kamargaon Tank is 5,237 million cubic feet, and in addition to this there is the after-monsoon discharge in the Krishna and Koyna Rivers; the supply, therefore, is ample.

Canal discharge.

33. The discharging capacity at the head of the canal will be $\frac{\text{irrigable area}}{100}$=370 cusecs.

The discharge shown in the 1907 Project was 286 cusecs.

The maximum designed discharge of the existing canal=140 cusecs. The work required consists in either realigning and constructing the whole canal, or in enlarging the existing canal, and constructing the extension of 70 miles.

Cost of canal.

34. The cost of the canal was given in the preliminary report at Rs. 21,00,000 or Rs. 20,000 per mile, which seems reasonable for the size of the canal.

One very difficult point on the canal will be the crossing of the Yerla River, where an aqueduct with 30 openings of 30 feet each will be required.

PURPOSE OF THE STORAGE AND CANAL.

35. The storage and other works proposed would serve to improve the irrigation near Karad, and render it possible to grow sugarcane, and other valuable crops on the rich lands near the river in Government Territory, and in Miraj and Sangli States. The percentage of perennial irrigation is already high under the existing canal and should increase when an assured supply of water is provided.

Disposal of produce.

36. The Southern Maratha Railway, which runs just outside the commanded area (see Presidency map) offers unusual facilities for transport. Several large market towns are situated either close to or inside the commanded area.

Rain and River Gauges.

37. Rain gauges were erected in this catchment at:—

Patan, Helwak, Bamnoli, Sonat, and Malcolm Peth.

38. A river gauge was put up at Helwak on the Koyna in 1902, and discharge observations have been made continuously since that year. The discharge of the river was gauged during the hot weather at Pundi in 1902, but the observations were discontinued after that year, as they were found to be unnecessary.

Financial Prospects.

Capital cost.

39. The rough estimate given in the 1907 Report, places the cost of the project at:—

	Rs.
Dam, etc.	22,00,000
Pick-up Weir and Feeder Canal	21,00,000
Enlargement and extension of canal	21,00,000
Total Irrigation Works	64,00,000
Add for all other charges 28 per cent.	17,92,000
Grand Total, Direct and Indirect charges	81,92,000

Revenue.

40. The net revenue per acre will be:—

Crop.	Water rate per acre.	Revenue.	Working expenses per acre.	Working expenses.	Net revenue.
		Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
¼ acre perennial ...	24	6 0 0	6 0 0	1 8 0	4 8 0
¼ „ 8 months ...	6	1 8 0	1 8 0	0 6 0	1 2 0
¼ „ rabi ...	3	0 12 0	0 12 0	0 3 0	0 9 0
¼ „ monsoon ...	3	0 12 0	0 12 0	0 3 0	0 9 0
1 acre irrigated ...		9 0 0		2 4 0	6 12 0

The result for 37,000 acres is—	Rs.
Gross revenue	3,33,000
Working expenses	83,250
Net revenue	2,49,750

This is equivalent to 3·00 per cent. on the total capital cost, direct and indirect.

Famine.

41. The area commanded is not seriously affected by famine.

Soil map.

42. Tracing No. 5 accompanying this report shows the excellent quality of the soil in the area commanded by this project.

B.—Investigation of the Krishna River.

Surveys.

43. The result of this investigation was reported on, under Superintending Engineer on Special Duty's No. 890 of 29th May 1907.

As noted in section 3 above under "Scope of Special Duty Surveys," the elimination of all the rivers south of the Krishna, as a source of supply for a canal to irrigate the eastern portion of Bijapur, left only the Krishna itself to be, considered.

Dhom Tank.

44. The only good site discovered for a storage tank is situated at the village of Dhom, some 5 miles above the town of Wai, (see topo sheet No. 201). The section (Drawing No. 3) appears a fairly favourable one, as hill-spurs approach close to the river on both banks. No trial pits have been taken, but on the right bank rock is exposed in several places. On the left bank it is possible that the foundation level may be rather deep, as in a well 3,700 feet from the river, ground level R. L. 2431·20, rock is not found till a depth of 40 feet is reached.

45. One contour was taken at R. L. 2401 and cross sections were taken at each mile, and the capacity calculated from these (see topo sheets Nos. 200 and 201).

Details of the Project.

46. Catchment area, 74·10 square miles; River discharge, gauge at Bhogaon a village about two miles below the dam site:—

River discharges.

Year.	Discharge in million cubic ft.	Run-off in inches.
1907	28,110	144
1908	26,160	134

Maximum flood.

The maximum flood discharge may be taken at 1 inch per hour or 47,819 cusecs.

The greatest observed flood discharge was 16,753 cusecs on July 25th, 1907.

Main features of storage work.

The bed level at the dam site	...R. L. 2300·66 above M. S. L.
Proposed F. S. L. ...	...R. L. 2405·66 above M. S. L.
Maximum depth of water	...105 feet.
Gross volume stored	...5,119 million cubic ft.
Loss from all causes, say $\frac{1}{8}$th	...640 „ „
Net storage	...4,479 „ „
Area of land submerged	...3,405 acres. „
Number of village sites submerged, or partially submerged	8
Length of dam	3,796 feet.
Length of waste weir...	904 „
Estimated discharge	48,231 cusecs.

Cost of dam.

47. The cost of the dam and waste weir with land and village compensation may amount to Rs. 450 per million cubic feet stored=Rs. 23,00,000.

Purpose of the Storage.

48. As water from this tank cannot be conveyed directly to the Bijapur lands, there are three other ways of making use of it:—

(i) Irrigation of lands on the Right and Left Banks of the Krishna near the town of Wai, by means of canals taking off directly from the tank.

(ii) Irrigation of lands under the extended Left Bank Krishna Canal below Khodsi weir.

(iii) Irrigation of lands in Northern Bijapur by means of a tunnel between the Krishna and Nira Valleys (for cost see para. 17 above).

49. Of these No. (iii) is out of the question, as the tunnel alone would cost 56 lakhs rupees.

No. (i) may prove a useful project, but no surveys have been made for the canals.

50. No. (ii) is probably the best way of using the water, as it would materially improve the financial prospects of the Krishna Left Bank Canal Extension Project.

Proposed project.

The storage proposed would not be sufficient for more than 30,000 acres of irrigation, for one month monsoon, 4 months rabi, and 4 months hot weather, or a gross area of 75,000 acres; hence the canal cannot be extended up to 105 miles, but would stop at 77 miles. On the other hand, a larger tank may be designed, as the discharge of the river appears to be satisfactory.

Financial Prospects of No. ii.

Capital cost.

	Rs.
51. Dam, etc.	23,00,000
Enlargement and extension of canal, 77 miles	15,00,000
Total Works	38,00,000
Add for all other charges 28 per cent.	10,64,000
Grand Total, Direct and Indirect charges	48,64,000

Revenue.

52. The net revenue will be 30,000 × Rs. 6·75 = Rs. 2,02,500 which is equivalent to 4·16 per cent. on the total Direct and Indirect Charges.

Rain and River Gauges.

53. A rain gauge has been erected in this catchment at Panchgani. A river gauge was put up at Bhogaon, 2 miles below the dam site in 1907 and discharge observations have been made continuously since that year.

H. F. BEALE,

Superintending Engineer.

Statement of the Standard Discharges of the River Krishna at Dhom from 1907. Catchment area, 83·82 square miles, 83·82 × 2·323 = 194·71,386 per inch run-off.

STANDARD.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total in cubic feet.	Equivalent run-off in inches.
1907	...	...	...	...	...	556	7,100	15,194	3,634	15,90	9	27	28,110	144
1908	...	...	...	...	...	64	11,741	10,464	3,657	109	81	44	26,160	134

Monthly rain gauged at Sonat, Bamnoli and Helwak.

Name of rain-gauge station.	Years.	June.	July.	August.	September.	October.	November.	December.	TOTAL.
Sonat	1907	2·71	89·75	94·5	5·59	...	0·61	...	193·16
	1908	20·045	125·455	45·73	8·92	1·10	2·0	...	203·25
Bamnoli ..	1907	3·3	65·63	78·61	8·27	0·8	0·32	0·2	157·13
	1908	13·005	49·51	34·17	8·76	2·02	1·18	...	108·64
Helwak ..	1902	...	93·91	39·79	25·00	3·30	1·49	5·71	169·20
	1903	16·46	120·15	48·27	16·99	9·66	1·06	...	212·59
	1904	54·78	62·74	41·59	17·46	5·32	...	...	181·89
	1905	19·46	95·17	34·84	11·09	8·13	0·93	...	169·62
	1906	45·25	81·99	39·59	23·55	0·39	0·78	...	191·55
	1907	4·05	17·90	10·68	5·62	0·16	1·70	...	40·11
	1908	27·48	145·77	83·22	7·72	1·20	0·23	...	265·62

Abstract Statement of the river Koyna at Helwak for the years 1902, 1903, 1904, 1905, 1906, 1907, 1908.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total discharges in million cubic feet.	Run-off in inches.
1902	...	...	...	...	...	...	54,334	26,030	22,856	1,185	389	362	105,156	122
1903	...	...	...	...	...	2,185	67,080	40,732	11,325	6,539	1145	446	129,452	153
1904	...	...	...	...	...	20,242	55,973	33,212	12,029	1,717	1122	562	124,857	149
1905	...	...	...	...	...	...	72,223	29,930	11,072	3,005	845	325	117,400	146
1906	...	...	...	...	...	9,712	61,703	26,966	17,983	1,681	386	181	116,670	145
1907	...	...	...	...	...	7,810	51,602	103,702	8,448	1,544	409	140	173,655	216
1908	...	...	...	...	...	2,513	106,018	70,303	7,620	1,586	518	237	188,795	235

Rainfall, in Inches.

No. of Years.	Krishna Valley.		Koyna Valley.
	Malcolm Peth.	Panchgani.	Patan.
1875 ...	340	.....	.....
1876 ...	243	.....	49
1877 ...	168	51	52
1878 ...	254	69	76
1879 ...	278	48	70
1880 ...	208	39	39
1881 ...	261	49	63
1882 ...	374	66	103
1883 ...	297	62	73
1884 ...	329	84	75
1885 ...	273	86	77
1886 ...	263	88	70
1887 ...	292	99	86
1888 ...	279	77	75
1889 ...	256	65	63
1890 ...	323	67	73
1891 ...	261	59	64
1892 ...	271	73	75
1893 ...	286	59	69
1894 ...	311	72	82
1895 ...	247	56	62
1896 ...	402	97	90
1897 ...	267	61	77
1898 ...	297	65	63
1899 ...	140	33	25
1900 ...	334	92	76
1901 ...	266	60	66
1902 ...	224	50	56
1903 ...	269	54	51
1904 ...	235	43	40
1905 ...	199	50	48
Average fall ...	272	64	66
No. of years ...	31	29	30
Minimum fall ...	140	33	25

GHATPRABHA RIGHT BANK CANAL PROJECT.

DADDI STORAGE.

CONTENTS.

		Pages
	Description	181 to 185
(*a*)	Estimates	185 to 191
(*b*)	Discharge through sluices	192
(*c*)	Calculations for discharge over weir	
(*e*)	Areas and volumes of tank	193 to 195
(*g*)	Abstract statement for land compensation	196 to 202
(*h*)	Abstract statement of village levels and house compensation.	203 to 206

GHATPRABHA STORAGE AT DADDI.

Index to Description.

	Paras.
Site	1
Comparision of sites	2
Foundations	3
Run-off from catchment	4
Size and design of dams	5
Do. of waste weir	6
Tail channel for waste weir	7
Protective wall and concrete apron	8
Sluices, etc., provided in dam	9
Description of contours	10
Land compensation	11
Village compensation	12
Kolhapur area and alternatives for Daddi Tank	13
Kalasgad gap	14
Belgaum-Vengurla Road diversion	15
Other roads	16
Comparison of R.L. 131 and 153 Tanks...	17

GHATPRABHA STORAGE AT DADDI.

GENERAL FEATURES.

		F. S. L. at R. L. 153 contour with automatic gates.
1.	Catchment area ... ... square miles.	410
2.	Average rainfall (in ordinary type) ... inches	Amboli. 267 | **138** Chandgad. 104 | **63** Wagothar. 215 Patne. 117
3.	Worst year's rainfall (in black type)... ...	
4.	Supply from river (average year), million cubic feet.	60,000 = 62″ run-off.
5.	Supply from river (worst year) „ „	30,000 = 31″ „
6.	Fall of river-bed above dam:—	
	Ghatprabha... ... ... feet per mile.	4·3
	Tamraparni... ... ... „ „	2·6
7.	Length of dam above ground ... ... feet.	2,870
8.	End walls below ground ... ... „	171
9.	Maximum depth of water above river-bed ... „	99·5
10.	Depth of F. S. L. to sill of outlet (R. L. 86) ... „	67
11.	Width of dam at top ... ... „	12
12.	Width of weir at crest ... ... „	19
13.	Construction of dam and weir	Coursed rubble masonry face-work, with uncoursed rubble hearting. Weir to contain cisterns for counter-weights and have piers on the crest. Roadway over whole length.
	Note.—The levels given below are referred to an arbitrary datum at Rajgoli which is 2,153·70 feet above mean sea level.	
14.	H. F. L. F. S. L. = R. L.	153
15.	Top of dam at F. S. L.	.....
16.	Top of parapets over F. S. L. ... ... feet	4·25
17.	Undersluices, R. L. 76	15 × 10′ × 6′
18.	Sluices for canal at R. L. 86	3 × 10′ × 6′
	Do. do. 115	3 × 10′ × 6′
19.	Crest of weir at R. L.	143
20.	Height of masonry on weir over weir crest ... feet	16·5
21.	Length of weir between abutments ... ... „	1,776
22.	Length of concrete wall at end of weir ... „	279
23.	Estimated maximum flood discharge inches per hour	0·5
24.	Do. do. do. do. cusecs.	1,32,287
25.	Description of weir	Clear overfall from sluice ways, fitted with automatic gates.
26.	Number of openings provided for weir ... No.	135
27.	Area of tank contour at R. L. 153. million square feet.	1,506·4
28.	Area of outlet level, R. L. 86 ... „ „	51·7
29.	Capacity of tank over sill of outlet „ cubic „	45,041
30.	Depth allowed for evaporation and absorption, feet on mean area.	4*
31.	Do. do. million cubic feet.	3,116
32.	Net available volume for discharge through sluices ... ... million cubic feet	41,925
33.	Cost of dam, weir and other works ... ... Rs.	52,91,348
34.	Cost of land and house compensation ... „	50,72,478
35.	Total cost ... ... „	1,03,63,826
36.	Cost of water stored above sill per million cubic feet. „	230

* October to June = 8 months.

GHATPRABHA STORAGE AT DADDI.

DESCRIPTION.

1. The proposed site for the dam is near Daddi, just below the junction of the Tamraparni with the Ghatprabha. Four alternative dam lines at short distances from each other have been carefully examined and trial pits dug to ascertain the nature of the foundations. The width of the valley at R. L. 153, depth of river bed, etc., at the several sites are given below:—

Site.

Site No.	Distance from Daddi, mile.	Width of valley at R. L. 153, feet.	R. L. of river bed.	Depth of river bed below R. L. 153, feet.	Probable volume of dam masonry at R. L. 153, 100,000 c. ft.	Remarks.
1	0	4,380	58·5	94·5	139	The river falls rapidly from site No. 3, and sites lower down will require high dams. There will, however, be no proportionate increase in the storage, as the valley is narrow for several miles below Daddi.
2	½	3,100	53·5	99·5	92	
3	1	2,120	41·0	112·0	74	
3A	1	2,070	35·0	118·0	72	

Comparison of sites.

2. The foundations are generally satisfactory on the left bank of the river at all sites. On the right bank it is good at sites 3 and 3A, but dips inwards and is very low at site 1. Site 3 or 3A would give the least volume of dam masonry, but it does not appear practicable to arrange for a suitable waste weir at either of the sites.

At site 1, there is a good site for waste weir on the left bank, but the rock line is low, and a dam will be very expensive owing to its great length.

Site 2 appears to be about the best, as besides satisfactory foundations, it has a fairly good site for the waste weir on the left bank.

The present estimates for the dam, etc., have been based with reference to site 2.

Foundations.

3. A number of bore holes and trial pits were dug and good rock found in all of them. The bore holes were completed after being taken 10 feet into hard rock, which at all the sites is a quartzite, reddish in colour. The foundations have been assumed to be taken $7\frac{1}{2}$ and 10 feet, respectively, for the dam and waste weir, according to the usual rule for the Special Duty Projects.

Run-off from catchment.

4. The catchment area of the river at the tank site is 410 square miles, of which 70 square miles is of the portion situated between Daddi and the original dam sites of Hadlag and Rajgoli. The statement below gives the combined discharge of the rivers as gauged at Hadlag and Rajgoli from 1903-1907.

The Ghatprabha had been gauged at Hadlag also from 1887 to 1891 :—

Year.	Total river discharge Hadlag and Rajgoli, million c. ft.	Equivalent run-off in inches on 410 sq. miles.	Rainfall in inches at				Remarks.
			Amboli.	Wagothar.	Chandgad.	Patne.	
1903 ...	66,509	89·8	259	219	98	117	Rainfall at Rajgoli in 1907, 45·44 inches. The 70 square miles catchment below Hadlag and Rajgoli has a weak rainfall and may not give a run-off of more than 2,000 million c. ft.
1904 ...	68,174	71·6	260	236	106	128	
1905 ...	35,674	37·5	179	167	64	86	
1906 ...	51,380	53·9	257	185	80	105	
1907 ...	86,903	91·2	279	263	123	149	

The supply that may be expected in ordinary years is at least 60,000 million cubic feet, of which it is proposed to store 45,000, the remaining 15,000 being passed direct into the canal during the monsoon.

For the maximum flood, provision has been made as before for a discharge of 132,287 cusecs, which is equivalent to a run-off of ½ inch per hour on the whole of the catchment.

Size and design of dam.

5. The storage required is obtained at R. L. 153, which is the F. S. L. proposed for the tank. The dam is 2,870 feet long and has a maximum height of 129 feet over bottom of foundations. The design is exactly similar to that adopted for other Special Duty Projects, with the exception of the offsets on the front and rear face, which have been omitted under instructions in the present design. Fresh calculations have been made for this new section, which show that the stability is not materially affected by the omission of the offset.

Size and design of waste weir.

6. The waste weir is on the left bank and is obtained by setting back the dam line from R. L. 120 and placing it along a contour. The position is not very favourable, as, owing to very sidelong ground, it involves both a heavy cutting at one side, and high overfall at the other. The ground on the right bank is flatter, but the weir cannot be placed there owing to the canal proposed on that bank, and besides the rock line there is lower.

The length of the weir is 1,776 feet, and its maximum height 64 feet. The openings provided are 135, each 10 feet wide, and to be fitted with automatic gates. The depth of flow is 10 feet and the maximum height of the overfall 29 feet. The design is exactly similar to that adopted in other Special Duty Projects.

Tail channel for waste weir.

7. The crest of the weir (R. L. 143) is well above the ground, and very little excavation is required for an approach channel. The tail channel will, however, be very expensive. This latter channel has been designed for a bed slope of 1 in 100, and a surface fall of 1 in 150. The width of the channel at its end opposite to the dam works out to 385 feet, the depth of the maximum flood there being 15 feet and the velocity 23 feet per second.

Provision is made for excavating the whole of the channel down to its bed, but it may be considered sufficient to excavate it only to about 10 feet below weir crest and trust to erosion to complete the removal of the material lower down up to the calculated bed. If this be approved, it might be possible to save about Rs. 2,00,000 from the estimated cost of the excavation.

Protective wall and concrete apron.

8. In order to divert the flood water from the downstream face of the dam, a protective wall 500 feet long is to be built in continuation of the weir on the downstream side, at its junction with the dam, and the tail channel will be continued to give the flood water a clear passage away from the dam.

The bed of the tail channel consists almost throughout of hard rock, but a narrow width of soft stuff is met with for a short distance along the toes of the weir. Two curtain walls are provided for this portion, one at the end of weir, and the other at 450 above.

A concrete apron 10 to 20 feet wide has been provided at the toe of the weir for the whole of the length in order to protect the foundations from scour. The apron may have to be covered with large boulders obtained from the excavations in order to enable it to withstand the shock of the overfall.

Sluices, etc., provided in dam.

9. Provision is made for the following sluices in the dam :—

(a) Undersluices,— 15 openings each 10′ × 6′ fitted with gates, are provided as per instructions.

The sill level is R.L. 76, which is 22·5 feet above river bed, and 77 below F. S. L. A full tank can be emptied by the sluices alone in 13·5 days. The number of openings may perhaps be reduced to 12, as there are three outlet sluices at R. L. 86, which also might assist in discharging the floods, the supply for irrigation, if wanted, being let out by the upper sluices.

(b) Outlet and upper sluices.—Three openings are provided at R. L. 86 and three at R. L. 115, all 10′×6′. The average discharge required for irrigation is 1,000 cusecs for the Gokak Canal, and 1,500 for the Right Bank Canal, a total of 2,500 cusecs. The openings provided would enable about double that discharge to be drawn off, if wanted, during periods of maximum irrigation.

The outlet level assumed for the Right Bank Canal during the actual surveys was R. L. 81. It is suggested that that level may be raised to R. L. 86 (please see para. 24 of Preliminary Report). The sill of the outlet sluices has, therefore, been assumed to be R. L. 86. The contents lost below R. L. 76 is 158 million cubic feet and that lost below R. L. 86 will be 514 million cubic feet.

(c) Turbine sluices.—Seven pipes each of $2\frac{1}{2}$ feet diameter have been provided as before, two to be fitted with valves and five with covers only.

(d) Working sluice.—One opening 4′×8′ is provided at the lowest level of the river bed, which will be closed permanently with masonry, when the dam rises to the level of the undersluices.

(e) Caging is provided for both the undersluices, and the lower set of outlet sluices at R. L. 86.

(f) Protective walls.—Two short walls are provided, one at the downstream side of the channel outside the undersluices, and the other between the above channel and the Right Bank Canal, which takes off immediately close to the undersluices. The canal bed will be 10 feet higher than the undersluice channel, and a wall will be required between the two as the space between the channels does not leave sufficient width of ground to retain the canal at the higher level.

Description of contours.

10. The following contours have been surveyed in the tank basin:—

(a) Above Hadlag dam site:—R. L. 110, 120, 130, 131, 138, 145, 148, 156, 160 and 168.

(b) Above Rajgoli dam site:—86, 96, 116, 131, 153 and 160,

(c) Above Daddi up to Hadlag and Rajgoli dam sites:—86, 106, 126, 131, 153 and 160.

The contours surveyed complete in the whole of the tank basin are those at R. L. 131 and R. L. 160. The former was the F. S. L. of the smaller tank required for the Gokak Project and the latter was surveyed in connection with the storage of 60,000 million cubic feet, which was originally proposed for the final stage of this tank. As now revised, the tank is to hold 45,000 million cubic feet, which is secured at F. S. L. 153.

The R. L. 153 contour has been surveyed complete in the Tamraparni Valley, and in the Ghatprabha only up to Hadlag. For the portion above Hadlag, the contour was not surveyed, but an intermediate value calculated from the actual values of the contours at R. L. 148 and 156, which have been surveyed. For calculating the land compensation, however, the figures for that valley have been assumed to be the same as for R. L. 156. The difference in the areas of the R. L. 153 and 156 contours is not great, and the error is on the safe side.

The area of the whole tank as calculated from the contour plans is equivalent to 34,942 acres, while the area according to the village registers is 35,161 acres. The difference is negligible.

11. The area and the assessment of the lands submerged in the tank are as follows:—

Land compensation.

	No. of villages affected.	Area in acres.	Assessment.	Proposed compensation.
			Rs.	Rs.
British—				
Surveyed	73	26,536	46,091	24,10,155
Unsurveyed	24	5,166	10,332	5,16,600
Kolhapur State—				
Surveyed	15	3,320	5,851	3,22,780
Unsurveyed	1	139	278	13,900
Total ...	113	35,161	62,552	32,63,435

The assessment in the case of unsurveyed villages has been assumed to be Rs. 2 per acre. The details of area under rice, garden and jirayat are given separately for each village in the abstract statement printed at pages 196-202.

The compensation has been valued as follows:—

Government land, rice and garden area...	... 50	times the assessment.
,, ,, jirayat	... 35	,, ,,
Inam and State, rice and garden area ...	... 60	,, ,,
Jirayat	... 40	,, ,,
Unsurveyed areas	... 50	,, ,,

In the case of the Kolhapur area, besides the above amount, a lump sum of Rs. 5,00,000 has been added as before to facilitate the acquisition of the State area, which is held under a Political Saranjam. The capitalized value of the abatement of the land revenue in the State has also been added as a direct charge to the cost of the tank.

12. The village sites affected are 74 in number, of which 41 will be wholly drowned: 7 of the villages belong to Kolhapur, out of which one will be wholly drowned, and the rest partially, including Nesari, in which the portion affected is one-third to the south of the village. The population affected is 21,100 British, 1,750 Kolhapur, total 22,850. The highest and lowest levels and the details of compensation are given for each village in abstract statement printed at pages 203-206. The house compensation works out to Rs. 10,64,746 for British and Rs. 77,632 for Kolhapur area, total Rs. 11,42,378.

Village compensation.

13. The area submerged in the Kolhapur State is 3,459 acres, which is only 1,381 acres more than that drowned by the F. S. L. 131 that was proposed for the smaller tank in connection with the Gokak Project. An alternative proposal to avoid altogether the damage to the State area, was to dam the Ghatprabha and Tamraparni separately at Adkur and Rajgoli, and to connect the two tanks by placing the waste weir of the former in a low gap (near Shirgaon) in the intervening ridge between the two rivers. The contents of the Adkur Tank would be used for the Gokak Canal, by letting out the water into the river and picking it up at Dhupdal. A plan showing levels along and across the ridge near Shirgaon has been prepared as directed.

Kolhapur area and alternatives for Daddi Tank.

14. A low gap was discovered in the main watershed of the Ghats near Kalasgad, about 3 miles above Patne. Its length at F. S. L. 153 is, however, very little, being 430 feet, and the lowest level is only R. L. 151·4. A small earthen bank is provided to close the gap.

Kalasgad gap.

15. The following miles of the Belgaum-Vengurla Road, and of the old Ramghat Road, are submerged by the tank:—

Belgaum-Vengurla Road—Miles 13·6 to 14·3, 15·8 to 16, 16·3 to 22·4, 22·9 to 23·1, 23·4 to 24·1; total 7·8 miles.

Old Ramghat Road—Miles 13·6 to 14·7, 20·5 to 20·6, 20·9 to 21·9, 22·2 to 22·3; total 1·9 miles.

Belgaum-Vengurla Road diversion.

A line of diversion has been sketched in on the Index Plans, commencing from the 13th mile of the Vengurla Road and joining it again in the 26th mile. The diversion would serve both the affected roads. The length may be about 28 miles, and the cost at the rate of Rs. 10,000 per mile will be Rs. 2,80,000.

Other roads.

16. Provision has been made also for the following works as in the previous project, all in lump sum :—

	Miles.
(i) A fair-weather road from Belgaum to Daddi *vid* Rajgoli ...	18
(ii) A fair-weather road from Butramhatti to Daddi	10
(iii) Metalling the existing Daddi Yemkanmardi road	10
(iv) Bungalow, office and store sheds.	

Comparison of R. L. 131 and 153 Tanks.

17. The following is a comparison of some of the main items of the tank as designed for the Gokak Canal Project alone, and as now proposed for both the Gokak and Right Bank Canals :—

No.	Items.	As designed for the Gokak Canal.	As now proposed.	Remarks.
1	Full supply level	R. L. 131	R. L. 153	
2	Depth above river-bed, feet ...	77·5	99·5	
3	Storage above outlet, million cubic feet	18,479	45,041	Volumes calculated up to dam site No. 2.
4	Villages submerged—			
	British Nos.	40	67	
	State Nos.	*Nil.*	7	
5	Land submerged—			
	British, acres	20,255	31,702	
	State, acres	2,078	3,459	
6	Cost of tank, including compensation	Rs. 71,00,000*	Rs. 1,04,00,000	
7	Cost per million cubic feet stored	384	230	

* Approximate.

(*a*)—Daddi Storage F. S. L. 153.

Abstract of Estimates—I.—Works.

Description.	Amount of Estimate.	Remarks.
	Rs.	
A—Preliminary expenses	75,000	
B—Land—		
Compensation for villages, British	10,64,746	
Do. do. Native	77,632	
Do. for land, British	29,26,755	
Do. do. Native	8,36,680	
Do. roads	13,440	
Add.—Capitalized abatement of Land Revenue for Native State	1,53,225	
C—Works	48,97,913	
K—Buildings	7,300	
M—Plantation	3,000	
O—Miscellaneous—Roads	3,07,000	
Embankment for Kalasgad-gap	1,135	
Total Works ...	1,03,63,826	

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

Ghatprabha Storage at Daddi, F. S. L., R. L. 153·00.

Abstract of Estimates.

Quantity.	Items.	Rate. Rs. a.	Per.	Amount. Rs.	Total. Rs.
	A.—Dam.				
	I.—Excavation for foundations.				
315,026 c. ft.	(1) In hard rock	7 0	100 c. ft.	92,052	
2,797,689 „	(2) In average rock ...	4 0	„	1,11,908	
1,225,696 „	(3) In soil boulders and soft rock	2 0	„	24,514	
173,951 sq. ft.	(4) Preparing foundations...	0 3	1 sq. ft.	32,616	
					2,61,090
	II.—Superstructure.				
7,717,882 c. ft.	(5) Uncoursed rubble masonry	20 0	100 c. ft.	15,43,576	
2,068 „	(6) Coursed rubble masonry.	28 0	„	579	
1,165,563 „	(7) Face work coarsed rubble masonry	32 0	„	372,980	
162,566 „	(8) Masonry for piers and walls over platforms, &c.	24 0	„	39,015	
12,683 „	(9) Masonry for arches ...	60 0	„	7,610	
2,103 „	(10) Paving	42 0	„	883	
77,320 „	(11) Curved coping and corbels	80 0	„	61,856	
47,407 „	(12) Extra for ashlar masonry.	50 0	„	23,703	
5,821 „	(13) „ for cement concrete	50 0	„	2,911	
516,009 „	(14) Concrete filling at toe of dam, &c.	18 0	„	92,882	
					21,45,995
	III.—Iron Works.				
31·5 tons.	(15) Caging to undersluices.	70 0	1 ton.	2,205	
15 Nos.	(16) Gates 10′×6′ for undersluices with frame and lifting gear	7,500 0	each	1,12,500	
3 „	(17) Gates for outlet sluices with frame and lifting gear	7,500 0	„	22,500	
3 „	(18) Gates for upper sluices with frame and lifting gear	6,000 0	„	18,000	
2 „	(19) Gates for turbine sluices, 30″ diameter, with frame and lifting gear.	800 0	„	1,600	
5 „	(20) Gates for turbine sluices, 30″ diameter, with covers only	150 0	„	750	
885·5 cwt.	(21) Cast iron pipes for turbine sluices	11 0	1 cwt.	9,741	
					1,67,296
	IV.—Approach and tail channel.				
	Excavation.				
869,000 c. ft.	(22) In average rock ...	4 0	100 c. ft.	34,760	
2,266,546 „	(23) In soil boulders and decayed rock	2 0	„	45,331	
					80,091

Quantity.	Items.	Rate.	Per.	Amount.	Total.
	V.—Protective walls at sluices.	Rs. a.		Rs.	Rs.
	Excavation for foundation.				
7,000 c. ft.	(24) In rock	7 0	100 c. ft.	490	
75,660 „	(25) In average rock ...	4 0	„	3,026	
29,610 „	(26) In soil and boulders ...	2 0	„	592	
	Superstructure.				
96,815 „	(27) Concrete wall with masonry casing	20 0	„	19,363	
					23,471
	VI.—Concrete and wall.				
1,368 c. ft.	(28) Excavation in rock ...	7 0	100 c. ft.	96	
25,308 „	(29) Excavation in average rock	4 0	„	1,012	
4,489 „	(30) Excavation in soil, boulders and decayed rock.	2 0	„	90	
	Superstructure.				
22,914 „	(31) Concrete wall up to F. S. L. 153	20 0	„	4,583	
					5,781
		Grand total	for dam..		26,83,724
	B.—Waste Weir.				
	VII.—Excavation for foundation.				
677,285 c. ft.	(32) In rock	7 0	100 c. ft.	47,410	
1,218,275 „	(33) In average rock ...	4 0	„	48,731	
720,262 „	(34) In soil and boulders ...	2 0	„	14,405	
67,728 sq. ft.	(35) Preparing foundations.	0 3	sq. ft.	12,699	
					1,23,245
	VIII.—Superstructure.				
1,957,434 c. ft.	(36) Heating of uncoursed rubble masonry ...	20 0	100 c. ft.	3,91,487	
342,987 „	(37) Coursed rubble masonry	32 0	„	1,09,756	
52,762 „	(38) Masonry for piers ...	42 0	„	22,160	
2,531 „	(39) Extra for skewbacks ...	60 0	„	1,519	
25,101 „	(40) Masonry in arching ...	60 0	„	15,061	
23,757 „	(41) Extra for paving ...	22 0	„	5,227	
21,978 „	(42) Coping and corbels ...	50 0	„	10,989	
101,890 „	(43) Extra for dressed sides of cisterns	20 0	„	20,378	
5,518 „	(44) Extra for arching for cisterns	30 0	„	1,655	
326,400 „	(45) Concrete at toe and over arches	18 0	„	58,752	
4,061 „	(46) Steps in manholes ...	42 0	„	1,706	
	Excavating trench in front of weir for gates.				
10,208 „	(47) In average rock ...	4 0	100 c. ft.	408	
32,649 „	(48) In soil and boulders ...	2 0	„	653	
					6,39,751

Quantity.	Items.	Rate.	Per	Amount.	Total.
	IX.—Iron Works.	Rs. a.		Rs.	Rs.
13,500 sq. ft.	(49) Automatic gates complete, including fixing.	33 0	1 sq. ft.	4,45,500	
135 No.	(50) W.—Iron covers over cisterns	50 0	each	6,750	
68 „	(51) W.—Iron covers over manholes	200 0	„	13,600	
					4,65,850
	X.—Waste weir channels.				
	Excavation.				
3,522,500 c. ft.	(52) In rock	7 0	100 c. ft.	2,46,575	
5,555,250 „	(53) In average rock ...	4 0	„	2,22,210	
5,849,990 „	(54) In soil boulders and soft rock	2 0	„	1,17,000	
					5,85,785
	XI.—Concrete apron and curtain walls.				
	Excavation.				
4,000 c. ft.	(55) In rock...	7 0	100 c. ft.	280	
214,631 „	(56) In average rock ...	4 0	„	8,585	
183,470 „	(57) In soil boulders and soft rock	2 0	„	3,669	
365,407 „	(58) Concrete apron... ...	18 0	„	65,773	
	Superstructure.				
27,229 „	(59) Curtain walls	24 0	„	6,535	
					84,842
	XII.—Protective wall at beginning of weir.				
	Excavation.				
28,280 c. ft.	(60) In rock	7 0	100 c. ft.	2,680	
83,564 „	(61) In average rock ...	4 0	„	3,343	
146,993 „	(62) In soil boulders and decayed rock ...	2 0	„	2,940	
	Superstructure.				
207,197 „	(63) Concrete wall with masonry casing ...	20 0	„	41,439	
					50,402
	XIII.—Concrete end wall with earthen embankment.				
	Excavation.				
2,232 c. ft.	(64) In rock	7 0	100 c. ft.	156	
7,416 „	(65) In average rock ...	4 0	„	297	
13,338 „	(66) In soil boulders, etc.	2 0	„	267	
	Superstructure.				
13,642 „	(67) Concrete wall	20 0	„	2,728	
39,477 „	(68) Embankment	1 4	„	493	
5,655 s. ft.	(69) Pitching	8 0	100 s. ft.	452	4,393
	Grand Total for waste weir...			...	19,54,268

Quantity.	Items.	Rate.	Per	Amount.	
	C.—*General.*	Rs. a.		Rs.	Rs.
3,552 R. ft.	(70) Hand railing	1 8	1 R. ft.	5,328	
36,487 c. ft.	(71) Road on top of dam and weir including consolidation	4 0	100 c. ft.	1,459	
2 No.	(72) Road gates	100 0	each	200	
	(73) Pumping and bailing water	Lump sum.		3,000	
	(74) Clearing site of dams ...	,,	,,	1,000	
	(75) Do. area after completion	,,	,,	500	
	(76) Clearing masonry after monsoon	,,	,,	1,200	
	(77) Sheds	,,	,,	6,000	
	(78) Works, road	,,	,,	1,500	
	(79) Kilns	,,	,,	3,000	
	(80) Testing machines ...	,,	,,	1,000	
	(81) Sanitary arrangements...	,,	,,	2,500	
	Total for General...	...	...	...	26,687
	Total for dam and weir...	...	...	...	46,37,992
	Total ...	...	...	...	46,64,679
	Contingencies at 5 per cent.	...	...	...	2,33,234
	Grand Total ...	...	...	...	48,97,913

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

Ghatprabha Storage at Daddi.

Embankment for the gap near Kalasgad.

Abstract of Estimates.

Quantity.	Items.	Rate.	Per.	Amount.	Total.
		Rs.		Rs.	Rs.
69875 c. ft. ...	Embankment	1	100 c. ft.	699	
5450 sq. ft. ...	Pitching	7	100 sq. ft.	382	
	Total... Rs.	...	.....	1,081	
	Contingencies at...		5%	54	
		Grand Total...			1,135
	Roads.				
	Works—				
28 miles ...	Diversion of Vengorla Road...	10,000	per mile.	2,80,000	
18 „ ...	Fair weather road from Belgaum to Daddi... ...	250	„	4,500	
10 „ ...	Fair weather road from Butramhatti to Daddi... ...	250	„	2,500	
10 „ ...	Metalling the existing Daddi-Yamkanwardi Road ...	2,000	„	20,000	
		Grand Total...			3,07,000
	Land Compensation.				
336 acres ...	33 ft. = 4 acres per mile for 28 miles of fair weather road 28×4 = ...112				
	66 ft. for Vengorla road =8 acres per mile for 28 miles, 28×8 = ...224				
	Total... 336	40	per acre	13,440	13,440
	Buildings.				
1 number ...	1st class bungalow and outhouses	6,500	Lot.	6,500	
1 „ ...	Office and store-shed ...	800	„	800	7,300
	Plantation.				
	Fence round tank and trees...	.....	.....	3,000	3,000

DADDI STORAGE.

Statement showing depths and nature of foundation for the various parts of the dam.

F. S. L. 153.

Chainage.	Reduced level of ground.	Reduced level of bottom of foundation.	Height of dam.			Depth of excavation.					Remarks.
			Below ground.	Above ground.	Total height.	In rock.	In average rock.	In soil and boulders.	In earth.	Total depth.	
175	120·0	90·5	29·5	33	62·5	7·5	16	6	Nil.	29·5	
...	...	...	...	...	...	7·5	9·5	7	„	24·0	
600	76·5	58·75	17·75	76·50	94·25	7·5	3·0	7·5	„	18·0	
...	...	...	...	...	...	7·5	6·5	7·0	„	21·0	
1,132	56·0	32·5	23·5	97·0	120·5	7·5	10	6	„	23·5	
...	...	...	...	...	...	10	12	4·5	„	26·5	
1,200	53·5	24·0	29·5	99·5	129	13	13·5	3	„	29·5	
...	...	...	...	...	...	10	16·5	4	„	30·75	
1,300	56·0	24·0	32	97	129	7·5	19·5	5	„	32·0	
...	...	...	...	...	...	7·5	20·5	5·5	„	33·5	
1,600	59·0	24·0	35	94	129	7·5	21·5	6	„	35	
...	...	...	...	...	...	7·5	23·5	7	„	38	
2,100	91·5	50	41·5	61·5	103	7·5	25·5	8·5	„	41·5	
...	...	...	...	...	...	7·5	19	5	„	31·5	
2,500	114·0	93·0	21	39	60	7·5	12	1·5	„	21·0	
...	...	...	...	...	...	7·5	11·5	5·5	„	24·5	
2,687	131·0	103·0	28	22	50	7·5	11	9·5	„	28	
...	...	...	...	...	...	5	23·5	6·5	„	35	
3,045	157·25	115·75	41·50	...	37·25	2	36	3·5	„	41·5	
					Concrete and wall.						
3,045	157·25	115·75	41·50	—4	37·5	2	36	3·5	„	41·5	
...	...	...	...	...	...	2	37	3·5	„	...	
3,216	165·0	121·5	43·50	—12	31·5	2	38	3·5	„	43·5	

DADDI STORAGE.

Statement showing depths and nature of foundation for the various parts of the waste weir.

Crest Level R. L. 143.

Chainage.	Reduced level of ground.	Reduced level of bottom of foundation.	Height of weir up to crest.			Depth of excavation.					Remarks.
			Below ground.	Above ground.	Total height.	In rock.	In average rock.	In soil and boulder.	In earth.	Total depth.	
0	120·0	88	32·0	23	55	10	16	6	*Nil.*	32·0	
L=606	...	...	...	...	...	10	18·5	11	„	...	
606	126·0	79 25	47	17	64	10	21	16	„	47·0	
L=374	...	...	...	...	...	10	24	10	„	...	
980	132·5	91·75	41	10·5	51·50	10	27	4	„	41·0	
L=277	...	114·0	...	...	...	10	15·5	5·5	„	...	
1,257	134 25	114·0	20·5	8·75	29	10	4	6·5	„	20·5	
L=344	...	...	...	...	...	10	11	5 5	„	...	
1,601	134·0	101·75	32·50	9	41·50	10	18	4·5	„	32·50	
L=175	...	...	...	...	...	10	15	4·5	„	...	
1,776	146 0	120·0	26	—3·0	23	10	11·5	4·5	„	26 0	
			Concrete wall at end up to the F. S. L. 153								
1,776	146·0	128	18	7	25	2	11·5	4·5	„	18·0	
...	...	...	...	...	...	2	8	5	„	...	
1,947	157·5	145·5	12·0	—4·5	7·5	2	4·5	5·5	„	12·0	
...	...	...	...	...	...	2	4·5	5 5	„	...	
2,055	163	151	12	—10	2	2	4·5	5·5	„	12·0	

(*b*).

GHATPRABHA STORAGE AT DADDI.

Calculations for discharge through under-sluices.

It may be assumed that the depth of water in the tail channel will be 10 feet above the floor of sluice and that the mean effective head on the sluice will be

$= \frac{2}{3}$ of depth of F. S. L. of tail channel below F. S. L. of tank.

$= \frac{2}{3} \{ 153 - (76+10) \} = \frac{2}{3} \times 67 = 44{\cdot}66' = h.$

The sluices are to be $6' \times 10'$ in size.

Discharge for one sluice = C. A. $\sqrt{2gh} = 0{\cdot}8 \times (10 \times 6) \times 8{\cdot}02 \sqrt{44{\cdot}66}$ = 2,579 cusecs.

The discharge for one day will be = $2579 \times 86{,}400 = 222{,}845{,}645$ c. ft.

With 15 sluices the discharge will be = $15 \times 222{,}845{,}645 = 3{,}342{,}684{,}672$ c. ft.

The tank is to store 45,000 millions c. ft., and the time required for emptying it will be $\frac{45000}{3342{\cdot}68} = 13\frac{1}{2}$ days nearly.

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

(*c*).

DADDI STORAGE.

Waste weir discharge.

The catchment area is 410 sq. miles. The maximum run-off may be $\frac{1}{2}$ inch per hour $\therefore$ discharge $= \frac{410 \times 645{\cdot}3}{2} = 132{,}287$ cusecs.

For a weir with clear overfall, open top and with openings separated by piers, take :—

$$\text{,, } D = \frac{2}{3} cbh \sqrt{2gh}.$$

with $C = 0{\cdot}577$

In the present design $b = 10$ feet and $h = 10$ feet.

Then for each opening

$$D = \frac{2}{3} \times 0{\cdot}577 \times 10 \times 10 \sqrt{2g} \times \sqrt{10} = 976{\cdot}4 \text{ cusecs.}$$

Number of openings required

$\frac{132287}{976} = 135$ nearly.

135 openings have been allowed for.

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

(*e*).

GHATPRABHA STORAGE AT DADDI.

Areas and Volumes of Tank.

F. S. L. 153.

Contour, R. L.	Area in million square feet.	Volume between contours, million cubic feet.	Total Volume million cubic feet above outlet.	Remarks.
Area from Daddi Dam upto Rajgoli and Hadlag Dam Sites.				
53·5				River bed level.
76	**18·8**	**141***		* Volume below R. L. 76 calculated.
86	40·7	290·5	290·5	Outlet level.
106	105·5	1,411·4	1,701·9	
116	**1371·7**	**1,210·0**	**2,911·9**	
126	168·8	2,718·4 above R. L. 106	4,420·3	
131	183·7	881·0	5,301·3	
153	236·2	4,606·8	9,908·1	
160	285·6	1,823·5	11,731·6	
Area above the Rajgoli Dam.				
65				River bed level.
76	**3**	**11**		Calculated.
86	11	65 7	65·7	Outlet level.
96	83· 8	326·0	391·7	
106	**214·53**	**1,441·0**	**1,832·7**	
116	405	4,487·0 above R. L. 96	4,878·7	
126	**571**	**4,863·0**	**9,741·7**	
131	662	7,923·90 above R. L. 116	12,802·6	
153	1,036·5	18,531·3	31,333·9	
160	1,269·5	8,057·0	39,390·9	

Contour, R. L.	Area in million square feet.	Volume between contours, million cubic feet.	Total Volume, million cubic feet above outlet.	Remarks.
Area above the Hadlag Dam Site.				
98	.....	.....		River bed level.
106	**2·00**	**5·3**		Below R. L. 106 calculated.
110	4·5	18·00	18·00	
116	**10·12**	**42 60**	**60·30**	Calculated.
120	22·3	122·80 above R. L. 110	140·80	
123	**57**	**344 8**	**485·6**	Calculated.
130	84·6	501·2 above R. L. 120	642	
131	95·5	90·00	732	
138	124·5	767·70	1,499 7	
145	170·1	1,027·10	2,526·8	
148	197·9	551·6	3,078·4	
153	**233·6**	**1,077·50**	**4,155·9**	Calculated.
156	249·5	1,785·40 above R. L. 148	4,863·80	
160	298·3	1,094·10	5,957·90	
Combined figures for the whole tank above Daddi.				
53·5	.....	.....		River bed level.
76	**21·8**	**158**		Outlet level up to R. L. 76, calculated.
86	51·7	356·2	356·2	Outlet level.
106	**322·0**	**3,178·4**	**3,534·6**	Calculated.
116	**552·3**	**4,316·6**	**7,857·2**	do.
126	**796·8**	**6,796·4**	**14,647·6**	do.
131	941·2	18,479·7	18,835·9	
153	**1,506·3**	**26,562·0**	**45,397·9**	Calculated for portion above Hadlag, surveyed in the rest of the basin.
160	1,853·4	11,682·5	57,080·4	

The total capacity from

R. L. 86 to R. L. 153 is

9,903·1+31,333·9+4,155·9 = 45,397·9 million c. ft.

Deduct for loss by evaporation:—

Area of contour at R. L. 153

236·2+1,036·5+233·6 = 1,506·3 million sq. ft.

Area at R. L. 86

40·7+11+0 = 51·7 „ „

1,558·0 „ „

Mean area 779·0 „ „

Assuming depth of loss 4 ft.
(from October 15 to June 15)
the loss will be 779 × 4 = 3,116 „ „

Net volume available for irrigation 42,282 million c. ft.

P. N. NATESAIYER,

Executive Engineer on Special Duty,
Gokak Survey.

Note.—The tank will be maintained at its F. S. L. during the remaining four months by the monsoon floods.

(g).

GHATPRABHA STORAGE AT DADDI.

Abstract statement giving the details of areas submerged for all the villages affected by R. L. 153.

NOTE:—For villages above Hadlag dam site, the details of areas, etc., given are for R. L. 156 contour.

Serial No.	Names of villages.	Taluka.	Whether in Ghatprabha or Tamraparni Valley or on what bank.	Area.	*Deduct*-Pot Kharab.	Details for the remaining cultivable area.								Remarks.
						Dry crops.		Garden.		Rice.		Total.		
						Area.	Assessment.	Area.	Assessment.	Area.	Assessment.	Area.	Assessment.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
				A. g.	A. g.	A. g.	Rs.	A. g.	Rs.	A. g.	Rs.	A. g.	Rs.	
	Government villages.													
1	Chinchani	Belgaum ...	Tamraparni River, Left Bank.	367 34	155 16	141 1	52	...	...	71 17	22	212 18	275	
				419 14	**6 28**	**321 38**	**134**	...	...	**90 28**	**277**	**412 26**	**411**	
2	Dundaga	„ ...		281 24	3 37	168 24	101	...	...	109 3	456	277 27	557	
				179 31	**2 32**	**84 36**	**60**	...	...	**92 3**	**361**	**176 39**	**421**	
3	Kowad	„ ...		251 11	2	80 38	69	...	...	168 13	558	249 11	627	
				395 3	**3 23**	**105 15**	**85**	...	...	**286 5**	**1,147**	**391 20**	**1,232**	
4	Nitur	„ ...		238 36	2 13	78 37	45	...	...	157 26	672	236 23	717	
				534 27	**6 12**	**207 8**	**173**	...	...	**321 7**	**1,302**	**528 15**	**1,475**	
5	Ghulewadi	„ ...		171 33	6 23	54 31	47	...	...	110 19	389	165 10	436	
				153 31	**1 38**	**47 9**	**38**	...	...	**104 24**	**420**	**151 33**	**458**	
6	Mahalewadi	„ ...		230 1	6 1	146 35	76	...	...	77 5	225	224 0	301	
				156 8	**2 13**	**67 12**	**54**	...	...	**86 23**	**284**	**153 35**	**338**	
7	Mangaon	Chandgad ...		368 17	3 19	204 29	91	...	...	160 9	688	364 38	779	
				189 37	**2 14**	**74 19**	**42**	...	...	**113 4**	**445**	**187 23**	**487**	
8	Dukarwadi	„ ...		460 27	4 0	227 0	126	0 10	1	229 17	899	456 27	1,026	
				169 25	**0 9**	**41 12**	**19**	...	...	**128 4**	**528**	**169 16**	**547**	
9	Chandgad	„ ...		325 31	2 25	212 33	56	0 23	1	109 30	292	323 6	349	
				222 36	**0 34**	**57 27**	**18**	...	...	**164 15**	**473**	**222 2**	**491**	
0	Adur	„ ...		88 12	1 37	47 20	13	1 6	5	33 29	105	82 15	123	
				32 4	**0 12**	**3 4**	**1**	...	...	**28 28**	**100**	**31 32**	**101**	
1	Kokare	„ ...		115 12	1 25	41 1	14	3 15	5	69 11	216	113 27	235	
				50 4	**0 37**	**18 29**	**6**	...	...	**30 18**	**103**	**49 7**	**109**	
2	Nhaweli	„ ...		98 19	0 31	57 10	17	...	...	40 18	101	97 28	118	
				43 39	**0 11**	**21 36**	**6**	...	...	**21 32**	**52**	**43 28**	**58**	
3	Umgaon	„ ...		200 15	6 28	130 22	29	...	...	63 5	140	193 27	169	
				11 24	...	**0 1**	...	...	...	**11 23**	**31**	**11 24**	**31**	
	Jambra	„ ...		16 28	1 29	0 29	1	...	...	14 10	39	14 39	40	

15	Rajgoli, B.	Belgaum ...	Tamraparni River, Right Bank.	303	37	52	18	114	1	68	...		...	187	18	691	251	19	789
				180	**20**	**1**	**0**	**67**	**2**	**51**	...		...	**112**	**18**	**597**	**179**	**20**	**648**
16	Kudnur	„ ...		646	30	15	27	241	7	217	3	28	6	386	8	2,117	631	3	2,340
				313	**33**	**3**	**17**	**127**	**35**	**130**	...		...	**182**	**21**	**965**	**310**	**16**	**1,095**
17	Kitwad	„ ...		4	8	...		2	33	2	...		...	1	15	6	4	8	8
18	Kalkundri	„ ...		340	7	14	9	94	13	85	2	1	10	229	24	1,031	325	38	1,126
				524	**32**	**5**	**33**	**192**	**28**	**172**	**5**	**12**	**26**	**320**	**39**	**1,408**	**518**	**39**	**1,606**
19	Kagni	„ ...		167	38	1	10	59	25	50	...		...	107	3	480	166	28	520
				252	**8**	**2**	**29**	**86**	**35**	**73**	...		...	**162**	**24**	**716**	**249**	**19**	**789**
20	Hundalwadi	„ ...		81	9	1	0	30	25	24	...		...	49	24	194	80	9	218
				140	**34**	**0**	**39**	**33**	**33**	**36**	...		...	**106**	**2**	**380**	**139**	**35**	**416**
21	Kini	„ ...		266	31	11	8	117	36	79	...		...	137	27	565	255	23	644
				387	**22**	**3**	**6**	**181**	**37**	**154**	...		...	**202**	**19**	**871**	**384**	**16**	**1,025**
22	Nagardala	„ ...		155	27	1	37	63	19	41	...		...	90	11	364	153	30	405
				156	**35**	**2**	**2**	**37**	**0**	**29**	...		...	**117**	**33**	**505**	**154**	**33**	**534**
23	Kadilga Bk.	„ ...		284	23	7	4	127	15	89	...		...	150	4	595	277	19	684
				221	**14**	**1**	**5**	**83**	**11**	**60**	...		...	**136**	**38**	**522**	**220**	**9**	**582**
24	Kadilga Kd.	„ ...		159	14	2	32	112	25	63	...		...	43	37	173	156	22	236
				64	**13**	**0**	**19**	**37**	**0**	**26**	...		...	**26**	**34**	**101**	**63**	**34**	**127**
25	Dholgarwadi	„ ...		177	7	2	3	68	16	35	...		...	106	28	388	175	4	423
				126	**14**	**0**	**6**	**62**	**14**	**37**	...		...	**63**	**34**	**229**	**126**	**8**	**266**
26	Mandedurga	„ ...	Tamraparni River, Basarga Nalla.	254	27	2	10	125	9	57	...		...	127	8	428	252	17	485
				129	**2**	**1**	**14**	**58**	**23**	**29**	...		...	**69**	**5**	**221**	**127**	**28**	**250**
27	Karwa	„ ...		381	17	1	36	315	38	158	...		...	63	23	154	379	21	312
				188	**29**	**1**	**15**	**122**	**17**	**62**	...		...	**64**	**37**	**225**	**187**	**14**	**287**
28	Mandola	Chandgad ...		117	1	0	7	83	2	22	...		...	33	32	133	116	34	155
				13	**2**	**0**	**7**	**5**	**16**	**2**	...		...	**7**	**19**	**33**	**12**	**35**	**35**
29	Jangamhatti	„ ...		162	17	1	27	127	3	41	...		...	33	27	80	160	30	121
				20	**27**	...		**4**	**34**	**2**	...		...	**15**	**33**	**41**	**20**	**27**	**43**
30	Basarga	Belgaum ...	Tamraparni River, Right Bank.	1,006	8	12	0	834	27	376	...		...	159	21	233	994	8	609
				323	**33**	**3**	**37**	**229**	**2**	**111**	...		...	**90**	**34**	**225**	**319**	**36**	**336**
31	Halkarni	Chandgad ...		744	5	7	7	582	12	164	1	12	4	153	14	521	736	38	689
				83	**2**	**1**	**13**	**8**	**11**	**3**	...		...	**73**	**18**	**271**	**81**	**29**	**274**
32	Ambewadi	„ ...		51	31	...		33	8	12	...		...	18	23	71	51	31	83
				12	**14**	**0**	**4**	**0**	**5**	...	...		...	**12**	**5**	**54**	**12**	**10**	**54**
33	Halarwadi	„ ...		617	34	4	21	540	5	174	...		...	73	8	229	613	13	403
				22	**37**	**0**	**1**	**4**	**25**	**2**	...		...	**18**	**11**	**67**	**22**	**36**	**69**
34	Karanjagaon... ...	„ ...	Tamraparni River, Patna Valley, Right Bank.	324	21	1	36	268	1	87	...		...	54	24	177	322	25	264
				44	**13**	**0**	**38**	**4**	**22**	**2**	...		...	**38**	**33**	**138**	**43**	**15**	**140**
35	Nandivada	„ ...		573	33	3	26	464	33	132	1	20	5	103	34	261	570	7	398
				26	**35**	**0**	**5**	**0**	**3**	...	...		...	**26**	**27**	**75**	**26**	**30**	**75**
36	Shewale	„ ...		165	17	2	19	117	7	23	0	11	1	45	20	119	162	38	143
				22	**5**	**0**	**4**	**5**	**38**	**2**	..		...	**16**	**3**	**46**	**22**	**1**	**48**
37	Patna...	„ ..		303	25	1	36	198	38	58	1	3	4	101	28	305	301	29	367
				23	**29**	**0**	**2**	**5**	**2**	**2**	...		...	**18**	**25**	**61**	**23**	**27**	**63**
38	Jelugde	„ ...		238	14	3	13	105	26	23	...		...	129	15	373	235	1	396
				37	**15**	...		**0**	**32**	**1**	...		...	**36**	**23**	**114**	**37**	**15**	**115**
39	Kodali	„ ...		242	7	3	3	75	1	18	...		...	164	3	248	239	4	266
				1	**37**	...		...		...	...		...	**1**	**37**	**4**	**1**	**37**	**4**

Serial No.	Names of villages.	Taluka.	Whether in Ghatprabha or Tamraparni Valley, or on what bank.	Area.	Deduct pot kharab.	Details for the remaining cultivable area.								Remarks.
						Dry-crops.		Garden.		Rice.		Total.		
						Area.	Assessment.	Area.	Assessment.	Area.	Assessment.	Area.	Assessment.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
				A. g.	A. g.	A. g.	Rs.	A. g.	Rs.	A. g.	Rs.	A. g.	Rs.	
40	Parla	Chandgad ...	Tamraparni River, Patna Valley Right Bank.	323 19	10 37	180 32	33	...	...	131 30	322	312 22	355	
41	Raindewadi	,, ...		**30 24**	**0 6**	**0 22**	**1**	...	...	**29 36**	**81**	**30 18**	**82**	
42	Gudavala	,, ...		95 19	1 0	69 0	14	...	...	25 19	66	94 19	80	
43	Khamdala	,, ...		**26 16**	**0 1**	**12 7**	**3**	...	...	**14 8**	**41**	**26 15**	**44**	
44	Savarda	,, ...		53 34	0 14	33 33	10	0 16	1	19 11	49	53 20	60	
45	Kolindra Sarkari ...	,, ...		**5 4**	...	**4 8**	**1**	...	...	**0 36**	**2**	**5 4**	**3**	
46	Shipur	,, ...		84 14	1 33	42 6	12	...	...	40 15	119	82 21	131	
47	Asgaon	,, ...	Tamraparni River Right Bank.	**9 19**	**0 1**	**0 16**	...	...	...	**9 2**	**29**	**9 18**	**29**	
48	Hambere	,, ...		92 10	0 33	50 27	12	...	...	40 30	117	91 17	129	
49	Nagawa	,, ...		**24 26**	...	**1 5**	**1**	...	...	**23 21**	**77**	**24 26**	**78**	
50	Ramewadi	Chikodi ...	Ghatprabha River Left Bank.	297 10	2 28	221 25	53	...	...	72 37	204	294 22	257	
51	Daddi	,, ...		**11 27**	...	**0 10**	...	...	...	**11 17**	**39**	**11 27**	**39**	
52	Bidrewadi	,, ...		178 4	2 17	140 5	39	...	...	35 22	112	175 27	151	
53	Aldhal	,, ...		**11 34**	**0 4**	...	...	...	...	**11 30**	**44**	**11 30**	**44**	
54	Attiyal	,, ...		340 4	5 7	249 37	70	...	...	85 0	264	334 37	334	
55	Kot	,, ...		**43 22**	**0 20**	**2 18**	**2**	...	...	**40 24**	**147**	**43 2**	**149**	
56	Belanki	,, ...		99 27	0 26	76 4	16	...	...	22 37	46	99 1	62	
57	Dhoudgatta	,, ...		**36 13**	**0 17**	**12 33**	**3**	...	...	**23 3**	**59**	**35 36**	**62**	
				138 7	8 3	60 17	15	1 12	5	68 15	169	130 4	189	
				50 36	...	**29 12**	**11**	...	...	**21 24**	**49**	**50 36**	**60**	
				364 21	115 20	192 31	115	7 19	17	48 31	251	249 1	383	
				301 11	**4 0**	**201 38**	**135**	**20 31**	**58**	**74 22**	**324**	**297 11**	**517**	
				16 8	0 31	15 17	5	...	...	...	...	15 17	5	
				6 26	**0 3**	**6 23**	**2**	...	...	...	...	**6 23**	**2**	
				27 24	25 24	2 0	1	...	...	...	...	2 0	1	
				0 16	...	**0 16**	**1**	...	...	...	...	**0 16**	**1**	
				6 21	4 12	2 9	1	...	...	...	...	2 9	1	
				0 24	...	**0 24**	**1**	...	...	...	...	**0 24**	**1**	
				8 37	0 38	7 19	3	...	...	0 20	1	7 39	4	
				11 18	...	**6 0**	**3**	...	...	**5 18**	**17**	**11 18**	**20**	
				47 8	0 20	39 27	30	0 2	...	6 39	18	46 28	48	
				219 32	**1 38**	**145 5**	**109**	**5 35**	9	**66 34**	**1 9**	**217 34**	**247**	
				22 3	0 6	12 14	5	...	...	9 23	50	21 37	55	
				18 26	**0 9**	**11 19**	**5**	...	...	**6 38**	**21**	**18 17**	**26**	
				19 14	0 11	2 17	2	...	...	16 26	73	19 3	75	
				30 5	**0 3**	**1 18**	**1**	**0 8**	**1**	**28 16**	**124**	**30 2**	**126**	

58	Khavnewadi ...	...	„	...	Ghatprabha River Left Bank.	145 39	1 34	120 19	84	...	...	23 26	84	144 5	168			
						213 16	**2 37**	**127 33**	**100**	...	...	**82 26**	**283**	**210 19**	**383**			
59	Modga		„	...		362 2	105 30	153 1	93	2 19	6	100 32	405	256 12	504			
						371 14	**2 19**	**212 3**	**279**	**0 27**	**1**	**156 5**	**596**	**368 35**	**876**			
60	Salamwadi		„	...		263 5	84 31	117 7	55	2 36	**2**	58 11	216	178 14	274			
						305 21	**3 21**	**151 21**	**87**	**0 23**	3	**149 36**	**583**	**302 0**	**672**			
61	Shettihalli		„	...		564 26	91 36	390 21	197	2 27	10	79 22	319	472 30	526			
						262 30	**6 10**	**145 37**	**87**	**0 19**	**2**	**110 4**	**471**	**256 20**	**560**			
62	Gavasa		„	...		78 9	...	52 24	79	0 9	1	25 16	105	78 9	185	All these villages are above Hadlag and the details of area for them are taken up to R. L. 156.		
						32 34	...	**20 5**	**22**	...	...	**12 29**	**49**	**32 34**	**71**			
						14,611 33	821 4	8,729 7	3,779	32 29	85	5,028 33	17,919	13,790 29	21,783			
						7,903 2	**81 28**	**3,505 4**	**2,476**	**33 35**	**99**	**4,282 15**	**16,557**	**7,821 14**	**19,132**			
	Inam Villages Surveyed.																	
63	Yertanhatti		Belgaum ...		G. R.	237 11	1 5	233 35	97	...	...	2 11	3	236 6	100			
					R. B.	**88 8**	...	**88 8**	**11**	...	...	...	...	**88 8**	**11**			
64	Talguli		„	...	T. R.	230 38	6 7	188 29	99	...	...	36 2	172	224 31	271			
					R. B.	**246 5**	**3 32**	**156 14**	**73**	...	...	**85 39**	**452**	**242 13**	**525**			
65	Sundi		„	...	.....	44 39	0 5	9 25	8	...	...	35 9	136	44 34	144			
						8 20	...	...	...	...	...	**8 20**	**24**	**8 20**	**24**			
66	Kolindra Inam ...		„	...	.....	87 39	0 13	68 36	15	...	...	18 30	71	87 26	86			
						28 30	**0 1**	**3 3**	**9**	...	...	**25 26**	**93**	**28 22**	**102**			
67	Maranhola		„	...	G. R.	**580 33**	**1 34**	**566 22**	**149**	...	...	**12 17**	**24**	**578 39**	**173**			
					R. B.													
68	Malatwadi		„	...	T. R.	121 33	3 20	20 26	33	...	...	97 27	443	118 13	476			
					L. B.	**35 31**	**0 12**	**17 18**	5	...	...	**18 1**	**61**	**35 19**	**66**			
69	Data		Chandgad ...		T. R.	**612 35**	**8 19**	**381 11**	**119**	...	...	**223 5**	**913**	**604 16**	**1,032**			
					L. B.													
70	Kanadi		„	...	G. R.	**199 15**	...	**121 21**	**77**	...	...	**77 34**	**236**	**199 15**	**313**	All these villages are above Hadlag and the details of area for them are taken up to R. L. 156.		
					L. B.													
71	Satavane		„	...	G. R.	**214 20**	...	**156 14**	**111**	**16 22**	**86**	**41 24**	**141**	**214 20**	**338**			
					R. B.													
						2,737 37	25 28	2,012 22	806	16 22	86	683 5	2,769	2,712 9	3,661			
	Inam Villages Surveyed (classification not available).																	
72	Rajgoli Kd.		Belgaum ...		Tamraparni Right Bank.	497 30	...	...	...	...	...	...	...	497 30	481			
						192 34	...	...	...	...	...	...	...	**192 34**	**429**			
73	Turkewadi		„	...		504 22	6 7	...	...	...	...	...	...	498 15	394			
						88 33	**0 36**	...	...	...	...	...	...	**87 37**	**211**			
						1,283 39	7 3	...	...	...	...	...	...	1,276 36	1,515			

Serial No.	Names of villages.	Taluka.	Whether in Ghatprabha or Tamraparni Valley, or on what bank.	Area.	Deduct pot kharab.	Details for the remaining cultivable area.								Remarks.
						Dry-crops.		Garden.		Rice.		Total.		
						Area.	Assessment.	Area.	Assessment.	Area.	Assessment.	Area.	Assessment.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
				A. g.	A. g.	A. g.	Rs.	A. g.	Rs.	A. g.	Rs.	A. g.	Rs.	
	Inam villages unsurveyed.													
74	Shivanga	Chandgad ...	Tamraparni River Left Bank.	566 12	...	...	...	...	...	...	...	566 12	1,132	Assessment calculated, assuming an average rate of Rs. 2 per acre.
	Malgad	,, ...		160 0	...	...	...	...	...	...	...	160 0	320	Do.
76	Jatewadi	,, ...		158 12	...	...	...	...	...	...	...	158 12	316	Do.
77	Ghudewadi	,, ...		40 0	...	...	...	...	...	...	...	40 0	80	Do.
78	Tambulwadi	,, ...		341 36	...	...	...	...	...	...	...	341 36	684	Do.
79	Narewadi	,, ...		205 20	...	...	...	...	...	...	...	205 20	412	Do.
80	Kurtanwadi	,, ...		164 32	...	...	...	...	...	...	...	164 32	330	Do.
81	Koraj	,, ...		287 20	...	...	...	...	...	...	...	287 20	575	Do.
82	Naganwadi	,, ...		214 0	...	...	...	...	...	...	...	214 0	428	Do.
83	Shirgaon	,, ...		532 22	...	...	...	...	...	...	...	532 22	1,065	Do.
84	Konewadi	,, ...		270 12	...	...	...	...	...	...	...	270 12	540	Do.
85	Motanwadi	,, ...	Tamraparni-Patna Valley.	171 0	...	...	...	...	...	...	...	171 0	342	Do.
86	Here	,, ...		360 28	...	...	...	...	...	...	...	360 28	722	Do.
87	Adkur	,, ...		414 14	...	...	...	...	...	...	...	414 14	829	All these villages are above Hadlag and the details of area for them are taken up to R. L. 156.
88	Uchalli	,, ...	Ghatprabha Left Bank.	176 0	...	...	...	...	...	...	...	176 0	352	Assessment calculated, assuming an average rate of Rs. 2 per acre.
89	Powachiwadi	,, ...		139 24	...	...	...	...	...	...	...	139 24	279	Do.
90	Ibrahampur	,, ...		67 4	...	...	...	...	...	...	...	67 4	134	Do.
91	Bijur	,, ...		0 20	...	...	...	...	...	...	...	0 20	1	Do.
92	Mahalunga	,, ...		106 11	...	...	...	...	...	...	...	106 11	213	Do.
93	Hindgaon	,, ...		162 18	...	...	...	...	...	...	...	162 18	325	Do.
94	Sawarda	,, ...		76 34	...	...	...	...	...	...	...	76 34	154	Do.
95	Kenchanwadi	,, ...		90 36	...	...	...	...	...	...	...	90 36	182	Do.
96	Ambroli	,, ...		310 0	...	...	...	...	...	...	...	310 0	620	Do.
97	Kurni	,, ...	Ghatprabha Right Bank.	148 12	...	...	...	...	...	...	...	148 12	297	Do
			G. R. L. B.	5,165 7	...	...	...	...	...	...	...	5,165 7	10,332	
	Surveyed villages, Kolhapur State.													
98	Vagarali	Gadhinglaj.	G. R. L. B.	14 2	1 12	11 18	22	...	...	1 12	3	12 30	25	
				3 28	...	...	...	...	...	3 28	19	3 28	19	

99	Shipur	Gadhinglaj...	Ghatprabha Left Bank.	3 8	...	0 24	1	...	...	2 24	5	3 8	6				
				1 36	...	...	...	0 31	3	1 5	3	1 36	6				
00	Helewadi	„ ...		12 16	...	...	...	...	...	12 16	31	12 16	31				
				25 37	0 5	12 11	11	4 10	16	9 11	31	25 32	58				
01	Tarewadi	„ ...		382 7	12 17	140 26	101	...	...	229 4	882	369 30	983	All these villages are above Hadlag and the details of area for them are taken up to R. L. 156.			
02	Hadlag	„ ...		456 34	192 28	215 17	139	...	...	48 29	211	264 6	350	Do.			
03	Nesari...	„ ...		289 22	8 15	63 22	67	3 17	12	214 8	830	281 7	909	Do.			
04	Talewadi	„ ...		38 17	...	12 30	41	...	...	25 27	58	38 17	99	Do.			
05	Maldewadi	„ ...		120 38	0 5	57 12	37	...	...	63 21	128	120 33	165	Do.			
06	Sawantwadi	„ ...		188 38	0 6	74 35	60	...	...	113 37	243	188 32	303	Do.			
07	Kandewadi	„ ...		187 16	...	118 27	161	...	...	68 29	211	187 16	372	Do.			
08	Saroli	„ ...		627 18	...	418 2	382	...	...	209 16	499	627 18	881	Do.			
09	Donewadi	„ ...	Ghatprabha Right Bank.	226 30	1 32	140 38	140	6 15	28	77 25	319	224 38	487	Do.			
10	Tawrewadi	„ ...		193 36	...	57 0	13	...	...	136 36	106	193 36	119	Do.			
11	Sambra	„ ...		246 4	...	107 9	90	0 4	1	138 31	522	246 4	618	Do.			
12	Kurani (Kumri ?) ...	„ ...		300 28	...	192 27	149	3 6	11	104 35	265	300 28	425	Do.			
				3,320 15	217 0	1,623 18	1,414	18 3	71	1,461 34	4,366	3,103 15	5,851				
	Unsurveyed Kolhapur State.																
13	Bidrewadi	Gadhinglaj .	G. R. L. B.	138 16	...	...	...	...	...	...	...	138 16	278				
	British Government villages.																
	Surveyed villages—							ABSTRACT.									
2	Govt. area of Govt. villages.	.....	.....	14,611 33	821 4	8,729 7	3,779	32 29	85	5,028 33	17,919	13,790 29	21,783				
2	Inam area of the do.	.....	.....	7,903 2	81 28	3505 4	2,476	33 35	99	4,282 15	16,557	7,821 14	19,132				
9	Do. do. Inam villages.	.....	.....	2,737 37	25 28	1,012 22	806	16 22	86	683 5	2,769	2,712 9	3,661				
2	Do. do. classification not available...	.....	.....	1,283 39	7 3	..	...	...	...	...	...	1,276 36	1,515				
24	Do. do. unserveyed villages ...	.....	.....	5,165 7	...	...	...	...	...	..	...	5165 7	10,332				
97	Total ...	.....	.....	31,701 38	935 23	18,246 33	7,061	83 6	270	9,994 13	37,245	30,766 15	56,423				
	Kolhapur State.																
15	Surveyed villages ...	.....	.....	3,320 15	217 0	1,623 18	1,414	18 3	71	1,461 34	4,366	3,103 15	5,851				
1	Unsurveyed villages...	.....	.....	138 16	..	...	...	...	..	..	...	138 16	278				
16	Total ...	.....	.....	3,458 31	217 0	1,623 18	1,414	18 3	71	1,461 34	4,366	3,241 31	6,129				
113	Grand Total ...	.....	.....	35,160 29	1,152 23	15,870 11	8,475	101 9	341	11,456 7	41,611	34,008 6	62,552				

No.	Description.	Garden.			Rice.			Dry crops.			Total assessment.	Total compensation.	Remarks.
		Assessment.	Number of times.	Compensation.	Asessment.	Number of times.	Compensation.	Assessment.	Number of times.	Compensation.			
	British Government villages.	Rs.		Rs.	Rs.		Rs.	Rs.		Rs.	Rs.	Rs.	
62	Government villages	85	50	4,250	17,919	50	8,95,950	3,779	35	1,32,265	21,783	10,32,465	
	Do. Inam area ...	**99**	**60**	**5,940**	**16,557**	**60**	**9,93,420**	**2,476**	**40**	**99,040**	**19,132**	**10,98,400**	
9	Inam villages do.	86	60	5,160	2,769	60	1,66,140	806	40	32,240	3,661	2,03,540	
9	Total Inam area surveyed ...	185	...	11,100	19,326	...	11,59,560	3,282	...	1,31,280	22,793	13,01,940	
2	Do. villages, unclassified	1,515	50	75,750	.....	...	.....	...	...	.....	1,515	75,750	
24	Unsurveyed	10,332	50	5,16,600	.....	...	.....	...	...	.....	10,332	5,16,600	
97	Total	12,117	...	6,07,700	37,245	...	20,55,510	7,061	...	2,63,545	56,423	29,26,755	
	Kolhapur State.												
15	Surveyed villages	71	60	4,260	4,366	60	2,61,960	1,414	40	56,560	5,851	3,22,780	
1	Unsurveyed do.	278	50	13,900	.....	...	.....	...	...	.....	278	13,900	
16	Total ...	349	...	18,160	4,366	...	2,61,960	1,414	...	56,560	6,129	3,36,680	
	Provision in lump sum to facilitate acquisition of Native State lands											5,00,000	
	Capitalized value of revenue lost to State (treated as direct charges											1,53,225	
	Total compensation, State ...											9,89,905	
113	Grand total for Daddi Tank ...	12,466	...	6,25,860	41,611	...	23,17,470	8,475	...	3,20,105	62,552	39,16,660	

Note.—Block figures refer to the Inam lands in each village, the details of which are given separately.

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA STORAGE AT DADDI.

Statement showing the estimated amount of compensation for houses and open sites liable to be submerged in all the villages affected by R. L. 153.

Serial Number.	Serial Number of land compensation statement.	Name of village.	Taluka or Mahal.	Total population.	Total number of houses in village.	Particulars about houses and sites to be submerged.				Total compensation of columns 7 and 9.	How much and what portion of the village site submerged.	Total compensation for R. L. 131.	Levels.		Population affected.	Remarks.
						Number of houses.	Estimated compensation on account of houses.	Area of open sites.	Estimated compensation on account of site.				Highest.	Lowest.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
		British Government villages.														
1	1	Chinchani	Belgaum ...	200	31	61	11,750	5 37	356	12,106	Wholly ...	17,015	143·06	132·37	200	The classification adopted for working out the compensation of the houses is given at the end of this Statement.
2	2	Dundga	,, ...	310	69	69	28,800	7 23	1,212	30,012	,, ...	37,825	134·03	106·48	310	
3	3	Kowad	,, ...	1,070	204	204	54,950	14 15	2,300	57,250	,, ..	154,480	152·26	93·37	1,070	
4	4	Nitur	,, ...	1,090	217	217	44,250	11 13	1,812	46,062	,, ...	149,660	141·09	102·30	1,090	
5	5	Ghulewadi	,, ...	230	28	28	5,450	3 20	595	6,045	,, ...	14,800	152·16	111·46	230	
6	6	Mahalewadi	,, ...	310	50	30	6,200	3 7	413	6,613	$\frac{3}{5}$ south ...	12,350	178·90	116·25	190	
7	7	Mangaon	Chandgad ...	1,010	157	125	22,750	30 34	6,787	29,537	$\frac{2}{5}$ south-west..	6,135	177·87	115·81	800	
8	8	Dukarwadi	,, ...	800	131	119	20,150	6 21	1,175	21,325	$\frac{2}{5}$ east ...	11,220	174·44	133·33	720	All houses up to R. L. 155 have been included in the Compensation Statements.
9	9	Chandgad	,, ...	1,390	322	242	45,900	25 31	3,609	49,509	$\frac{2}{5}$ south-east..	...	195·61	134·45	1,100	
10	10	Adur	,, ...	130	27	4	350	0 21	47	397	$\frac{1}{3}$ south ...	...	167·18	149·55	20	
11	11	Kokare	,, ...	360	65	30	2,550	2 5	319	2,869	$\frac{1}{3}$,, ..	...	174·30	148·60	170	
12	15	Rajgoli B.	Belgaum ...	520	78	78	27,410	8 0	1,920	29,330	Wholly ...	36,359	134·94	98·15	520	
13	16	Kudnur	,, ...	1,240	203	203	60,350	27 4	5,691	66,041	,, ..	1,45,590	141·19	112·09	1,240	
14	18	Kalkundri	,, ...	1,520	273	273	1,97,075	20 0	4,200	2,01,275	,, ...	2,33,000	226·18	123·90	1,520	
15	19	Kagni	,, ...	760	91	58	10,850	7 39	1,595	12,445	$\frac{3}{4}$ west ...	...	171·67	131·58	490	
16	20	Hundalwadi	,, ...	150	20	20	4,790	3 0	420	5,290	Wholly ...	7,550	124·89	120·00	150	
17	21	Kini	,, ...	650	127	127	25,100	10 32	2,376	27,476	,, ...	34,075	148·37	129·63	650	
18	24	Kadilaga Kd. ...	,, ...	240	34	34	9,563	5 0	850	10,413	,, ...	15,038	136·50	127·89	240	
19	25	Dholgerwadi	,, ...	510	82	82	37,935	15 0	2,550	40,485	,, ...	47,420	141·00	117·50	510	
20	30	Basarga	,, ...	480	64	10	1,100	3 2	397	1,497	$\frac{1}{5}$ south-west.	2,490	179·64	142·64	80	
21	27	Karwa	,, ...	350	58	9	750	2 22	408	1,158	$\frac{1}{6}$ south-west.	...	197·23	153·00	60	
22	31	Halkarni	Chandgad ...	770	153	67	22,150	20 25	2,888	25,038	$\frac{1}{2}$ west ...	16,460	190·09	125·80	340	
23	34	Karanjgaon	,, ...	240	52	46	4,900	6 33	1,092	5,992	$\frac{7}{9}$ north ...	7,850	162·24	132·91	210	
24	47	Asgaon	,, ...	270	55	51	8,450	16 4	2,254	10,704	Wholly ...	685	152·00	131·35	270	
25	48	Hambere	,, ...	80	11	11	1,900	5 31	462	2,362	,, ...	...	153·05	137·17	80	
26	49	Nagwa	,, ...	430	46	11	1,950	0 14	35	1,985	$\frac{1}{4}$ N.-West ...	...	182·72	148·02	100	
27	36	Shewale	,, ...	150	29	2	100	0 31	62	162	$\frac{1}{9}$ N.-West ...	...	208·89	142·97	10	

Serial Number.	Serial Number of land compensation statement.	Name of village.	Taluka or Mahal.	Total population.	Total number of houses in village.	Particulars about houses and sites to be submerged.				Total compensation of columns 7 and 9.	How much and what portion of the village site submerged.	Total compensation for R. L. 131.	Levels.		Population affected.	Remarks.
						Number of houses.	Estimated compensation on account of houses.	Area of open sites.	Estimated compensation on account of sites.				Highest.	Lowest.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
		British Government villages.														
28	37	Patna	Chandgad ...	650	176	10	2,000	1 37	231	2,231	¼ N.-W. S.	...	180·79	150·49	40	
29	38	Jelugda	„ ...	350	91	88	8,700	8 38	1,164	9,864	⅛ N.-West	...	158·11	134·32	340	
30	41	Raindewadi	„ ...	60	19	8	600	1 9	147	747	South	...	161·70	148·03	20	
31	44	Sawarda	„ ...	140	39	17	1,750	4 8	504	2,254	South	...	159·86	147·26	120	
32	45	Kolindra	„ ...	200	45	29	2,200	2 23	155	2,355	South	...	166·23	144·35	90	
33	46	Shipur	„ ...	100	16	1	400	0 34	102	502	South	...	166·18	153·60	10	
34	35	Nandivada	„ ...	420	98	78	10,650	7 17	1,337	11,987	⅛ South	5,180	166·39	142·60	340	
35	50&51	Ramewadi & Daddi ...	Chikodi ...	1,520	377	377	92,650	40 34	6,945	99,595	Wholly ...	1,04,650	146·39	86·73	1,520	
36	59	Modga	„ ...	510	111	111	21,400	15 16	2,772	24,172	„ ...	38,600	102·84	84·06	510	
37	58	Khavnewadi	„ ...	240	45	45	7,250	7 28	1,309	8,559	„ ...	...	211·60	203·91	240	
38	60	Salamwadi	„ ...	410	76	76	13,850	7 15	1,328	15,178	„ ...	15,500	123·00	107·06	410	
39	61	Shettihalli	„ ...	600	98	98	20,000	6 39	349	20,349	„ ...	21,750	134·09	114·34	600	
						3,153	8,38,923	370 2	62,168	9,01,091		10,35,682			16,610	
		Hamlets of Government villages.														
40	1	Kamewadi	Belgaum ...	150	28	28	9,350	7 0	840	10,190	Wholly ...	14,550	118·81	96·16	150	
41	8	Bagilga	Chandgad ...	330	55	55	10,700	11 39	2,156	12,856	„ ...	6,145	132·66	121·27	330	
42	30	Dhumrechiwadi ...	Belgaum ...	90	10	10	2,050	0 20	...	2,050	„ ...	...	120·83	112·56	90	
43	27	Karwawadi	„ ...	180	31	31	3,350	4 37	640	3,990	„ ...	5,510	150·78	136·44	180	
44	33	Gavleswadi (Hamlet of Halarvad)	Chandgad ...	80	16	16	950	...	...	950	„ ...	...	145·99	140·31	80	
45	49	Pasachewadi	„ ...	50	8	2	800	0 11	28	828	⅓ North ...	...	174·49	141·52	10	
46	1	Nadgadda	Chikodi ...	60	9	9	1,350	4 34	97	1,447	Wholly ...	1,400	112·36	106·50	60	
47	39	Kalasgad	Chandgad ...	240	61	61	3,650	4 39	348	3,998	„ ... (island).	...	168·29	157·07	240	
						212	32,200	34 20	4,109	36,309		27,605			1,140	

		Inam villages.														
48	75	Malgad	Chandgad ...	50	7	7	1,100	4	7	626	1,726	Wholly ...	...	160·31	141·07	50
49	76	Jatewadi	„ ..	190	19	19	3,050	4	7	626	3,676	„ ...	...	158·00	147·94	190
50	78	Tambulwadi	„ ...	400	57	57	20,595	...		...	20,595	„ ...	21,755	131·42	117·45	400
51	79	Narewadi	„ ...	100	17	17	1,600	6	22	983	2,583	„ ..	1,045	145·28	140·14	100
52	69	Date	„ ...	480	91	91	15,750	21	23	3,452	19,202	„ ...	2,330	160.41	119·90	480
53	80	Kurtanwadi	„ ...	140	21	21	3,540	3	...	450	3,990	„ ...	3,540	138·46	128·60	140
54	82	Naganwadi	„ ...	360	50	30	4,300	5	1	754	5,054	⅔ south ...	...	168·58	149·99	220
55	72	Rajgoli Kd.	Belgaum ...	910	160	146	28,000	21	35	3,719	31,719	⅔ west ...	48,750	173·30	127·03	830
56	64	Talguli	„ ...	150	84	84	7,400	7	18	1,267	8,667	Wholly ...	3,500	144·00	126·46	150
57	84	Konewadi	Chandgad ...	120	43	40	5,750	6	5	919	6,669	⅘ south-east .	3,601	145·71	124·51	120
58	85	Motanwadi	„ ...	160	40	8	150	2	3	311	461	⅛ south-west.	...	161·10	153·58	10
59	87	Adkur...	„ ...	320	185	9	1,800	6	1	904	2,704	⅛ north-west.	...	202·77	150·92	20
60	63	Yertanhatti	Belgaum ...	60	19	19	1,100	5	10	105	1,205	Wholly ...	400	140·02	125·50	60
61	67	Maranhole	„ ...	180	31	31	6,250	4	35	439	6,689	„ ...	8,300	108·86	103·74	180
						524	1,00,385	98	7	14,555	1,14,940		93,221			2,900
		Hamlets of Inam villages.														
62	69	Belbhatwadi	Chandgad ...	110	21	21	2,500	...		...	2,500	Wholly ...	735	152·45	142·25	110
63	73	Talewadi	Belgaum ...	60	20	20	1,450	...		...	1,450	„ ...	...	139·65	126·69	60
64	73	Kalwadi	„ ...	140	35	35	3,550	7	18	820	4,370	„ ...	...	142·19	129·77	140
65	81	Koraj	Chandgad ...	10	...	2	400	...		...	400	„ ...	...	...	166·74	10
66	74	Shiwanga	„ ...	580	101	6	1,600	0	35	131	1,731	⅔ N.-east ...	...	233·63	150·08	30
67	72	Jainhatti	Belgaum ...	100	25	25	1,850	10	20	105	1,955	Wholly ...	...	15302	135·48	100
						109	11,350	18	33	1,056	12,406		735			450
		Kolhapur State villages.														
68	101	Tarewadi	Gadhinglaj	220	49	49	9,650	5	21	829	10,479	Wholly ...	...	145·53	138·41	220
69	103	Nesari...	„ ...	2,070	568	126	35,500	10	14	828	36,328	½ south ...	...	217·01	146·31	630
70	106	Sawantwadi	„ ...	40	15	12	750	4	5	330	1,080	¼ south ...	...	159·50	140·33	30
71	107	Kandewadi	„ ...	170	35	18	4 900	3	33	574	5,474	⅔ N.-east ...	...	171·81	149 51	90
72	108	Saroli	„ ...	420	70	56	10.750	2	32	224	10,974	⅔ N.-east ...	...	170 04	145·03	330
73	110	Tawrewadi	„ ...	130	22	5	1,000	3	11	295	1,295	⅔ S.-west ...	...	176·96	146 03	30
74	112	Kumri...	„ ...	460	61	55	11,550	3	9	452	12,002	⅔ S.-east ...	...	162·07	143·52	420
						321	74,100	33	5	3,532	77,632		...			1,750

CLASSIFICATION OF HOUSES FOR COMPENSATION.

Class.	Description.	Average rate of compensation per house.	Mean rate per square foot of floor area.	Remarks.
Special I ...	Temples and Samadhis, etc.	To be judged.	Rs. a. p.	
Special II ...	Inamdars' houses or wadas		2 to 1 0 0	
1st Class A ..	Stone and mud, outer wall strong, tiled roof partition walls, first class carpentry and good workmanship throughout, pointed with mortar	600	0 8 0	
1st Class B ...	Do. do. do. inferior, and of medium workmanship...	400	0 6 0	
2nd Class C ...	Mud walls and fair carpentry	200	0 3 0	
3rd Class D ...	Mud outer walls, thatched kacha tiles, rough carpentry, etc.	50	0 1 6	

Serial No.	Description.	No. of villages submerged.			Population affected.	No. of houses submerged.	Compensation for houses.	Area of open sites.		Compensation for open sites.	Total compensation = Columns 8 and 11.	Compensation for R. L. 131.	Remarks.
		Fully.	Partial.	Total.				Acres.	Gunthas.				
1	2	3	4	5	6	7	8	9	10	11	12	13	14
	British Government villages.				No.		Rs.			Rs.	Rs.	Rs.	
1	Government villages ...	19	20	39	16,610	3,153	8,38,923	370	2	62,168	9,01,091	10,35,682	
2	Hamlets of villages ...	7	1	8	1,140	212	32,200	34	20	4,109	36,309	27,605	
3	Inam villages	9	5	14	2,900	524	1,00,385	93	7	14,555	1,14,940	93,221	
4	Hamlets of villages ...	5	1	6	450	109	11,350	18	33	1,056	12,406	735	
	Total...	40	27	67	21,100	3,998	9,82,858	521	22	81,888	10,64,746	11,57,243	
	Kolhapur State.												
5	Inam villages	1	6	7	1,750	321	74,100	33	5	3,532	77,632	.....	
	Grand Total...	41	33	74	22,850	4,319	10,56,958	554	27	85,420	11,42,378	11,57,243	

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

REPORT ON GHATPRABHA RIGHT BANK CANAL SURVEYS.

No. 1159 of 1908.

Executive Engineer's Office,
Gokak Survey,
Belgaum, 11th July 1908.

To

THE CHIEF ENGINEER
For Irrigation, P. W. D.,
Poona.

Sir,

As directed by the Superintending Engineer on Special Duty, Protective Works, I have the honor to submit herewith the following papers in connection with the Ghatprabha Right Bank Canal Project.

Book 1—Containing the Preliminary Report on the canal with accompaniments.

Book 2—Giving a description of the Daddi Tank F. S. L. 153, with estimates and accompaniments.

I beg to add that the plans in connection with the above are nearly ready, and will be submitted in about 10 days.

I have the honor be,
Sir,
Your Most Obedient Servant,

P. N. NATESAIYER,
Executive Engineer, Gokak Survey.

INDEX

Ghatprabha Right Bank Canal Project.

		PAGES
Preliminary Report		214 to 232
1.	Note on the proposed Markandeya Weir	233 & 234
2.	Statement of area under command for the whole of Main Canal and Branches	236 to 238
3.	„ cuts of over 10 feet in depth in the 1st section.	239
4.	„ high embankments of over 10 feet height in the 1st section	240
5.	„ lengths of canal in steep ground in the 1st section	242 & 243
6.	„ River and Hill Torrent Works in the 1st section	246 to 261
7.	„ Road Bridges and Regulators in the 1st section	264 & 265
8.	„ details of area commanded and discharge required in the 1st section	266
9.	„ bed falls in the 1st section	267 to 271
10.	„ extra lengths of alignment required to avoid certain high banks and deep cuts in the 1st section	272
11.	„ canal dimensions in the 1st section	274 to 276
12.	„ Alternatives, Abstract in the 1st section ...	278 to 281
13.	Note on the pipe syphon for the crossing of the Hire Nulla in the 1st section	282 & 283

Estimates,

14.	General Abstract of cost of earthwork in the 1st section ...	284 to 287
15.	Abstract of cost of earthwork of typical miles in the 1st ...	288 to 291
16.	„ „ cuts in the 1st section	292
17.	„ „ high embankments in the 1st section ...	293
18.	„ „ steep ground in the 1st section ...	294 & 295
19.	„ „ for main alternatives in the 1st section...	296 to 298
20.	Note on the extension of the canal beyond the tail section...	299 & 300
21.	Note on cost of Yadvad Branch and Distributaries (for accompaniments *see* Index at page 303)	301 to 337

INDEX TO
Ghatprabha Right Bank Canal Project Preliminary Report.

	Para.
Preliminary	1
History of early surveys	2
Gross command	3
Command beyond the Malprabha not wanted	4
Supply	5
Supply required for Left Bank Canal	6
Possibility of utilising supply from the Markandeya	7
Probable supply from the Markandeya	8
Supply from the Beldari Nulla	9
Total supply available for canal	10
Discharge, duties and losses assumed	11
Total losses by leakage	12
Gross command required	13
Extent of perennial irrigation to fully utilise storage	14
Irrigable area	15
Restriction of command under perennial irrigation	16
Nature of soil and rainfall	17
Brief description of canal	18
Native State area under Lokapur and Tail Branches	19
Lengths of alignment in British Territory and Native States	20
1st Section of Main Canal—(*From paras 21 to 41*).	
Preliminary—Obligatory points	21
Nature of ground	22
Gross command up to Yergatti	23
Bed fall	24
Depth of water	25
Canal section	26
Discharge and size of canal	27
Details of alignment	28
Difficulties.	
Porous nature of soil	29
Sidelong ground	30
Madval Cut	31
Hire Nulla syphon	32
Difficult aqueducts	33
Minor Cuts, high embankments and other difficulties	34
Alternatives.	
Shahabunder Cut	35
Special difficulties in alternatives and comparison	36
Alternatives for Murkanhatti Cut	37
Pick-up weir on the Markandeya	38
Other alternatives	39
Estimates.	
Earthwork	40
Masonry works	41
Second and Tail Sections of Main Canal—(*From paras 42 to 46*).	
Description	42
Yergatti cut	43
Alignment in 2nd section	44 &45
Tail section	46
Branches—(*From paras 47 to 53*).	
Daddi Left Bank Canal	47
Yadvad Branch	48
Alignment	49,50&51
Lokapur Branch	52
Command beyond the Tail Section	53
Estimates—(*From paras 54 to 57*).	
Rates for Main Canal and Branches	54
Rates for Minors and Distributaries	55
Cost of Project	56
Revenue and Return on Capital expenditure	57
Land submerged and irrigable areas	58

STATEMENT SHOWING RAINFALL BY SEASONS IN THE BELGAUM DISTRICT FOR THE YEARS 1885-1905-06.

Year.	BELGAUM.																		Description of Seasons in Area Commanded.
	MURGOD.						GOKAK.						HUKERI.						
	1st January to 10th April.	11th April to 4th June.	5th June to 14th August.	15th August to 21st October.	22nd October to 30th November.	Grand Total.	1st January to 10th April.	11th April to 4th June.	5th June to 14th August.	15th August to 21st October.	22nd October to 30th November.	Grand Total.	1st January to 10th April.	11th April to 4th June.	5th June to 14th August.	15th August to 21st October.	22nd October to 30th November.	Grand Total.	
	Early rain.	Ante-Monsoon.	Monsoon Kharif.	Monsoon Rabi.	Late rain.		Early rain.	Ante-Monsoon.	Monsoon Kharif.	Monsoon Rabi.	Late rain.		Early rain.	Ante Moonsoon.	Monsoon Kharif.	Mon soon Rabi.	Late rain.		
1905-06 ...	...	3·91	6 81	7·78	0·44	18·94	...	3·42	5·37	8·07	0·33	17·19	...	3·78	9·49	6·02	0·48	19·77	Both Kharif and Rabi very poor, due to failure of rain.
1904-05 ...	0·77	3·32	6·30	6·27	0·77	17·43	0·90	4·07	3·93	7·34	1·11	17·35	0·98	5·83	7·46	5·14	1·43	20 84	Poor to fair ; late Rabi rains failed.
1903-04 ...	...	5·71	6·31	11·48	3·45	26·95	0·14	2·01	5·81	12·35	1·08	21·39	0·30	4·83	13·43	7·18	0·93	26 67	Fair Kharif ; satisfactory Rabi.
1902-03 ...	0·81	5·45	4·85	7·02	8·20	26·33	0·38	6·14	4·95	9·17	9·39	30·03	...	4·47	8·22	7·12	8·70	28·51	On the whole, fair.
1901-02 ...	1·89	6·20	4·72	5·15	1·14	19·10	3·07	6 92	4·52	8·03	0·33	22·87	3·13	6·01	6·64	5·94	1·07	22 79	Rain deficient in both seaons, crops 4 to 8 annas.
1900-01 ...	0·36	2·96	11·97	3·24	0·14	18·67	1·25	2·39	12·90	2·87	0·14	19·55	0·52	0·92	17·29	2·16	0·08	20·97	Kharif poor, below 4 annas; Rabi very poor, 1 to 2 annas.
1899-1900..	0·37	2·97	4·41	6·40	0·12	14·27	...	6·04	2·96	5·48	0·50	14·98	...	4·60	4·28	4·71	1·09	14·68	Kharif withered and *nil*; Rabi suffered, 2 to 6 annas.
1898-99 ...	0·55	6·73	9·39	12·46	3·22	32·35	0·29	6·99	6·20	10·50	2·85	26·83	0·16	10·43	13·29	14·37	1·97	40·22	Kharif good ; Rabi late rain failed, 8 annas.
1897-98 ...	0·52	6·15	8·49	7·75	1·18	24·09	0·11	10·09	8·12	10·28	2·75	31·35	...	5·16	10·60	8·91	0·34	25·01	Kharif good; Rabi suffered from deficiency of late rain, 4 annas to 8 annas.
1896-97 ...	0·78	4·14	9·10	2·23	1·58	17·83	1·03	1·95	7·24	3·53	0 92	14·67	2·19	3·44	10·97	3·85	0·58	21·03	Kharif dried up; Rabi not sown.
1895-96 ...	0·30	5·32	7·00	14·89	1·15	28·66	0·12	9·94	7·63	10·07	2·79	30·55	...	4·72	9·42	11·53	3·02	28·69	Both seasons good.
1894-95 ...	1·20	4·36	10·38	5·57	1·74	23·25	0·84	3·02	9·18	7·67	1·79	22·50	4·08	3·33	7·91	4·00	3·06	22·88	Irregular but fair.
1893-94 ...	0·01	6·12	8·01	10·30	3·53	27·97	1·88	6·84	4·74	17·10	2·59	33·15	3·72	1·96	9·02	14·39	2·09	31·18	Kharif suffered ; Rabi fair.
1892-93 ...	1·78	7·34	9·09	12·93	4·86	36·00	1·50	7·28	6·84	15·03	4·03	34·68	2·44	7·26	10·22	7·92	3·69	31·53	Fair to good.
1891-92 ...	2·10	3·13	9·92	5·73	0·50	21·38	4·11	1·68	8·07	7·15	1·62	22·63	3·40	3·44	11·32	6·02	0·85	25·03	Both Kharif and Rabi rain especially deficient, crops failed. Relief work opened.
1890-91 ...	0·52	2·86	9·21	5·80	6·13	24·52	0·11	1·78	7·72	4·98	4·45	19·04	2·31	1·65	13·89	4·86	7·35	30·06	Both fair on the whole.
1889-90 ...	...	2·39	4·98	19·42	0·70	27·49	...	6·38	3·84	19·32	0·66	30·20	...	6·81	6·41	17·66	0·15	31·03	Rains deficient in both seasons, but crops fair.
1888-89 ...	0·60	3·04	5·12	15·64	1·93	26·33	0·62	3·17	4·79	14·45	3·10	26·13	1·10	4·72	5·53	13·69	2·56	27·54	Both crops good.
1887-88 ...	0·40	3·51	6·64	14·13	6·32	31·00	0·13	5·46	7·21	6·83	5·73	25 36	0·07	5·81	9·66	13·14	2·45	31·13	Both crops good.
1886-87 ...	...	4·12	7·96	9·59	5·52	27·19	...	3·49	8·69	10·70	8·14	31·02	...	2·64	7·94	8·56	4·48	23·62	Both crops good.
1885-86 ...	...	...	...	...	...	...	0·38	4·73	8·13	10·24	3·93	27·41	...	...	...	...	...	...	Rain not seasonable, but heavy.

STATEMENT SHOWING RAINFALL BY SEASONS IN THE BIJAPUR DISTRICT FOR THE YEARS 1885 to 1905-06.

Year.	BIJAPUR.												Description of seasons in area commanded.
	Bagalkot.						Badami.						
	1st January to 10th April.	11th April to 4th June.	5th June to 14th August.	15th August to 21st October	22nd October to 30th November.		1st January to 10th April.	11th April to 4th June.	5th June to 14th August.	15th August to 21st October	22nd October to 30th November.		
	Early rain	Ante monsoon.	Monsoon Kharif.	Monsoon Rabi.	Late rain.	Grand Total.	Early rain.	Ante monsoon.	Monsoon Kharif.	Monsoon Rabi.	Late rain.	Grand Total.	
1905-06	0·04	4·43	6·36	3·02	0·01	13·86	...	4·96	4·26	4·49	0·01	13·72	Season almost complete failure. Famine declared
1904-05	0·16	0·92	3·47	9·61	0·45	14·61	1·12	0·75	4·07	5·71	...	11·65	July and August inadequate, November, December rainless. Season very poor.
1903-04	0·02	0·44	8·24	14·72	1·12	24·54	...	1·13	7·49	17·08	1·61	27·31	On the whole good.
1902-03	0·29	2·39	6·84	8·66	4·21	22·39	0·20	3·63	7·79	12·30	6·74	30·66	Kharif suffered from want of rain, Rabi rain excessive.
1901-02	2·13	4·92	3·23	5·04	1·16	16·48	2·50	3·59	3·57	12·57	0·86	23·09	Both Kharif and Rabi failed and withered.
1900-01	0·37	1·84	10·33	8·02	0·43	20·99	0·05	2·28	7·31	6·95	0·80	17·39	Both crops poor, 4 to 8 annas.
1899-00	0·07	5·55	0·95	15·23	0·37	22·17	1·50	3·20	0·63	16·07	...	21·40	Both Kharif and Rabi withered.
1898-99	0·44	0·65	6·95	11·04	2·24	26·32	...	...	...	...	...	.....	Kharif failed or completety lost, Rabi deficient, late rains, 8 to 9 annas.
1897-98	0·10	4·49	6·56	9·82	0·94	21·91	0·67	3·30	4·40	13·49	...	21·86	Kharif suffered fromdeficiency of early rain and Rabi for want of late rains, 4 to 6 annas both season.
1896-97	0·29	1·23	3·12	2·28	2·32	9·24	0·09	3·46	6·09	2·20	2·81	14·65	Both Kharif and Rabi dried up.
1895-96	0·61	2·73	4·26	10·70	2·37	20 67	2·45	0·86	6·46	7·84	3·57	21·18	Both seasons good, but no December rain.
1894-95	0·20	3·25	6·77	9·52	3·45	23·19	1·00	4·82	7·18	11·43	3·71	28·14	On the whole favourable.
1893-94	3·24	4·73	8·94	15·42	2·07	34·40	1·66	7·18	7·22	18·88	1·70	36·64	A very good year; excessive rain at harvest.
1892-93	0·33	3·83	9·89	20·73	6·41	41·19	0·50	3·68	8·40	22·17	5·65	40·40	Both crops damaged by excessive rain at harvest.
1891-92	0·57	2·44	5·18	5·76	0·03	13·98	1·25	3·24	4·72	6·19	1·70	17·10	Absolute absence of general rain. Famine declared.
1890-91	0·04	5·95	3·02	9·07	5·90	23·98	...	3·23	4·03	15·74	6·10	29·10	Fair on the whole.
1889-90	...	2·40	4·05	17·00	0·43	23·88	...	1·44	8·36	23·50	...	33·30	Both fair, but rabi late rain deficient.
1888-89	0·34	4·20	9·52	10·60	1·20	25·86	...	5·78	6·96	19·74	2·04	34·52	Both seasons very fair.
1887-88	0·27	6·08	7·74	9·29	4·09	27·47	...	2·37	6·22	13·45	3·51	25·55	Both crops good.
1886-87	...	3·98	10·97	12·96	6·59	34·50	...	9·41	13·68	12·78	1·62	37·49	Kharif good; Rabi excellent.
1885-86	0·35	3·32	4·09	10·00	6·88	24·64	...	1·81	5·34	12·00	4·61	23·76	Kharif poor; Rabi a bumper crop.

GHATPRABHA RIGHT BANK CANAL PROJECT.
PRELIMINARY REPORT.

1. The proposed canal forms a part of the Ghatprabha system of works which is to comprise the following:— Preliminary.

(*a*) A storage on the Ghatprabha River at Daddi capable of holding 45,000 million cubic feet;

(*b*) The Gokak Left Bank Canal, submitted as a separate project; and

(*c*) The proposed Right Bank Canal.

A canal is proposed also on the left bank of the river immediately below Daddi, but it will be a small one, and it has been decided to take it as a branch from the Right Bank Canal and to carry it to the left bank by means of a syphon across the river.

2. A report dealing with the earlier investigations on the project was submitted in June, 1907. The canal line considered then was to start from a point 39 feet higher than the lowest outlet of the Daddi Tank, and this line was subsequently surveyed regularly for 65 miles, up to Yergatti. Further preliminary surveys were done at the same time for a canal to start from a low level from the tank, and the results were reported in the abstract statements submitted in August, 1907, in which the camparative merits of the two alternative lines were discussed. It was seen that the low level canal would not be much more difficult than a high level one, and that there would be no material reduction in the area under command by adopting the former. As a low level canal will enable the whole of the tank contents to be used on the right bank of the river if wanted, the higher line was rejected, and it has been finally decided to start the canal from a low outlet in the tank. History of early surveys.

3. The total command available between the Ghatprabha and the Malprabha up to their confluence with the Krishna is 8,84,390 acres, and it is also proposed to supply 25,000 acres on the left bank of the Ghatprabha by a branch, the first item in the abstract given below:— Gross command.

British and Native State.	Main Canal.	Branches.		Spare command (beyond the tail Section of main canal) not taken into account in present project.	Remarks.
		Acres.	Name of Branch.		
British					
Belgaum District.	1,14,266	25,000	L. B. Canal.	.....	The uncommanded areas shown on the index maps have been marked carefully with reference to the actual levels taken for the preliminary surveys, and where these were wanting, with reference to the map contours. The areas shown as under command are thus fairly accurate.
		1,61,408	Yadwad.	.....	
		24,096	Lokapur.	.....	
Bijapur District.	973	1,09,863	Tail.	2,97,619	
Dharwar District.	.....	38	Tail.	410	
Total	1,15,239	3,20,405	.....	2,98,029	
Native States.					
Kolhapur	53,618	269	Yadwad.	12,166	
		3,373	Tail.	.....	
Sangli	1,100	.....	.....	.....	
Mudhol	.....	4,359	Yadwad.	.....	
		46,630	Lokapur.	.....	
		33,191	Tail.	.....	
Ramdurg...	781	1,517	Tail.	12,467	
Jamkhandi	1,984	4,262	Yadwad.	.....	
Total	57,483	93,601	.....	24,633	
Grand Total	1,72,722	4,14,006	.....	3,22,662	
	5,86,728 acres.		.....	.....	

In the above figures no deduction has been made for the areas on the river banks which are likely to be flooded. The total length of the rivers bounding the command is 250 miles, and the area under floods may be about 80,000 acres. If this area is to be excluded the net command will not be less than 825,000 acres. The command under the Daddi Left Bank Canal is 25,000 acres, which is included in the above.

Command beyond the Malprabha not wanted.

4. Preliminary levels were taken along the foot of the hills to the north-east of Saundatti, to see whether the command could be extended to the south side of the Malprabha. The ground traversed by the line was found rocky and very difficult, but no insuperable difficulties were met with.

It was noticed, however, that the command available on the left side of the Malprabha is already in excess of requirements, and it was decided by the Chief Engineer that the extension will not be wanted. Further surveys for the same were then stopped.

The command under the proposed canal is to be restricted to 577,500 acres, *vide* para. 13 below.

Supply.

5. The volume annually available from the Ghatprabha at Daddi is estimated to be 60,000 million cubic feet, of which it is proposed to pass 15,000 million cubic feet down the right bank canal during the monsoon, and to store the remaining 45,000 million cubic feet in the tank. The supply stored will be utilised as under :—

	Million cubic feet.
Loss by evaporation, absorption, etc., in tank (4 feet on mean area)	3,116
Requirements of Gokak Left Bank Canal	18,566
Balance available for issue on Right Bank Canal	23,318
Total ...	45,000

Supply required for Left Bank Canal.

6. The requirements of the Left Bank Canal and Mills have been calculated as follows :—

The average discharges required on the Left Bank Canal during the monsoon, rabi and hot weather are 990, 930 and 750 cusecs (*vide* Appendix No. 32, Book No. 3, Gokak Project.)	
The supply required for irrigation will be (990 + 930 + 750) 1 cusec × 4 months = 10·4 million cubic feet, 2670 × 10·4 =	27,768
Supply required for Mills at 136 cusecs continuous	4,243
Loss in transit and in the Dhupdal weir	555
Total supply required ...	32,566
Probable supply that can be picked up by the regulating weir at Dhupdal after construction of Daddi Tank (*vide* accompaniment to this Office No. 515, dated 10th March 1907) ... ... about	*14,000
Balance of requirements to be drawn off from the Daddi Tank million cubic feet, as taken in the above.	18,566

Possibility of utilising supply from the Markandeya.

7. The possibility of picking up a portion of the supply from the Markandeya and sending it into the Right Bank Canal has been investigated. The valley of this river is very narrow for about one mile just above the gauge site at Shirur. Three sites have been examined in this portion, and the probable storage ascertained. With a dam of 110 feet height, the storage will be about 3,000 million cubic feet, and the waste weir will be on the right bank in a saddle of the main ridge between the Rangadholi and Suldhal villages.

* Rough—Worked out from the monthly discharges over the 'Dhupdal Weir.'

A weir 60 feet high will be 1,000 feet long and would store about 500 million cubic feet. The depth of flood over the weir will be 7·25 feet. The pick-up weir crossing proposed for the Right Bank Canal (para. 38) is about ¾ mile below the weir site and a subsidiary weir can be placed at that site. The canal could cross between the main and subsidiary weirs.

A short note is attached giving the results of the rough surveys.

Probable supply from the Markandeya.

8. The Markandeya has been gauged at Shirur during 1906-07 and for a part of the year 1905, and the records show that the total supply available in ordinary years will be about 4,500 million cubic feet, nearly the whole of which can be secured by the construction of the 60 feet weir above referred to. A pick-up weir alone will enable about 3,000 million cubic feet to be sent down the canal. But in both these cases, the volume to be stored at Daddi will have to be increased proportionately as the supply to be drawn from the Ghatprabha during the monsoons will be less by 4,000 and 3,000 million cubic feet, respectively, which quantity would otherwise run to waste from that river.

A dam above Shirur will have no special advantage as regards supply, except it be to store water to start irrigation in the early part of the monsoon.

Supply from the Beldari Nulla.

9. The Beldari is another large nulla from which it would be possible to take some supply into the canal, which crosses it about 5 miles after the Markandeya. The catchment area of this nulla is 143 square miles, and 1,000 millions may, perhaps, be utilised if a pick-up weir could be constructed on it at a suitable site above the crossing.

No investigations have been made on this nulla.

Total supply available for canal.

10. The total supply available for the Right Bank Canal will thus be :—

(a) From the Ghatprabha Storage at Daddi :—

	Million cubic feet.
(i) During monsoons	15,000
(ii) From the Daddi Tank after monsoons ... (assuming that the supply required for left bank canal will not exceed that calculated in para. 6).	23,518
Total...	38,518
Other sources :—	
(iii) Markandeya weir	4,000
(iv) Beldari Nulla (not examined)	1,000
Total...	43,518

The supply available from Daddi, *viz.*, 38,518 million has alone been taken, into account in the calculations that follow regarding irrigable areas, etc.

Discharge, Duties and Losses assumed.

11. It has been directed by the Chief Engineer that the canal should be designed to carry a discharge of 1,500 cusecs at the head. The duties allowed for calculation of discharges of canal are :—

(a) In main canal, one cusec for every 500 acres of gross command exclusive of losses by leakage, etc., which should be separately allowed for.

(b) In branches, one cusec for every 175 acres of actual irrigation, no allowance for losses being made for lengths under 40 miles.

The losses by leakage, etc., are to be calculated at the rate of 8 cusecs for every million square feet of wetted perimeter.

Total losses by leakage.

12. According to the above rule for losses, the rate for leakage, etc., works out to :—

3·5	cusecs per mile for the 1st 20 miles of the canal from Daddi.				
3·25	„	„	from miles	21 to	45
3·00	„	„	„ „	46 to	66
2·75	„	„	„ „	67 to	77 at Yergatti.
2·00	„	„	„ „	78 to	110 from Yergatti to Saleli.
1·75	„	„	„ „	111 to	120 Saleli to end below Hoskoti.
1·5	„	„	„ „	0 to	10 in the tail branch for the portion

in excess of the 40 mile limit prescribed above.

No allowance for leakage will be necessary in the other branches, as the distance of irrigation under them will not exceed the above limit.

The total loss by leakage, etc., in the whole of the canal will be :—

	Cusecs.
(1) From Daddi to Yergatti	246
(2) Yergatti to Saleli	66
(3) Saleli to end	18
(4) In tail section	15
Total loss...	345

Gross command required.

13. The net discharge available for irrigation after deducting the above losses will be 1,500—345=1,155 cusecs. At the rate of 500 acres per cusec the gross command required will be 577,500 acres.

The length of main canal and branches provided is sufficient to secure a gross command of 586,728 acres.

Extent of perennial irrigation to fully utilise storage.

14. The volume available for issue on the Right Bank Canal is 38,518 million cubic feet, *vide* para. 10 above. With the canal running full for 8 months, the quantity utilised will be 31,400 millions, leaving 7,118 to be used during the hot weather, which will be equivalent to a continuous discharge of 684 cusecs for 4 months. If 134 cusecs may be assumed to be lost by leakage, etc., the net discharge that will be useful for actual irrigation will be 550 cusecs, which may be utilised for maturing perennial crops. With a duty of 40 acres per cusec, in the hot weather, the area under perennial should be about 550 × 40 or 22,000 acres.

Irrigable area.

15. The irrigable areas will be :—

	4 months Crops. Acres.
During monsoon and rabi=8 months (1,500—345) or 1,155 cusecs at 175 acres per cusec for 4 months=1,155 × 175 × 2	4,04,250
During hot weather—	
22,000 acres perennial	88,000
Total ...	4,92,250

Assuming the area under monsoon, rabi, and 8 months crops to be equal, the actual area under irrigation will be :—

	Actual irrigable area.	Equivalent 4 months crops.
Monsoon	79,063	79,063
Rabi	79,063	79,063
8 months	79,062	1,58,124
Perennial	22,000	1,76,000
Total ...	2,59,188	4,92,250

The total irrigable area is 2,59,188 acres, which is 44 per cent. of the gross command provided.

16. The area under perennial is to be confined principally to tracts near the tank, with a view to give employment to the population displaced from the tank basin. If the gross command required for the perennial be assumed to be 8 times the whole area under it, the perennial irrigation may have to be restricted to the following portions of the canal :—

Restriction of command under perennial irrigation.

	Length in miles.	Gross command in length.	Maximum distance from Daddi.	Remarks.
		Acres.	Miles.	
Main canal up to Yergatti	77·5	76,845	77·5	
Main canal up to Harihal Nulla (86·5 M.)	9	30,163	86·5	
Left Bank channel.	13·5	25,000	22·0	
Yadwad Branch up to Mamdapur minor (5·5 miles.)	83	40,360	83	
	Total ...	1,72,368 acres.		

17. All the villages under the command of the canal on both banks have been classified as regards quality of soil, and the soil maps are under preparation. Statement No. 22 (*not printed*) gives the rainfall month by month, so far as records are available, for the following stations in or close to the tract commanded by the canal :—

Nature of soil, rainfall.

Belgaum.	Ramdurgh.
Gokak.	Mudhol.
Sampgaon.	Bagalkot
Saundatti.	Badami.
Katkol.	

18. The canal crosses the main water-shed by the deep cut near Yergatti in the 78th mile, and nearly gains the top of ridge at Saleli in the 110th mile, the total command up to this point being 346,112 acres. Beyond Saleli the ridge rises very considerably, and the canal, after crossing it, will be continued on the north or Ghatprabha side till its end in the 120th mile near Hoskoti, which will be the starting point of the Lokapur Branch. The command from Saleli up to here will be 92,634 acres. The balance of the gross command required at this point is 1,38,754 acres, which will be obtained by extending the main canal as a tail branch till the main ridge will again be reached near Fakir Budhihal in the 29th mile of this section.

Brief description of Canal.

19. It may be a question for consideration, whether the Lokapur Branch should be constructed in its entirety. The command under it is 70,746 acres, of which 46,630 acres lies in the Native State of Mudhol About 33,191 more belonging to the same State is commanded by the Tail Branch. The whole area of 79,821 acres is in a compact block and can, if wanted, be excluded, in which case, the Tail Branch will have to be extended to secure the 80,000 acres. The whole of this extra area would be obtained easily in the famine area of the Bijapur District. In the present rough estimates this alternative has not been considered.

Native State area under Lokapur and Tail Branches.

The command from Saleli to two miles beyond Anigundi on the south or Malprabha side is in hilly and difficult country and belongs to Native States Ramdurg and Torgal (Kolhapur). The area is 35,872 acres which is mostly State and as it will be very expensive to arrange for its irrigation, it has been excluded in the present estimate.

20. The lengths of main canal and branches proposed, and of portions of the same in Native States and British territory are given below :—

Lengths of alignment in British Territory and Native States.

Miles. From.	Miles. To.	Territory.
		Main Canal—I Section.
0	1·2	Belgaum Taluka.
1·2	6·2	Sangli State, Shahapur.
6·2	11·6	Belgaum, Hukeri.
11·6	15·8	Kolhapur State, Gad-Hinglaj.
15·8	23·8	Belgaum, Hukeri.
23·8	24·5	Kolhapur State, Gad-Hinglaj.
24·5	35·0	Belgaum, Hukeri.
35·0	37·9	Kolhapur State, Gad-Hinglaj.
37·9	38·6	Sangli State, Shahapur.
38·6	77·1 end	Belgaum, Gokak and Parasgad.
		II Section.
77·1	89·7	Belgaum, Parasgad.
89·7	95·5	Kolhapur State, Gad-Hinglaj.
95·5	116·5	Do. (Torgal jagbir).
116·5	119·0	Ramdurg State.
119·0	120·0 end	Belgaum, Gokak.
		Daddi Left Bank Canal.
0	13·5 end	Belgaum, Hukeri.
		Yadwad Branch.
0	25 end	Belgaum, Gokak and Parasgad.
		Lokapur Branch.
0	6 end	Belgaum, Gokak.
		Tail Section.
0	1·5	Belgaum, Gokak.
1·5	9·5	Kolhapur State (Torgal).
9·5	29·0 end	Bijapur, Badami.

Abstract.

	Main Canal, Miles.	Branches, Miles.
Length in British territory	77·3	65·5
„ Native States	42·7	8·0
Total ...	120·0	73·5

1st Section of Main Canal.

21. The first section of the canal up to Yergatti has been regularly aligned commencing from the dam site (No. 2) at Daddi with outlet level R. L. 2234·70 (=R. L. 81 Rajgoli Datum). It is suggested in para. 24 below that this level may be raised to 2239·70. The section is in exceedingly difficult country and the following points along the route are obligatory :—

Preliminary—Obligatory points.

(1) The Madval Cut, which is a critical part as it enables the alignment to get through the chain of hills on the right bank of the Markandeya ;

(2) The Hire Nulla Syphon enabling the line to be carried without losing level clear of the hills to the north of Hire Budnur ; and

(3) The Shahabunder Cut. An alternative alignment in contour has also been surveyed round Vantmuri to avoid this cut, but the cut appears to be preferable. The length up to end of Yergatti cut measured along the alignment in contour round the Shahabunder cut, is 78·5 miles, while the length, by accepting that cut, will be 60 miles.

22. For the first 30 miles up to the water-shed of the Markandeya near Pachapur the line passes through forest land and decayed quartzite much fissured both horizontally and vertically, and with but a thin layer of soil on the top. The rock line is about 4 or 5 feet below the surface, excepting for a few miles (27·29) of the alignment round Vantmuri, where it occurs on the surface. The hill slopes are steep for the first 6 miles, but in the rest of the length they are flatter, except at the Kumpgatti spur (near the take-off of the Left Bank Canal) and in portions along the right bank of the Shahabunder Nulla, where the slopes are very steep. The ground is not much broken, but most of the valleys on the Vantmuri line are deep, narrow and have steep sides. At three places in the first 6 miles, the line comes dangerously close to the river, but the portions will be practicable.

Nature of ground.

From 30·47 miles, the line is situated in the valley of the Markandeya, which consists almost entirely of fairly deep black soil, overlying "shadoo." The only difficulty in this valley will be the foundations for masonry works, which in some cases will be very deep.

From the Madval cut (47th mile) upto Murkanhatti, in the (54th mile) and from Guranhatti (58th mile) upto Yerghanvi (70th mile) the line is again on the outskirts of forest and passes through decayed quartzite and the general nature of the ground is similar to that of the first 30 miles. The portion from Hanmankadbi (66th mile) upto half-a-mile beyond the Kanvi Nulla (67th mile) is very difficult and contains two or three valleys which are narrow and deep.

The remaining portions from miles 54 to 58, and beyond Yerghanvi upto Yergatti are in average ground, with a thin layer of soil overlying hard muram. Portions near miles 60 and 64 are rocky, and miles 73 to 76 near Yergatti are rocky and much broken.

23. This has been carefully ascertained by means of flying levels which are entered on the index plans. For the area to the south of Gokak the canal water can be dropped into the Ghader Nulla immediately after the Madval cut, and can be picked up lower down by means of a weir on the nulla. Three sites were examined for the weir, and the most suitable would be one mile to the south of Hoshatti, near the 4th mile of the Gokak-Ankalgi road. The area between the Ghader and Kanvi Nullas could be commanded by a distributary, taking off from the 57th mile of the main canal near Navapur. From the levels shown it would appear that no pick-up weir would be required on the Kanvi Nulla for the command to the east of Gokak.

Gross command upto Yergatti.

The total command from Daddi to Yergatti is estimated to be 76,845 acres, which is exclusive of 25,000 acres commanded by the Left Bank Canal branching off from the 9th mile.

24. A low bed-fall of 6 inches per mile has been adopted for this section in order to take the canal at as high a level as possible to Yergatti, as the main command is situated beyond that cut. The rate of fall, though low, is sufficient to give a velocity of a little over 2·5 feet per second, but it does not leave a margin of head for future lengthenings and other improvements to the alignment. It was ordered that spare head may be reserved for this purpose by having drops of 6 inches in the canal bed at every 5 miles, which, however, has not been done, as the surveys were far advanced. A statement (No. 10) has now been made of the maximum deviation that could readily be seen to be possible at nulla and ridge crossings on an inspection on the drawings and for the portion from Madval cut to Yergatti the head required for the extra lengths so calculated has been kept in reserve at intervals along the line. For the remaining portion from Daddi to the Madval cut it is suggested that the extra head that may be found necessary later on may be obtained by starting the canal from a higher outlet, say, upto 2139·70 (R. L. 86 Rajgoli Datum), instead of from R. L. 2134·70 as now surveyed. The extra contents that would be lost by raising the outlet level to 2139·7 will be 356·2 million cubic feet only.

Bed-fall.

Extra rates of fall varying from 2 feet to 8 feet per mile have been given in all cuts and steep grounds to reduce the canal section. The details of the bed-falls allowed are given in Statement No. 9. The loss of head required to create the increased velocities to be maintained by the extra rates of falls have been calculated and provided for. The total head used up from Daddi to Yergatti is 70·70 feet, which is equivalent to an average fall of 0·91 feet per mile.

Depth of water.

25. The depth of full supply has been taken to be 8 feet in this section. The greater part of the survey was done assuming the depth to be 10 feet, until it was reduced to 8 under instructions from the Chief Engineer, but the alignment has not been vitiated by the lower depth. The depth of the full supply in deep cuts and steep grounds provided with extra falls, has been assumed to be 50 per cent. more, *viz.*, 12 feet, to be obtained by lowering the bed in that portion.

Canal section.

26. The canal section has been calculated by the usual formula with Kutter's coefficient assuming N=·020, with side slopes $\frac{1}{2}$ to 1. The value of N is to be increased to ·0225 after the first section. In rock cuttings, the sides are vertical and N is assumed to be=·0225.

Discharge and size of canal.

27. The discharge has been taken to be 1,500 cusecs at the canal head, and the canal section at points lower down have been reduced according to the rules given in para. 11, *viz.*, by allowing (1st) for irrigation at the rate of one cusec for every 500 acres of gross command upto that point, and (2nd), for losses by leakage, etc., at the rate of 8 cusecs per million square feet of wetted perimeter. The rates of losses have been calculated in cusecs per mile and are given in para. 12.

The discharge and dimensions of the canal are given in Statement No. 11. The bed width of the canal varies from 68 feet at Daddi to 48 feet at Yergatti before the take-off of the Yadvad Branch, and 31 feet after that branch. The discharges in the canal before and after that branch will be 1,050 and 710 cusecs respectively.

Details of alignment.

28. The canal generally follows the contour of the country, and has been aligned so as to secure, as far as practicable (*a*) in normal ground, an average cutting of 3 to 5 feet on the centre line, and (*b*) in steep ground a cutting of about 1* foot at the downstream edge of the canal. Rock excavation could, however, not be avoided altogether even with these low depths. The bed levels were readjusted after the completion of the surveys and portions of the alignment, especially near Yergatti, are capable of improvement in this respect.

Difficulties.

Porous nature of soil.

29. The excavation for a great length of the canal will be in disintegrated quartzite, which is much fissured and is likely to lead to great loss by leakage. A puddle trench may probably be required for the side banks, and in order to cover its cost, the rates for embankment in such ground has been assumed to be Re. 1 per 100 cubic feet for banks of ordinary size, and Re. 1-4 per 100 cubic feet for full banks of over 10 feet in height. In the hilly and forest areas, suitable soil for the banks is not available close to the line, but cultivation is not far, and the same can be procured at a moderate lead.

Sidelong ground.

30. Statement No. 5 gives details of ground with slopes steeper than 5 to 1. Extra falls have been given to reduce the canal section in all cases. An additional difficulty here is the porous nature of the soil referred to above. Where the slopes are steeper than $3\frac{1}{2}$ feet to 1, the following extra provision is made, besides the usual benching, in order to strengthen the side bank:—

(i) A thin wall to protect the core, which will be placed on the inside slope at the F. S. L. and founded on good rock.

(ii) A dry stone-wall at the down-stream toe to support about 4 feet of the bank.

* The cutting on the centre line will vary from 5 to 8 feet.

Four cases requiring special mention are those from miles 1·1 to 1·2, 1·4 to 1·6, 3·5 to 3·9, and 4·4 to 4·7, in all of which the slopes are steeper than 2½ to 1, and the first three portions are dangerously close to the river. In these places, it is proposed to dispense with the downstream side bank, and to provide instead a wall of suitable section founded well in rock.

Madval Cut.

31. The main details of the cut are:—

Section.		Length.	Width at bed.	Nature of Strata.	Remarks.
Depth of cutting.	Side.				
15-30	West.	2,700	21	Soil, and 24′ shadu and muram.	Fall adopted only 3′ per mile. Rate of fall to be increased if head can be spared after raising the outlet at Daddi. Widths calculated for 12′ depth of water.
30-53	„	2,960	21	Soil, and 41′ shadu and soft rock.	Maximum depth of cut, 53 feet.
53-30	East.	2,340	21		
30-15	„	1,000	21	Soil, and 18′ shadu and soft rock.	
Total ...		9,000			

Rock occurs very low and that only in a small portion of the cut on the east side. The rock line appears to be higher on the east than on the west side and on the north than on the south side of the cut. The principal difficulty is the very great depth of the layer of shadu and muram which occurs in the excavation. Excepting the top 7 or 8 feet which consists of sandy and black soil and the bottom 5 feet which is made up of hard red muram, the main part of the excavation will be in the shadu. The material is grey in colour and is very stiff to dig when dry, but was found to become very soft and greasy when wet and cannot stand even flat slopes. The difficulty will be considerably increased by the high spring level, which, according to observation made in April 1908, is as follows:—

			Spring level from ground surface.
Madval side at	15′	cutting	10′
„	30′	„	15′
Jaganhatti site	35′	„	17′
„	15′	„	11′

It is possible that lining may be required for a considerable length of the cut. The estimated cost of the cut is Rs. 3,20,000. The cut twice crosses the Gokak-Belgaum Road which will have to be diverted for about half-a-mile.

Hire Nulla Syphon.

32. The nulla is crossed in the 63rd mile. The width of the crossing is 1,100 feet, and the maximum depth below canal bed 105 feet. Surveys were made for alternatives, but it was found quite impracticable to take the alignment higher up, as the valley gets very precipitous on the right bank about ¼ a mile above the site. This and the adjacent crossing on the Kanvi Nulla were avoided by the higher line originally surveyed (para. 2), as the same was carried on the south side of the hills, but the cuts at Chikbudnur, Hirebudnur, and Madgali, which were heavy even for that line, will be quite impracticable for the present low level canal.

The pipe syphon will be 13·25 feet in diameter and will be of reinforced concrete up to 30 feet head, and above that head will consist of a ¼-inch steel pipe encased in concrete. The pipe will be carried over the nulla on an aqueduct and will have to sustain a maximum head of pressure of 92 feet. The calculations and details are attached to the rough estimates which amount to Rs. 2,00,000 or

an equivalent rate of Rs. 180 per running foot. A masonry aqueduct for the whole of the crossing may not be impracticable, as the foundations are excellent, but the cost will be about Rs. 3,60,000.

Difficult aqueducts.

33. (*a*) The Kanvi nulla is crossed in the 68th mile in a gorge between hills, the canal bed being 44 feet above the lowest point of the nulla. The width of the crossing is only 400 feet. To reduce the headway it will be necessary to go beyond the hills, towards the Madgalli, where the valley widens the cut, but the detour will be 2 miles. Two spans of 20 feet will be sufficient for the crossing, but 4 are provided so as to reduce the height of approaches to 25 feet. The ground between the Kanvi Nulla and Hanmankadvi on the left bank is very bad, and an alternative crossing was examined lower down in the narrow portion opposite Bol Kadbi and Hanmankadbi, but the valley is rather wide here and the maximum height is 76 feet. The alternative will also have to cross a low gap on the ridge between Bol Kadbi and the main hills to the south, which will require to be heavily banked.

(*b*) The most difficult of the aqueducts is that on the Beldhari Nulla in the 42 and 43 miles, in which the foundations will have to be entirely in clay. The catchment area of the nulla is 143 square miles and 12 spans of 30 feet are provided. The Railway bridge on the nulla two miles higher up has 8 spans of 30 feet and 2 of 16½ feet and is founded on wells sunk 35 feet in clay.

(*c*) The Markandeya is crossed with 12 spans of 30 feet, the catchment area at the crossing being 167 square miles. The site is a good one with suitable approaches, but the nature of foundations has not been ascertained. The Railway bridge on the river two miles lower down consists of 5 spans of 60 feet and is founded in muram which is 17 feet below bed. The line of muram is likely to be higher at the aqueduct site as the hills are close on both banks.

(*d*) The aqueduct crossings in miles 18 to 20 and 24 are all difficult, but these are in the Vantmuri line and add to its difficulty which is referred to in para. 36 below.

Minor cuts, high embankments and other difficulties.

34. The Shahabunder cut and other principal difficulties are referred to among the alternatives. Statement Nos. 3 and 4 give the datails of the deep cuts and high embankments along the line. None of the latter present any exceptional difficulties. A few of them might be modified, such as those at mile 54 and 56 on the Murkanhatti and Ghader Nullas, but the rest are more or less obligatory, owing to the peculiar nature of the ground.

Alternatives.

Shahabunder cut.

35. The three alternatives given below have been surveyed and estimated for in some detail. The differences in length between the alternatives are very considerable, and as the rate of leakage is high, being nearly 3·5 cusecs per mile near the cut, the capitalized value of the losses has also been taken into account in the comparison. One cusec discharge continuous for 8 months will irrigate 350 acres of 4 months crops, and the capitalized value of the net revenue on this area will be nearly Rs. 20,000. The alternatives to be considered are:—

I.—Alignment *vid* Shahabunder cut with an aqueduct crossing on the Markandeya.

II.—Alignment in contour round Vantmuri, with an aqueduct crossing for the Markandeya.

III.—Alignment in contour round Vantmuri, with a syphon crossing for the Markandeya near Pachapur.

Nos. I and II above commence from 13·5 miles and end in 36·7 miles, continuous mileages being obtained by accepting No. II. The syphon alternative (No. III) starts from the mile 30·5 on the Vantmuri line, and ends in mile 44·7 just before the Madval cut. The comparison now made for all the three are from 13·5 mile on the left bank of the Shahabunder Nulla upto 44·75 mile just before the Madval cut.

Serial No.	Items compared.	Alignments.		
		I. *Vid* Cut.	II. In Contour.	III. *Vid* Syphon.
1	Length of alignments, miles ...	12·90	31·20	23·40
2	Cross slopes :—			
	(i) Between 1 in 3 to 1 in 5 feet	*Nil.*	10,400	12,400
	(ii) Between 1 in 5 to 1 in 10 feet	600	9,550	7,550
3	Nature of ground...	Red sandy or black soil, 8 miles; cut, 4 miles; broken ground, *nil.*	Forest land hard and rocky or broken ground, 18 miles; black or red soil in rest.	
4	Head spent, feet	20·4	20·4	21·1
5	Cuts above 8 feet depth—			
	(i) Total length, feet	20,200	2,000	2,600
	(ii) Maximum depth, feet ...	94·5 67′ in rock.	13·5	19
6	Embankments above 10 feet—			
	(i) Total length, feet	3,650	7,150	3,500
	(ii) Maximum height, feet ...	25 (in Markandeya).	40 (VantmuriNulla)	40 (VantmuriNulla)
7	Other difficulties	Markandeya & Beldhari aqueducts.	Markandeya & Beldhari aqueducts.	Markandeya Syphon.
8	Cost of alignment	15,85,000	18,15,000	17,57,000
9	Capitalised value of leakage ...	8,78,000	20,65,000	15,60,000
10	Total cost, including leakage ...	24,63,000	38,80,000	33,17,000

Special difficulties in alternatives and comparison.

36. (*a*) Alignment No. II is that which has been accepted for showing the continuous mileages of the whole canal, but it will be seen that it is the longest and the most costly, especially when the leakage is taken into account. The principal difficulties are (1) the porous nature of the decayed and fissured rock through which the line passes for nearly 15 miles, (2) rocky ground (3 miles), and (3) the numerous valleys to be crossed between Vantmuri and Chilbavi, which are all deep and narrow, and have very steep sides. High embankments in these places cannot be avoided to any extent even by crossing the valleys high up, and with bad angles.

(*b*) Alignment No. III is only a continuation of No. II just when the latter enters into the easy ground of the Markandeya Valley near Pachapur in the 31st mile; and the difficulties referred to above apply to this also. Its advantage over No. II is the reduction in length by adopting a syphon crossing for the Markandeya instead of going in detour for an aqueduct crossing higher up at Shirur. Rough estimates have been made for the cost of the syphon, which will be carried over the river on a narrow aqueduct. The length of the syphon will be 3,050 feet. The maximum pressure is that due to a head of 45 feet. Its cost is about Rs. 5,37,000, which is equivalent to an average rate of Rs. 175 per running foot. An alternative estimate has been prepared for extending the aqueduct, and heightening the piers, so as to carry the syphon at a high level, in order to reduce the head of pressure to 30 feet. The cost of the latter will be Rs. 4,40,000.

(c) Alignment No. I.—The main details of the Shahabunder cut are:—

Portion with depth of cutting.	Length of Section.	Maximum depth of rock § cutting.	Fall in mile.	Calculated bed width.	Cost.	Remarks.
† 8 to 20 ...	1,750	*Nil.*	6″	‡63		† West side of cut.
†20 to 45 ...	2,800	33	3′	24		* East side of cut.
†45 to 67 ...	1,800	55	4′	21		§ Quartzite.
					5,20,000	The rock line on the east side is very low. Maximum depth of cut at centre is 95 feet.
*67 to 47 ...	2,290	45	4′	21		
*47 to 25 ...	3,530	24	3′	24		
*25 to 8 ...	3,500	*Nil.*	6″	63		
Central portion, 67′ on west to 67′ on east side.	4,520	68	8′	16	4,90,000	‡ Width for falls other than 6″ calculated for 12′ depth of water.
				Total ...	10,10,000	

The valley lines along which the cut is aligned are water-bearing, and the spring level is high, which will add to the difficulties of the excavation, especially on the east side of the cut. On this side, the strata met with in the section from 35′—8′ cutting is shadu and muram which is stiff enough when dry, but when wet, was found to become very soft and yielding and could stand only very flat slopes. The level of springs as observed in January 1908, are:—

	At depth of cutting.	Level of spring below ground.
Shahabunder side	12′ ...	6′
Do.	30′ ...	8′
Basapur side	35′ ...	9′
Do.	20′ ...	7′
Do.	8′ ...	5′

The alignment No. 1 appears to be the most preferable. The only difficulty is the excessive length and depth of the cut, coupled with the other difficulties mentioned above. The whole of the cut has been treated as open in preparing the estimate, but for the central portion the cost estimated is equivalent to a rate of Rs. 110 per running foot. It may be possible to construct this portion in short lengths of tunnel with open cuts between.

The length of canal that will be saved by adopting the cut, is all in very bad ground. The saving in cost, when the leakage is taken into account, would be sufficient to line portions of the cut and tunnel if this should be found to be necessary.

Alternatives for Murkanhatti cut.

37. The length of this cut, which occurs in the 54th mile, is 5,600 feet, and the maximum depth 57 feet. The rock line in the cut is very high. An alternative contour run round the cut is 5·6 miles long and passes almost throughout rocky and bad ground. The difficulties, etc., are compared in detail in the statement of alternatives, please see Statement No. 12. The cost of the alternative would be Rs. 6 lakhs against Rs. 3,42,000 estimated for the cut. The cut may be accepted.

Pick-up weir on the Markandeya.

38. This has been surveyed as an alternative for the aqueduct crossing on the same river. The proposed site is about 3,500 feet above that of the aqueduct. The nature of the foundations has not been examined, but judging from that of the Railway bridge, the rock line is likely to be deep. A curtain wall has also been provided which will be 15 feet high above bottom of foundations. The pick-up weir will be 700 feet long and the maximum height over bottom of founda-

tions will be about 42 feet, the depth of flood calculated is 8·5 feet. The cost, etc., of the aqueduct and of the weir will compare as follows:—

	Length of alignment.	Cost. Rs.	Supply from river.
Aqueduct crossing ...	3,035 ...	1,20,000 ...	*Nil.*
Pick-up weir crossing ...	7,040 ...	*2,30,000 ...	3,000 million cubic feet.

* Cost, including the extra leakage, will be Rs. 2,99,000.

The increase in canal length by adopting the weir will be 4,000 feet and that in the actual cost Rs. 1,10,000, while the advantage will be that a supply of about 3,000 million cubic feet can be drawn off from the Markandeya during the monsoon. The pick-up weir may be accepted.

Other alternatives.

39. Alternatives have also been considered for the crossings of the Sutkatta Nulla (5th mile) and for the Yerjharvi cut (70th mile), and the comparisons are made in Statement No. 12. The accepted alignments are the cheaper.

Three alternatives have been considered for the crossing of the Shahabunder Nulla, but these are required in connection with the Vantmuri alignment, which appears to be unfavourable [please see para. 36 (*a*)].

Estimates.

Earthwork.

40. Two miles in every ten have been estimated in detail as instructed by the Superintending Engineer. The type sections adopted for taking out the quantities are shown on the drawings. Deep cuts, steep ground, and high bank have been separately estimated, and the total costs have been worked out for every 5 miles, based on the estimate for the typical mile.

Masonry works.

41. The sizes of the cross drainage works have been calculated fairly accurately, and the costs entered approximately have been based on the actual estimated figures of similar works provided in the Gokak Canal Project, or from the type estimates for the Nira Right Bank Canal, whichever was suitable.

The sizes of bridges, regulators, etc., have been calculated, and rough costs worked out from the actual estimates made for the Gokak Project.

Lump provision has also been made for bungalows and other miscellaneous works, so as to approximate as closely as possible to the cost of this section of the canal.

The figures of cost, etc., are entered under the estimates for the whole project worked out in para. 56 below.

SECOND AND TAIL SECTIONS OF MAIN CANAL.

Description.

42. The second and tail sections of the canal have been roughly surveyed. Contours were run on both the Ghatprabha and Malprabha sides of the ridge and the probable lengths of the alternative alignments will be as follows:—

	Length of probable mean alignment, miles.	Gross command, acres.	Remarks.
(*a*) Yergatti-Saleli.			
*Ghatprabha side ...	44	1,75,000	* Country on west side of main Yadwad ridge very difficult, especially in valleys of Yerganvi and Muglihal Nullas.
Malprabha side ...	32	70,000	
(*b*) Saleli ridge 2 miles east of Anigundi.			
Ghatprabha side ...	31	1,50,000	† Do. for a small length of the contour in the valley of the Anigundi Nulla.
† Malprabha side.	28	40,000	

(*a*) About 20 miles of the Yadwad branch would be saved if the canal line could be carried on the north or Ghatprabha side, but the difficulties on that side are very great (please see paras. 49-50 below). The loss of head will also be excessive, which will considerably increase the difficulties in the alignment to the east of Saleli.

The main canal from Yergatti to Saleli has, therefore, been assumed to be on the Malprabha side of the ridge.

(*b*) From Saleli to Anigundi. There is not much difference in length of alignment on the two sides of the ridge. The country on the north side is slightly less difficult than that of the south, and besides, about 10 miles of the Lokapur branch will be saved by keeping to the former side. It is, therefore, proposed to carry the alignment on the Ghatprabha side.

Yergatti cut.

43. This cut, which is situated on the main water-shed, is a critical point in the canal alignment and extends from mile 77·5 to 78·5. The main details are:—

Section.	Length of section.	Fall, feet, per mile.	Remarks.
Depth of cutting.			Maximum depth of cut, 45·5; canal bed width, 22 feet; strata met with in centre 5 feet black soil, 13 feet shadu and kankar, 5 feet gravelly, and 12 feet hard muram. Rock at south end 17 feet below ground.
16 to 28, Ghatprabha side.	600	3′	
28 to 45, „ „	1,360	4′	
45 to 29, Malprabha „	1,440	4′	
29 to 16, „ „	800	3′	
Total ...	4,200		

Rock occurs very low, but the main excavation will be in muram and no special difficulties are likely to be met with. The spring level is very low.

Alignment in 2nd section.

44. The country in this and the succeeding sections is comparatively less difficult and bears a general resemblance to that on the Gokak Left Bank Canal with the exception that the nullas here are less shallow and can probably be crossed with suitable headways, without long banks. From Yergatti to Saleli, the only points requiring consideration will be the alignment from miles 80 to 82 along the Sapadla spur, where the Kaladgi road is crossed four times and the cut two miles to the north-west of Katkol, which, if found practicable, may save 4 miles of the alignment from miles 90 to 95. The maximum depth of the cut will be 55 feet and its length 6,000 feet. Rough estimates show that the cut may be the cheaper, but as it is so deep, the alignment has been assumed to be in contour. The canal discharge at Yergatti will be 710 cusecs, while that at Saleli will be 500 cusecs.

45. The lowest level at the gap in the main ridge near Saleli is R.L. 2,132, which is only 4 feet higher than the calculated canal bed. The alignment from the gap upto the end of the main canal in the 120th mile near Hoskoti will be somewhat winding. Two shallow cuts in the 113th and 116th miles will save about two miles of alignment. The ground is otherwise not difficult. The bed-level at the end of the main canal will be about R. L. 2,118 and the discharge about 450 cusecs.

Tail section.

46. The country traversed in this section is more difficult, and the line will be very winding. The ground is somewhat broken near Venkatapur and Batkurki and one or two valleys are narrow; but they are not deep and there would be no special difficulties in the alignment.

Branches.

Daddi Left Bank Canal.

47. This will be taken as a branch from the main canal on the right bank from near the 9th mile. The river will be crossed by means of a pipe syphon of 3'-3" diameter. A contour surveyed for this canal direct from Daddi showed that the country is very steep and broken in the portion intervening from Daddi upto the syphon crossing.

The contour has been continued from the syphon crossing for 16 miles with a fall of 3 feet per mile upto the limit of the British territory near Khanapur.

The bed-level at start on the right bank is R. L. 2,221·5, and that on the left will be R. L. 2,200, the drop allowed being sufficient to create and maintain a velocity of 8 feet per second through the syphon. The length of the crossing will be 2,300 feet and the maximum head of pressure in the pipe will be 120 feet in the river-bed. The total length of the alignment on the left bank will be 13 miles. Three deep cuts will be required and their lengths will be 4,200, 2,600 and 2,000 feet, the corresponding depths being 45, 20 and 20 feet, respectively. The country is otherwise not very difficult.

The command and discharges of the branch are given in para. 54 below.

Yadwad Branch.

48. It was directed that this branch and the distributaries under it should be surveyed in some detail, so as to ascertain approximate rates suitable for similar works in the tract commanded by the canal. Detailed surveys have been made for 10 miles of the branch and for an aggregate length of about 115 miles of minors and distributaries. The costs have been worked out roughly for all the above, and a note is attached giving a summary of the results.

Alignment.

49. The branch starts just before the Yergatti cut, from the 78th mile of the main canal. It crosses the main Yadwad ridge in the 20th mile near Bhagoji and gains its top in the 25th mile. The length of the Bhagoji cut will be 1,300 feet, and the maximum depth 26 feet. The ground in the first 20 miles is difficult and is exceedingly broken in the valleys of the Yarganvi and Muglihal Nullas. In both valleys the line has to cross a large number of long, deep and narrow valleys with short spurs between, which throws the alignment alternately into deep cuts and heavy banks.

In the case of the Yarganvi valley, the above difficulties seem to be almost insuperable. An alternative would be to cross the valley by means of a syphon in a narrow part just above that village, and this has been investigated. The details of the syphon and other difficulties met with in the first 10 miles are given in the note referred to in para. 48 above.

50. An alternative was examined to see whether the very bad ground in both the Yarganvi and Muglihal valleys could be avoided by carrying the branch at a lower level. The bed-level at start of branch is 2,163·50, that on the right bank opposite Yarganvi is R. L. 2,155·5. A contour with bed 30 feet lower was surveyed from the right bank of the Yarganvi valley upto the end of the rugged ground beyond Muglihal.

The difficulties in the first valley would be reduced, but there is no improvement in the ground in the Muglihal valley, even with a lower line. On the other hand, about 10,000 acres of command would be lost by the lowering of bed.

51. A second alternative that might be considered in preference to the above would be :—

(*i*) To stop the present branch immediately after the take-off of the large Mamdapur minor in the 6th mile ; and

(*ii*) To arrange for the irrigation of the area near Kaujalgi and Yadwad by taking separate branch from the 107th mile of main canal near Chandargi and bringing it along the east side of Yadwad bridge round Hirekop and Bhagoji.

Rough comparative estimates show that the alternative would cost only slightly less than the present alignment, but would lose a gross command of about 25,000 acres. Careful surveys will be necessary to decide about the alternatives.

Lokapur Branch.

52. This branch will only be 6 miles long. At its start it is situated on the top of the ridge, but from its second mile to its end it will run in contour at the foot of the hills to the south of Hoskoti. The bed-level at start will be about R. L. 2,118. The discharge and command are given in para 54.

Command beyond the tail section.

53. The total command under the canal and branches described above is 586,728 acres, including the 25,000 acres on the Daddi Left Bank Canal. The tail section near its end is almost on the top of the ridge, and there will be no difficulty in extending it, if wanted, in order to increase the command. The total gross command available between the Ghatprabha and Malprabha Rivers up to their junction with the Krishna is about 800,000 acres, and the area left out now is thus 240,000 acres, which can easily be taken up in any future extensions of the project. A note is attached giving the results of the preliminary surveys done in this area.

Estimates.

Rates for Main Canal and Branches.

54. Rates for earthwork have been worked out for typical miles in the 1st section and for a few miles of the Yadvad Branch. Averages of these obtained for different sections of the canal and branch are given below. The corresponding rates for masonry works have also been worked out roughly and are given.

No.	Section of Canal.	Mean canal discharge.	Rates per mile.			Remarks.
			Earthwork.	Masonry work.	Total.	
	1st Section.	Cusecs.	Rs.	Rs.	Rs.	
1	Miles 0—13·6 (Shahabunder Nulla).	1,454	67,595 *	13,985 †	81,580	* Includes masonry side walls in very steep ground.
2	Miles 13·5—30·5 (Vantmuri line).	1,380	50,652	10,671 †	61,323	† Nullas crossed, small.
3	Miles 30·5—44·8 (Madval cut).	1,290	28,545 ‡	25,383	53,928	Includes Markandeya and Beldhari aqueducts.
4	Miles 44·8—77·1 (Yergatti)	1,128	48,882 §	20,164 ¶	69,046	‡ Rate low as the length is mostly black soil.
5	Miles 0—77·1 (whole of section).	1,279	48,158	18,543	66,701	§ Excluding Madval and Murkanhatti cuts.
	Yadvad Branch.					
6	Miles 0—3 (Yerganvi Nulla).	420	14,158	8,400 †	22,558	¶ Includes Hire Nulla syphon.
7	Miles 3—6 (very broken ground near Yerganvi).	378	36,383 (*a*)	33,338 (*b*)	69,721	(*a*) Includes a number of high banks. Ground very broken.
8	Miles 6—10 (average ground).	332	14,730	11,031 †	25,761	(*b*) Includes Yerganvi syphon.
9	Miles 0—10 (whole of section).	374	20,203	16,933	37,136	

The rates proposed for the remaining sections of the canal and branches are given below together with their command and discharge under each. The discharges required in branches have been calculated at the rate of 1 cusec for 400 acres gross, so as to allow for fluctuations in supply.

No.	Section of canal or branch.	Gross command at head of section.	Discharge at head of section.	Rate proposed per mile.		
				Earth-work.	Masonry work.	Total.
	Main Canal. 2nd Section.	Acres.	Cusecs.	Rs.	Rs.	Rs.
1	Miles 77 to 110 (Saleli).	305,675	710	35,000	15,000	50,000
2	Miles 110 to 120 ...	231,271	511	25,000	12,000 taken as	(37,000) 40,000
	Tail Section.					
3	Miles 0 to 29 (end) ...	147,981	385	18,000	12,000	30,000
	Yadvad Branch.					
4	Miles 0 to 20 (valley end of very difficult ground.)	170,298	426	*25,000	*15,000	40,000
5	Miles 20 to 5 (tail portion).	78,008	195	12,000	5,000 taken	(17,000) as 20,000
	Lokapur Branch.					
6	Miles 0 to 6	70,746	177	10,000	5,000	15,000
	Daddi L. B. Canal.					
7	Miles 0 to 13·5 ...	25,000	70	†8,000	3,000 taken	(11,000) as 12,000

Rates for earthwork generally high to allow for difficulties.
* Rates very high to allow for long lengths of exceedingly broken ground.
† Rates very high to allow for cuts and other difficulties.

Rates for minors and distributaries.

55. Actual rates have been estimated roughly for these works in the Yadvad Branch and are given in the note on cost of distributaries. The average rates are given below, which are exclusive of water channels :—

No.	Description.	Total length of channel on which average is taken.	Gross command.	Average rate per acre.	Remarks.
		Miles.	Acres.	Rs.	
1	Distributaries (terminal).	46	1,500—5,000 mean 2,000	2·2	Includes one distributary in steep ground near river, 2·4 miles long, costing Rs. 3·9 per acre.
2	Distributaries (main and branch).	41	8,500—11,000 mean 9,800	2 9	
3	Distributaries (main and branch) in steep ground near river.	12	6,200—6,600 mean 6,400	4·0	Includes 17 miles of item 1, but excluding item 3.
4	Minors, on direct length, excluding distributaries.	·23	30,000—42,000 mean 37,000	1·4	Appraximate. Four large minors will take off from the branch, of which three are estimated. Rough figures have been assumed for the fourth.
5	Minors, on direct length, including distributaries.	95	30,000—42,000 mean 37,000	3·8	
6	For the whole Yadvad Branch, excluding cost of Branch.	155	170,298	3·6	

The cost of water-courses is not included in the above, and if this be taken at Re. 1 per acre, the total average rate per acre of gross command will be about Rs. 4-8. This is a very high rate and is due to—

(1) The large number of vertical drops that have to be provided even along the minors on account of the steep nature of the country; and

(2) The long lengths of minors and main distributaries that are required as the main canal and branches are situated close to the watershed and far from the rivers. The cost of the whole canal will give an average rate of only Rs. 42 per acre of gross command, including, all charges.

Cost of project.

56. The estimated cost of the project, including headworks will be as follows:—

I.—Head Works.

The proposed storage at Daddi is to hold 45,000 millions, of which 18,000 millions are to be reserved for the Gokak Left Bank Canal, 3,100 will be lost by evaporation, and the balance to be issued to the Right Bank Canal would be nearly 23,400 million cubic feet. If the two canals are to be treated separately, the cost of the headworks may be assumed to be divided proportionately, according to the volume supplied to each, *viz.*, in the ratio of 18:24. The cost to be taken for the Right Bank Canal will be:—

	Total figure for Daddi Tank. Rs.	Proportionate cost for B. R. Canal. Rs.
Cost of dam, weir, etc. ...	52,91,348	30,23,627
Land and village compensation	50,72,478	28,98,559
Total ...	1,03,63,826	59,22,186

II.—Main Canal.

	Rs.
(*a*) 1st section (0-77 miles) as per rough estimates:—	
Earthwork	40,95,662
Cross drainage works	13,00,720
Bridges, regulators	1,29,000
	55,25,382
(*b*) 2nd section:—	
Miles 78-110 @ Rs. 50,000 per mile...	16,50,000
Miles 111-120 @ Rs. 40,000 per mile...	4,00,000
	20,50,000
Total Main Canal...	75,75,382

III.—Branches.

(*c*) Daddi L. B. Canal:—	
Pipe siphon 3′-3″ diameter, length 2,400 feet, at Rs. 35 per R. ft. 2400 × 35 = 84,000, taken as (including Head-walls), etc.	94,000
13 miles @ Rs. 12,000 per mile	1,56,000
	2,50,000
(*d*) Yadvad Branch:—	
0-20 miles @ Rs. 40,000	8,00,000
21-25 miles @ Rs. 20,000	1,00,000
	9,00,000
(*e*) Lokapur Branch:—	
0-6 miles @ Rs. 15,000 per mile	90,000
(*f*) Tail section:—	
0-29 miles @ Rs. 30,000 per mile	8,70,000
Total for Branches	21,10,000

IV.—Distributaries.

At Rs. 4-8-0 per acre:—	
$5\,86{,}728 \times \frac{9}{2}$	26,40,276

Rs.

V.—Preliminary Expenses.

Land, Buildings and Miscellaneous, roughly	4,00,000

Abstract.

Headworks	59,20,000
Main canal	75,80,000
Branches	21,10,000
Distributaries	26,40,000
Land, buildings and miscellaneous ...	4,00,000
Total works ...	1,86,50,000
Establishment and Tools and Plant on Rs. 1,50,00,000	38,00,000
Total Direct Charges...	2,24,50,000
Capitalized abatement of land revenue ...	15,00,000
Leave and Pension allowances	4,50,000
Total Indirect Charges	19,50,000
Grand total for Project	2,44,00,000

Revenue and return on Capital Expenditure.

57. The irrigable area under the canal is 259,188 acres, which is equivalent to 492,250 acres on the 4 months' basis. If the net revenue per acre, after deducting working expenses, be assumed to be Rs. 2-4, the total net revenue from irrigation will be Rs. 11,07,562. This is equivalent to a return of about 4·5 per cent. on the capital cost, including all charges.

Land submerged and irrigable areas.

58. The proposed storage at Daddi will submerge 31,701 acres in British territory and 3,459 acres in the Kolhapur State in all 35,160 acres. The area irrigated will be :—

120,000 acres under the proposed Gokak L. B, Canal, and
259,188 acres under the proposed Ghatprabha R. B. Canal.

Total.....379,188 acres under irrigation, which is nearly 11 times the area submerged.

The gross area commanded in the Kolhapur State by both the canals will be :—

43,782 acres under the Gokak L. B. Canal.
57,260 acres under the present R. B. Canal.

Total...101,042 acres, which is 29 times the area submerged in that State.

P. N. NATESAIYER.
Executive Engineer, Gokak Survey.

(1).—NOTE ON THE PROPOSED MARKANDEYA WEIR.

Proposed works and site.

1. Surveys were made in the valley of the Markandeya to ascertain whether it will be feasible to use any part of the supply from it for irrigation under the proposed Ghatprabha R. B. Canal, which crosses the river 1 mile below the gauge site at Shirur. The nature of the works required has yet to be decided. A storage tank may not be wanted. The work required will either be a pick-up weir or a high weir to regulate the supply.

The site for the pick-up weir will be 0·25 mile below the gauge site. That for the weir may be about 3,000 feet above that gauge.

Catchment area and run-off.

2. The catchment area of the river at the weir site will be 165 square miles. The whole of the catchment lies just outside the Ghat. The river has been gauged since July 1905 upto date, and a statement is attached giving the discharges observed during every month with the equivalent run-off in inches. The rainfalls recorded at Belgaum and Patne during the corresponding months are also given. Belgaum is in the centre of the catchment, and Patne is the nearest station just outside the area.

The run-off seems to bear a close relation to the rainfall at Belgaum. In 1906, which was a year of weak rainfall, the discharge recorded is 4,100 million cubic feet, which is equivalent to a run-off of 10·45 inches on the catchment. A 12 inches run-off would give 4,600 million cubic feet. The supply in ordinary years may not be less than 4,500 million cubic feet.

Capacity of Tank.

3. Cross-sections were taken at intervals along the valley, and a contour at R. L. 2250 was actually surveyed, from both of which contours at other heights have been sketched in. The areas and volumes will be roughly:—

R. L. of contour.	Area of contour, million square feet.	Volume between contours, million cubic feet.	Total contents, million cubic feet.	REMARKS.
2220	6·55	.....	.....	River bed at R. L. 2190 calculated.
2240	18·86	243·40	243·4	Do. do.
2260	37·68	554·60	798·0	Surveyed.
2290	64·99	1521·60	2319·6	Calculated.
2300	75·40	701·30	3020·9	Do.

Supply available.

4. About 3,000 million cubic feet can be drawn off from a pick-up weir without any regulation. A weir 60 feet high would store 500 million and if it be assumed to be emptied 3 times during the monsoon, the supply that may be drawn off will be 1,500+3,000=4,500 million cubic feet, which is about the whole supply in an average year.

The supply may be assumed to be not less than 4,000 million cubic feet.

Size of weir.

5. A weir 60 feet high above river-bed will be 1,000 feet in length. The hills at the sides are rocky, and it is assumed that good foundations will be obtained 10 feet below bed. The maximum height of weir over bottom of foundations will be about 80 feet. The flood discharge to be provided for will be 60,000 cusecs=·56 inch run-off on whole catchment. The depth of flood over the weir will be 7·25 feet.

A subsidiary weir will be required for which sites are available immediately below. If the canal should cross between the main and subsidiary weirs the latter may have to be placed at this site selected for the pick-up weir, which, however, is more than ¾ mile below. A higher crossing will not be suitable for the canal as the flood level of the river will be higher than the canal bed (R. L. 2202) at sites higher up. The pick-up weir would be 700 feet long, and will have a maximum height of 42 feet above bed of foundations. The depth of flood over it will be 8·5 feet. A curtain wall will have to be provided below the pick-up weir. Its height over bed of foundations will be 15 feet.

Cost.

6. The volume of masonry in the main weir is about 16,00,000 cubic feet and the rough cost by comparison with the figures for the Hadlag and Daddi dams may be about Rs. 5,00,000. The pick-up weir with the curtain walls may cost Rs. 1,75,000.

The supply to be utilized by the latter weir is 3,000 million cubic feet, so that the extra supply to be secured by the main weir is 1,000 millions and the cost of the main weir per million cubic feet of supply will be Rs. 500. The cost per million cubic feet of total supply will be Rs. 170.

The storage at Daddi will have to be increased by 4,000 millions in case the Markandeya weir is constructed, and the above rates will have to be increased by Rs. 230, which is the cost per million stored at Daddi.

P. N. NATESAIYER,
Executive Engineer, Gokak Survey.

ACCOMPANIMENT TO NOTE ON THE PROPOSED MARKANDEYA WEIR.

Statement of Discharges of the Markandeya River, at Shirur, from July 1905 to December 1907.

MONTHS.	1905.				1906.				1907.				REMARKS.
	Discharge.	Equivalent run off in inches.	Rainfall. Belgaum.	Rainfall. Patne.	Discharge.	Equivalent run off in inches.	Rainfall. Belgaum.	Rainfall. Patne.	Discharge.	Equivalent run off in inches.	Rainfall. Belgaum.	Rainfall. Patne.	
June ...	...	...	4·03	11·17	68	·1	4·93	31·78	38	·1	4·70	24·52	The gauging commenced on 9th July 1908. The catchment area of the river at gauge site, 165·5 square miles. The rain-gauge at Patne is outside the catchment. The observed discharge seems to bear a close relation to the rainfall at Belgaum. The year 1906 had a weak rainfall. Assuming run-off in ordinary years to be 12 inches, a discharge of 4,600 millions may be expected in average years.
July ...	1033	2·7	12·28	47·50	1944	5·05	15·37	45·37	883	2·3	9·16	47·40	
August ...	578	1·5	3·89	14·93	1028	2·6	6·80	18·24	6262	16·2	23.74	59·45	
September...	200	·5	0·61	5·57	555	1·4	6·56	6·35	744	1·9	9·26	12·10	
October ...	88	·2	4·12	3·93	249	·6	6·79	1·89	242	·6	·74	·44	
November...	26	·07	0·80	·22	212	·5	·96	·35	141	·4	1·03	·90	
December ...	19	·05	*Nil*	*Nil*	82	·2	·13	·65	88	·2	*Nil*	·2	
Total ...	1944	5·02	28·97	8 5·89	4138	10·45	47·69	104·83	8398	21·7	51·95	149·28	

GHATPRABHA RIGHT BANK CANAL PROJECT.

(2).—Statement of Area Under Command for the Whole of Main Canal and Branches.

GHATPRABHA RIGHT BANK CANAL PROJECT.

(2).—Statement of area under command for the whole of Main Canal and Branches.

Serial No.	NALLA LIMITS.	MILEAGE.		Total area including uncommanded and forest areas.	Uncommanded area.	Forest area.	Gross area under command in Native States.						Gross area under command, British.		Total gross area under command.	REMARKS.
		From	To				Jamkhandi acres.	Torgal acres.	Kolhapur acres.	Ramdurg acres.	Mudhol acres.	Sangli acres.	Taluka and District.	Acres.		
	I. Section, Main Canal.															
1	Daddi dam site to Islampur Nalla ...	0	13·4	2,233	.....	416	...	...	205	...	...	870	Chikodi (Belgaum).	742	1,818	
2	Islampur Nalla to Markandeya River..	13·4	37·6	43,245	13,069	3,584	...	...	1,299	...	...	...	Gokak and Chikodi (Belgaum).	25,293	26,592	A gross command of 25,000 acres under the Daddi Left Bank Canal should be added to the area given under the 1st Section.
3	Markandeya River to Gadhar Nalla ...	37·6	47	53,209	34,208	51	...	...	...	...	...	230	Do. do.	18,720	18,950	
4	Gadhar Nalla to Hire Nalla	47	62·2	33,651	10,784	4,230	...	...	...	...	...	...	Gokak (Belgaum).	18,637	18,637	
5	Hire Nalla to Yergatti cut	62 2	77·5	14,765	1,587	2,330	...	...	...	...	...	...	Parasgad Gokak (Belgaum).	*10,848	10,848	*435 acres out of this area to be added to item No. 10.
	Total ..	...	...	147,103	59,648	10,611	...	...	1,504	...	...	1,100	Belgaum.	74,240	76,845	
	II. Section, Main Canal.															
6	Manoli Contour to Harihal Nalla ...	78·5	86·25	37,472	7,309	...	...	4,198	...	...	...	...	Parasgad (Belgaum).	25,965	30,163	
7	Harihal Nalla to Tas Nalla	86·25	103	52,800	22,784	...	...	12,595	8,902	...	...	...	Do. do.	8,518	30,016	
8	Tas Nalla to Bannur Nalla	103	110	18,317	4,090	...	...	13,126	...	128	...	...	Badami (Bijapur).	973	14,227	
9	Hosur Nalla, Nalla just above mile 56 of Belgaum and Lokapur Road ...	110	120	30,336	8,448	...	1,984	13,274	...	653	...	...	Parasgad and Gokak (Belgaum).	5,978	21,886	
	Total ...	...	...	1,38,925	42,631	...	1,984	43,193	8,902	781	...	...	Belgaum.	41,434	96,292	
	Yadwad Branch.															
10	Yergatti Cut to Bettigeri Nalla ...	0	8·18	46,162	8,793	1,670	...	...	...	...	...	...	Parasgad and Gokak (Blegaum).	*35,699	35,699	* See remark against item No. 5.
11	Bettigeri Nalla to Mellikeri	8·18	20	18,624	4,563	...	...	...	...	...	...	...	Do. do.	14,061	14,061	
12	Mellikeri to Konjalgi Nalla	...	...	45,395	3,245	57	...	...	...	...	...	...	Do. do.	42,093	42,093	
13	Konjalgi Nalla to Timapur Nalla ...	...	...	40,410	1,549	...	3,072	...	...	...	1,082	...	Gokak (Belgaum).	34,707	38,861	
14	Timapur Nalla to Hirekop Kunual Nalla.	...	...	39,660	8,921	57	...	...	...	...	3,277	...	Parasgad Gokak (Belgaum).	27,405	30,682	
15	Kunual Nalla to Hosur	...	...	9,536	1,069	...	1,190	269	...	...	...	...	.....	7,008	8,467	
	Total ...	...	...	1,99,787	28,140	1,784	4,262	269	...	...	4,359	...	Belgaum.	1,60,973	169,863	

	Lokapur Branch.														
16	Between Nalla just above Mile 56 of Belgaum-Lokapur Road to Hoskot Nalla...	...	...	82,688	11,942	...	...	19	...	...	46,630	...	Gokak (Belgaum).	24,096	70,746	
	Tail.															
17	Between Hoskot Nalla to Lokapur Nalla...	1·75	14	28,819	7,808	...	...	3,373	...	...	12,589	...	Badami (Bijapur).	5,050	21,011	
18	Between Lokapur Nalla and Hanamueri Nalla	14	22	46,432	6,016	...	...	...	...	...	20,602	...	Badami Bagalkot (Bijapur).	19,814	40,416	
19	Hanamueri Nalla and Kaladgi Nalla ..	...	...	59,366	11,385	...	...	...	...	...	...	...	Do. Do.	47,981	47,981	
20	Hirehal Nalla to Hulasgeri Nalla ...	...	...	9,344	.....	...	...	...	...	...	...	...	.....	9,344	9,344	Portion of item No. 24.
21	Between Hoskeri Nalla and Somankop Nalla...	...	...	46,470	17,241	...	...	...	...	1,517	...	...	Navalgund (Dharwar) Badami (Bijapur).	38 27,674 27,712	29,229	
	Total for Tail ...	...	...	1,90,431	42,450	...	...	3,373	...	1,517	33,191	...	(Bijapur) (Dharwar)	1,09,863 38 1,09,901	147,981	
	Command beyond Tail Section not included in Project.															
22	Kaladgi to Muchkhandi Nalla ...	...	...	47,308	12,057	...	...	...	...	...	...	...	Badami Bagalkot (Bijapur).	35,251	35,251	
23	Muchkhandi Nalla to Bagalkot Nalla...	...	...	30,579	6,893	...	...	...	...	...	...	...	Do. do.	23,686	23,686	
24	Between Bagalkot Nalla, Hirehal Nalla, Kamatgi Nalla and along the Contour up to the river near Railway line ...	...	...	45,261	16,877	...	...	...	...	...	...	...	Badami Bagalkot, Hungund (Bijapur)	28,384	28,384	Excludes item No. 20.
25	Between Railway line and Ghatprabha River	...	...	28,633	6,534	...	...	...	...	...	...	...	Bagalkot (Bijapur)	*22,099	22,099	*If the canal is continued level with the Shirur Gap, an additional Command of 24,576 acres will be obtained.
26	Up to Junction	...	...	138,554	47,328	...	...	...	...	...	...	...	Bagalkot, Hungund (Bijapur).	91,226	91,226	
27	Bannor Nalla to Halgatti Nalla ...	...	...	34,624	12,774	...	...	12,083	83	6,912	...	...	Badami (Bijapur).	2,771	21,850	
28	Halgatti Nalla to Hoskeri Nalla ...	...	...	31,136	17,114	...	...	...	...	3,347	...	...	Do. Do.	10,675	14,022	
29	Somankop Nalla and Badami Nalla ...	...	...	68,205	26,016	...	...	...	...	2,208	...	...	Ron (Dharwar) Badami (Bijapur).	410 39,571 39,981	42,189	
30	Between Badami Nalla and Niralgi Nalla	...	...	23,693	13,011	...	...	...	...	...	...	...	Badami (Bijapur).	10,682	10,682	
31	Niralgi Nalla to Hirehal Nalla ...	...	...	65,754	32,480	...	...	...	...	...	...	...	Do. Do.	33,274	33,274	
	Total for Command beyond Tail...	...	...	5,13,747	1,91,084	...	...	12,083	83	12,467	...	...	(Bijapur) (Dharwar).	*2,97,619 410 2,98,029	3,22,663	*This excludes item No. 20.
	Grand Total ...	...	...	12,72,681	3,75,895	12,395	6,246	58,937	10,489	14,765	84,180	1,100	.....	7,08,672	8,84,390	

GHATPRABHA RIGHT BANK CANAL PROJECT.

(2).—Statement of area under command for the whole of Main Canal and Branches—*concluded.*

Serial No.	NALA LIMITS.	MILEAGE. From	MILEAGE. To	Total area including uncommanded and forest areas.	Uncommanded area.	Forest area.	Gross area under command in Native States. Jamkhandi acres.	Torgal acres.	Kolhapur acres.	Ramdurg acres.	Mudhol acres.	Sangli acres.	Gross area under command, British. Taluka and District.	Gross area under command, British. Acres.	Total gross area under command.	REMARKS.
	ABSTRACT.															
1	I Section	...	...	1,47,103	59,648	10,611	...	...	1,504	...	...	1,100	.....	74,240	76,845	
2	II Section	...	...	1,38,925	42,631	...	1,984	43,193	8,902	781	...	...	.....	41,434	96,292	
3	Yadwad Branch	...	...	1,99,787	28,140	1,784	4,262	269	...	...	4,359	...	.....	160,973	1,69,863	
4	Lokapur Branch	...	...	82,688	11,942	...	...	19	...	...	46,630	...	.....	24,096	70,746	
5	Tail	...	...	190,431	42,450	...	...	3,373	...	1,517	33,191	...	.....	109,901	1,47,981	
6	Command beyond Tail Section not included in Project	...	...	5,13,747	1,91,084	...	...	12,083	83	12,467	...	...	.....	2,98,029	3,22,663	
	Grand Total ...	...	...	12,72,681	3,75,895	12,395	6,246	58,937	10,489	14,765	84,180	1,100	.....	*7,08,672	†8,84,390	

* Abstract for these quantities given below.

† Is exclusive of the command under the Daddi L. B. Canal which is about 25,000 acres.

ABSTRACT OF COMMAND IN BRITISH TERRITORY.

Section.	Belgaum.	Bijapur.	Dharwar.	Total.
I—Section	74,240	.....	.....	74,240
II—Do.	40,461	973	.....	41,434
Total for Main Canal ...	1,14,701	973	.....	1,15,674
Yadwad Branch	1,60,973	.....	.....	1,60,973
Lokapur Branch	24,096	.....	.....	24,096
Tail Section	.....	1,09,863	38	1,09,901
Total ...	1,85,069	1,09,863	38	2,94,970
Command beyond Tail Section.	.....	2,97,619	410	2,98,029
Grand Total ...	2,99,770	4,08 455	448	7,08,673

NOTE—No deduction has been made from the gross area under Command for the flooded area on the banks of the three rivers, the total length of which is 250 miles, the flooded area may be about 80,000 acres.

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT

(MAIN CANAL, 1ST SECTION).

(3).—Statement of Cuts over 10′ in Depth.

Cut No.	Position in miles.	Maximum depth in feet.	Length of Cut in feet.	Length of alternative contour.	Cost.	REMARKS.
			Cuts.	Feet.	Rs.	
1	38	13·47	2,000	5,900 (Alignment.)	13,281	Alignment round the Spur would pass for a length of ½ mile through steep ground and would require an extra bridge.
2	45-47	52·42	11,005	34 miles.	3,20,560	Madwal Cut, Length of contour scaled off from 1 inch to the mile, Topo Sheet.
3	54-55	56·42	6,340	5½ miles, (Alignment.)	2,30,701	Murkanhatti Cut.
4	55-56	12·47	900	2,000′	8,330	Navapur Cut, Length of contour scaled off from 1 inch to the mile, Topo Sheet.
5	57	19·51	1,971	6½ miles.	50,607	
6	70	29·92	2,790	1 mile and 2,620′	49,654	Yerajharvi Cut.
7	71	17·58	790	1,940′	5,388	
8	74	35·42	743	4,350′	23,262	
9	74	40·80	690	5,900′	26,311	
10	75	30·46	780	2,750′	23,481	
		On	Markandeya Syphon	Crossing.		(Alternative.)
I	33	11·60	577	3,500′	2,481	Contour scaled off from 1 mile to an inch, Topo Sheet.
II	35	18·77	2,600	6 miles	17,859	
		On	Alignment *vid* Shah	abandar Cut.		(Alternative.)
I	15-17	94·54	20,189	22 miles (Alignment.)		

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK.

Canal 1st Section.

(4).—Statement of Embankment over 10′ in Height.

Embankment No.	Position, miles.	Maximum height in feet (below C. B.)	Length of embankment in feet.	Cost.	Remarks.
			Embankment.	Rs.	
1	5	14·32	689	9,527	Sutkatta Nala, height of Embankment on Nala bank 7·5′.
2	10	12·66	585	10,245	
3	12	12·00	563	.....	
4	13	9·80	700	8,388	
5	14	14·00	1,070	14,102	Shahabander Nala, height on Nala banks 5′.
6	18	37·08	380	.....	
7	19	40·20	679	48,207	Vantmuri Nala, height on Nala banks 32′.
8	21	25·05	332	12,993	
9	23	29·87	544	25,848	
10	24	27·33	465	15,858	
11	25	21·58	436	18,477	
12	30	16·65	580	.....	
13	38	25·22	918	38,616	Markandeya River, height on Left Bank, Zero. Markandeya River height on Right Bank, 8 feet.
14	41	9·83	1,020	.....	Nala flat and cultivated. Embankment necessary to get suitable headway.
15	43	17·63	1,546	24,946	Beldari Nala, height 7′ on banks.
16	44	13·47	530	.....	Height on Right Bank 3′.
17	44	11·53	640	9,810	
18	49	14·58	837	16,985	
19	49	24·96	792	27,823	Garh Nala.
20	54	14·82	1,232	20,404	Murkanhatti Nala, height on banks 10·5′.
21	56	15·19	1,375	23,607	Gadhar Nala, height on banks 10·5′.
22	58	18·52	1,135	16,563	
23	60	28·43	415	16,091	
24	62	14·69	500	.....	
25	65	12·25	535	7,519	Height on banks 8′.
26	67	28·13	586	31,519	Height on banks 22′.
27	68	44·10	370	.....	Kanvi Nala, an aqueduct will be provided in the central portion reducing the depth of bank to 25′.
28	68	29·38	488	20,044	
29	69	19·39	620	16,376	Height on banks 12′.
30	70	14·31	895	18,564	
31	71	15·51	530	6,533	Height on banks 7·5′.
32	74	17·28	180	.....	
33	74	14·57	250	.....	
34	77	29·22	822	29,897	Height on banks 20′.
35	77	10·82	718	9,702	
		Markan	deya Syphon	Crossing.	(Alternative.)
36	32	7·58	3,251	.....	

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal, 1st Section.

(5).—Statement giving Lengths of Canal in Steep Grounds.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal, 1st Section.

(5).—Statement giving Lengths of Canal in Steep Grounds.

Chainages.		Lengths.				Remarks.
		Cross Slopes between				
From	To	0-2½	2½-3½	3½-5	5-10	
3,558	4,284	.....	.....	.....	726	
4,699	6,350	(a c) 592	(b) 526	.....	170	
			200	.....	.....	
			163	.....	.....	
6,350	7,050	.....	424	.....	276	
7,050	8,578	(a c) 950	(b) 347	.....	.....	
			231			
8,578	8,793	.....	215	.....	.....	
8,793	9,330	.....	.....	.....	537	
10,196	10,690	.....	.....	494	.....	
10,690	13,238	.....	.....	.....	2,548	
14,555	16,255	.....	.....	.....	1,700	
16,882	17,945	.....	.....	.....	1,063	
17,945	18,528	.....	.....	583	.....	
18,528	20,773	(ac) 1,918	327	.....	.....	
21,383	21,613	.....	.....	.....	230	
21,613	22,292	.....	.....	.....	679	
22,926	23,583	.....	.....	.....	657	
23,583	25,053	(a) 1,201	.....	269	.....	
26,287	27,639	(a) 691	375	.....	.....	Very steep and close to a Nalla.
		286	.....	.....	.....	
27,639	28,464	.....	.....	.....	825	
29,142	30,414	.....	(b) 322	.....	389	
			561	.....	.....	
33,953	35,436	.....	.....	.....	1,483	
35,436	35,775	.....	.....	339	.....	
.....	36,960	.....	.....	.....	1,185	
.....	37,696	.....	.....	.....	736	
.....	38,036	.....	.....	.....	340	
42,794	43,795	.....	.....	.....	1,001	
43,795	46,905	.....	(b) 1,155	1,626	.....	Kampgutti spur near take-off of Daddi Left Bank Canal.
				329		
46,905	47,215	.....	.....	310	.....	
48,807	50,622	.....	.....	.....	1,815	
51,176	51,606	.....	.....	.....	430	
52,800	53,501	.....	.....	.....	701	
64,426	65,335	.....	.....	.....	909	
73,608	75,061	.....	(b) 500	610	.....	On Right Bank of Shahabunder Nalla.
				343		
75,061	76,487	.....	.....	.....	1,426	
76,487	78,127	.....	(b) 840	800	.....	
.....	78,480	.....	.....	.....	353	
81,987	82,977	.....	.....	.....	990	
89,975	90,532	.....	.....	.....	557	
92,176	93,328	.....	(b) 519	397	.....	On two banks of Vantmuri Nalla.
				236		
93,723	94,728	.....	(b) 1,095	.....	.....	
95,087	97,133	.....	.....	2,046	.....	
97,475	98,426	.....	.....	.....	951	
106,189	106,789	.....	.....	.....	600	
106,789	107,690	.....	.....	901	.....	
108,082	108,319	.....	.....	641	.....	
116,495	116,770	.....	.....	275	.....	
117,369	118,708	.....	.....	.....	1,339	
121,009	121,632	.....	.....	.....	623	
125,241	125,843	.....	.....	.....	602	
125,843	126,843	.....	.....	(b) 1,000	.....	On Left Bank of Mangaon Nalla.
127,406	127,716	.....	.....	310	.....	

(a) Side bank omitted and wall provided instead on down stream side.
(b) A thin wall provided near the centre of side bank and also a dry stone wall at down stream toe of bank.
(c) These portions are within one chain of river bank.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal, 1st Section.

(5).—Statement giving Lengths of Canal in Steep Grounds.

Chainages.		Lengths.				Remarks.
From	To	Cross Slopes between				
		0-2½	2½-3½	3½-5	5-10	
152,948	153,230	.....	.....	.....	282	
123,548	154,548	.....	.....	.....	1,000	
171,387	172,801	.....	.....	.....	1,414	
248,883	249,618	.....	.....	.....	735	
257,739	258,465	.....	.....	.....	726	
263,080	264,888	.....	.....	.....	1,808	
265,893	266,625	.....	.....	.....	732	
266,625	267,193	.....	.....	.....	568	
267,193	267,903	.....	(*b*) 552	.....	158	Above Kaitnab Village.
267,903	268,045	.....	.....	.....	142	
268,753	270,137	.....	.....	.....	1,384	
270,137	270,418	.....	.....	281	.....	
.....	271,791	.....	.....	.....	1,373	
307,654	308,146	.....	.....	.....	492	
311,840	313,624	.....	.....	.....	1,784	
.....	314,384	.....	.....	760	.....	
314,784	315,454	.....	.....	670	.....	
327,661	328,969	.....	(*b*) 610	698	.....	On Left Bank of Hiar Nalla.
330,099	330,919	.....	.....	.....	820	
331,596	332,796	.....	(*b*) 155	1,045	.....	Near Jamnal village.
333,651	334,501	.....	.....	.....	850	
349,858	351,348	.....	(*b*) 800	412	.....	Near Kanvi Nalla.
.....	.....	.....	.....	278		
351,348	351,534	.....	.....	186	.....	
.....	352,095	.....	.....	.....	561	
361,708	363,068	.....	.....	.....	1,360	
363,638	365,098	.....	.....	.....	1,410	
		5,638	9,917	15,839	43,440	

For (*b*), see note on preceding page.

Total length of Main Canal, 1st Section, 77·1 mile.

Lengths of steep grounds.

Cross slopes between	0-2½	5,638	
Do.	2½-3½	9,917	
Do.	3½-5	15,839	
Do.	5-10	43,440	
Total lengths		74,834	=14·2 miles.

P. N. NATESAIYER,

Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal—1st Section.

(6).—Statement of River and Hill Torrent Works.

Note.—The Costs entered are rough and have been worked out as follows :—

Aqueducts and Culverts—(i) Portions above springing roughly from type estimates for similar works made for the Gokak and Nira Right Bank Canal Projects.

(ii) Below springing—From approximate rates per foot in height of amounts worked out from actual estimate made for the Gokak Left Bank Canal Project.

Concrete Drains.—By working out approximate rate per running foot of drains of various sizes with additional amounts for wings.

GHATPRABHA RIGHT

MAIN CANAL

(6).—Statement of River and Hill

No. of Nala.	Chainage. Miles in Decimals.	Chainage. Discharge in cusecs. Feet.	Available Head-way.	Nature of Nala-bed.	Average fall at Site.	Catchment area in square miles.		Maximum run-off in cusecs (from curve adopted).	Assumed maximum velocity allowable through openings.
1	·15	1,500 803	10·02	1'S. and B.=S. M. ... 2' do. =AV. M. ... Large Boulders=S. R. below.	1 in 35	2·00		2,650	9·8
2	·57	1,500 2,998	3·38	3'—6" S. and B.=S.M. 2'—6"Grav.S.&B.=AV.M. 0'—6"Decayed S.Stone H. M. S. R. below.	1 in 16	0·16		404	14·06
3	·74	1,500 3,893	2·37	1¾ Sandy Soil ... ... 1'—0" S. and B.=S. M. S. R. below.	1 in 10	0·05	·09	266	12·56
4	·82	1,500 4,344	2·00	1½' S. and B.=S. M. S. R. below.	1 in 7	0·04			
5	1·01	1,500 5,310	11·22	1½' S. and B.=S. M. S. R. below.	1 in 7	0·07		223	11·51
6	1·24	1,500 6,558	7·22	Assumed bed same as of No. 7.	1 in 20	0·04	·07	223	11·51
7	1·30	1,500 6,883	8·02	9" Sandy Soil ... ... 1' Soil and 2' Boulders } S. M. H. M. S. R. below.	1 in 18	0·03			
8	1·81	1,500 9,548	Cutting—1·24	2½ S. and B.=S. M. ... 5½ Grav. S. and B.=AV. M. Rock below.	1 in 18	0·35		728	13·27
9	2·74	1,500 14,477	1·93	2¾ S. and B.=S. M. ... 4¾ Grav. S. and B.=H. M. 1¾ S. R.	1 in 7	0·13		346	12·04
10	2·94	1,500 15,515	2·96	6'—3" S. and B.=H. M. S. R. below.	1 in 15	0·09			
11	2·96	1,500 15,645	2·72	Assumed same as ditto. ...	1 in 8	0·14	·32	728	13·27
12	3·01	1,500 15,896	—0·47 in cutting	4'—6" S. and B =AV.M. 2'—0" S. R. ...	1 in 10	0·09			
13	3·44	1,500 18,181	8·99	4¼ S. and B.=S. M. ... 4 decomposing rock H. M. S. R. below.	1 in 5	0·03		114	12·67
14	4·22	1,500 22,292	—2·05 in cutting	9' S. and B.=H. M.... ...	1 in 5	0·03		114	12·67
15	4·81	1,480 25,423	14·32	Bed Soil and boulders ...	1 in 10	8·75		8,050	10·5
16	5·81	1,480 30,681	13·44	4'—9" S. and B.=H. M S R. below.	1 in 10	2·77			
17	6·21	1,480 32,784	—·51 in cutting	4' Sandy Soil ... ... ½' Soil and B.=H. M. H. M. at bottom.	1 in 25	0·20	2·97	3,600	11·1
18	6·35	1,480 36,147	4·30	9½ S. and B.=H. M. S. R. below.	1 in 12	0·18		440	12·03
19	7·31	1,470 38,594	5·29	6' S. and B.=H. M. S. R. below.	1 in 17	0·16		404	13·3
20	7·67	1,470 40,480	8·74	3½' S. and B.=S. M. ... 2½' do. =H. M. ... 3' Laterite=H. M. ...	1 in 25	0·81		1,540	11·6
21	7·88	1,470 41,606	—3·72 in cutting.	Assume same as No. 20 ...	1 in 20	0·12	0·93		

362	C/13	2	15	3′	10·07	.....	2,700 16,000 600	Divert into No. 100. Murkanhatti Nala. Divert into No. 100.
54·9	D/50	3	6	1′-6″	2	.....	4,000	
1,195	A/13	5	20	4′	9·19	.....	3,0000 3,300	Gadhar Nala. Divert into No. 103.
150	A/14	1	15	3′	13·77	.....	12,500 400	Depth of flood assumed, 10ft. Divert into No. 105.
100	C/14	1	10	2′	12·52	.....	1,800 7,500	Divert into No. 108. Depth of flood assumed 10′.
24·3	D/51	1	6	1′-6″	3	.....	400 2,000	Divert into No. 110.
9	D/52 (Slabbed.)	1	3	.....	3	.....	1,000	
100	A/15	1	10	2′	21·15	.....	19,000	Depth of flood assumed 10′.
24·3	D/53	1	6	1′-6″	3	.....	2,000	
30·3	D/54	1	6	1′-6″	4	.....	2,000	
6·0	D/55 (Slabbed.)	1	3	.....	2	.....	1,000	Ground very steep between 115 and 116.
3312	Pipe Syphon aqueduct.	6	30	5′	15	.....	198,570	Hire Nala.
12·0	D56 (Slabbed).	1	3	.....	4	.....	1,000	Ground steep between Nos. 116 and 117.

		1,110							
118	63·67	337,251	13·10	2½′ decayed S.M., Sand Stone Rock below	1 in 14½	0·45		885	12·6
		1,110							
119	64·38	339,921	21·80	Rocky	1 in 51	0·46			
		1,110							
120	64·6	341,126	12·25	10 Grav. soil and B=H. M., S. and B=H. M., H.M. below.	1 in 22	0·03	0·73	1,294	12·9
		1,110	Cutting						
121	64·98	343,083	—2·75	5′ red murramish, S. and B=S. M., S. M below	1 in 21	0·24			
		1,100							
122	65·83	347,598	Cutting	2′ S. M., Rock at bottom ...	1 in 21	0·25		493	11·6
		1,090	—3·59						
123	66·78	352,623	32·18	Assume same...	1 in 46	0·12		328	10·8
		1,090							
124	66·92	353,348	28·13	.....	1 in 46	0·50		960	9·6
		1,090							
125	67·25	355,057	44·10	Rocky	1 in 56	8·25		7,700	12·4
		1,090							
126	67·53	356,563	29·38	5′ H. M., H. M. at bottom ...	1 in 97	0·2		560	11·4
		1,080							
127	68·09	359,498	4·57	Rock	1 in 24	0·3		114	12·7
		1,080		5′-3″ S. M.					
128	68·4	361,178	0·76	2′-9″ H. M. ... ... H. M. below	1 in 31	0·2	0·87	1,420	14·2
		1,080		1′-6″ Soil					
129	68·8	363,243	19·39	4′-0″ S. M. ... ... S. M. below	1 in 53	0 85			
		1,080		Assume.					
130	69·38	366,332	14·31	8′ S. M. and B=A. H. M., H. M. at bottom....	1 in 138	1·70		2,382	10·8
		1,070		2′ S. M.					
131	70·22	370,758	9·35	4′ H. M. ... ... H. M. below	1 in 94	3·25		3,820	10·6
		1,070		3′ S. M.					
132	70·52	372,367	15·51	5′ H. M.	1 in 61	5·25	5·65	5,700	...
		1,070		1′-6″ Soil...					
133	70·79	373,784	9 63	6′-6″ H. M. ... ... H. M. below	1 in 66	0·40			
		1,070							
134	71·48	377,408	3·41	2′ Soil Rock close probably...	1 in 166	0·50		960	11·3
		1,070							
135	72·18	381,113	5·66	4′-6″ Sand and B.=S. M. T. P. incomplete.	1 in 260	1·6		2,280	9·6
		1,070							
136	72·58	383,246	6·13	9″ Soil ... ... 9″ Decayed rock, Rock ...	.....	0·30	0·38	808	11·5
		1,070							
137	72·91	385,183	0·96	2′ H. M. ... ... Boulders=H. M. below...	.....	0·08			
		1,070							
138	73·31	387,074	17·28	Rocky	.....	0·08		245	12·6
		1,070							
139	73·53	388,234	14·67	Do.	1 in 18	0·08	0·10	288	11·9
		1,070							
140	73·59	388,544	13·41	Do.	1 in 20	0·02			

13·3	D/12	1	6	1′-6″	2	.....	1,500	Ground between Nalas 20 and 22 steep.
42·2	D/13	1	7	1′-6″	5	.....	2,750	
30·3	D/14	1	6	1′-6″	4	.....	2,250	Ground steep between Nala Nos. 24 and 25.
185	C/4	1	20	4′	6·66	.....	8,000	Divert into No. 25.
64·7	D/15	1	10	2′	5	.....	3,500	Ground Steep between Nala Nos. 27 and 25.
							1,100	Divert into No. 27.
28·2	D/16	1	7	1′-6″	3	.....	2,250	
24·3	D/17	1	6	1′-6″	3	.....	2,000	
130	C/5	1	20	4′	3·80	.....	600	Divert into No. 32.
							7,500	
1485	A/2	5	30	5′	6·5	.....	1,500	Divert into No. 34.
							40,000	Shahabunder Nala.
							300	Divert into No. 34.
35·2	D/18	1	7	1′-6″	4	.....	2,250	
220	C/6	2	15	3′	.....	.....	10,000	
30·3	D/19	1	6	1′-6″	4	.....	2,250	
36·6	D/20	2	6	1′-6″	2	.....	3,000	Ground between Nala Nos. 39 and 40 steep.
30·3	D/21	1	6	1′-6″	4	.....	2,250	
100	A/3	1	10	2′	33·68	.....	21,000	Depth of flood assumed 10′.
19·4	D/22	1	5	1′-3″	3	.....	1,750	Ground steep between Nos. 42 and 41.
21·2	D/23	1	7	1′-6″	2	.....	2,000	Ground steep between Nos. 43 and 44.

		1,370							
44	19·07	100,711	40·20	1′ Boulders and thin Sheet of Rock.	1 in 143	2·71	2·96	3,600	15
		1,370							
45	19·5	102,963	0·89	1′ Soil, 5′ Rock	1 in 22	0·25			
		1,370							
46	19·84	104,749	0·74	Assume 2½′ S. & B.=S.M. 3′ H. M., Rock at bottom.	1 in 16	0·07		223	12·2
		1,370							
47	20·44	107,904	25·05	2′ S. & B.=S. M., Rock below. Results from T. P. at lower crossing.	1 in 20	0·30		646	11·5
		1,370							
48	21·44	113,211	9·30	2½′ S. and B. / 1′—0″ M. and B. } =S.M. 2¾′ S. and B. B.=H. M. Big boulders below.	1 in 35	0·15		386	12·7
		1,360							
49	22·15	116,966	29·87	¾′ Soil ... ... 2¼′ S. and B.=S. M. ... S. R. below	1 in 30	0·2		560	11·4
		1,360							
50	22·59	119,262	19·19	1½′ Soil / 4½′ S. and B., S. M. } From T. P. at lower crossing. S. and B.=S. M. below.	1 in 30	030		646	11·5
		1,360							
51	23·66	124,949	27·33	Assume 6′ Soil and boulders and Rock below.	.....	0·50		960	.....
		1,350							
52	24·07	127,113	24·38	3′ Soil ... ... 5½′ S. and B.=S. M. ... S. and B.=H.M. at bottom	1 in 75	0·51	0·87	1,420	12·0
		1,350							
53	24·24	127,996	11·02	Assume 4′ S. M. B.=S. M. ... 1¾′—do—Rock at bottom.	1 in 61	0·36			
		1,350							
54	24·36	128,623	9·82	Assume ... ... 4′ S. M. B.=S. M. ... 1¾′—do—H. M. Rock at bottom.	1 in 20	0·35		728	11·2
		1,350							
55	25·52	134,741	3·51	2′ S. and B.=S. M. ... 2′ S. M. Rock at bottom..	1 in 50	0·23		560	11·5
		1,340							
56	25·7	135,721	0·45	2′ S. and B.=H.M., S.R., below.	1 in 50	0·24	1·41	2,068	11·5
		1,340							
57	25·84	136,454	12·46	2′-3″ S. and B.=S. M. ... 0-9″ do. =H. M., S. R., below.	1 in 40	1·17			
		1,340							
58	26·2	138,360	8·10	1¾′ S. and B.=S. M. ... ¾′ S. R.	1 in 37	0·45		885	11·8
		1,340							
59	27·32	144,248	2·35	¾′ Soil ... ... 1′ S. & B.=H. M., S. R. below.	1 in 120	0·45		885	12·1
		1,330	cutting						
60	28·45	150,248	—1·23	1′ Soil and boulders=S. M., rock below.	1 in 14	0·15		386	13·4
		1,330							
61	29·05	153,384	16·65	3′ S. and B.=S. M. ... 1′ do. =H. M. ... 1½′ S. R....	1 in 17	0·11		308	12·7
		1,330							
62	29·42	155,348	10·86	6′-3″ S. and B.=S. M. ... 2′-6″ do. =H. M. ... 1′-0″ S. R.	1 in 5	0·18		440	12·5

240	A/4	1	20	4′	34·20	.....	26,000 2,000	Vantmuri Nala—Depth of flood assumed=12 ft. Divert into No. 44.
18·3	D/24	1	6	1′-6″	2	.....	1,750	
56·2	D/25	1	7	1′-6″	7	.....	3,250	
30·3	D/26	1	6	1′-6″	4	.....	2,250	
49·2	D/27	1	7	1′-6″	6	.....	2,750	
56·2	D/28	1	7	1′-6″	7	.....	3,250	
100	A/5	1	10	2″	23·83	.....	19,000	Depth of flood assumed =10 ft. Ground steep between Nos. 51 and 52.
120	A/6	1	10	2″	20·88	.....	18,000 1,000	Depth of flood assumed 12′. Divert into No. 52.
64·7	D/29	1	10	2′-0″	5	.....	3,250	Ground steep and intervening spur high between Nos. 54 and 52.
48·6	D/30	2	6	1′-0″	3	.....	3,250	Do. do. between Nos. 55 and 56.
185	C/7	1	20	4′	6·46	.....	600 7,500	Divert into No. 57.
74·7	D/31	2	9	1′-8″	3	.....	4,250	Ground steep between 58 and 57.
72·9	D/32	3	6	1′-6″	3	.....	4,500	
28·7	D/33	2	5	1′-3″	2	.....	2,500	
24·3	D/34	1	6	1′-6″	3	.....	2,000	
35·2	D/35	1	7	1′-6″	4	.....	2,250	Ground steep between 62 and 61.

		1,330	Cutting	½ Grav. S. and B.=H. M.					
63	30·12	159,930	—2·06	S. R. at bottom	1 in 23	0·13		346	12
		1,230		1′ Sandy soil					
64	31·03	164,078	11·46	9′ Stiff red M.=S. M. ...	1 in 25	0·45		885	12·6
		1,280		Stiff red murum below ...					
65	31·57	166,693	10·44	2′ Sandy soil	1 in 100	1·10		1,720	9·0
				3′—9″ H. M.					
		1,280	Cutting-	2′-6″ S. and B=H. M. ...					
66	32·32	170,643	—2·71	3′-0″ decayed sand-stone =H. M.	1 in 12	0·06		245	13·4
		1,230							
67	33·08	174,663	1·53	Sandy soil	1 in 54	0·44			
		1,280							
68	33·29	175,781	4·37	Do.	1 in 20	0·54	3·35	3,986	10·2
		1,280		6′-0″ Soil					
69	33·36	176,151	9·27	4′-0″ Sand and M.=S.M. S. M. below.	1 in 20	2·37			
		1,270		9′-3″ Soil ...					
70	34·33	181,271	6·69	0′-9″ S. M. S. M. below	From adjoint pit.	1 in 10	0·25	560	12·1
		1,270	Cutting-						
71	35·35	186,662	—3·00	6′ Soil	1 in 10	0·35		728	11·5
		1,270		6′ Soil					
				7′ Shadoo					
72	36·37	192,031	11·41	2′-Shadoo and M. ...	1 in 20	3·61	7·79	7,360	9·9
				2′-3″ Consolidated gravel, H. M. below.					
		1,270		4′ Soil					
73	36·53	192,901	8·97	14′ Shadoo	.....	4·18			
		1,270		3′ Sand, soil and B. ...					
74	36·61	198,595	25·22	No. trial pits, soil boulders in bed.	1 in 450 up stream 1 in 525 down stream.	166·75		60,700	11·2
		1,270		2′-9″ Soil					
75	38·39	202,733	8·09	8′-6″ S. and B.=S. M. 0′-9″ S. and B.=H. M. S. R.	1 in 30	0·90		1,481	9·4
		1,260							
76	38·83	205,003	3·78	6′ Soil	1 in 25	0·21	0·42	808	12·5
		1,260							
77	39·11	206,513	10·96	Red Murum	1 in 100	0·21			
		1,260							
78	40·46	213,643	Cutting	Bunded and cultivated ...	1 in 75	0·40			
		1,250	—0·42	4′ Earth					
79	40·96	216,263	9·83	3′ Shadu and M. ...	1 in 90	1·00	1·70	2,382	9·2
				3′ Red M.=S. M... ...					
		1,250		3′ H. M., H. M. below ...					
80	41·63	219,783	·29	Soil	1 in 130	0·30			

28·7	D/36	2	5	1′-3″	2	.....	2,500	
70·4	D/37	2	7	1′-6″	4	.....	3,750	
192	C/8	1	9	5′	·294	.....	9,000	Velocity kept low, owing to deep black soil.
18·3	D/38	1	6	1′-6″	2	.....	1,750	
								Divert into 69.
589	A/7	3	25	5′	1·77	.....	20,000	Divert into 69. The bed is black soil and the velocity can be reduced by deepening the Nala.
46·3	D/39	1	9	1′-8″	4	.....	2,750	
63·5	D/40	3	7	1′-6″	2	.....	4,500	
744	A/8	4	25	5′	3·91	.....	35,000	
5,400	A/9	12	30	5′	17·72	.....	1,00,000	Markandeya River Depth of flood assumed 15′. Extra fall to be given to reduce section of aqueduct.
159	C/9	2	15	3′	3·34	.....	11,000	Hills are close on both banks and the foundation is assumed to be 15 feet and to rest in hard murum 4 feet
64·7	D/41	1	10	2′-0″	5	.....	500 3,250 1,300	Divert into No. 77. Divert into No. 79.
260	C/10	2	20	4′	3·83	.....	15,000 1,400	Divert into No. 79.

81	42·61	1,240 224,988	17·63	Sandy soil in bed. No trial pits.	.....	142·75		57,840	14·4
82	43·16	1,240 227,869	13·47	Soil	1 in 80	12·75		10,800	9·6
83	43·53	1,240 229,853	11·53	6′-6″ Soil ... ... Soil below	1 in 160	1·30		1,956	9·[illegible]
84	44·75	1,240 236,293	Cutting —2·65	4′ Soil ... ... 20′ Shadu & M.=M. S. M. below.	1 in 46	3·1		3,688	.....
85	47·09	1,230 248,628	Cutting —0·48	6′ Soil ... ... 4′ Shadu & M.=S. M.... 4′ Shadu=S. M. ... 2′ S. M. ... ... 1′ H. M., S. R. below ...	.....	0·55		1,029	12·1
86	47·62	1,190 251,442	6·92	2′-3″ M. and B. ... ... 1′-3″ S. R.	1 in 19	0·09		266	13·7
87	48·09	1,190 253,921	14·58	4′-3″ Soil, then S. and B. ...	.....	0·40		808	12·5
88	48·77	1,190 257,516	24·96	2″-3″ S. and B.=S. M. ... 1′-9″ S. and Big B.=H. M. S. R.	1 in 60	6·50		6,460	13·5
89	49·22	1,190 259,870	Cutting —1·13	1½ S. and B.=S. M. ... 1½ M. and B.=S. M. ... 1½ H. M. S. R. below ...	1 in 12½	0·05	1·50	2,180	9·9
90	49·45	1,190 261,113	9·96	4′-6″ S. and B.=S. M. ... 3′-6″ S. in with H., S.=S. M. S. M. below.	1 in 100	1·20			
91	49·72	1,190 262,538	4·30	Do. do.	1 in 20	0·25			
92	49·98	1,190 263,883	2·16	Assume 2′ S. & B.=S.M. 5′ H.M., S. R., at bottom.	1 in 9	0·03	0·13		
93	50·22	1,190 265,186	6·17	3′ S. & B.=S. M., S. M. below.	1 in 8	0·10		346	11·4
94	50·57	1,190 267,033	8·02	1½ Soil & B.=S.M. ... 1½ S. M., 1½ H. M., Rock at bottom.	1 in 5	0·05		176	12·2
95	51·25	1,180 270,623	9·27	1′ Soil ... ... 1′-9″ S. R.	1 in 5	0·14		366	12·1
96	51·87	1,180 273,891	13·54	2′-3″ S. and B.=S. M. 2′-6″ H. Sand=S. M. H. M. below.	1 in 25	0·09	0·15	386	12·7
97	52·02	1,180 274,657	4·06	Assume do. do.	1 in 30	0·06			
98	52·40	1,180 276,671	7·66	7′ S. and B.=S. M. S. and B.=S. M. at bottom.	1 in 28	0·18		440	12·5

4,020	A/0	10	30	5′	10·13	.....	1,00,000	To be founded on wells sunk 35 feet in clay. Beldari Nala. Extra fall to be given through aqueduct to reduce its section.
1,128	A/1	4	30	5′	5·97	.....	34,000	
222	C/1	1	30	5′	4·03	.....	11,000	
.....	Syphon Super passage	2	15	3′	8	9·65	20,000	Madval Nala. Velocity assumed for canal discharge 4 feet per second
84·7	D/42	4	7	1′-6″	2	.....	5,500	
19·4	D/43	1	5	1′-3″	3	.....	1,750	
64·7	D/44	1	10	2′-0″	5	.....	2,250	
480	A/12	2	20	4′	18·96	.....	24,000	Garh Nala. Depth of flood assumed 12 feet.
219	C/12	2	15	3′	5·21	.....	300 10,000 1,200	Divert into No. 90. Divert into No. 90.
30·3	D/45	1	6	1′-6″	4	.....	200 2,000	Divert into No. 93.
14·4	D/46	1	5	1′-3″	2	.....	1,500	
30·3	D/47	1	6	1′-6″	4	.....	2,000	
30·3	D/48	1	6	1′-6″	4	.....	2,000 300	Divert into No. 96.
35·2	D/49	1	7	1′-6″	4	.....	2,250	

		1,180							
99	53·05	280,103	5·66	3¼ S. and B.=I.... ... / 3½ S. M. and B=A.V.M. / 3½ S. M., S. M below ...	1 in 70	0·70	3·48		
		1,180							
100	53·31	281,457	14·82	6½ Sandy E. ... ... / 3½ S. and B.=S. M. ...	1 in 200	2·70		4,096	11·3
		1,180							
101	53·61	283,082	0·30	Assume / ¾ Black Soil, 1½ A M. / 5′ H. M. S. R.	1 in 66	0·08			
		1,170	Cutting						
102	55·0	290,388	—0·47	Assume ... ... / 4′ Earth ... ... / ¼ Murum, do. at bottom	1 in 44	0·30		646	11·8
		1,170							
103	55·67	293,918	15·19	3′—3″ Sand and So ... / T. P. closed owing to water.	1 in 226	15·75	16·05	12,800	10·1
		1,170							
104	56·28	297,179	0·18	1 Earth / 1¾ A. V. M. / 2′ H. M. H. M. below ... From a joint T. P.	1 in 100	0·30			
		1,160							
105	57·38	302,972	18·52	Assume, / 1¼ H. M., Rock at bottom ...	1 in 125	1·1	1·16	1,840	12·3
		1,160							
106	57·65	304,375	5·59	1′—3″ H. M. S. R. below ...	1 in 65	0·06			
		1,120							
107	57·83	305,330	5·57	5′-6″ Soil... ... ... / 1 A. V. M. ... ... / 0-6 H. M. ... ... / S. R. at Bottom... ...	1 in 214	0·35	0·70		
		1,120						1,229	12·3
108	58·14	306,968	16·02	2¾ S and B.=Soil, Rock at bottom.	1 in 48	0·35			
		1,120							
109	58·36	308,146	4·41	¾ Earth ... ... / 1½ S. M. ... ... / 1 A. V. M. ... ... / 2′ H. M. S. R.	1 in 9	0·04	0·10	288	11·9
		1,120							
110	58·67	309,794	19·89	3¾ S. and B.=S. M ... / ¾ A. V. M. ... ... / 4½ H. M. H. M.... ...	1 in 10	0·06			
		1,120							
111	59·02	311,644	28·43	3′ S. and B.=S. M. S. R. below.	1 in 14	0·04		146	16·2
		1,120							
112	59·56	314,484	24·65	5¾ Grav. S. and B.=A.M. / 4½ do. = V. H. M. ... / V. H. M. below...	1 in 50	0·70		1,229	12·3
		1,120							
113	60·36	318,691	20·98	¼ S. and B.=S. M. ... / Big boulders=S. R ... / S. R. below ...	1 in 27	0·10		288	11·9
		1,120							
114	61·14	322,829	14·69	Rocky...	1 in 17	0·13		346	11·4
		1,110							
115	62·17	328,271	0·99	Rocky	1 in 4½	0·02		80	13·3
		1,110							
116	62·38	329,389	106·26	Sand and Rock	1 in 800	61·75		34,000	10·3
		1,110							
117	62·71	331,127	16·50	2¾ S. and B=H. M. ... / ½ S. R.	1 in 20	0·04		146	12·2

270	C/1	2	20	4′	402	.....	15,000	
28·74	D/1	2	5	1′-3″	2	.....	2,750	
21·18	D/2	1	7	1′-6″		.....	2,000 100	Divert into Nala No. 3.
19·37	D/3	1	5	1′-3″		.....	1,500	
19·37	D/4	1	5	1′-3″		.....	100 1,750	Divert into Nala No. 7.
54·87	D/5	3	6	1′-6″	2	.....	4,250	
28·74	D/6	2	5	1′-3″	2	.....	2,750	Cannot be diverted into No. 10 owing to intervening steep ground.
54·87	D/7	3	6	1′-6″	.....	.....	4,250 200	Divert into No. 10.
9·00	D/8 (Slabbed).	1	3	.....	3	.....	1,000	
9·00	D/9 (Slabbed).	1	3	.....		.....	1,000	
764	A/1	3	25	5′	6·8	.....	25,000	Sutkatta Nala.
324	C/2	2	15	3′	8·6	.....	15,000 600	Divert into No. 16.
36·6	D/10	2	6	1′-6″		.....	3,000	
30·3	D/11	1	6	1′-6″		.....	2,250	
132	C/3	2	10	2′	5·4	.....	8,000 600	Divert into No. 20.

		1,460		3′ S. and B.=S. M. ...					
22	8·02	42,366	·02	2¾′ S. and B.=H. M., S. R. at bottom.	1 in 12	0·08		245	13·4
		1,410							
23	8·98	47,390	8·72	1′ S. and B.=H. M. S. R. below	1 in 50	0·22		510	12·1
		1,410							
24	9·62	50,796	12·02	7¾′ S. and B.=H. M. ... 2¼′ S. R.	1 in 30	0·13		346	11·4
		1,410							
25	9·85	52,002	12·66	1½′ Soil and B.=H. M. ...	1 in 50	1·21	14·1		
		1,410						2,068	11·2
26	9·88	52,176	11·03	2′ S. and B.=H. M., S. R. at bottom.	1 in 18	0·20			
		1,410							
27	10·15	53,568	10·13	3′ S. and B.=H. M. ... 2¼′ S. R.	1 in 40	0·30			
		1,410							
28	10·7	56,476	—1·62 in cutting.	1′ S. and B.=S. M. ... 2′ Grav. S. and B.=H.M., S. R. below	1 in 14	0·08	·38	808	12·5
		1,410							
29	11·36	59,995	4·21	3′ S. and B.=S. M. 2¼′ decomposing Sand Stone & gr. S. R. below. H.M.	1 in 30	0·13		346	12·3
		1,410							
30	11·89	62,781	12·00	Assume 1′ Soil and gravel =S. M. 2¾′ H. M., S.R. at bottom.	1 in 6	0·14		366	15·1
		1,410							
31	12·42	65,603	2·26	2′ S. and B.=S. M. ... 2½′ S. and B.=H. M. Rock at bottom.	1 in 7	0·17	·77	1,353	10·4
		1,410							
32	12·59	66,470	9·80	7′ S. and B.=S. M., S. and B. at bottom. (*Taken from higher line. T.P*).	1 in 100	0·60			
		1,410							
33	13·17	69,543	2·99	2′ S. and B.=S. M 2½. H.M.V. H.M. at bottom	1 in 42	1·25			
		1,410					19·61		
34	13·41	70,830	14·00	3½′ Soil and Sand, S. and B. at bottom.	1 in 350	18·42		15,000	10·1
		1,410							
35	13·67	72,159	—2·33 in cutting.	Assume 6¼′ soil ... ... 1′ S. and B, S and B at bottom.	1 in 50	0·12			
		1,400	4·16	Assume 2¾′ S. & B.=S. M. 2′ H.M., S. R. at bottom.	1 in 40	0·17		422	12·0
36	14·34	75,731							
		1,400							
37	15·07	79,582	10·05	4′ Soil and Boulders 2′ H.M., S. R., at bottom.	1 in 64	1·40		2,068	9·4
		1,390							
38	15·78	83,312	17·16	Rocky	1 in 11	0·12		328	10·8
		1,390							
39	16·56	87,457	4·89	5′-9″ S. & B.,=S. M., S. & B. S. M., below.	1 in 25	0·21		493	13·5
		1,380							
40	16·96	89,551	6·01	Assume 2′ boulders=H. M., H. M. at bottom.	1 in 35	0·14		366	12·1
		1,380							
41	17·7	93,459	37·18	Rocky...	1 in 50	0·65		1,164	11·6
		1,380							
42	17·98	94,943	32·06	2½′ S. & B.=S. M., 6″ H. M., S. R. at bottom.	1 in 75	0·07		223	11·5
		1,370							
43	18·67	98,570	0·30	Assume 5′ S. & B.=S. M., H. M. at bottom.	1 in 23	0·10		288	13·6

70·4	D/57	2	7	'-6"	4	.....	3,500	
100	A/16	1	10	2'	18·30	.....	12,500 200 2,700	Depth of flood assumed 0. Divert into No. 119.
42·4	D/58	2	7	1·6"	2	.....	3,000	
30·3	D/59	1	6	16"	4	.....	2,000	Intervening ridge high between Nos. 123 and 124.
100	A/17	1	10	2'	24·63	.....	21,000	Depth of flood assumed 10'.
600	A/18	4	25	5'	36·60	.....	46,000**	**Kanvi Nala. 2 Spans will suffice for the discharges. Four provided to reduce height of approaches which are steep. Section of aqueduct to be reduced by extra fall.
49·2	D/60 (Slabbed).	1	7	1'-6'	6	.....	2,750	
9·0	D/61	1	3	.....	3	.....	1,000	Intervening ridge high and ground steep between Nos. 127 and 128.
100	A/19	1	10	2'	15·89	.....	200 15,000	Divert into No. 129. Depth of flood assumed 10.
220	C/15	1	20	4'	8·31	.....	9,000	
360	A/20	3	20	4'	3·35	.....	16,000	Ridge high between Nos. 131 and 132.
572	A/21	2	25	5'	80	.....	20,000 1,800	Divert into No. 132.
84·7	D/62	4	7	1'-6"	2	.....	5,250	
237	A/22	3	15	3'	3·25	2·44	13,000	
70·4	D/63	2	7	1'-6"	4	.....	3,500 1,4 00	Divert into No. 136.
19·4	D/64	1	5	1'-3"	3	.....	1,750	
24·3	D/65	1	6	1'-6"	3	.....	1,750 100	Divert into No 139.

141	73·93	1,060 390,334	19·71	Boulders	1 in 58	0·10		288	11·9
142	74·26	1,060 392,079	27·81	Sand ... ... Rock close	1 in 57	1·20		1,840	15·4
143	74·35	1,060 392,544	9·92	Boulders	1 in 25	0·02	0·23	560	11·4
144	74·48	1,060 393,014	12·01	D.	1 in 50	0·21			
145	74·72	1,060 394,529	Cutting —1·37	Rocky	1 in 30	0·04	0·12	328	11·4
146	74·91	1,060 395,534	Cutting —1·29	D.	1 in 19	0·08			
147	75·12	1,050 396,639	Cutting —1·80	Soil and gravel	1 in 10	0·15	0·35	955	14·8
148	75·25	1,050 397,329	9·40	Gravel and boulders ...	1 in 50	0·13			
149	75·45	1,050 398,398	5·99	Rocky	taken as 1 in 50	0·07			
150	75·92	1,050 400,854	Cutting —1·11	From nearest T. P., 6′ S. M. 2½ H. M.	1 in 14	0·03	1·53	2,280	15·2
151	76·11	1,050 401,844	29·22	6′ S. M., 2½ H. M., H. M. at bottom.	1 in 100	1·5			
152	76·63	1,050 404,629	10·82	Rocky	1 in 25	0·40		808	11·5
153	77·27	407,996	Cutting —2·11	2′-9″ Soil, ... 2′-9″ S. M. ... ... 3′-9″ H. M., H. M. below.	taken as 1 in 30	0·30		646	11·8

Markandeya Syphon Crossing

1	32·95	173,995	64·36	No pit in bed	0·70 in one mile.	359·39		107,329	12·4
2	33·82	178,553	Cutting —2·86	2½ Sandy S. and S. M. = 1½ grav. S. and B. = A. V. M. S. and B. = A.V. M. below	1 in 15	0·06		200	10·1
3	34·24	180,793	Cutting —0·47	1½ Hard reddish Soil ... 1½ S. M. ... ... 4′ Soft rock, S. R. below.	1 in 100	0·16		404	14
4	35·45	187,186	0·83	10½ Sandy Soil	1 in 200	3·50		4,096	...
5	36·28	191,553	Cutting —3·52	4′ Black Soil	1 in 125	0·60		1,097	...
6	36·72	193,890	Cutting —1·58	2½ Black Soil, Soil below ...	1 in 150	0·85		1,420	...

BANK CANAL.

1st Section.

Torrent Works.

Area of opening provided.	Provision made. A—Aqueduct. C—Culvert. D—Con-drain.	No. of Openings or Spans.	Span.	Rise.	Height of abutment.	Deepening of Nala bed.	Estimated cost (rough).	Remarks.
24·3	D/66	1	6	1'-6"	3	.....	1,750	
120	A/23	1	10	2'	24·31	.....	19,000	Holer Nala.
49·2	D/67	1	7	1'-6"	6	.....	100 2,750	Divert into No. 144.
28·7	D/68	2	5	1'-3"	2	.....	500 2,500	Divert into No. 146.
64·3	D/69	1	9	1'-8"	6	.....	800 3,250 1,800	Divert into No. 143. Divert into No. 143.
150	A/24	1	15	3'	24·47	.....	200 22,000	Divert into No. 151. Depth of flood, assumed 10'.
70·4	D/70	2	7	1'-6"	4	.....	3,500	
54·9	D/71	3	6	1'-6"	2	.....	3,250	Not diverted into No. 152 owing to the intervening Bridge and Regulator for Yadwad Branch.

Alternative.

89·16	Syphon aqueduct.	12	30	5'	22·5	.....	536,953	Depth of flood assumed 25 feet.
18·3	D/1	1	6	.....	2	.....	1,750	
28·7	D/2	2	5	1'-3"	2	.....	2,500	
3·2	.....	2	15	3'	8·5	6·17	20,000	Velocity assumed for canal discharge 4' per second,
.....	.....	...	...	.....	.....	.....	3,000	Divert into No. 4.
.....	.....	...	...	.....	.....	.....	5,900	Do. do.

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal—1st Section.

(7).—Statement of Road-Bridges and Regulators.

Note.—The costs entered are rough and based on the estimated figures of similar works on the Gokak Left Bank Canal Project.

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL—1ST SECTION.

(7).—Statement of Road-Bridges and Regulators.

No.	Distance from Head-Works.		Purpose of Bridge.	Description of Road.	Width of Road-way, between parapets, feet.	Sectional area of Canal.		Openings for Canal.		Height of abutment.	Approximate Cost.	Remarks.
	Miles in Decimals.	Feet.				Breadth, feet.	Depth, feet.	No. of Spans.	Size of Spans, feet.		Rs.	
1	2·17	11,454	Foot Traffic ...	Footpath Parsauhatti to Nargund ..	6′	67+4	8	4	18	8	2,750	
2	4·30	22,726	Do.	Footpath, Sutkatta to Nargund ...	6′	67+4	8	8	9	8	4,250	Combined with Regulator No. 1.
3	6·28	33,173	Traffic	Poona-Belgaum made Road ...	20′	67+4	8	4	18	8	5,000	
4	7·16	37,796	Foot Traffic ...	Kataboli to forest	10′	66+4	8	4	18	8	3,250	
5	10·88	57,476	Cultivator's ...	Footpath, Biranholi to fields ...	10′	64+4	8	4	18	8	3,250	
6	12·81	67,665	Traffic	Islampur to Yamkanmardi ...	12′	64+4	8	7	10	8	5,000	Combined with Regulator No. 3.
7	16·06	84,787	Foot Traffic ...	Footpath to forest	6′	63+4	8	4	18	8	2,750	
8	18·28	96,493	Do. ...	Footpath, from Vantmuri to forest..	6′	62+4	8	2 2	18 15	8	2,500	
9	20·11	106,189	Do. ...	From Halli Vantmuri to Chilbhavi and Arlikatti.	6′	62+4	8	7	10	8	4,250	Combined with Regulator No. 4.
10	21·96	115,970	Do. ...	From Ramankatti to forest ...	6′	62+4	8	2 2	18 15	8	2,500	
11	24·96	131,808	Cultivator's ...	From Arlikatti to Chilbhavi and Mangaon.	10′	61+4	8	1 2	25 20	8	3,000	
12	26·92	142,161	Traffic	Pachhapur to Mangaon	12′	61+4	8	1 2	25 20	8	3,250	
13	29·27	154,548	Foot Traffic ...	Kanvihatti to forest	6′	61+4	8	1 2	25 20	8	2500	
14	31·47	166,177	Traffic	Pachhapur to Mangaon	12′	59+4	8	1 2	25 20	8	3, 50	
15	34·70	183,248	Do.	Karguppi and Yellapur to Pachhapur Railway Station.	12′	58+4	8	1 2	25 20	8	3,250	
16	36·91	194,921	Do.	Musalmari and Bassapur to Hargedal and Shirur.	12′	58+4	8	7	9	8	4,750	Combined with Regulator No. 6.
17	38·06	200,983	Cultivator's ...	Harankol to fields	10′	57+4	8	1 2	25 20	8	3,000	
18	39·63	209,283	Traffic	From Mallapur and Musalmari to Kundargi.	12′	57+4	8	1 2	25 20	8	3,250	
19	39·77	210,008	Railway line, Poona to Belgaum.	For S. M. Ry. from Belgaum to Poona.	28′	57+4	8	7	9	8	7,500	
20	42·09	222,223	Traffic	Made Road from Gokak to Belgaum.	20′	57+4	8	7	9	8	6,000	Combined with Regulator No. 7.

21	43·69	230683	Traffic	Aktangerhal to Madval and Villages above canal.	10′	57+4	8	1 2	25 20	8	3,000	
22	50·85	268506	Foot Traffic ...	Foot path from Kaitnal to forest ...	6′	54+4	8	3	20	8	2,500	
23	52·12	275198	Do.	Foot path from Murkanhatti to Hosur and forest.	6′	54+4	8	6	10	8	3,750	Combined with Regulator No. 9.
24	53·75	283793	Traffic	Cart track Murkanhatti to Kaitnal.	10′	⅔ of 31 =21	8	1	20	8	2,000	
25	56·08	296098	Do.	Road from Gokak to Vanur ...	12′	53+4	8	3	20	8	3,250	
26	56·93	300598	Do.	Vanur to Mamdapur	12′	52+4	8	1 2	20 18	8	3,250	
27	61·93	326971	Foot Traffic ..	Shiltibhavi to Murgod	6′	51+4	8	7	8	8	3,750	Combined with Regulator No. 10.
28	63·35	334501	Do.	Jamnal village to forest	6	51+4	8	1 2	18 20	8	2,500	
29	66 09	348998	Cultivator's ..	Hanmarkadbi to villages below canal	10′	51+4	8	6	9	8	4,000	Combined with Regulator No. 11.
30	68·92	363898	Traffic	Cart track from Yerjharvi to Madgalli	12′	50+4	8	3	18	8	3,000	
31	69·96	369370	Do.	Cart track Yerjharvi to Murgod ...	12′	⅔ of 34 =23	8	1	25	8	2,250	
32	73·06	385740	Foot Traffic ...	Naganhatti to forest	6′	⅔ of 33 =22	8	3	8	8	2,750	Combined with Regulator No. 12.
33	76·52	404000	Traffic	Gokak Saundatti made Road ...	20′	48+4	8	3	18	8	4,250	
				Regulators.								
2	8·78	46376	Access to Regulator and traffic.	.....	6′	27	8	3	9	8	2,750	Take-off of pipe syphon for Daddi Left Bank canal.
5	30·69	162085	Do.	.. ..	6′	59+4	8	7	9	8	4,000	Pachhapur Minor.
8	46·98	248078	Do.	Foot path to fields and forest ...	6′	54+4	4	6	10	8	3,750	
13	77·13	407273	Do.	Cart track from Yergatti to Yadwal	12′	20+3 31+4	6 8	3 4	9 9	6 8	7,000	Take-off of Yadwad Branch.
				Markandeya Syphon Alternative Bridges and Regulators.								
1	30·95	163420	Railway line ...	S. M. Ry. from Belgaum to Poona	30	.....	.....	1	30	.....	15,500	Aqueduct above Southern Maharatha Railway.
2	31·77	167728	Traffic	Made Road from Pachhapur to Konur	20	58+4	8	7	9	8	6,000	Combined with Regulator No. 5, Main Canal.
3	34·80	183753	Cultivator's ...	.....	10	58+4	8	1 2	25 20	8	3,000	
4	36·89	194812	Traffic	Made Road from Gokak to Belgaum	20	58+4	8	1 2	25 20	8	4,500	

33 Bridges in 78·5 miles=1 in 2·5 miles approximately.
In addition to this, short tunnels may, if cheaper, be provided at all deep cuts to facilitate traffic.

P. N. NATESAIYER,

Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal—1st Section.

(8).—Statement giving details of area under command and the discharge required.

Serial No. of Branch, Minor or Distributary.	Mileage on Main Canal.	Gross Area under Command of Branch, Minor or Distributary, in acres	Average estimated discharge in Cusecs for Branch, Minor or Distributary.	Total discharge required for irrigation from Headworks up to Distributary, Minor or Branch.	Total leakage in Cusecs in canal from Headworks.	Discharge required in Canal at the Head of Branch, Minor or Distributary.		Remarks.
						Before take-off.	After take-off	
* D 1	2·17	205	·50	·50	7·00	1,493	1,493	* Please see note below.
D 2	4·43	352	·75	1·25	16·00	1,484	1,483	
D 3	7·10	576	1·00	2·25	24·5	1,475	1,473	
* B 1	8·78	...	50	52·25	30 50	1,467	1,417	Take off of Daddi Left Bank canal.
D 4	10·89	685	1·50	53·75	38·50	1,409	1,408	
D 5	16·06	864	1·75	55·5	56·00	1,390	1,388	
D 6	20·11	1,184	2·50	58	70·00	1,374	1,372	
D 7	21·96	608	1·25	59·25	76 5	1,365	1,364	
D 8	23·08	378	·75	60·00	79·75	1,361	1,360	
D 9	25·26	621	1·25	61·25	87·00	1,353	1,352	
D 10	28·00	1,043	2·00	63·25	96·00	1,343	1,341	
* M 1	30·70	19,558	39	102·25	105·00	1,332	1,293	Pachhapur minor, length 4·62 miles.
D 11	34·04	2,035	4·00	106·25	115·50	1,282	1,278	
D 12	36·92	301	·50	106·75	125·25	1,269	1,268	
D 13	38·70	538	1·00	107·75	131·00	1,262	1,261	
D 14	40·63	1,261	2·50	110·25	136·5	1,256	1,253	
D 15	43·99	1,421	2·75	113	148·00	1,242	1,239	
D 16	44·89	2,259	4·50	117·5	151·25	1,236	1,231	
M 2	47·00	13,472	27	144·5	157·25	1,225	1,198	At end of Madval cut, length of minor 4 miles.
D 17	50·80	582	1·25	145·75	168·50	1,187	1,186	
D 18	53·70	397	·75	146 5	177·50	1,177	1,176	
D 19	54·86	410	·75	147·25	180·5	1,173	1,172	
D 20	56·55	570	1·25	148·5	185·75	1,167	1,166	
M 3	56·94	15,936	32	180·5	187·50	1,164	1,132	At end of Navapur cut, length of minor 5·75 miles.
D 21	61·93	742	1 50	182	202·25	1,118	1,116	
D 22	66·10	4,160	8·50	190·5	214·25	1,104	1,095	
D 23	67·90	1,216	2·50	1·93	220·25	1,089	1,087	
D 24	69·48	1,062	2·25	193·25	223·75	1,083	1,081	
D 25	71·92	934	2·00	197·25	230 75	1,074	1,072	
D 26	73·03	3,040	6·00	203·5	233·50	1,069	1,063	
B 2	77·14	170,297	340·5	5·44	246	1,050	710	End of 1st section. Take-off of Yadwad Branch.

Note.—"D" stands for distributary; "M" for minor; and "B" for branch.
Leakage allowed in distributary, minors and branches only where their length exceeds 40 miles.
Discharge is calculated at the rate of 1 cusec for every 500 acres, gross command.
Leakage in main canal calculated at the rate of 3·5 cusecs for miles 0-20
3·25 " " 21-45
3 00 " " 46-66
2·75 " " 67-77

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT,

Main Canal—1st Section.

(9).—Statement of Bed Falls.

Chainage. From	Chainage. To	Length.	Rate of bed fall per mile.	Head used up in length.	Canal bed level at end of section.	Remarks.
...	...	...	...	...	2234·70	Outlet level at Daddi.
...	4699	4699	6″	0·45	2234·25	
...	...	...	...	Drop	·35	
...	...	...	...	...	2233·90	
4699	5507	808	2½′	0·38	2233·52	
...	...	...	...	Drop	·09	
...	...	...	...	...	2233·43	
5507	6350	843	3′	·47	2232·96	
6350	7050	700	6″	·07	2232·89	
...	...	...	...	Drop	·52	
...	...	...	...	...	2232·37	
7050	8578	1528	3½′	1·01	2231·36	
8578	18523	9950	6″	0·94	2230·42	
...	...	...	...	Drop	·52	
...	...	...	...	...	2229·90	
18523	20773	2245	3½′	1·49	2228·41	
20773	23583	2810	6″	·27	2228·14	
...	...	...	...	Drop	·52	
...	...	...	...	...	2227·62	
23583	24442	859	3½′	·57	2227·05	
24442	25053	611	2′	·23	2226·82	
25053	26287	1234	6″	0·12	2226·70	
...	...	...	...	Drop	·52	
...	...	...	...	...	2226·18	
26287	27639	1352	3½′	0·90	2225·28	
27639	29142	1503	6″	0·14	2225·14	
...	...	...	...	Drop	·35	
...	...	...	...	...	2224·79	
29142	30414	1272	2½′	·60	2224·19	
30414	43795	13381	6″	1·27	2222·92	
...	...	...	...	Drop	·35	
...	...	...	...	...	2222·57	
43795	44917	1122	2½′	·53	2222·04	
...	...	...	...	Drop	·09	
...	...	...	...	...	2221·95	
44917	46250	1333	3′	·76	2221·19	
46250	46905	655	2½′	·31	2220·88	At Chainage 46,376 Daddi Left Bank Canal takes off.
46905	73609	26704	6″	2·52	2218·36	At Chainage 71,609 Shahabunder cut alternative line begins C. B. L. 2218·55.
...	...	...	...	Drop	·35	
...	...	...	...	...	2218·01	
73609	75061	1452	2½′	·69	2217·32	
75061	76487	1426	6″	·13	2217·19	
...	...	...	...	Drop	·35	
...	...	...	...	...	2216·84	
76487	78129	1642	2½′	·78	2216·06	
78129	92176	14047	6″	1·33	2214·73	
...	...	...	...	Drop	·35	
...	...	...	...	...	2214·38	
92176	93328	1152	2½′	·54	2213·84	
93328	93723	395	6″	0·04	2213·80	
...	...	...	...	Drop	·35	
...	...	...	...	...	2213·45	
93723	94768	1045	2½′	0·49	2212·96	
94768	125843	31091	6″	2·95	2210·01	

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL—1ST SECTION.

(9).—Statement of Bed Falls—(*contd.*)

Chainage. From	Chainage. To	Length.	Rate of bed fall per mile.	Head used up in length.	Canal bed level at end of section.	REMARKS.
...	...	...	...	Drop	·35	
...	...	...	...	...	2209·66	
125843	126843	1000	2½′	0·47	2209·19	
126843	135206	8363	6″	0·79	2208·40	
135206	210008	74802	6″	7·09	2201·31*	* At 160,959 Markandeya syphon crossing alternative line begins C. B. 2215·96.
...	...	...	...	Drop	·38	
...	...	...	...	...	2200·93	At 194,394 Shahabunder cut alternative joins C. B. 2202·79.
210008	236298	26290	6″	2·5	2198·43	At 196,398 Pick-up weir alternative begins C. B. 2202·6.
...	...	...	...	Drop	·25	At 199,433 Pick-up weir alternative begins joins 2101·93.
...	...	...	...	...	2198·18	At 236,398 Markandeya Syphon
236298	238250	1952	6″	0·18	2198·00	crossing alternative line joins.
...	...	...	...	Drop	·41	Canal Bed by alternative line
...	...	...	...	...	2197·59	2197·45.
238250	247298	9048	3′	5·14	2192·45	Madwall cut.
247298	267193	19895	6″	1·88	2190·57	
...	...	...	...	Drop	·40	
...	...	...	...	...	2190·17	
267193	267903	710	3′	0·40	2189·77	
267903	283798	15895	6″	1·50	2188·27	At 283,498 alternative alignment
...	...	...	...	Drop	·40	contour new spur would begin
...	...	...	...	...	2187·87	C. B. 2188·29.
283798	284963	1165	3′	·66	2187·21	
...	...	...	...	Drop	·14	
...	...	...	...	...	2187·07	Murkanhatti cut.
284963	287663	2700	4′	2·05	2185·02	
287663	289398	1735	3′	1·00	2184·02	
289398	298798	9400	6″	·89	2183·13	At 291,898 alternative alignment in
...	...	...	...	Drop	·64	contour round spur would join.
...	...	...	...	...	2182·49	Probable C. B. by alternative
298798	327661	28863	6″	2·73	2179·76	would be 2182·29.
...	...	...	...	Drop	·31	
...	...	...	...	...	2179·45	
327661	329000	1339	2½′	·63	2178·82	
329000	330099	1099	7½′	2·85	2175·97	Hira Nala syphon.
330099	331596	1497	6″	0·14	2175·83	
...	...	...	...	Drop	·39	
...	...	...	...	...	2175·44	
331596	332796	1200	3′	·68	2174·76	
332796	349858	17062	6″	1·62*	2173·04	* This includes the drop of ·1
...	...	...	...	Drop	·39	given at chainage.
...	...	...	...	...	2172·65	
349858	351348	1490	3′	·85	2171·80	
351348	367830	16482	6″	1·56	2170·24	
...	...	...	...	Drop	·24	
...	...	...	...	...	2170·00	
367830	369370	1540	2′	·59	2169·41	At 367,968 alignment in contour
...	...	...	...	Drop	·27	round the spur may be assumed
...	...	...	...	...	2169·14	to begin. Canal bed 2170·31.
369370	385740	16370	6″	1·55	2167·59	At 369 855 above alternative may
...	...	...	...	Drop	·24	be assumed to join Canal bed by
...	...	...	...	...	2167·35	alternative line would be 2169·65.
385740	386370	630	2′	·24	2167·11	
386370	389434	3064	6″	0·29	2166·82	

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal, 1st Section.

(9).—Statement of Bed Falls—(*contd.*)

Chainage. From	Chainage. To	Length.	Rate of bed-fall per mile.	Head used up in length.	Canal bed level at end of section.	Remarks.
...	...	...	...	Drop	·24	
...	...	...	...	...	2166·58	
389434	390014	580	2′	0·22	2166·36	
390014	395694	5680	6″	·54	2165·82	
...	...	...	...	Drop	·24	
...	...	...	...	...	2165·58	
395694	396304	610	2′	0·23	2165·35	
396304	407273	10969	6″	1·04	2164·31	Take-off of Yadwad Branch.
407273	409694	2421	9″	0·34	2163·97	
...	...	...	...	Drop	·23	
...	...	...	...	...	2163·74	
409694	410294	600	3′	·34	2163·40	Yergatti cut.
...	...	...	...	Drop	·10	
...	...	...	...	...	2163·30	
410294	413094	2800	4′	2·12	2161·18	
413094	413894	800	3′	·45	2160·73	
413894	414494	600	1′	·11	2160·62	
	Lower line by Shahab under cut (alternative).					
...	...	...	...	...	2218·55	Bed on River Bank of Shahabunder station $\frac{A}{132}$.
71609	75301	3692	6″	·35	2218·20	
...	...	...	...	Drop	·42	
...	...	...	...	...	2217·78	
75301	78102	2801	3′	1·59	2216·19	Shahabunder cut.
...	...	...	...	Drop	·16	
...	...	...	...	...	2216·03	
78102	79899	1797	4′	1·36	2214·67	
...	...	...	...	Drop	·56	
...	...	...	...	...	2214·11	
79899	84419	4520	8′	6·85	2207·26	
84419	86709	2290	4′	1·74	2205·52	
86709	90242	3533	3′	2·01	2203·51	
90242	97752	7510	6″	·72	2202·79	At station $\frac{H}{69}$ $\left(\frac{A}{320}\right)$. Chainage 194379 of accepted line.
	Markandeya Syphon Crossing (alternative).					
...	...	...	...	...	2205·96	At station $\frac{A}{289}$ at 160959 of accepted line on main Ridge between Ghatprabha and Markandeya Rivers.
160959	172618	11659	6″	1·10	2204·86	On Left Bank of Markandeya.
172618	175619	3001	7′	1·50 (drop)	*2203·86	*Markandeya River. Concrete pipe syphon.
...	...	...	...	4·06	*2199·30	*On Right Bank of Markandeya.
175619	195153	19534	6″	1·85	‡2197·45	‡At station $\frac{39}{D}$ at chainage 236398 of accepted line round Markandeya River. Canal bed according to accepted line=2198·17.

P. N. NATESAIYER,

Executive Engineer on Special Duty,
Gokak Survey.

Accompaniment to Statement No. 9.

GHATPRABHA RIGHT BANK PROJECT, MAIN CANAL, 1st SECTION.

Table of Canal discharges with details of calculations for different bed widths and bed falls.

Bed width.	Wetted perimeter.	Area.	R	$\sqrt{R}$	N (Kutter's co-efficient).	6″ per mile. C	6″ per mile. $C\sqrt{S}$	6″ per mile. V	6″ per mile. D	Remarks.
68	85·89	576	6·706	2·590	·020	104·16	1·014	2·626	1513	Side slopes assumed to be ½ to 1. The calculations are approximate and based on Higham's Tables.
67	84·89	568	6·691	2·587	,,	104·12	1·013	2·620	1488	
66	83·89	560	6·675	2·584	,,	104·08	1·013	2·617	1465	
65	82·89	552	6·659	2·581	,,	104·03	1·012	2·612	1442	
64	81·89	544	6·643	2·577	,,	103·99	1·012	2·608	1419	
63	80·89	536	6·226	2·574	,,	103·94	1·011	2·602	1395	
62	79·89	528	6·609	2·571	,,	103·89	1·011	2·599	1372	
61	78·89	520	6·591	2·567	,,	103·84	1·010	2·593	1348	
60	77·89	512	6·573	2·564	,,	103·90	1·010	2·590	1326	
59	76·89	504	6·555	2·560	,,	103·74	1·009	2·583	1301·8	
58	75·89	496	6·535	2·557	,,	103·70	1·009	2·580	1279·7	
57	74·89	488	6·516	2·553	,,	103·64	1·008	2·573	1255·6	
56	73·89	480	6·496	2·549	,,	103·59	1·008	2·569	1233·1	
55	72·89	472	6·476	2·545	,,	103·53	1·007	2·563	1209·7	
54	71·89	464	6·454	2·540	,,	103·46	1·007	2·558	1186·9	
53	70·89	456	6·433	2·536	,,	103·40	1·006	2·551	1163·2	
52	69·89	448	6·410	2·532	,,	103·35	1·006	2·547	1141·1	
51	68·89	440	6·3869	2·527	,,	103·28	1·005	2·540	1117·6	
50	67·89	432	6·3632	2·523	,,	103·22	1·004	2·533	1094·2	
49	66·89	424	6·3387	2·518	,,	103·15	1·003	2·526	1071·0	
48	65·89	416	6·3135	2·513	,,	103·08	1·003	2·5205	1048·5	
47	64·89	408	6·2875	2·507	,,	103·00	1·002	2·5120	1024·9	
46	63·89	400	6·2607	2·502	,,	102·93	1·001	2·5045	1001·8	
31	48·89	280	5·7271	2·393	·0225	90·10	1·074	2·570	719·6	
64	80	512	6·400	2·530	·0225	92·72	·902	2·282	1178·4	Sides vertical. The calculations are approximate and based on Higham's Tables.
59	75	472	6·293	2·508	·0225	92·41	·899	2·255	1054·2	
70	86	560	6·512	2·551	,,	93·01	·905	2·309	1292·8	
69	85	552	6·494	2·548	,,	92·97	·905	2·306	1272·9	
						8′ per mile.				
25	41	200	4·878	2·209	·0225	86·01	3·350	7·400	...	Sides vertical.
24	40	192	4·800	2·191	,,	83·78	3·340	7·318	...	
23	39	184	4·718	2·172	,,	85·54	3·330	7·233	...	
						13½′ per mile.				
40	56	320	5·714	2·390	·017	*N =	2·359	4·060	...	* Taken from Moore's Tables.
39	55	312	5·673	2·382	·017	*D =	·930	4·043	...	
			Pipe Syphons.				**7′ per mile.**			
14	diameter.	153·94	3·50	1·871	·015	*N = 5·988, *D = ·6567		8·290	1276	
						7′-6″ per mile.				
13·25	,,	137·8	3·313	1·820	·015	N = 6·191, D = 0·6546		8·286	1141·8	
13	,,	132·7	3·25	1·803	,,	...	...	8·160	1082·8	
13·50	,,	143·1	3·375	1·837	,,	...	...	8·391	1200·7	
						8′ per mile.				
13·50	,,	...	...	...	,,	N = 6·394, D = ·653		8·747	...	
13	,,	132·7	3·25	1·803	,,	...	...	8·461	...	

GHATPRABHA RIGHT BANK PROJECT.

MAIN CANAL, 1ST SECTION.

Table of Canal discharges with details and calculations for different bed-widths and bed-falls—*concld.*

Bed width.	Wetted perimeter.	Area.	R	$\sqrt[2]{R}$	N (Kutter's Co-efficient)	Fall 2′ per mile.				Fall 2′-6″ per mile.				Fall 3′ per mile.				Fall 3′-6″ per mile.				Fall 4′ per mile.				Remarks.
						C	$C\sqrt{S}$	V	D	C	$C\sqrt{S}$	V	D	C	$C\sqrt{S}$	V	D	C	$C\sqrt{S}$	V	D	C	$C\sqrt{S}$	V	D	
45	61	360	5·901	2·429	·0225	89·02	1·732	4·207	1514·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Sides vertical, calculations based on Higham's Tables.
44	...	352	5·866	2·422	,,	88·94	1·731	4·192	1475·6																	
43	...	344	5·831	2·415	,,	88·87	1·730	4·178	1437·2																	
42	...	336	5·793	2·407	,,	88·78	...	...	...																	
41	...	328	5·754	2·399	,,	88·69	...	...	...	88·54	1·927	4·623	1516·3													
40	...	320	5·714	2·390	,,	88·58	...	...	...	88·43	1·925	4·601	1472·2													
39	...	312	5·673	2·382	,,	88·48	...	...	...	88·34	1·923	4·581	1429·2													
38	...	304	5·630	2·373	,,	...	...	...	...	88·24	1·920	4·556	1385·0	88·10	2·100	4·983	1514·8									
37	...	296	5·585	2·363	,,	...	...	...	...	88·12	1·917	4·530	1340·9	87·99	2·097	4·955	1466·7									
36	...	288	5·538	2·353	,,	88·14	1·716	4·037	1162·6	88·01	1·915	4·506	1297·7	87·88	2·095	4·929	1419·5	87·78	2·266	5·332	1535·6					
35	...	280	5·490	2·343	,,	88·02	1·713	4·013	1123·6	87·89	...	...	...	87·77	2·093	4·904	1373·1	87·67	2·263	5·302	1484·6					
34	...	272	5·440	2·332	,,	87·88	1·711	3·990	1085·2	87·77	...	...	...	87·65	2·089	4·872	1325·2	87·55	2·260	5·270	1433·4					
33	...	264	5·388	2·322	,,	87·76	1·708	3·966	1047·0	87·65	1·907	4·428	1169·0	87·54	2·087	4·846	1279·3	87·44	2·257	5·241	1383·6	87·34	2·404	5·582	1473·6	
32	...	256	5·333	2·309	,,	87·61	1·705	3·937	1007·9	87·50	1·904	4·396	1125·4	87·40	2·084	4·812	1231·9	...	...	...	...	87·20	2·401	5·544	1419·2	
31	...	248	5·277	2·297	,,	87·46	1·702	3·909	969·4	87·36	1·901	4·367	1083·0	87·25	2·080	4·778	1184·9	...	...	...	...	87·06	2·397	5·506	1365·5	
30	...	240	5·217	2·284	,,	87·29	1·699	3·881	931·4	87·19	...	...	...	87·09	2·076	4·742	1138·1	...	...	...	...	86·91	2·392	5·463	1311·1	
29	...	232	5·155	2·270	,,	...	...	...	...	...	...	...	...	86·91	2·071	4·701	1090·6	...	...	...	...	86·74	2·387	5·418	1256·9	
28	44	224	5·090	2·256	,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	86·57	2·383	5·376	1204·2	
27	43	216	5·0232	2·241	,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	86·38	2·377	5·3268	1150·6	
28	44	224	5·090	2·256	·025	...	...	...	...	...	...	...	...	78·47	...	...	...									
27	43	216	5·0232	2·241	·025	...	...	...	...	...	...	...	...	78·28	1·866	4·1817	903·2									
22	38	176	4·6316	2·152	·025	...	...	...	...	...	...	...	...	77·15	1·338	3·9553	696·1	...	...	...	...	77·10	2·122	4·5665	803·7	
21	37	168	4·5405	2·131	,,	...	...	...	...	...	...	...	...	76·89	...	...	...	...	...	...	...	76·86	2·116	4·5091	757·5	
20	36	160	4·4444	2·108	,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76·60	2·109	4·4457	711·3	
19	35	152	4·3428	2·084	,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	76·29				
18	34	144	4·2353	2·058	,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	75·95				
17	33	136	4·1212	2·030	,,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	75·59				

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK PROJECT.

(MAIN CANAL, 1ST SECTION.)

(10).—Statement of extra lengths of Alignment that may be required if certain high Banks and Cuts are to be avoided.

Serial No.	Mileage at Nalas or Spurs	Length along accepted Alignment.	Chainage along detour to be considered.	Head spent along accepted Alignment.	Head spent along Detour.	Extra Head required for Detour.	REMARKS.
1	4·81	1234	1900	·12	·60	·48	Round Sutkatta Nalla, 3½ P. M. fall given in portion of detour.
2	8·97	326	380	·03	·04	·01	
3	9·62	434	520	·04	·05	·01	
4	9·88	750	1160	·07	·11	·04	
5	11·9	790	895	·08	·08	·00	
6	16·6	802	870	·08	·08	·00	
7	17·7	395	872	·39	·66	·27	1st Vantmuri Nalla detour.
8	19·07	950	2560	·09	·73	·64	Continued with 2½ P. M. fall.
9	22·15	599	1260	·06	·12	·06	2nd Vantmuri Nalla, portion of Detour
10	22·6	465	780	·04	·07	·03	on left bank with 2½ ft. fall P. M.
11	23·7	515	620	·05	·06	·01	
12	24·07	490	820	·05	·08	·03	
13	26·2	738	880	·07	·08	·01	
14	30·7	2022	5030	·19	·48	·29	
15	37·6	3035	7038	·29	·67	·38	Main ridge near Pachhapur between the Ghatprabha and Markandeya rivers; provision for this extra fall made at the Railway crossing.
16	41·6	4506	5680	·43	·54	·11	
17	42·6	1961	6250	·19	·59	·40	Beldari Nalla, the extra head of 2·39 required up to the Madwal cut, will have been obtained by raising the outlet at Daddi.
18	48·09	1082	1570	·10	·15	·05	
19	48·7	874	2250	·08	·21	·13	
20	49·4	950	1200	·09	·11	·02	
21	53·3	1850	3170	·17	·30	·13	Murkanhatti Nalla.
22	55·7	1500	4100	·14	·39	·25	Gadher Nalla.
23	57·4	1500	2800	·14	·27	·13	A reserve head of 0·64 has been kept at the Navapur cut.
24	62·7	420	500	·04	·05	·01	
25	64·6	758	1420	·07	·13	·06	
26	66·8	1638	2020	·15	·19	·04	A reserve head of ·10 has been kept at the Jamnal village site.
27	66·9						
28	67·5	1333	1450	·13	·14	·01	Nalla east of Kanvi Nalla.
29	68·8	720	1370	·07	·13	·06	
30	69·4	980	1590	·09	·15	·06	
31	70·4	1770	2280	·17	·22	·05	Saving of 0·39 head.
32	70·5						
33	73·1	1096	1620	·54	·15	...	Holer Nalla saving of 0·29 head.
34	73·9	506	580	·05	·06	·01	
35	73·8	1782	2800	·55	·26	0·0	A reserve head of 2·7 has been kept here, the Yergharvi cut, the head of (·39+·29) saved by the detour at miles 73 and 75, may be utilized to make up the small difficiences in the reserve heads left after the Madwal cut and also for any contingencies.
36	74·2	905	930	·09	·09	0·0	
37	76·1	1508	2480	·14	·23	·09	
38	76·6	1200	1540	·11	·15	·04	

P. N. NATESAIYER.

Executive Engineer on Special Duty

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT,

Main Canal-1st Section.

(11.)—Statement of Canal Dimensions.

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL-1ST SECTION.

(11.)—Statement of Canal Dimensions.

MILEAGE.		CANAL SECTION.				DISCHARGE.				REMARKS.
From mile.	To mile.	Bed width, feet.	Depth of water, feet.	Side slope.	Declivity of bed per mile, feet.	Value of (n.)	Mean velocity, feet per mile.	Calculated discharge, cusecs.	Required discharge, cusecs, at head of Section.	
0	·89	68	8	½ to 1	·5	·02	2·63	1513	1500	
·89	1·04	41	8 12	Vertical.	2·5	·0225	4·62	1516	1497	
1·04	1·2	38 25	8 12	Do.	3	·0225	4·98	1515	1496	
1·2	1·33	67	8	½ to 1	·5	·02	2·62	1488	1496	
1·33	1·62	35 23	8 12	Vertical.	3·5	·0225	5·32	1485	1496	
1·62	3·51	67	8	½ to 1	·5	·02	2·62	1488	1495	
3·51	3·93	35 23	8 12	Vertical.	3·5	·0225	5·3	1485	1487	
3·93	4·47	67	8	½ to 1	·5	·02	2·62	1488	1486	
4·47	4·63	35 23	8 12	Vertical.	3·5	·0225	5·32	1485	1483	
4·63	4·74	44 29	8 12	Do.	2	·0225	4·19	1476	1483	
4·74	4·98	67	8	½ to 1	·5	·02	2·62	1488	1482	
4·98	5·23	35 23	8 12	Vertical.	3·5	·0225	5·3	1485	1481	
5·23	5·52	67	8	½ to 1	·5	·02	2·62	1488	1480	
5·52	5·76	40 27	8 12	Vertical.	2·5	·0225	4·6	1472	1480	
5·76	7·1	67	8	½ to 1	·5	·02	2·62	1488	1479	
7·1	8·3	66	8	½ to 1	·5	·02	2·62	1465	1473	
8·3	8·5	40 27	8 12	Vertical.	2·5	·0225	4·6	1472	1469	
8·5	8·76	37 25	8 12	Do.	3	·0225	2·95	1467	1468	
8·76	8·78	40 27	8 12	Do.	2·5	·0225	4·6	1472	1467	
8·78	8·88	39 26	8 12	Do.	2·5	·0225	4·58	1429	1417	Daddi Left Bank Canal takes off.
8·88	13·94	64	8	½ to 1	·5	·02	2·61	1419	1416	
13·94	14·22	39 26	8 12	Vertical.	2·5	·0225	4·56	1385	1398	
14·22	14·49	63	8	½ to 1	·5	·02	2·6	1395	1397	

14·49	14·8	39 26	8 12	Vertical.	2·5	·0225	4·57	1385	1397	
14·8	17·46	63	8	½ to 1	·5	·02	2·6	1395	1396	
17·46	17·68	38 25	8 12	Vertical.	2·5	·0225	4·56	1385	1383	
17·68	17·75	62	8	½ to 1	·5	·020	2·60	1372	1383	
17·75	17·95	38 25	8 12	Vertical.	2·5	·0225	4·56	1385	1382	
17·95	23·83	62	8	½ to 1	·5	·020	2·60	1372	1381	
23·83	24·02	37 25	8 12	Vertical.	2·5	·0225	4·53	1340	1357	
24·02	30·70	61	8	½ to 1	·5	·020	2·60	1348	1356	
30·70	34·04	59	8	½ to 1	·5	·020	2·58	1302	1293	Pachapur minor takes off.
34·04	38·70	58	8	½ to 1	·5	·020	2·58	1280	1278	
38·70	43·99	57	8	½ to 1	·5	·020	2·57	1256	1261	
43·99	45·12	56	8	½ to 1	·5	·020	2·57	1233	1239	
45·12	46·83	32 21	8 12	Vertical.	3	·0225	4·81	1232	1231	Madval Cut.
46·83	47·00	56	8	½ to 1	·5	·020	2·57	1233	1225	
47·00	50·60	54	8	½ to 1	·5	·020	2·56	1187	1198	
50·60	50·74	31 21	8 12	Vertical.	3	·0225	4·78	1185	1187	
50·74	53·75	54	8	½ to 1	·5	·020	2·56	1187	1187	
53·75	53·97	31 21	8 12	Vertical.	3	·0225	4·78	1185	1176	Murkanhatti Cut.
53·97	54·48	27 18	8 12	Do.	4	·0225	5·33	1162	1175	
54·48	56·56	53	8	½ to 1	·5	·020	2·55	1163	1174	
56·56	56·94	64	8	0 to 1	·5	·0225	2·28	1174	1166	
56·94	61·93	52	8	½ to 1	·5	·020	2·55	1141	1133	
61·93	62·06	51	8	½ to 1	·5	·020	2·54	1118	1116	
62·06	62·31	32 21	8 12	Vertical.	2·5	·0225	4·40	1125	1116	
		Diar.		Section.						
62·31	62·51	13·25	Circular		7·5	·015	8·28	1142	1115	Hire Nala concrete pipe syphon.
62·51	62·80	51	8	½ to 1	·5	·020	2·54	1118	1114	
62·80	63·03	29 19	8 12	Vertical.	3	·0225	4·70	1091	1113	
63·03	66·10	51	8	½ to 1	·5	·020	2·54	1118	1113	
66·10	66·26	50	8	½ to 1	·5	·020	2·53	1094	1095	
66·26	66·54	29 19	8 12	Vertical.	3	·0225	4·70	1091	1095	
66·54	69·48	50	8	½ to 1	·5	·020	2·53	1094	1094	
69·48	69·66	49	8	½ to 1	·5	.020	2·53	1071	1081	
69·66	69·96	34 23	8 12	Vertical.	2	·0225	3·99	1085	1080	
69·96	73·06	49	8	to 1	·5	·020	2·53	1071	1079	
73·06	73·18	33 22	8 12	Vertical.	2	·0225	3·07	1047	1063	Yerjharvi Cut.

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL-1ST SECTION.

(11.)—Statement of Canal Dimensions—*concluded.*

MILEAGE.		CANAL SECTION.				DISCHARGE.				REMARKS.
From mile.	To mile.	Bed width, feet.	Depth of water, feet.	Side slope.	Declivity of bed per mile, feet.	Value of (*n.*)	Mean velocity, feet per mile.	Calculated discharge, cusecs.	Required discharge, cusecs, at head of Section.	
73·18	73·76	49	8	½ to 1	·5	·020	2·53	1071	1063	
73·76	73·87	33 22	8 12	Vertical.	2	·0225	3·97	1066	1061	
73·87	74·94	49	8	½ to 1	·5	·020	2·53	1071	1060	
74·94	75·06	33 22	8 12	Vertical.	2	·0225	3·97	1047	1058	
75·06	77·14	48	8	½ to 1	·5	·020	2·52	1051	1050	Yadwad Branch takes off.
Alignment vid Shahabunder Cut (Alternative).										
13·56	14·26	63	8	½ to 1	·5	·020	2·60	1395	1405	
14·26	14·79	36 24	8 12	Vertical.	3	·0225	4·93	1419	1404	Shahabander Cut.
14·79	15·13	32 21	8 12	Do.	4	·0225	5·54	1419	1402	
15·13	15·99	24 16	8 12	Do.	8	·0225	7·32	1405	1402	
15·99	16·42	32 21	8 12	Do.	4	·0225	5·54	1419	1398	
16·42	17·09	35 23	8 12	Do.	3	·0225	4·90	1373	1395	
17·09	18·51	63	8	½ to 1	·5	·020	2·60	1395	1390	
Alignment vid Markandeya Syphon Crossing (Alternative).										
30·48	32·69	58	8	½ to 1	·5	·020	2·58	1279	1289	
32·69	33·26	14 Diar.	Circular	Section.	7	·015	8·29	1276	1281	Markandeya River concrete Pipe Syphon.
33·26	36·96	58	8	½ to 1	·5	·020	2·58	1279	1279	

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT,

Main Canal, Ist Section.

(12).—Comparative Statement of Main Alternatives.

(12.)—Ghatprabha Right Bank Canal Project, Main Canal,

Serial No.	Items compared.	Alternatives for Shahabander Cut, compared from mile 13·5 to 44·75 (continuous mileage from Daddi.)		
		Alignment round Vantmuri.	Alignment *vid* Markandeya Syphon.	Alignment *vid* Shahabander Cut.
1	2	3	4	5
1	Total length of alignment.	1,64,789 feet.	1,30,544 feet.	68,162 feet.
2	Cross Slopes :—			
	(*i*) 1 in 2½ and steeper.	.....	....	.....
	(*ii*) Between 1 in 2½ and 1 in 5.	10,423 feet.	12,423 feet.	.....
	(*iii*) Between 1 in 5 and 1 in 10.	10,737 „	8,723 „	600 feet.
3	Nature of ground ...	Sandy soil and boulders. Fissured rock. Forest for 17 miles. Cultivation red and black soil for remaining portion.	For the first 15 miles same as on Vantmuri line, column 3. In the remaining portion cultivation in black soil.	Brown and black soil and cultivation in the portion excluding cut.
4	Deep cuts max. height...	13·47 feet.	18·77 feet.	94·54,66·5 feet in rock.
	Do. length...	2,005 „	2,600	20,189 feet.
5	High banks—Length less than 500'.	2,336' in 6 places, max. height 30'	Same as under column 3 + 3,150' on main ridge maximum height 7·6 feet.	*Nil.*
	Length more than 500'	4,829' in 6 places do. 40'		3,649' in 4 places and maximum height 25·22' in the river bed.
6	Leakage in cusecs ...	103·19	78	43·87
7	Cost of earth work ...	12,24,062	9,95,597	12,25,535
	„ Masonry ...	5,89,600	7,79,508	3,59,950
	Total ...	18,13,662	17,75,105	15,85,485
8	Capitalised value of leakage.	20,63,800	15,60,000	8,78,000
9	Grand Total Cost ...	38,77,462	33,35,105	24,63,485
10	Special Difficulties ...	High proportion of side long ground for the first 11 miles. For the first 15 miles rock much fissured. Proportionate leakage will be much. High rock level from 26-30. High banks and aqueducts. Difficulty in getting earth for banks. Remaining portion Shadoo and Murum. Difficulties of foundations for Beldari Nala and Nala near to it.	For the first 15 miles same as column 3. Syphon alternative goes through 20 chains of steep ground. Difficulty of providing for the drainage between the Urbanhatti and Madwal cuts. The main difficulty is the syphon which will be 14 feet in diameter and will have to be carried over the Markandeya. Maximum head of pressure in syphon 45'.	Excessive depth and length of the Shahabander cut. On the east side a great part of excavation in Shadoo which will give great trouble owing to the high spring level. Difficulties east of cut are the Markandeya and Beldari aqueducts.
11	Remarks	This alternative is the least satisfactory.	The advantages are the same as the Vantmuri line, column 3 piusa long syphon but there will be a considerable reduction in the length over column 3.	Is more satisfactory than the alternatives, columns 3 and 4, and is recommended but will be very difficult.

Alternatives for Murkanhatti Cut compared from mile 53·5 to 55.		Alternatives for Markandeya Aqueduct compared fro mile 37·25 to 38 (continuous mileage from Daddi.)	
Alignment *via* cut.	Alignment in contour round cut.	Aqueduct crossing.	Pick-up weir crossing.
6	7	8	9
8,400 feet.	29,750 feet.	3,035 feet.	7,038 feet.
.....	.....	.....	.....
.....	3,650 feet.	.....	1,000 feet.
.....	13,300 „	.....	500 „
Brown and black soil cultivated.	Excepting ¾ mile cultivated in black soil and remaining soil and boulders. Forest land. Rock about 2 feet below surface of ground.	Cultivated black soil.	About 15 chains in soil and boulders. Forest land. Remaining cultivated in black and red soil.
56·42, 51 feet in rock.	.....	.....	.....
4,340 feet.	.....	.....	.....
Nil.	Not ascertained but one or two valleys moderately deep, width not great.	*Nil.*	*Nil.*
do.		918′ height, 25·22′ in river bed and 7 feet on banks.	Central portion below bed of canal about 700 feet wide will be closed by a weir.
4·5	16·5	2·0	5·25
2,46,044	2,42,282	19,189	21,010
6,000	27,250	1,00,000	2,07,312
2,52,044	2,69,532	1,19,189	2,28,322
90,000	3,30,000	40,000	1,05,000
3,42,044	5,99,532	1,59,189	3,33,322
High rock cutting. Extra length of distributaries at each end.	Alignment through hard and rough ground with high proportion of steep ground.	Aqueduct over the Markandeya, 12 spans of 30 feet.	Compensation for submerged land and portion of Shirur village site. Difficulty of access to the Shirur village to the right bank of the river. Curtain wall provided below weir which will serve as a water cushion.
The cut may be accepted.	.....	.....	The pick-up weir may secure supply of 3,000 million cubic feet from the Markandeya and may be accepted.

Alternatives for the crossings of the Shahabander Nala compared from mile 12·25 to 15 (continuous chainage from Daddi).			Alternatives for the mile 4·5 to 5·25
Accepted crossing.	Crossing near Temple.	Syphon crossing.	Accepted line.
10	11	12	13
14,103 feet.	8,403 feet.	1,339 feet.	4,140 feet.
.....	.....	.....	2,178 „
3,093 feet.	1,640 feet.	.....	644 „
2,435 „	1,526 „	.....	.....
Mostly sandy soil and boulders.	Sandy soil and boulders.	Sand, soil and boulders.	Sandy soil and boulders, rough ground.
.....	.....	.....	.....
.....	.....	.....	.....
Nil.	*Nil.*	.....	.....
1,770 in 2 places, maximum height 14 feet on bank.	1,600 feet, maximum height 29 and 21 on bank.	Canal bed 45 feet above Nala.	729 feet, 14·32′ in bed, 7·5 on bank.
9·6	5·25	.....	2·6
1,38,334	1,40,809	*Nil.*	1,49,362
57,150	49,600	1,31,699	29,250
1,95,484	1,90,400	1,31,699	1,78,612
1,92,000	1,05,000	*Nil.*	52,000
3,87,484	2,95,409	1,31,699	2,30,612
Nala to be crossed 3 times. Bad angles on Right Bank. Loss of head due to long lengths of steep ground.	Heavy banks and high aqueducts. Large Nala to be diverted. Foundations probably not so satisfactory as in accepted line, column 10.	A concrete pipe syphon 15′ in diameter and maximum head of pressure 30 feet.	Long length of steep ground.
Accepted to avoid heavy banks, but seem to be inferior to the syphon crossing, column 12.	.....	Advantages—Saving in length, avoiding all steep ground and high bank and aqueduct.	Accepted to avoid banks but 2 or 3 very bad angles.

1st Section—Comparative Statement of Main Alternatives.

crossing of the Sutkatta Nala compared from (continuous mile from Daddi.)		Alternatives for Yerjharvi Cut compared from mile 69·5 to 70 (continuous mileage from Daddi).		Remarks.	
Direct crossing with a canal Tank.	Syphon crossing.	Alignment *vid* cut.	Alignment in contour avoiding cut.		
14	15	16	17	18	
1,170 feet.	1,170 feet.	1,887 feet.	7,014 feet.	1. The following 2 alternative estimates have been worked out for the Markandeya syphon (*vide* alternate column 4).	
.....	.....	.....	.....		
.....	.....	.....	1,000 feet.		
.....	.....	.....	2,500 „	Rough cost of syphon.	
Sandy soil and boulders.	Sandy soil and boulders.	Black soil and boulders.	Hard murum ground with rock at surface at places.	(*i*) Low aqueduct, for syphon, maximum head of pressure 45·5 feet	Rs. 5,36,953
.....	.....	29·92 feet.	.....	(*ii*) Long and high aqueduct to reduce head of pressure to 30 feet.	4,42,304
.....	.....	1,887 feet.	.....		
.....	.....	.....	Filling up a tank 16′ below canal bed.	2. The following alternatives have been worked out for the crossing of the Hire Nala in the 63rd mile.	
1,160 ft., 41·33 ft. in bed, 32 ft. on bank.	Canal bed above Nala bed 41·33 feet.	.....			
1	.....	1	4	Cost of crossing.	
.....	.....	36,047	40,304		
137,545	114,201	2,250	8,000	(*i*) Pipe syphon 13′-3″ diameter on low aqueduct, maximum head of pressure 92 feet...	Rs. 1,98,570
137,545	114,201	38,297	48,304		
20,000	.....	20,000	80,000	(*ii*) Pipe syphon 13′-3″ diameter on long and high aqueduct to reduce head of pressure to 30 feet...	2,30,630
157,545	114,201	58,297	128,304		
High banks and difficulties in getting suitable earth for embankments. Increased silt in canal. Automatic gates Some outlet arrangements will be necessary to keep down silt in tank.	Diameter of pipe 15′-6″ to be wholly of reinforced concrete. Maximum head 30′ and the line to cross the valley over a light concrete platfrom at the ends and a narrow aqueduct in the centre.	Cut.	Extra head may be required to deal with steep ground above Yerjharvi village.	(*iii*) Masonry aqueduct for whole crossing...	3,55,363
Unsatisfactory ...	Compares well with accepted line as regards cost but difficulties are not so bad as to justify a syphon.	Accepted ...	.....		

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

(13).—Pipe Syphon for the Crossing of the Hire Nalla in the 63rd mile.

1. The width of the valley at the site of crossing is 1,100 feet and the maximum depth from lowest point in nalla up to canal bed is 105 feet. The discharge through the siphon will be 1,116 cusecs. Sufficient head is allowed to create and maintain a velocity of 8·3 feet per second in the siphon. The diameter of the proposed pipe is calculated to be 13′-3″.

2. The pipe will cross the nulla over an aqueduct consisting of 6 spans of 30 feet. A light concrete platform 8 feet wide and made up of arches of 10 feet span will support the central portion of the pipe in the embankments forming the approaches to the aqueduct.

3. For heads up to 30 feet the pipe will be of concrete reinforced on the outside by expanded metal, and on the inside by a net-work of round bars laid transversely and longitudinally along the pipe.

For heads above 30 feet, a $\frac{1}{4}$″ steel plate is provided for instead of the above net-work of bars. The calculations are given below. The maximum tensile stress assumed is 7 tons per square inch for the steel. The total pressure round the circumference of the pipe per foot of head

$$= 2 \times \text{radius} \times \cdot4335^{*} \text{ lbs.}$$
$$= 13\cdot25 \times 12 \times \cdot4335$$
$$= 68\cdot93 \text{ lbs.}$$

* Pressure of 1 foot of water over 1 square inch.

4. (*a*) Head 0—30 feet. Maximum pressure for 30 feet head $= 30 \times 68\cdot93$
$= 2{,}068$ lbs.

If the equivalent thickness of metal required in the section to resist the pressure be t,

$2\,t \times 7$ tons ... ... $= 2{,}068$ lbs.

or t... ... ... $= \frac{2{,}068}{2 \times 7 \times 2{,}240}$
$= \cdot066$ inches.
$= \frac{1}{15}$th inch nearly.

Circumference of pipe 13′-3″ diameter ... ... = 41·6 feet.

Equivalent weight of metal required per foot in length of pipe at 30 feet head ... ... $= 41\cdot6 \times 2\cdot6$ †
$= 108$ lbs.

† Weight of 1 square foot of Plate $\frac{1}{12}$ inch thick.

The net-work of bars required will consist of $\frac{5}{8}$″ round iron bars laid axially at 1 foot intervals, and $\frac{1}{2}$″ round bars laid at 6″ transversely. The weight of the net work per foot in length of pipe will be:—

$\frac{5}{8}$″ round bars, 42×1 at 1·02 lbs. per R.ft.	43 lbs.
$\frac{1}{2}$″ round bars, 2×42 at ·66 lbs. per R.ft.	55 lbs.
Total weight in section	98 lbs.

The weight required as calculated is 108 lbs., and it is assumed that the balance of strength will be obtained from the expanded metal reinforcement on the outside of the pipe.

(*b*) Head over 30 feet. The maximum head in the pipe is on the aqueduct and is—

F. S. L. above siphon = R. L. 2186·8
Bed of siphon above aqueduct = R. L. 2094·6 } ... ... = 92·2 feet.

Total pressure in pipe for a head of 92·2 feet ... ... $= 92\cdot2 \times 68\cdot93$.
$= 6{,}355$ lbs.

Assuming t to be thickness of steel plate in pipe, $2t \times 7$ tons $= 6{,}355$ „

or t ... $= \frac{6{,}355}{2 \times 7 \times 2{,}240}$
$= \cdot20$ inches.

The thickness of plate is taken to be $\frac{1}{4}$ inch for all heads above 30 feet.

5. The thickness of concrete assumed for the different sections of the pipe are:—

6″ for heads from 0—30 feet, $7\frac{1}{2}$″ for heads from 30—61 feet, 9″ for heads from 61—92 feet.

Cement plaster $\frac{1}{2}$″—$\frac{7}{8}$″ thick is provided for the interior of the pipe, and has been separately estimated.

6. The cost per running foot of the pipe will be roughly as follows :—

(*a*) Head 0—03 feet—

		Rs.
(*i*)	Net-work of bars, weight 98 lbs. @ Rs. 12 per cwt., including labour	$\frac{98}{112} \times 12 = 11$
(*ii*)	Cement concrete=43 × ·5 or 21·5 cubic feet @ Rs. 100 per 100 cubic feet, including expanded metal reinforcement and constructing pipe ...	= 21
(*iii*)	Cement plaster on the inside, $\frac{1}{2}$″ thick=42 square feet @ Rs. 12 per 100 square feet	$\frac{42 \times 12}{100} = 5$
(*iv*)	Laying pipe, etc.	10
(*v*)	Contingencies 10%	3
	Rate per R.ft. ...	50

(*b*) Head, 33—61 feet—

(*i*)	Steel pipe, $\frac{1}{4}$″ thick, weight 41·6 × 10·2 = 424 lbs. @ Rs. 20 per cwt., including labour	$\frac{424 \times 20}{112} = 75$
(*ii*)	Cement concrete=$\frac{43 \times 15}{2 \times 24}$=27 cubic feet @ Rs. 100 per 100 cubic feet, including expanded metal reinforcement, construction, etc.	27
(*iii*)	Cement plaster inside of pipe, $\frac{7}{8}$″ thick=42 square feet @ Rs. 20 per 100 square feet	$\frac{42 \times 20}{100} = 8$
(*iv*)	Laying pipe, etc.	10
(*v*)	Contingencies, 10%	12
		132
		Say 135

(*c*) Head 61—92 feet—

(*i*), (*iii*) and (*iv*).	Same as above	75
		8
		10
(*ii*)	Cement, concrete $\frac{44 \times 3}{4}$ = 33 cubic feet @ Rs. 100 per 100 cubic feet	33
(*v*)	Contingencies 10%	13
	Total ...	139
	Say ...	140

7. The cost of the siphon, with that of aqueduct, concrete platform for the portion of the pipe carried on embankment, and head-walls, etc., as calculated in the accompanying sheet, works out to Rs. 2,00,000. The length of siphon is 1,100 feet. The through rate per R.ft. works out to Rs. 182.

P. N. NATESAIYER,
Executive Engineer,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal, 1st Section.

(14).—General Abstract of cost of earthwork.

Mileage.	Length actually estimated. Chainage. From	To	Length in feet.	DESCRIPTION.	Cost.	Total.
					Rs.	
0–5	4,699	6,350	1,651	Steep ground	73,771	
	7,050	8,578	1,528	Do.	62,853	
	18,528	20,773	2,245	Do.	1,00,797	
	23,583	25,053	1,470	Do.	59,002	
	25,053	26,287	1,234	Sutkatta Nalla Crossing	11,976	
			8,128		3,08,399	
			18,159	at Rs. 27,874 per mile	95,868	
					4,04,267	
				Add 5°/₀ contingencies	20,213	
						4,24,480
				Average cost per mile	84,896	
5–10	26,287	27,639	1,352	Steep ground	70,829	
	29,142	30,414	1,272	Do.	28,853	
	34,795	46,905	3,110	Do.	76,894	
	15,696	52,281	585	Full bank	9,757	
			6,319		1,86,333	
			20,194	at Rs. 40,826 per mile	1,56,144	
					3,42,477	
				Add 5°/₀ contingencies	17,124	
						3,59,601
				Average cost per mile	71,920	
10—15	64,126	73,608	9,482	Islampur Nalla Crossing	55,670	
	73,608	75,061	1,453	Steep ground	31,737	
	75,061	76,487	1,426	Islampur Nalla Crossing	9,912	
	76,487	78,127	1,640	Steep ground	33,631	
			14,001		1,30,950	
			12,326	at Rs. 36,081 per mile	84,230	
					2,15,180	
				Add 5°/₀ contingencies	10,759	
						2,25,939
				Average cost per mile	45,188	
15–20	92,176	93,328	1,152	Steep ground	25,751	
	93,723	94,728	1,005	Do.	29,644	
	1,00,291	1,00,970	679	Full bank	45,912	
			2,836		1,01,307	
			21,066	at Rs. 40,211 per mile	1,80,012	
					2,81,319	
				Add 5°/₀ contingencies	14,066	
						2,95,385
				Average cost per mile	59,077	
20–25	1,07,735	1,08,067	332	Full bank	12,375	
	1,16,785	1,17,292	507	Do.	24,617	
	1,24,746	1,25,211	465	Do.	15,103	
	1,25,843	1,26,843	1,000	Steep ground	16,541	
	1,26,950	1,27,386	436	Full bank	17,598	
			2,740		86,234	
			23,660	at Rs. 29,243 per mile	1,31,040	
					2,17,274	
				Add 5°/₀ contingencies	10,864	
						2,28,138
				Average cost per mile	45,628	
				Carried over ...		15,33,543

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal, 1st Section.

(14).—General Abstract of cost of earthwork—*continued.*

Mileage.	Length actually estimated. Chainage. From	To	Length in feet.	DESCRIPTION.	Cost.	Total.
					Rs.	
				Brought forward ...		15,33,543
25–30	....	...	26,400	at Rs. 43,133 per mile	2,15,665	
				Add 5% contingencies	10,783	2,26,448
				Average cost per mile	45,289	
30–35	.....	.....	26,400	at Rs. 26,782 per mile	1,33,910	
				Add 5% contingencies	6,695	
				Average cost per mile	28,121	1,40,605
35–40	183,657	190,657	2,000	Basapur cut	12,649	
	198,450	198,475	25		.....	
	198,475	198,907	432	Full bank	9,767	
	198,907	199,368	461		.....	
			2,918		22,416	
			23,482	at Rs. 21,220 per mile	94,372	
					1,16,788	
				Add 5% contingencies	5,839	
				Average cost per mile	24,525	1,22,627
40–45	223,697	224,770	1,073	Full bank	15,768	
	225,100	225,243	143			
	229,543	230,183	640	Do.	9,343	
			2,186		25,111	
			23,612	at Rs. 19,013 per mile	85,026	
					1,10,137	
				Add 5% contingencies	5,507	
				Average cost per mile	23,129	1,15,644
45–50	236,998	248,003	11,005	Mudwal cut	3,05,295	
	253,708	254,545	837	Full bank	16,176	
	256,915	257,707	792	Do.	26,498	
			12,634		3,47,969	
			14,368	at Rs. 33,160 per mile	90,235	
					4,38,204	
				Add 5% contingencies	21,910	
				Average cost per mile	92,023	4,60,114
				Average cost excluding Mudwal cut.	46,185	
50–55	267,193	267,903	710	Steep ground	15,975	
	280,628	281,860	1,232	Full bank	19,433	
	283,538	289,898	6,340	Murkanhatti cut	2,19,715	
			8,282		2,55,123	
			18,118	at Rs. 30,981 per mile	1,06,309	
					3,61,432	
				Add 5% contingencies	18,072	
				Average cost per mile	75,902	3,79,504
				Average cost excluding Murkanhatti cut ...	39,680	
55–60	291,898	292,798	900	Khanergaon cut	7,934	
	293,283	294,658	1,375	Full bank	22,483	
	298,647	300,618	1,971	Navapur cut	48,201	
	302,248	303,383	1,135	Full bank	15,774	
	311,404	311,819	415	Do.	15,323	
			5,796		1,09,715	
			20,604	at Rs. 39,897 per mile	1,55,687	
					2,65,402	
				Add 5% contingencies	13,270	
				Average cost per mile	55,734	2,78,672
				Carried over ...		32,57,157

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal, 1st Section.

(14).—General Abstract of cost of earthwork—*concluded.*

Mileage.	Length actually estimated. Chainage. From	To	Length in feet.	DESCRIPTION.	Cost.	Total.
					Rs.	
				Brought forward ...		32,57,157
60–65	327,661	328,969	1,308	Steep ground	34,424	
	331,596	332,791	1,195	Do.	17,571	
	340,851	341,386	535	Full bank	7,152	
			3,038		59,147	
			23,362	at Rs. 38,487 per mile	1,70,292	
					2,29,439	
				Add 5 °/₀ contingencies	11,472	
						2,40,911
				Average cost per mile	45,446	
65–70	349,858	351,348	1,490	Steep ground	42,158	
	353,152	358,738	586	Full bank	30,018	
	356,375	356,863	488	Do.	19,090	
	363,068	363,688	620	Do.	15,597	
	365,848	366,743	895	Do.	17,680	
	366,888	369,678	2,790	Yerjarvi cut...	47,290	
			6,869		1,71,833	
			19,531	at Rs. 18,172 per mile	67,466	
					2,39,299	
				Add 5 °/₀ contingencies	11,965	
						2,51,264
				Average cost per mile	50,253	
70–75	371,068	371,858	790	Cut	5,132	
	372,063	372,593	530	Full bank	6,222	
	385,626	386,389	763	Madamgeri cut	22,154	
	389,384	390,074	690	Cut	25,058	
	395,614	396,454	840	Cut	22,363	
			3,613		80,929	
			23,241	at Rs. 28,896 per mile	1,27,190	
					2,08,119	
				Add 5 °/₀ contingencies	10,406	
						2,18,525
				Average cost per mile	43,705	
75–77·1	401,596	402,418	822	Full bank	28,474	
	404,314	405,032	718	Do.	9,240	
			1,540		37,714	
			9,279	at Rs. 26,893 per mile	84,005	
					1,21,719	
				Add 5 °/₀ contingencies	6,086	
						1,27,805
				Average cost per mile	25,561	
				Grand Total Rs. ...		40,95,662

P. N. NATESAIYER,

Executive Engineer on Special Duty.

Accompaniment to Statement No. 14.

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL, 1ST SECTION.

Schedule of rates assumed for earthwork.

Serial No.		Rate adopted. Rs.	a.	p.	Unit.
	Excavation in—				
1	Earth	0	8	0	Per 100 cubic feet.
2	Soil and boulders, shadoo and murum, and materials equivalent to soft murum.	0	12	0	,, ,,
3	Soil and boulders, equivalent to hard murum	1	8	0	,, ,,
4	Big boulders, equivalent to rock, 1st 5'	3	0	0	,, ,,
5	Rock less than 30' to 5'	5	0	0	,, ,,
6	,, more than 30'	8	0	0	,, ,,
7	,, ,, ,, 40'	10	0	0	,, ,,
8	,, ,, ,, 50'	12	0	0	,, ,,
9	,, ,, ,, 60'	15	0	0	,, ,,
10	,, ,, ,, 70' ... ... / ,, less than 80'	20	0	0	,, ,,
	Embankment—				
11	From fresh material for banks less than 10'	0	12	0	Per 100 cubic feet.
12	,, ,, for portions of canal passing through fissured rock and steep ground.	1	0	0	,, ,,
13	,, ,, for banks more than 10'	1	0	0	,, ,,
14	,, ,, for portions of canal passing through fissured rock and steep ground.	1	4	0	,, ,,
15	From canal excavation (earth for core only)	0	4	0	,, ,,
16	Dressing slopes	0	6	0	,, ,,

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT MAIN CANAL,

(15).—Abstract of Cost

Items.	Rate.		Mile 2½—3½. Ch. 13,255—179,945.		Mile 7—8. Ch. 36,960—42,240.		Mile 11—12. Ch. 58,080—63,360		Mile 15—16. Ch. 79,127—84,534.	
			Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.
	Rs.	a.								
Excavation—										
Excavation in soil ...	0	8	.....	.....	.....	.....	109,940	550	.....	.....
„ soft murum.	0	12	616,228	4,622	247,629	1,857	471,795	3,538	762,130	5,716
„ hard „	1	8	376,288	5,644	1,083,205	16,243	352,610	5,289	394,390	5,916
„ in rock less than 5′.	3	0	101,812	3,054	94,407	2,832	72,471	2,174	314,334	9,430
„ in rock less than 30′.	5	0	.....	.....	.....	.....	.....	.....	46,310	2,316
			.....	13,320	.....	20,937	.....	11,551	.....	23,378
Embankment—										
From fresh material ...	1	4	.....	.....	.....	.....	717,663	8,971	274,272	3,428
For banks above 10′ high.	1	0	1,005,961	10,060	1,833,477	18,335	1,352,130	13,521	1,283,839	12,838
For banks less than 10′ high.	0	12	.....	.....	...	.....	.....	.....	.....	.....
For core got from the excavation of canal.	0	4	.....	.....	.....	.....	98,773	247	.....	.....
Dressing banks and canal roads.	0	6	368,058	1,380	414,494	1,554	477,698	1,791	409,075	1,534
			.....	11,440	.....	19,889	.....	24,530	.....	17,800
			.....	24,760	.....	40,826	.....	36,081	.....	41,178

Mile 21—22. Ch. 110,880—116,160.		Mile 29—30. Ch. 153,120—158,400.		Mile 34—35. Ch. 179,520—184,800.		Mile 38—39. Ch. 200,640—205,925.	
Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.
187,049	935	.....	.....	582,135	2,911	887,596	4,438
507,080	3,803	355,705	2,668	.....	.....	79,932	599
110,507	1,658	42,034	631	.....	.....	.....	.....
181,696	5,451	392,602	11,778	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
.....	11,847	.....	15,077	.....	2,911	.....	5,037
.....	.....	440,169	5,502	.....	.....	.....	.....
1,526,429	15,264	2,068,641	20,686	.....	.....	.....	.....
.....	.....	.....	.....	2,776,219	20,822	1,819,074	13,643
177,496	444	.....	.....	330,103	950	305,334	763
450,164	1,688	498,050	1,868	559,865	2,099	479,303	1,797
.....	17,396	.....	28,056	.....	23,871	.....	16,203
.....	29,243	.....	43,133	.....	26,782	.....	21,240

Mile 40—41. Ch. 211,200—216,480.		Mile 49—50. Ch. 258,720—264,000.		Mile 51·5—52·5. Ch. 271,791—277,236.		Mile 58—59. Ch. 306,240—311,404.	
Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.
1,172,522	5,863	.....	.....	118,318	592	.....	.....
7,729	58	640,474	4,804	606,779	4,551	554,537	4,159
.....	.....	197,343	2,960	93,133	1,397	292,192	4,383
.....	.....	123,135	3,694	5,450	164	309,053	9,272
.....	.....	1,199	60	.....	.....	15,508	775
.....	5,921	.....	11,518	.....	6,704	.....	18,589
.....	.....	.....	.....	302,570	3,782	.....	.....
.....	.....	1,992,801	19,928	1,927,520	19,275	815,362	8,154
1,409,877	10,507	.....	.....	.....	.....	1,427,829	10,709
372,978	932	.....	.....	112,365	281	.....	.....
440,699	1,653	457,134	1,714	508,660	1,907	418,027	1,568
.....	13,092	.....	21,642	.....	25,245	.....	20,431
.....	19,013	.....	33,160	.....	31,949	.....	39,020

BANK CANAL PROJECT.

1st Section.

of Typical Miles.

Mile 61—62. Ch. 322,080—327,366.		Mile 71·5—72·5 Ch. 377,768—382,998.		Mile 67·7—68·7. Ch. 357,578—363,063.		Mile 75—76. Ch. 396,454—396,527.		Remarks.
Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	
.....	.....	389,572	1,948	82,756	414	190,019	950	
456,695	3,425	396,855	2,976	1,051,882	7,889	95,049	713	
.....	.....	458,289	6,874	293,789	4,407	145,466	2,182	
396,993	11,910	379,893	11,397	.....	.....	648,252	19,448	
.....	.....	.....	.....	.....	.....	205,793	10,290	
.....	15,335	.....	23,195	.....	12,710	.....	33,583	
512,152	6,402	.....	.....	.....	.....	.....	.....	
1,504,213	15,042	.....	.....	.....	.....	.....	.....	
.....	.....	545,240	4,089	627,828	4,709	1,148,590	8,614	
.....	.....	98,339	246	54,662	137	129,550	324	
467,323	1,752	291,138	1,092	356,936	1,339	312,040	1,170	
.....	23,196	.....	5,427	.....	6,185	.....	10,108	
.....	38,531	.....	28,622	.....	18,895	.....	43,691	

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Main Canal, 1st Section.

(16).—Abstract of cost of deep cuts.

ITEMS.	Rate per 100 feet.	Ch. 186,657—1,90,667.		Ch. 236,998—248,003.		Ch. 283,558—289,898.		Ch. 291,898—292,798.		Ch. 298,647—300,618.	
		Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.
Excavation.											
Excavation, soil	8	535,955	2,680	7,589,738	37,949	178,082	890	20,585	103	124,342	622
Do. soft murum ...	12	513,255	3,449	14,651,151	2,19,767	210,911	1,582	261,449	1,961	287,808	2,159
Do. hard murum	1 8	407,989	6,120	338,909	8,473	800,613	12,009	98,549	1,478	131,553	1,973
Do. rock less than 5 ft.	3 ...	...	...	519,312	39,106	804,828	24,145	129,360	3,881	414,692	12,441
Do. do. 30 ft.	5 ...	...	...	262,804		2,546,777	1,27,339	10,220	511	620,124	31,006
Do. do. 40 ft.	8 ..	...	...	...	...	392,357	31,389	...	...	...	...
Do. do. 50 ft.	10 ...	...	...	...	...	193,658	19,366	...	...	...	...
Do. do. 60 ft.	12 ...	...	...	...	...	24,957	2,995	...	...	...	...
		...	12,249	...	3,05,295	...	2,19,715	...	7,934	...	48,201

ITEMS.	Rate per 100 feet.	Ch. 366,688—369,678.		Ch. 371,068—371,858.		Ch. 385,626—396,369.		Ch. 389,384—390,074.		Ch. 395,674—396,454.	
		Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.
Excavation.											
Excavation, soil	... 8	187,002	685	66,040	330	...	...	...	...	...	...
Do. soft murum ...	... 12	205,413	1,541	143,375	1,075	1,570	12	...	...	...	...
Do. hard murum ...	1 8	909,267	13,639	248,663	3,727	41,562	623	14,505	218	10,535	158
Do. rock less than 5ft.	3 ...	278,080	8,342	...	...	91,245	2,737	81,950	2,459	104,300	3,129
Do. do. 30ft.	5 ...	461,657	23,083	...	...	322,970	16,149	307,780	15,389	360,400	18,020
Do. do. 40ft.	8 ...	...	...	...	...	32,912	2,633	87,395	6,992	13,200	1,056
Do. do. 50ft.	10 ...	...	...	...	...	...	...	...	...	...	...
Do. do, 60ft.	12 ...	...	...	...	...	...	...	...	...	...	...
		...	47,290	...	5,132	...	22,154	...	25,058	...	22,363

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL—1ST SECTION.

(17).—Abstract of Cost of High Embankments.

Serial No.	Miles.	Chainage.		Fresh material for banks above 10 feet height.		Fresh material for banks less than 10 feet height.		For Core got from the excavation of canal.		Dressing banks and canal roads.		Total Cost.	REMARKS.
				Rate per 100 cft. 1-0-0.		Rate As. 12 per 100 cft.		Rate As. 4 per 100 cft.		Rate As. 6 per 100 cft.			
		From	To	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.		
				Cft.	Rs.	Cft.	Rs.	Cft.	Rs.	Cft.	Rs.	Rs.	
1	4	25,157	25,846	163,806	1,638	927,735	6,958	.....	.....	117,044	439	9,035	
2	9	51,696	52,281	459,572	4,596	635,894	4,764	.....	.....	104,648	392	9,757	
3	12	66,060	66,760	.....	.....	1,008,044	7,560	.....	.....	114,323	429	7,989	
4	13	70,370	71,440	469,728	4,697	1,066,280	7,997	.....	.....	170,800	641	13,335	
5	19	100,291	100,970	4,424,848	44,243	116,230	872	.....	.....	212,497	797	45,912	
6	20	107,735	108,067	1,082,334	10,823	167,696	1,258	.....	.....	78,348	294	12,375	
7	22	116,785	117,292	2,221,100	22,211	253,696	1,903	.....	.....	134,255	503	24,617	
8	23	124,746	125,211	1,260,486	12,605	283,026	2,123	.....	.....	100,081	375	15,103	
9	24	126,950	127,386	1,559,609	15,596	212,506	1,594	.....	.....	108,806	408	17,598	
10	37	198,450	199,368	3,023,310	30,233	758,304	5,687	.....	.....	228,414	857	36,777	
11	42	223,697	225,293	736,218	7,362	2,049,440	15,371	.....	.....	273,226	1,025	23,758	
12	43	229,543	230,183	367,400	3,674	702,590	5,269	.....	.....	106,690	400	9,343	
13	48	253,708	254,545	857,586	8,576	934,420	7,008	.....	.....	157,806	592	16,176	
14	53	280,628	281,860	1,016,041	10,160	1,129,475	8,471	.....	.....	213,857	802	19,433	
15	55	293,283	294,658	934,923	9,349	1,628,790	12,216	.....	.....	244,923	918	22,483	
16	57	302,248	303,383	436,571	4,366	1,425,317	10,690	.....	.....	191,387	718	15,774	
17	59	311,404	311,819	1,286,550	12,866	281,020	2,108	.....	.....	93,070	349	15,323	
18	64	340,851	341,386	85,254	853	794,043	5,955	.....	.....	91,831	344	7,152	
19	66	353,152	353,738	2,859,011	28,590	110,185	826	.....	.....	160,640	602	30,018	
20	67	356,375	356,863	1,653,067	16,531	281,160	2,109	.....	.....	120,093	450	19,090	
21	68	363,068	363,688	1,380,654	13,807	174,911	1,312	.....	.....	127,370	478	15,597	
22	69	365,848	366,743	1,044,553	10,446	878,849	6,591	.....	.....	171,407	643	17,680	
23	70	372,063	372,593	47,376	474	722,809	5,421	.....	.....	37,165	327	6,222	
24	76	401,596	402,418	2,437,768	24,378	452,556	3,394	.....	.....	187,208	702	28,474	
25	76	404,314	405,032	429,300	4,293	602,602	4,520	.....	.....	113,998	427	9,240	
26	48	256,915	257,707	2,305,046	23,050	375,343	2,815	.....	.....	168,673	633	26,498	

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL—1ST SECTION.

(18).—Abstract of Cost of Earthwork in Steep Ground.

ITEMS.	Rate per cft.	Mile 1. Ch. 4699–6350.		Mile 2. Ch. 7050–8578.		Mile 3. Ch. 18528–20778.		Mile 4. Ch. 23583–25053.		Mile 5. Ch. 26287–27639.		Mile 5. Ch. 29142–30414.		Mile 8. Ch. 43795–46905.		Mile 14. Ch. 73608–75061.	
		Quantity	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.
Excavation—																	
Excavation in soil ...	8	33,255	166	.....	...	.....	.....	.....	...	16,487	82	3,869	19	.....	...	.....	...
„ „ soft murum	12	103,996	780	115,062	863	284,889	2,137	.....	...	.....	...	.....	...	169,109	1,268	50,257	377
„ „ hard murum	1 8	35,846	538	64,451	967	133,460	2,002	356,927	5,334	216,428	3,246	162,150	2,432	560,875	8,413	141,390	2,121
„ rock less than 5′	3	186,217	5,587	193,761	5,813	133,732	4,012	128,784	3,864	104,961	3,149	164,974	4,949	16,820	505	175,978	5,279
„ rock from 5′ to 30′	5	26,979	1,349	45,759	2,288	16,922	846	16,890	845	70,249	3,512	23,481	1,174	.....	...	63,842	3,192
			8,420		9,931		8,997		10,043		9,989		8,574		10,186		10,969
Embankment—																	
From fresh material for banks above 10′ high	...	34,632	433	.....	...	.....	.....	.....	...	.....	...	.....	...	.....	...	.....	...
Do. do. less than 10′ high	1 4	1,317,960	16,475	575,261	7,190	.....	.....	146,035	1,825	.....	...	891,307	11,141	3,178,071	39,726	844,730	10,559
For core got from the excavation of canal.	...	.....	...	.....	...	.....	.....	.....	...	.....	...	.....	...	.....	...	.....	...
Dressing banks of canal roads ...	6	166,001	623	76,615	287	.....	.....	23,760	89	.....	...	410,055	1,538	379,142	1,422	109,036	409
	Per R. ft			R. ft.		R. ft.		R. ft.		R. ft.		R. ft.		R. ft.		R. ft.	
Dry stone wall ...	5	1,059	5,295	578	2,890	.....	.....	.....	...	.....	...	380	1,900	1,278	6,390	490	2,450
Core wall	15	1,059	15,885	578	8,670	.....	.....	.....	...	.....	...	380	5,700	1,278	19,170	490	7,350
Wall at downstream	45	592	26,640	753	33,885	2,040	91,800	1,045	47,025	1,352	60,840	.....	...	.....	...	.....	...
			65,351		52,922		91,800		48,939		60,840		20,279		66,708		20,768
			73,771		62,853		100,797		58,982		70,829		28,853		76,894		31,737

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL—1ST SECTION.

(18).—Abstract of Cost of Earthwork in Steep Ground—*concluded.*

ITEMS.	Rate per cft.	Mile 14. Ch. 76487-78127.		Mile 17. Ch. 92176-93328.		Mile 17. Ch. 93723-94728.		Mile 24. Ch. 125843-126843.		Mile 50. Ch. 267193-267903.		Mile 62. Ch. 327661-328969.		Mile 63. Ch. 331596-332791.		Mile 66. Ch. 349858-351348.	
		Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.
Excavation—			Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Excavation in soil ...	8	.....	...	.....	...	.....	...	.....	...	.....	...	35,560	178	.....	...	.....	...
„ „ soft murum. ...	12	188,667	1,415	133,252	999	255,484	1,916	122,094	916	107,375	805	.....	...	.....	...	204,950	1,537
„ „ hard murum	1 8	292,299	4,384	123,861	1,858	8,694	130	43,022	645	.....	...	17,715	266	97,765	1,466	.....	...
„ rock less than 5′	3	96,357	2,891	55,279	1,658	4,105	123	11 9,450	3,584	61,838	1,855	122,049	3,661	45,065	1,352	105,282	3,158
„ rock from 5′ to 30′	5	.....	...	6,473	324	.....	...	14,698	735	26,163	1,308	28,413	1,421	1,716	86	43,956	2,198
			8,690		4,839		2,169		5,880		3,968		5,526		2,904		6,893
Embankment—																	
From fresh material for banks above 10′ high ...	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...
Do do. less than 10′ high	1 4	559,012	6,988	9,20,636	11,508	1,011,759	12,647	544,739	6,809	282,486	3,531	1,350,837	16,885	992,567	12,407	892,823	11,160
For core got from the excavation of canal ...	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...
Dressing banks of canal roads	6	94,094	353	123,714	464	119,405	448	83,203	312	46,962	176	163,532	613	133,261	500	156,106	585
	Per	R. ft.		R. ft.		R. ft.		R. ft.		R. ft.		R. ft.		R. ft.		R. ft.	
Dry stone wall	5	880	4,400	447	2,235	719	3,595	77	885	415	2,075	570	2,850	88	440	1,176	5,880
Core wall...	15	880	13,200	447	6,705	719	10,785	177	2,655	415	6,225	570	8,550	88	1,320	1,176	17,640
Wall at downstream ...	45	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	...
			24,941		20,912		27,475		10,661		12,007		28,898		14,667		35,265
			33,631		25,751		29,644		16,541		15,975		34,424		17,571		42,158

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

MAIN CANAL—1ST SECTION.

(19).—Abstract of cost of Main Alternatives.

	Rate per 100 cubic feet.		Markandeya Syphon Crossing, Alternative No. 12-A.								Markandeya Pick up Weir Crossing, Alternative No. 15-A.		Alternative Alignment by the Shahabunder Cut No. 3-A, first portion, West of Cut.	
			Full Bank, Ch. 164, 380-167,273, I.		Cut, Ch. 169,203-169,780, II.		Cut, Ch. 182,103-184,703, III.		Type Mile, Ch. 184,800-190,080, IV.		Ch. 196,398-203,436 I.		Ch. 71,609-73,553, I.	
			Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.
	Rs.	a.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
In soil	.....	8	.....	...	279,896	1,399	1,162,319	5,812	12,35,075	6,175	914,995	4,575	689,563	3,448
Soft murum	.....	12	.....	...	128,512	964	1,065,149	7,989	.....	...	785,453	5,891	.....	.....
Hard murum	1	8	.....	...	.....	...	213,869	3,208	.....	...	.....	...	.....	.....
Rock less than 5'	3	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	.....
Do. do. 30'	5	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	.....
Do. do. 40'	8	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	.....
Do. do. 50'	10	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	.....
Do. do. 60'	12	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	.....
Do. do. 70'	15	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	.....
Do. do. 80'	20	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	.....
Total	.....	...	.....	...	.....	2,363	.....	17,009	.....	6,175	.....	10,466	.....	3,448
From fresh material (for banks above 10' high).	1	...	.....	...	...	...	.....	...	.....	...	1,745,175	17,452	.....	.....
Do. less than 10' high	.....	12	3,280,517	24,604	...	...	.....	...	567,979	4,260	1,178,294	8,837	212,140	2,121
For core got from the excavation of canal.	.....	4	.....	...	...	...	.....	...	563,407	1,409	292,650	732	103,581	259
Dressing banks and canal roads	.....	6	424,946	1,594	...	...	.....	...	400,147	1,501	595,771	2,234	120,423	452
Core and dry stone walls	(15+5) =20p.Rft	...	.....	...	...	...	.....	...	.....	...	...	...	.....	.....
Total	.....	...	.....	26,198	...	...	.....	...	.....	7,170	...	29,255	.....	2,832
Grand Total	.....	...	.....	26,198	...	2,363	.....	17,009	.....	13,345	...	39,721	.....	6,280

	Rate per 100 cubic feet.		Alternative alignment by the Shahabunder Cut No. 3-A, first portion, West of Cut—*contd*				Alternative Shahabunder Nalla, Alternative No. 2. Crossing near Temple.						
			Ch. 73,553-93,742. II.		Ch. 93,742-97,752. III.		Ch. 64,126-69,361. Chainage by accepted line 75,061. I.		Chainage as per Alternative—69,361. Ch. 75,061-76,487. II.		Steep ground. Ch, 76,487-78,127. III.		
			Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	
	Rs.	A.		Rs.		Rs.		Rs.		Rs.		Rs.	
In Soil	.....	8	7,317,851	36,589	755,905	3,779	13,329	67	...	...	.....	...	
Soft Murum	.....	12	9,176,458	68,823	.....	...	377,255	2,829	164,766	1,236	188,667	1,415	
Hard Murum	1	8	3,030,428	45,456	.....	...	415,417	6,231	208,565	3,128	292,299	4,384	
Rock less than 5'	3	...	1,897,248	56,917	.....	...	72,770	2,183	66,598	1,998	96,357	2,891	
Do. do. 30'	5	...	7,136,609	3,56,830	.....	...	63,180	3,159	...	...	.....	...	
Do. do. 40'	8	...	1,711,715	1,36,937	.....	...	.....	...	...	...	.....	...	
Do. do. 50'	10	...	1,173,979	1,17,398	.....	...	.....	...	...	...	.....	...	
Do. do. 60'	12	...	709,155	85,099	.....	...	.....	...	...	...	.....	...	
Do. do. 70'	15	...	367,124	55,069	.....	...	.....	...	...	...	.....	...	
Do. do. 80'	20	...	16,400	3,280	.....	...	.....	...	...	...	.....	...	
Total ...	.....	...	.....	9,62,398	.....	3,779	.....	14,469	...	6,362	.....	8,690	
From fresh Material (for banks above 10' high)...	1	...	.....	...	.....	...	6,192,113	61,921	...	...	.....	...	
Do. less than 10' high...	.....	12	.....	...	1,087,622	10,876	1,458,510	10,939	317,995	3,180	559,012 at Rs. 1-4-0 per 100 cft.	6,988	
For Core got from the excavation of Canal ...	.....	4	.....	...	345,379	863	13,329	33	...	...	.....	...	
Dressing banks and Canal roads	.....	6	.....	...	353,125	1,324	667,219	2,502	98,815	370	94,094	353	
Core and dry Stone walls	(15+5)= 20 p. R.ft.	...	.....	...	.....	...	.....	...	...	...	880	17,600	
Total ...	.....	...	.....	...	.....	13,063	.....	75,395	...	3,550	.....	24,941	
Grand Total ...	.....	...	.....	9,62,398	.....	16,842	.....	89,864	...	9,912	.....	*33,631	* Rs. 697 to be added to the Grand Total being the cost of 102 ft. (from Chainage 78,127 to 78,229) Rs. 36,081 per mile.

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

Accompaniment to Statement No. 19.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Abstract Showing Total Cost of Main Alternatives.

Miles. From	Miles. To	Chainages. From	Chainages. To	Length.	Description.	Cost, Rs.	Remarks.
		Shahabunder Nala Alternative No. 2, near temple, of accepted line.					
12·16	14·81						
		64,126	69,361	5,235	Ordinary ground.... ...	89,864	Chainages by accepted line 75,061 as per Ab. No. 19, Col. 1.
		75,061	76,487	1,426	„ „	9,912	Columns II and III of Statement No. 19.
		76,487	78,127	1,640	Steep ground...	33,631	
		78,127	78,229	102	Ordinary ground	697	At Rs. 3,608 per mile.
				8,403		134,104	
					Add. Contingencies @ 5 °/°	6,705	
					Grand total ...	1,40,809	
		Shahabunder Cut Alternative (No. 3-A.)					
13·56	18·51						
		71,609	73,553	1,944	West portion, Shahabunder side...	6,280	As per Cols. I, II and III of statement No. 19.
		73,553	93,742	20,189	Cut portion...	9,62,398	
		93,742	97,752	4,010	East portion	16,842	
				26,143		9,85,520	
					Add. 5 °/° Contingencies.	49,276	
					Grand total ...	10,34,796	
		Markandeya Syphon Alternative (No. 12-A.)					
30·5	36·96						
		164,880	167,273	2,893	Full Bank	26,198	On Main Ridge as per Cols. No. I, II and III of Statement No. 19.
		169,203	169,780	577	Cut	2,363	
		182,103	184,703	2,600	Cut	17,009	
				6,070		45,570	
				25,123 †	At Rs. 13.345 per mile ...	63,490	† 3001 feet deducted from this length for the concrete syphon.
					Add. 5 °/° Contingencies.	5,453	
					Grand total ...	1,14,513	
		Markandeya Pick-up Weir Alternative (No. 15-A.)					
37·2	38·51						
		196,398	203,436	7,038	Ordinary ground... ...	20,010	700 feet deducted for this length for the River.
					Add. Contingencies @ 5 °/°	1,000	
					Grand total ...	21,010	

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

(20).—NOTE ON THE EXTENSIONS OF THE CANAL BEYOND THE TAIL SECTION.

1. The tail section of the canal ends close to the gap in the main ridge near Fakir Budihal, the bed-level here being about 10 feet below the lowest point in the gap. The top of the ridge will be gained, if the canal could be continued 10 miles farther. The command in the section is the area to the north of the ridge, up to the Hulgeri-Kaladgi Nulla, and on the south that between the Hoskeri and Somankop Nullas.

2. The area left out of account in the Preliminary Report is the following :—

	Acres.
(*a*) Kaladgi Nulla to Bagalkot Nulla	58,937
(*b*) Bagalkot Nulla and Hirehal Nulla near Guladgud up to junction of rivers ...	141,709
(*c*) Hirehal Nulla to Badami Nulla	43,956
(*d*) Badami Nulla to Somankop Nulla	42,189
Total ...	286,791

without excluding flooded areas near river.

3. In order to command the above area, the main canal will have to be extended 10 miles beyond the tail section up to the 121st mile of the Dharwar-Bijapur Road, which will make a total length of 159 miles for the main canal. Two additional branches will besides be required for Badami and Bagalkot.

Badami Branch.

4. This would command items (*c*) and (*d*) in the para. 2 above. The preliminary surveys done here consisted only in fly levels along all important ridges and spurs. The country is exceedingly hilly, and it will be somewhat difficult to determine the exact line for the branch. No exceptional difficulties are, however, likely to be met with in the alignment. The branch may commence from the 157th mile of the main canal, about two miles to the north-west of Kerur, and cross the main ridge immediately after by means of a small cut. A low gap exists on the Badami ridge about one mile to the south of Kerur and the branch would reach this point in the 7th mile. A minor will take off from here to the south for the command of the area between the Somankop and Badami Nullas. The branch will continue eastwards, crossing the ridge in the low gap between the Kadpatti and Maninagar hills, and might end in its 12th mile, on the branch ridge, one mile to east of Hulikeri. A minor can be continued from there for the command lower down the ridge.

Bagalkot Branch.

5. This branch will command items (*a*) and (*b*) in para. 2, in all about two lakhs acres, and will continue from the main canal along the ridge. The ridge has a fall of 15 feet in the first 5 miles and is hilly for the next 2, but from mile 7 to 7·5 mile there is a sudden drop of about 125 feet towards the gap near Katgeri. The level of the gap is R. L. 1918, which would be about 130 feet lower than the canal bed two miles higher.

6. A contour was surveyed for the branch commencing from the gap at Katgeri. The line winds through the hills to the north of that village and gains the top of the ridge in the 10th mile. The Railway is crossed near the 5th mile in a low gap with a headway of 15 feet. A long and low gap extends along the main ridge from two miles west of Sirur to two miles west of Bankatti. The lowest level of the gap is R. L. 1791, which is about 110 feet lower than the canal bed on the high ground in the 10th mile. The line was dropped 30 feet before getting down to the gap and then followed the ridge with a gentle slope, till the low point was reached. From here the contour was re-started and the Bankatti hills were crossed by means of a short cut one mile to east of that village. The topography of the hills in this part is not shown quite correctly on the maps as the gaps are not indicated therein. From Bankatti the ground is easy and flat, but there may

be difficulty in getting suitable headways in the nullas up to Bairanmatti in the 24th mile. The line was stopped in the 32nd mile on the boundary of Beur and Chavdapur, about 3 miles short of the main watershed of this area, as the ground beyond was of ordinary description. A cut was examined near Bairanmatti which will be 1½ miles long and 45 feet deep, and, if found practicable, may save 6 miles of the contour. The total length of the branch from its commencement from the main canal may be about 8 (on ridge) +32 (contour surveyed) +15 (unsurveyed), total about 55 miles, of which 50 may be in contour.

Sirur Gap.

7. The Sirur Gap is an exact counterpart of the Mantur ridge occurring on the Gokak Left Bank Canal, with the difference, that, while at Mantur no command can be obtained unless the ridge is reached at Sirur, nearly 110,000 acres of command can be obtained, of which 80,000 will be in easy country, even after dropping the canal bed to the lowest level of the gap, *viz.*, by about 110 feet. If the gap were to be crossed on the level, without dropping head, the bed level at the end of the gap may be about R. L. 1850, and the advantage in the higher level will be:—

(1) 30,000 acres lying to the north of the hills and to the west of the Bhagwati ridge, will be commanded with less difficulty.

(2) The length of the branch may be reduced by about 10 miles.

(3) An additional command of about 35,000 acres may be secured.

A noteworthy feature in connection with this gap is that in a length of 15 miles before the gap, the branch will lose in all about 240 feet of head, *viz.*, 130 feet at Katgeri and 110 before this gap. An alternative that may perhaps be considered in connection with this crossing would be whether it will be feasible to utilise this great height of fall in deriving power to raise the water about 70 or 80 feet on the other side of the gap, which would be sufficient to secure the advantages mentioned above. As stated already, plenty of command is available even by continuing the canal from the lowest level, and the higher crossing will not be a necessity.

P. N. NATESAIYER,

Executive Engineer, Gokak Survey.

(21).—Note on

YADWAD BRANCH,

MINORS AND DISTRIBUTARIES.

INDEX.

Yadwad Branch and Distributaries.

Note on the cost of the Branch and Distributaries.

(*A*) Statement of command, bed fall and dimensions of branch, Miles 1 to 10.

(*B*) Do. Hill and River Torrent Works, Miles 1 to 10.

(*C*) Do. Bridges and Regulators, Miles 1 to 10.

(*D*) General abstract of cost, Miles 1 to 10.

(*E*) Abstract of cost of typical miles, etc., Miles 1 to 10.

(*F*) Statement of gross command and discharges under Minors and Distributaries.

(*G*) Do. Bed slopes for different velocities and discharges.

(*H*) Do. tabular, of rough cost of masonry Falls.

(*I*) Abstract statement of cost of Minors and Distributaries.

(*J*) Details of statement of cost of Minors and Distributaries.

GHATPRABHA RIGHT BANK CANAL PROJECT.

Note on Cost of Yadwad Branch and Distributaries.

Yadvad Branch.

1. The branch has been briefly described in paras. 48-51 of the Preliminary Report. The length of the branch is 25 miles, of which 10 has been regularly surveyed. The total gross command is 1,70,297 acres, and the discharge at head 426 cusecs, being at the rate of 1 cusec for every 400 acres. The corresponding duty on the main canal was 1 for every 500 acres, and a higher duty is assumed for the branch in order to allow a margin of 25% for fluctuations in supply. No allowance for leakage will be necessary in the branch, as the maximum distance of irrigation under it from the head at Yergatti is under 40 miles, the actual distance being roughly 38 miles.

Bedfall and dimensions of Branch.

2. The general rates of bedfall adopted are 13½ inches per mile for the first 9 miles, 16 inches from mile 10 to 20, and 21 inches from mile 21 to end, the minimum velocity being assumed to be nowhere less than 2½ feet per second. The corresponding discharges at head are 426, 324, and 200 cusecs respectively. The depth of F. S. L. is taken to be 6 feet at the head of branch which may be reduced to 4·5 feet at the tail. The bed widths will vary from 24·5 to 14. Statement No. A gives the command, discharge, and the dimensions of the branch from miles 0 to 10. A fall of 6 feet per mile has been given in deep cuts—the head necessary to produce the increased velocity.

Pipe siphon for crossing the Yerganvi Nulla.

3. A pipe siphon of 8′-3″ diameter is proposed for the main Yerganvi Nulla, which would almost do away with the difficulties of alignment in its valley. Rough estimates are attached. The Muglihal valley, though very difficult, is not quite so bad as at Yerganvi, and the alignment in that valley will be practicable.

Cuts and high embankments.

4. The following are the deep cuts and high embankments in the first 10 miles:—

Serial No.	Position, mile.	Maximum depth in feet.	Length in feet.	Length of alternative contours.	Cost, Rs.	Remarks.
			Cuts.			
1	4	30	550	2,100	8,700	Yerganvi valley.
2	4	34	790	2,300	6,100	
3	6	30	1,610	6,300	11,000	Near Karubgutti.
4	10	31·5	2,025	14,500	18,000	Near Milanhatti.
			High Embankments.			
1	4	12·5	465	.....	7,000	Yerganvi valley.
2	4	26·0	645	.....	15,000	

Estimates.

5. Miles 1 to 3 and 6 to 10 of the alignment are in average country, and the earthwork has been estimated for two typical miles in this portion. One mile has been estimated for the remaining portion in bad ground. The type sections followed are the same as in the first section of main canal,

Rough figures of cost have also been worked out for the cross drainage works, bridges and regulators in the 10 miles. The average rates calculated are referred to in the Preliminary Report. Abstract statements of cost are attached.

Minors and Distributaries.

Minors.

6. The gross command under the branch is divisible into 4 main blocks which will each require a minor as follows :—

Serial No.	Name of minor.	Mileage on branch at take-off.	Gross command, acres.	Remarks.
		Miles.		
I.	Mamdapur	5·2	29,511	I. & II. & III. surveyed in detail.
II.	Kaujalgi West	20	42,093	
	Yadvad	25	28,600	
	Kaujalgi, East	25	28,861	
	Distributaries directly commanded by branch.	0·25	31,232	
	Total area under branch.		1,60,297	

Duty for calculating discharge.

7. The instructions regarding duty are that one cusec should be allowed for 175 acres of actual irrigation. The following figures have been assumed for the duty per gross command for calculating the discharge in minors and distributaries :—

	Command in acres.	Duty acres per cusec.
Minors ...	40,000	350
,, ...	25,000	300
Distributaries...	10,000	250
,, ...	4,000	200
,, ...	1,000	175

For intermediate command figures have been assumed roughly by proportion.

Bedfall.

8. The lines of the minors and distributaries are situated almost entirely on ridges, which have steep slopes and would necessitate a large number of vertical "Falls." The ground is generally not hard enough nor are stones available to justify (rapids). A table has been worked out giving roughly the rates of bedfall sufficient to give velocities ranging from 2 to 6 feet per second for different discharges, and the maximum fall suited to the nature of soil has been given in all cases, before deciding about the provision to be made under "Falls".

Falls avoided where possible.

9. In a large number of cases (items 6, 9–11, 13–15, 22, 24, and 27 in Statement No. J.), a series of falls is required where the ridge slopes are very steep, and it may be possible to reduce the number by letting the distributaries flow into some natural watercourse, just above the series and picking up the supply lower down by means of a weir. The distributary may then be taken in contour along the foot of the slopes. Some provision for cross drainage works may be necessary in this alternative, but these will not be many. In the cases cited above, the above arrangement would be the cheaper, and this has been taken into account in working out the cost.

Cost of Falls.

10. A type design has been made for a 5-feet "Fall" to discharge about 65 cusecs. The depth of cistern has been assumed to be one-third of (height of 'Fall' + depth of F. S. L.), the length = 3 × depth up to commencement of 1 in 3 slope, and the maximum width of the cistern = 2 × bed width + depth of F. S. L. The notch has been kept rectangular, as it is not likely to affect much the rough estimates. Rough figures of cost have been worked out based on this design, and a table is attached showing the rates assumed, for different discharges and heights of fall.

Cost of earthwork.

11. This has been worked out roughly assuming rates per mile per cusec of discharge which are given below. These rates are for a channel in contour. When the lines are on ridges, the rates are assumed to be 25 per cent. less. For the portions in contour, rates inclusive of cross drainage as assumed are given in columns 5 and 6. The actual rates obtain-

ed on typical miles in average ground on the main canal and the Yadvad Branch are Rs. 20 and 35, and the corresponding rates, including masonry works, Rs. 50 and 65, the figures being all per cusec of discharge, per mile. Rates were worked out approximately for certain average discharges assuming typical sections, and on comparison, the rates given below appear to be suitable :—

Serial No.	Discharge in cusecs.	Rate for earthwork assumed per cusec per mile. In contour, Rs.	Rate per mile earthwork alignment on ridge. Rs.	Rate per mile including cross drainage.		Remarks.
				Line in contour, easy ground, Rs.	Line in contour, difficult ground, Rs.	
1	2	3	4	5	6	7
		(*a*)		(*b*)	(*c*)	
1	6	85	400	800	1,000	
2	15	80	900	1,800	2,500	
3	25	70	1,250	2,500	3,500	
4	35	60	1,500	3,000	4,000	
5	50	45	1,750	3,500	4,500	
6	65	40	1,900	3,750	5,000	
7	80	35	2,000	4,000	5,500	
8	100	30	2,250	4,500	6,000	
9	120	30	2,750	5,500	7,000	

(*a*) Rate per mile worked roughly from type sections—

Cusecs.	Rs. per mile.
15	83
50	45
100	31

(*b*) 50% added to cost as calculated by rates under (*a*).
(*c*) About ⅛ more than (*b*).

Rates for intermediate discharges have been taken roughly proportionate to above. Land compensation and other contingent expenses are included in the above rates.

Rate per acre.

12. The total length of minors and distributaries required for the branch are about 30 and 125 miles, of which the lengths surveyed are 22 and 72 miles, respectively. For the unsurveyed portions, the costs have been roughly determined according to their length and discharge by proportion based on the surveyed portions. The rate for three of the minors works out to Rs. 3·8 per acre. The average rate for the whole branch is Rs. 3·6 per acre. These rates are exclusive of the cost of water channels, for which separate provision will have to be made.

Detailed abstracts of cost are attached.

P. N. NATESAIYER,

Executive Engineer, Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT, YADVAD BRANCH.

(A).—Statement of Command, Bed-falls and Dimensions of Branch, mile 0—10.

Mileages. From Mile.	Mileages. From Feet.	Mileages. To Mile.	Mileages. To Feet.	Gross Command, in Acres.	Discharges required.	Bed-fall per mile.	Canal Section. Bed width, feet.	Canal Section. Depth of water, feet.	Canal Section. Side Slopes.	Discharge. Value of (n) Kutter.	Discharge. Mean Velocity, Feet per Second.	Discharge. Calculated discharges in Cusecs.	Remarks.
0	.....	2	4,095	1,70,297	426	13½″	24·5	6′	½ to 1	0·225	2·59	427	At ch. 407,273 of Main Canal section. R. L. of bed of Main Canal 2164·31, Starting bed-level of Branch, 2164·00.
2	4,095	2	5,262	1,66,233	416	.....	24	6′	½ to 1	.....	2·58	417	
2	5,262	3	439	.....	.....	6′	15·5	6′	Vertical	0·250	4·52	420	
3	439	3	2,318	.....	.....	13½″	24	6′	½ to 1	0·225	2·58	417	
3	2,318	3	3,304	.....	.....	13′	Circular	pipe 8′-3″	diameter.	0·015	8·00	428	Concrete pipe Syphon, Yarganvi Nala.
3	3,304	3	4,945	.....	.....	13½″	24	6′	½ to 1	0·225	2·58	417	
3	4,945	4	129	.....	.....	6′	15·5	6′	Vertical	0·250	4·52	420	
4	129	5	61	.....	.....	13½″	24	6′	½ to 1	0·225	2·58	417	
5	61	5	672	.....	.....	.....	24	6′	½ to 1	.....	2·58	.....	
5	672	5	1,612	1,36,210	341	6′	13·5	6′	Vertical	0·250	4·26	345	Karubgatti Cut.
5	1,612	7	498	.....	.....	13½″	20	6′	½ to 1	0·225	2·50	344	
7	498	9	80	.....	.....	13½″	20	6′	½ to 1	.....	2·50	.....	
9	80	9	908	1,29,503	324	13½″	19	6′	½ to 1	.....	2·47	326	
9	908	9	2,285	.....	.....	6′	13	6′	Vertical	0·250	4·27	333	Milanhatti Cut.
9	2,285	9	4,743	.....	.....	16″	20	5′-5″	½ to 1	0·225	2·60	325	End of the surveyed portion of Branch R. L. of Canal bed=2144·78.

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT, YADVAD BRANCH.

(B).—Statement of River and Hill Torrent Works.

Note.—The costs entered are rough and have been worked out as follows :—

Aqueducts and Culverts. (*i*) Portions above springing roughly from type estimates for similar works made for the Gokak and Nira Right Bank Canal Projects.

(*ii*) Below springing from approximate rates per foot in height of amounts worked out from actual estimate made for the Gokak Left Bank Canal Project.

Concrete drains.—By working out approximate rate per R. ft. of drains of various sizes with additional amounts for wings.

Pipe Siphon, Yerganvi Nala—Rough estimates attached.

(B).—Statement of River and

No. of Nala.	Chainage. Miles in decimals	Chainage. Feet.	Available head-way.	Nature of Nala bed.	Average fall at site.	Catchment area in square miles.		Maximum run-off in cusecs from curve adopted.	Assumed velocity through Openings.
1	·15	816	9·26	9′-6″ Stiff red soil=S. M. nearly.	1 in 90	1·68		2,080	10·5
2	·44	2,307	3·64	5′-3″ Black soil, 4′-6″ S. M....	1 in 60	0·41		823	11·70
3	1·5	7,928	4·38	3′ Soil and B.=S. M. nearly	1 in 35	0·05		176	12·25
4	1·91	10,084	1·60	Bed assumed . ..	1 in 45	0·09			
5	2·07	10,922	6·40	5′ soil, 8′-6″ stiff clay, 1′-6″ sand.	1 in 150	0·45	·60	1,101	11·3
6	2·43	12,834	4·60	1′ S. M., 3 H. M.	1 in 80	0·06			
7	2·81	14,856	11·00	6″ red M., 1′-6″ H. M. ...	1 in 35	0·01			
8	2·88	15,209	4·13	Assume „ ...	1 in 12	0·03	·04	146	10·16
9	3·12	16,467	16·22	H. M. assumed	1 in 8	0·03			
10	3·23	17,036	21·25	Rocky	1 in 45	0·03			
11	3·36	17,739	12·69	Assume soil (H. M. below 5′ and H. M. below 10).	assume 1 in 15	0·01	·07	223	11·51
12	3·54	18,706	60·47	Uncertain; assume rock within 10′	...	1·91		2,258	11·1
13	3·83	20,222	26·06	Rocky	1 in 30	0·10			
14	3·89	20,554	22·85	Rocky	1 in 15	0·01	·11	308	12·68
15	4·09	21,595	0·11	H. M.	assume 1 in 20	0·01			
16	4·26	22,486	7·86	Assume soil (H. M. after 10′ depth).	1 in 25	0·04	·05	176	12·25
17	4·49	23,699	9·18	Assume S. M. 3′ over H. M.	1 in 12	0·01			
18	4·57	24,121	6·44	„ „ „ „	1 in 5	0·01	·04	146	10·16
19	4·69	24,766	7·36	„ „ „ „	1 in 25	0·02			
20	4·78	25,219	7·64	„ „ „ „	1 in 50	0·02			
21	4·9	25,863	5·45	„ „ „	1 in 85	0·08			
22	5·04	26,621	1·80	4′-9″ S. M.	1 in 120	0·12	·22	510	12·03
23	5·43	28,672	2·84	3′ soil	1 in 30	0·02			
24	5·59	29,555	4·53	4′-9″ soil 5′-3″ S. M. ...	1 in 170	0·18	·20	476	11·24
25	6·12	32,332	2·89	Soft murum	1 in 15	0·02			
26	6·23	32,902	10·68	Assume soil (soil 4′-9″ over S. M).	1 in 70	0·06	·08	245	12·65
27	6·4	33,804	2·45	Soil „ „	assume 1 in 70	0·01			
28	6·5	34,304	9·34	„ „ „	1 in 90	0·06	·07	223	11·51
29	6·67	35,237	10·17	4′-9″ soil, S. 4-9 over S. M., 2′-9″ S. M.	1 in 75	0·51		974	12
30	6·91	36,508	5·19	Soil	1 in 75	0·44		1,600	10
31	7·14	37,713	0·51	Soil	1 in 150	0·76	1·20		
32	7·48	39,479	2·71	6′-6″ soil	1 in 30	0·11			
33	7·73	40,809	1·24	Assume sandy (soil) ..	1 in 150	0·10	·21	493	11·44
34	8·19	43,238	6·13	Brown soil (assume soil) sand gravel.	1 in 150 assume	0·91		1,840	10
35	8·34	44,044	3·71	Murumish soil (assume soil) sand gravel.	1 in 30	0·13	1·04		
36	8·62	45,521	0·23	Brown soil (do. over S. M.)...	1 in 30	0·04		146	10·16
37	9·03	47,669	3·82	Gravel=H. M.	1 in 25	0·08		245	12·65
38	9·55	50,437	0·65	H. M.	1 in 15	0·03			
39	9·69	51,163	0·45	„	1 in 15	0·05	·23	526	11·76
40	9·86	52,065	9·49	„	1 in 30	0·15			

PROJECT, YADVAD BRANCH.

Hill Torrent Works.

Area of opening provided.	Provisions made. A-Aqueduct. C-Culvert. D-Concrete drain.	No. of Openings or Spans.	Span.	Ris	Height of abutment.	Deepening of Nala bed.	Estimated cost. (Rough.)	Remarks.
197	C/1	2	15	3	4·51	...	10,000	
70·36	D 1	2	7	1′-6″	4	...	2,500	
14·37	D/2	1	5	1′-3″	2	...	1,000	
							125	Divert into 5.
97·4	C/2	2	10	2	2·90	...	7,500	
							250	Divert into 5.
14·37	D/3	1	5	1′-3″	2	...	1,000	
							75	Divert into 7.
							100	Divert into 10.
19·37	D/4	1	5	1′-3″	3	...	1,250	
							50	Divert into 10.
203·5	Pipe syphon on aqueduct.	1	15	3	11·5	...	85,663	Yerganvi Nala.
24·29	D/5	1	6	1′-6″	3	...	1,250	
							.....	Divert into 13.
14·37	D/6	1	5	1′-3″	2	...	75	Divert into 16.
							1,000	
							25	Divert into 18.
14 37	D/7	1	5	1′-3″	2	...	1,000	
							75	Divert into 18.
							75	Divert into 21.
42·36	D/8	2	7	1′-6″	2	...	2,250	
							400	Divert into 21.
42·36	D/9	2	7	1′-6″	2	...	50	Divert into 24.
							2,000	
							.....	Divert into 26.
19·37	D/10	1	5	1′-3″	3	...	1,250	
19·37	D/11	1	5	1′-3″	3	...	.....	Divert into 28.
							1,250	
81·2	C/3	1	10	2	6·63	...	7,500	
159·5	C/4	2	15	3	3 25	2·81	9,000	
							2,900	Divert into 30.
43·11	D/12	3	5	1′-3″	2	...	650	Divert into 33.
							2,500	
159·5	C/5	2	15	3	3·25	1·87	9,000	
							450	Divert into 34.
14·37	D/13	1	5	1′-3″	2	...	1,100	
19·37	D/14	1	5	1′-3″	3	...	1,250	
							125	Divert into 40.
44·71	D/15	1	10	1′-3″	3	...	400	Divert in o 40.
							1,750	

P. N. NATESAIYER,

Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT—YADVAD BRANCH.

(C).—Statement of Road Bridges and Regulators.

No.	Distance from Head Works.		Purpose of Bridge.	Description of Road.	Width of Roadway between Parapets, feet.	Sectional area of canal.		Openings for canal.		Height of abutment.	Approximate Cost.	Remarks.
	Miles in decimals.	feet.				Breadth, feet.	Depth, feet.	No. of Spans.	Size of Spans, feet.			
											Rs.	Costs calculated roughly by assuming the following rates :— Rs. 2-8-0 per square foot of structure for 10′×12′ bridges. Rs. 3 do. do. 6′ wide. Rs. 4 for single spans. Rs. 15 per Rg: foot of clear opening for stop gates.
1	·41	2,167	Traffic ...	Cart track, Yergatti to Yerganvi.	10′	24½ + 3	6′	2	15′	6′	1,500	
2	1·63	8,623	Foot Traffic	Foot path, Yergatti, Yerganvi and tract from No. 1 to Gokak Saundatti Road.	6′	24½ + 3	6′	2	15′	6′	1,250	
3	3·28	17,309	Traffic ...	Cart Track, Yergatti to Yerganvi 2nd crossing.	10′	24 + 3	6′	3	9′	6′	1,750	Combined with Regulator No. 1.
4	5·06	26,708	Do. ...	Cart Track, Kurabgatti to Sattigeri.	12′	24 + 3	6′	3	9′	6′	2,000	Combined with Regulator No. 2.
5	5·49	28,973	Foot Traffic.	Foot path, Kodlivad to Gadmadkeri.	6′	20 + 3	6′	3	8′	6′	1,000	
6	6·84	36,119	Cultivator's.	Cart Track, Sattigeri to Kodlivad.	10′	20 + 3	6′	3	8′	6′	1,250	
7	7·35	38,803	Do.	Cart Track, Sattigeri to Muglihal.	10′	20 + 3	6′	3	8′	6′	1,250	
8	8·46	44,644	Foot Traffic.	Foot path, Milanhatti to fields..	6′	20 + 3	6′	3	8	6′	1,000	
9	9·12	48,179	Do. ...	Cart Track, Sattigeri to Muglihal.	6′	19 + 3	.....	3	8′	6′	1,500	Combined with Regulator No. 3.

Note—9 Bridges in 10 miles, one bridge per mile approximately. In addition to this, tunnels may be provided at all deep cuts if found necessary owing to the broken nature of the ground.

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT.

(YADVAD BRANCH.)

(D).—General Abstract of Cost of Earthwork from 0-10 miles.

Mileage.	Length actually estimated Chainage. From	To	Length.	Description.	Cost.	Remarks.
					Rs.	
0 to 3	.....	.....	15,784	At Rs. 13,709 for 5,115 feet.	42,304	
						42,304
				Average per mile	14,151	
3 to 6	15,784	16,330	546	Cut...	9,153	
	17,507	17,972	465	Full bank	7,308	
	19,681	20,325	644	Do.	15,953	
	20,715	21,504	789	Cut	6,383	
	26,700	28,313	1,613	Do.	11,532	
			4,057		50,329	
			10,839	At Rs. 25,485 per mile ...	52,316	
						1,02,645
			14,896	Average per mile	36,383	
6 to 10	47,944	49,970	2,026	Cut	19,076	
			16,264	At Rs. 10,372 per mile ...	31,949	
						51,025
			18,290	Average per mile	14,730	
				Grand Total...	.....	1,95,974

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT, YADVAD BRANCH.

(E).—Abstract of cost of earthwork of Typical Miles, Cuts and High Embankments.

Items.	Rate.	Miles ch. 8,085-13,200.		Miles ch. 21,271-26,551.		Miles ch. 36,960-42,240.		Miles ch. 15,784-16,330.		Miles ch. 20,715-21,504.		Miles ch. 26,700-28,313.		Miles ch. 47,344-49,970.		Miles ch. 17,507-17,972.		Miles ch. 19,681-20,325.	
		Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.	Quantity.	Cost.
Excavation.	Rs.a.				*Type*	*miles.*					*Cuts.*						*Full*	*banks.*	
Excavation in soil.	0-8	2,46,531	1,233	.....	...	4,16,449	2,082	.....	...	.....	....	.....	...	.....	...				
„ in S. M.	0-12	1,60,856	1,206	2,27,060	1,703	61,898	464	4,759	36	2,59,755	1,948	2,16,874	1,627	2,30,517	1,729				
„ in H. M.	1-8	1,81,897	2,728	1,62,942	2,444	1,37,805	2,067	.....	...	1,18,082	1,771	30,452	457	1,48,027	2,220				
„ in Rock less than 5 feet.	3-0	.....	...	2,88,170	8,645	1,09,544	3,286	55,410	1,662	78,661	2,360	74,222	2,227	90,564	2,717				
Excavation in Rock from 5 feet to 30 feet	5-0	.....	...	.....	...	.....	...	1,40,383	7,019	.....	...	1,33,433	6,672	2,30,041	11,502				
								Total ...	8,717	.....	6,079	.....	10,983	.....	18,168				
								Contingencies at 5%	436	.....	304	.....	549	.....	908				
Embankment.								Grand Total.	9 153	.....	6,383	.....	11,532	.....	19,076				
Banks above (10 feet).	1-0	.....	...	.....	...	.....	...									3,63,266	3,633	18,10,251	13,103
„ less than 10 feet.	0-12	8,97,942	6,735	13,72,686	10,295	1,42,554	1,069									4,06,284	3,047	2,14,979	1,612
For core got from excavation.	0-4	39,534	99	.....	...	1,08,307	271									.....	...	.....	...
Dressing banks.	0-6	2,86,196	1,073	3,15,850	1,184	1,70,286	639									74,708	280	1,27,586	478
	Total ...		18,074	.....	24,271	.....	9,878									Total ...	6,960	.....	15,193
	Contingencies at 5%.		654	.....	1,214	.....	494									Contingencies at 5%	348	.....	760
	Grand Total.		13,728	.....	25,485	.....	10,372									Grand Total.	7,308	.....	15,953

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT, YADVAD BRANCH.

(F).—Statement of Gross Command and Discharges under Minors and Distributaries.

GHATPRABHA RIGHT BANK CANAL

(F).—Statement of Gross Command and

Serial No.	Name of Distributary or Minor.	No. Distributary (D) or Minor (M).	No. and mileage of channel from which it starts.		Mileage.		Command at the head of Section.	Discharge at the head of Section.	Remarks.
					From	To			
	Surveyed Distributaries.								
	Terminals.								
1	Madamgeri	D 1	1·2	Br.	Start.	0·3	2,292	12·5	
	„	.....	.....	.....	0·3	2·2	1,428	8·0	
2	Kurabgatti	D 2	0·89	M. I.	Start.	1·4	1,805	10	
3	Kodlivad	D 3	1·7	.....	Start.	2·2	5,133	24·5	
	„	.....	.....	.....	2·2	4·3	2,477	13	
4	Naudi	D 4	4·1	.....	Start.	1·1	2,291	12·5	
5	Shivapur	D 5	5·7	.....	Start.	3·1	5,799	27	
	„	.....	.....	.....	3·1	5·0	3,143	16	
6	Upparhatti	D 7	5·2	D 6	Start.	2·5	2,374	13	
	„	.....	.....	.....	2·5	3·9	1,407	8	
7	Kallarkop	D 8	8·0	D 6	Start.	1·4	1,190	7	
8	Akisagar	D 9	9·0	Br.	Start.	2·2	4,659	23	
	„	.....	.....	.....	2·2	3·0	1,824	10	
9	Gosbal	D 11	0·4	D 10	Start.	2·2	2,054	11	
10	Koujalgi	D 12	5·7	M II.	Start.	1·8	4,038	20	
	„	.....	.....	.....	1·8	2·5	1,702	9·5	
11	Lingapur	D 14	1·4	D 13	Start.	2·2	1,978	11	
12	Tigdi	D 16	1·6	D 15	Start.	2·4	5,338	25·5	
	„	.....	.....	.....	2·4	3·6	2,925	15	
13	Hunkopi	D 18	2·4	D 17	Start.	1·1	1,709	9·5	
14	Laxmeshwar	D 19	2·4	D 17	Start.	1·5	4,978	24	
	„	.....	.....	.....	1·5	4·0	3,474	18	
15	Kalligudi	D 21	1·25	M III.	Start.	1·9	3,091	16	
16	Kulgod	D 23	0·8	D 22	Start.	1·1	2,304	12·5	
17	Venktapur	D 25	0·7	D 24	Start.	0·9	3,738	19	¾ Mile unsurveyed.
	„	.....	.....	.....	0·9	3·1	1,709	9·5	
18	Aurvad	D 27	1·5	D 26	Start.	2·4	2,605	14	
	Branch Distributaries.								
19	Bagarnal	D 10	3·5	M II,	Start.	0·4	3,104	16	
	„	.....	.....	.....	0·4	1·8	1,050	6	
20	Udgatti	D 13	6·3	M II.	Start.	0·4	11,111	44	
	„	.....	.....	.....	0·4	1·4	9,101	37·5	
	„	.....	.....	.....	1·4	2·5	6,592	30	
	„	.....	.....	.....	2·5	4·3	4,608	22·5	
	„	.....	.....	.....	4·3	5·2	2,669	14	
21	Bilkundi	D 15	7·4	M II.	Start.	1·6	10,254	41	
	„	.....	.....	.....	1·6	3·6	4,590	22·5	
	„	.....	.....	.....	3·6	4·5	2,990	15·5	
22	Hirekop	D 20	20·5	Br.	Start.	5·75	8,467	36	
	„	.....	.....	.....	5·75	7·0	5,973	28	
	„	.....	.....	.....	7·0	7·5	3,452	18	
	„	.....	.....	.....	7·5	11·0	1,724	9·5	2½ Miles unsurveyed.
23	Hunshal	D 22	8·1	M IV.	Start.	0·8	9,094	37	
	„	.....	.....	.....	0·8	3·0	6,374	29	
	„	.....	.....	.....	3·0	4·3	2,880	15	¾ Mile unsurveyed.
24	Bisankop	D 24	9·4	.....	Start.	0·7	6,586	30	
	„	.....	.....	.....	0·7	3·7	2,624	14	½ Mile unsurveyed.
25	Yargudri	D 26	9·4	.....	Start.	1·5	6,259	29	
	„	.....	.....	.....	1·5	3·55	3,136	16	¾ Mile unsurveyed.
	Main Distributaries.								
26	Mamdapur Main ...	D 6	5·7	M I.	Start.	5·2	9,849	40	
	„ ...	.....	.....	.....	5·2	8·0	4,551	22	
	„ ...	.....	.....	.....	8·0	9·6	1,268	8	
27	Koujalgi West ...	D 17	7·4	M II.	Start.	2·4	8,549	36	
	Minors.								
28	Mamdapur	M I.	5·0	Br.	Start.	0·8	29,511	94	
	„	.....	.....	.....	0·8	1·7	27,706	90	
	„	.....	.....	.....	1·7	4·1	21,926	76	
	„	.....	.....	.....	4·1	5·7	16,403	60	

PROJECT, YADWAD BRANCH.

Discharges under Minors and Distributaries.

Serial No.	Name of Distributary or Minor.	No. Distributary (D) or Minor (M).	No. and mileage of channel from which it starts.		Mileage. From	Mileage. To	Command at the head of Section.	Discharge at the head of Section.	Remarks.
	Minors.		*—contd.*						
29	Koujalgi West ...	M II.	20	Br.	Start.	2·0	42,093	118	
	„ ...	.....	.....	.....	2·0	3·5	40,973	116	
	„ ...	.....	.....	.....	3·5	6·2	35,725	106	
	„ ...	.....	.....	.....	6·2	6·8	30,362	96	
	„ ...	.....	.....	.....	6·8	7·9	19,251	69	
30	Yadwad	M III.	25·0	Br.	Start.	1·25	28,600	92	
	„	.....	.....	.....	1·25	2·1	24,786	83	5 Miles unsurveyed.
	„	.....	.....	.....	2·1	3·0	20,159	71	
	„	.....	.....	.....	3·0	6·5	15,462	58	
31	Koujalgi East ...	M IV.	25·0	Br.	Start.	3·6	38,861	112	
	„ ...	.....	.....	.....	3·6	6·3	33,658	102	
	„ ...	.....	.....	.....	6·3	8·1	27,392	89	
	„ ...	.....	.....	.....	8·1	9·4	15,772	58	
	Unsurveyed Distributaries. *Terminals.*								
1	Tavalgeri	D 3 *a*	2·7	M I.	Start.	1·5	2,566	14	
2	Muglihal	D 9 *a*	18·5	Br.	Start.	2·0	9,402	37·5	
	„	.....	.....	.....	2·0	3·5	2,848	15	
3	Dasnal	D 9 *b*	2·4	M II.	Start.	0·75	2,624	14	
4	Betgeri	D 13 *a*	0·4	D 13	Start.	1·0	2,010	11	
5	Talkatnal	D 16 *a*	3·6	D 15	Start.	1·0	1,487	8	
6	Hulkund	D 20 *a*	5·8	D 20	„	3·0	1,112	8	
7	Chipalkatti	D 20 *b*	7·0	.....	„	2·0	2,412	13	
8	Husaddipara	D 20 *c*	7·5	.....	„	0·75	1,728	9	
9	Kunnal	D 21 *a*	2·1	M III.	„	3·0	4,627	22·5	
10	Manami Secondary ...	D 21 *c*	2·0	D 21 *b*	„	0·5	1,638	9	
11	Yadwad Sub.... ...	D 21 *d*	6·5	M I.I.	„	1·5	3,052	16	
12	Yadwad	D 21 *e*	6·5	.....	„	5·5	8,737	36	
13	Koujalgi East ...	D 21 *f*	3·6	M IV.	„	0·5	1,584	9	
14	Raderhatti	D 21 *g*	5·0	.....	„	0·75	1,625	9	
15	Kulgod South ...	D 21 *h*	6·3	.....	„	1	1,626	9	
16	Timapur Sub... ...	D 21 *j*	0·5	D 21 *i*	„	1	1,299	7	
	Branch Distributaries.								
17	Manami	D 21 *b*	3·0	M III.	Start.	2·0	4,595	22	
	„	.....	.....	.....	2·0	3·0	1,472	9	
18	Timapur	D 21 *i*	6·9	M IV.	Start.	0·4	2,930	15	
	„	.....	.....	.....	0·4	1·0	1,574	8	
	Surveyed Portion.								
	Yadwad Branch ...	.....	.....	.....	Start.	1·2	170,297	426	
		.....	.....	.....	1·2	2·8	168,883	422	D I. starts.
		.....	.....	.....	2·8	4·5	166,233	416	
		.....	.....	.....	4·5	5·0	165,721	414	M I. starts.
		.....	.....	.....	5·0	7·1	136,210	341	
		.....	.....	.....	7·1	9·0	134,162	335	D 9 starts.
	Unsurveyed Portion after mile 10.								
	Yadwad Branch ...	.....	.....	.....	9	18·5	129,503	324	D 9*a* starts.
		.....	.....	.....	18·5	20	120,101	300	M II. starts.
		.....	.....	.....	20	20·5	78,008	195	D 20 starts.
		.....	.....	.....	20·5	24	69,541	174	
		.....	.....	.....	24	25	67,451	169	M III. & IV. start.

Minor III. and IV. start after end of the Branch at mile 25.

P. N. NATESAIYER,
Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL, YADWAD BRANCH

(G).—Statement of Bed Slopes suitable for different Velocities and Discharges in Minors and Distributaries.

Velocity.	2' per second.		2·5 per second.		3' per second.		4' per second.		5' per second.		6' per second.		Remarks.
Discharge in Cusecs.	Depth of F. S. L. assumed.	Slope of Bed.	Depth of F. S. L. assumed.	Slope of Bed.	Depth of F. S. L. assumed.	Slope of Bed.	Depth of F. S. L. assumed.	Slope of Bed	Depth of F. S. L. assumed.	Slope of Bed.	Depth of F. S. L. assumed.	Slope of Bed.	
	feet.	1 in.	feet.	1 in.	feet.	1 in.	feet.	1 in.	feet.	1 in.	feet.	1 in.	
6	1·25	350	1	180	1	100	1	45	·75	25	·75	15	The rates of bed-slopes given are rough and have been calculated from Moor's Tables with the following values for (*n*) (Kutter's Co-efficients).
15	1·5	600	1·5	360	1·5	210	1 5	90	1·25	55	1	30	Discharge cusecs. / Velocity feet, per second. / Value of (*n*) assumed.
25	2	950 5·3 per mile.	2	525	2	300	2	140	1·75	75	1·5	48	6 / 2-6 / ·0275
35	2·5	1,400	2·5	800	2·5	500	2·25	185	2	100	2	62	15·5 / 2-3 / ·025
50	3	1,900	3	1,100	3	650	2 5	250	2·5	130	2·25	85	15·5 / 4-6 / ·0275
75	3	2,800	3	1,675	3	1,100	3	400	3	225	2·75	140	75 125 / 2-3 / ·0225
100	3·5	3,400	3·5	2,200	3 5	1,320	3·5	500	3	275	3	160	75·125 / 4-6 / ·025
125	3·5	3,800	3·5	2,250	3·5	1,450	3·5	575	3·5	320	3·5	200	The maximum Velocities assumed in distributaries are:— In black soil ...2 ft. per second. Firm soil or soil and single. ...2½ ,, ,, Soil and murum ...3 ,, ,, Hard murum ...4 ,, ,, Soft rock ... ...5 ,, ,, Rock ... ...6 ,, ,, In minors the minimum velocitiy is assumed to be not less than 2½ feet per second.

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL PROJECT, YADWAD BRANCH.

(H).—Statement of Cost of Falls for different Discharges and Height of Drops.

Serial No.	Discharges.	COST OF FALL. Height of Drop. 5′	4′	3′	2′	Remarks.
	Cusecs.	Rs.	Rs.	Rs.	Rs.	
1	10	300	270	230	200	
2	18	430	380	330	270	Amount as per rough estimate.
3	25	500	440	370	300	
4	37·5	620	550	440	350	Amount as per rough estimate.
5	45	660	580	480	400	
6	55	710	630	530	450	
7	67	760	680	600	520	Amount as per rough estimate.
8	75	820	730	640	550	
9	85	880	790	700	590	
10	100	970	870	770	650	
11	125	1,116	997	885	745	Amount as per rough estimate.

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

GHATPRABHA RIGHT BANK CANAL.

(I).—Abstract Statement of Cost

No. of distributary.	Length in miles. Surveyed.	Unsurveyed.	Total.	Command in acres.	Cost including falls.	Cost of outlet.	Cost of regulator.	Total cost of distributary or minor.	Rate per acre.	Remarks.
					Rs.	Rs.	Rs.	Rs.		
				Terminals Distributaries Surveyed.						
D 1 ...	2·2	...	2·2	2,292	2,960	150	300	3,410	1·49	
D 2 ...	1·4	...	1·4	1,805	1,140	150	500	1,790	·99	
D 3 ...	4·3	...	4·3	5,133	12,920	375	500	13,795	2·69	Cost of outlet taken at Rs. 75 for every 1,000 acres of command.
D 4 ...	1·1	...	1·1	2,291	2,840	150	500	3,490	1·52	
D 5 ...	5·0	...	5·0	5,799	17,270	450	500	18,220	3·14	
D 7 ...	3·9	...	3·9	2,374	4,440	150	500	5,090	2·14	
D 8 ...	1·4	...	1·4	1,190	560	75	300	935	0·79	Cost of regulators assumed to be Rs. 300 from a distributary to distributary and 500 from a minor or branch to a distributary.
D 9 ...	3·0	...	3·0	4,659	8,950	375	300	9,625	2·07	
D 11 ...	2·2	...	2·2	2,054	4,270	150	300	4,720	2·30	
D 12 ...	2·5	...	2 5	4,038	6,370	300	500	7,170	1·78	
D 14 ...	2·2	...	2·2	1,978	4,500	150	300	4,950	2·50	
D 16 ...	3·6	...	3·6	5,338	7,140	375	300	7,815	1·46	
D 18 ...	1·1	...	1·1	1,709	2,800	150	300	3,250	1·9	
D 19 ...	4·0	...	4·0	4,978	11,070	375	300	11,745	2·36	Cost of regulators from the branch to a minor has been assumed to be Rs. 1,000.
D 21 ...	1·9	...	1·9	3,091	7,770	225	500	8,495	2·75	
D 23 ...	1·1	...	1·1	2,304	2,770	150	300	3,220	1·4	
D 25 ...	2·3	0·8	3·1	3,738	9,612	300	300	10,212	2·7	
D 27 ...	2·4	...	2 4	2,605	9,450	225	300	9,975	3 83	
				Distributaries Unsurveyed.						
D 3 *a* ...	...	1·5	1·5	2,566	4,950	225	500	5,675	2·21	
D 9 *a* ...	...	3·5	3·5	9,402	17,775	675	500	18,950	2·02	
D 9 *b* ...	...	0·75	0·75	2,624	1,500	225	500	2,225	0·85	
D 13 *a* ...	...	1·0	1·0	2,010	2,000	150	300	2,450	1·22	
D 16 *a* ...	...	1·0	1·0	1,487	1,000	75	300	1,375	0·92	
D 20 *a* ...	...	3·0	3·0	1,112	9,000	75	300	9,375	8·43	
D 20 *b* ...	...	2·0	2·0	2,412	5,200	150	300	5,650	2·34	
D 20 *c* ...	...	0·75	0·75	1,728	1,050	150	300	1,500	0·87	
D 21 *a* ...	...	3·0	3·0	4,627	13,500	375	500	14,375	3·11	
D 21 *c* ...	...	0·5	0·5	1,638	900	150	300	1,350	0·82	
D 21 *d* ...	...	1·5	1·5	3,052	4,725	225	500	5,450	1·79	
D 21 *e* ...	...	5·5	5·5	8,737	29,975	675	500	31,150	3·57	
D 21 *f* ...	...	0·5	0·5	1,584	1,000	150	500	1,650	1·04	
D 21 *g* ...	...	0·75	0·75	1,625	1,500	150	500	2,150	1·32	
D 21 *h* ...	...	1·0	1·0	1,626	2,000	150	500	2,650	1·63	
D 21 *j* ...	...	1·0	1·0	1,299	1,500	75	300	1,875	1·44	
				Branch Distributaries Surveyed.						
D 10 ...	1·8	...	1·8	1,050	2,420	75	500	2,995	0·96	Direct cost and length.
Add D 11 .	2·2	...	2·2	2,054	...	...	...	4,720	...	
Total ...	4·0	...	4·0	3,104	...	...	...	7,715	2·48	Direct cost and length.

Branch Distributaries Surveyed—concl.

					Rs.	Rs.	Rs.	Rs.		
D 13 ...	5·2	...	5·2	7,123	22,815	525	500	23,840	2·15	Direct cost and length.
Add D 14 .	2·2	...	2·2	1,978	...	...	...	4,950	...	
„ D 13 *a*	...	1·0	1·0	2,010	...	...	...	**2,450**	...	
Total ...	7·4	1·0	8·4	11,111	...	...	...	31,240	2·81	
D 15 ...	4·5	...	4·5	3,429	16,950	225	500	17,675	1·72	Direct cost and length.
Add D 16 .	3·6	...	3·6	5,338	...	...	...	7,815	...	
„ D 16 *a*	...	1·0	1·0	1,487	...	...	...	**1,375**	...	
Total ...	8·1	1·0	9·1	10,254	...	...	...	26,865	2·62	
D 20 ...	8·5	2·5	11·0	3,215	34,475	225	500	35,200	4·16	Direct cost and length.
Add D 20 *a*	...	3·0	3·0	1,112	...	...	...	**9,375**	...	
„ D 20 *b*	...	2·0	2·0	2,412	...	...	...	**5,650**	...	
„ D 20 *c*	...	0·8	0·8	1,728	...	...	...	**1,500**	...	
Total ...	8·5	8·3	16·8	8,467	...	...	...	51,725	6·11	
D 22 ...	3·5	0·8	4·3	6,790	20,370	525	500	21,395	2·35	Direct cost and length.
Add D 23 .	1·1	...	1·1	2,304	...	...	...	3,220	...	
Total ...	4·6	0·8	5·4	9,094	...	...	...	24,615	2·71	
D 24 ...	3·2	0·5	3·7	2,848	14,090	225	500	14,815	2·25	Direct cost and length.
Add D 25 .	2·3	0·8	3·1	3,738	...	...	...	10,212	...	
Total ...	5·5	1·3	6·8	6,586	...	...	...	25,027	3·80	
D 26...	2·8	0·8	3·6	3,654	13,933	300	500	14,733	2·35	Direct cost and length.
Add D 27...	2·4	...	2·4	2,605	...	...	...	9,975	...	
Total ...	5·2	0·8	6·0	6,259	...	...	...	24,708	3·95	
				Unsurveyed.						
D 21 *b*	...	3	3	2,957	7,150	225	500	7,875	1·71	Direct cost and length.
Add D 21 *c*	...	0·5	0·5	1,638	...	...	...	1,350	...	
Total ...	...	3·5	3·5	4,595	...	...	...	9,225	2·0	
D 21 *i*	...	1	1	1,631	2,000	150	500	2,650	0·90	Direct cost and length.
Add D 21 *j*	...	1	1	1,299	...	...	...	1,875	...	
Total ...	...	2	2	2,930	...	...	...	4,525	1·54	

					Rs.	Rs.	Rs.	R		
					Main	*Distributaries.*				
D 6...	9·6	...	9·6	6,285	31,780	450	500	32,30	3·32	Direct cost and length
Add D 7...	3·9	...	3·91	2,374	...	...	...	5,00	...	
„ D 8...	1·4	...	1·4	1,190	...	...	...	35	...	
Total ...	14·9	...	14·9	9,849	...	...	...	38,55	3·90	
D 17...	2·4	...	2·4	1,862	8,970	150	500	9,80	1·12	Direct cost and length.
Add D 18...	1·1	...	1·1	1,709	...	...	...	3,50	...	
„ D 19...	4·0	...	4·0	4,978	...	...	...	11,45	...	
Total ...	7·5	...	7·5	8,549	...	...	...	24,15	2·88	
					Minors.					
					Mamdapur Minor.					
M. I. ...	5·7	...	5·7	2,068	38,145	150	1,000	39,95	1·33	Direct cost and length.
Add D 2 ...	1·4	...	1·4	1,805	...	...	...	1,90	...	
„ D 3 ...	4·3	...	4·3	5,133	...	...	...	13,95	...	
„ D 3*a*...	...	1·5	1·5	2,566	...	...	...	5,75	...	
„ D 4 ...	1·1	...	1·1	2,291	...	...	...	3,90	...	
„ D 5 ...	5·0	...	5·0	5,799	...	...	...	18220	...	
„ D 6 ...	14·9	...	14·9	9,849	...	...	...	38755	...	
Total ...	32·4	1·5	33·9	29,511	...	...	...	1,21020	4·1	
					Koujalgi	*West*	*Minor,*			
M. II. ...	7·9	...	7·9	2,413	55,728	150	1,000	5,878	1·35	Direct cost and length.
Add D 9*b*...	...	0·8	0·8	2,624	...	...	...	2225	...	
„ D 10...	4·0	...	4·0	3,104	...	...	...	7,715	...	
„ D 12...	2·5	...	2·5	4,038	...	...	...	7,170	...	
„ D 13...	7·4	1·0	8·4	11,111	...	...	...	31,240	...	
„ D 15...	8·1	1·0	9·1	10,254	...	...	...	26,865	...	
„ D 17...	7·5	...	7·5	8,549	...	...	...	24,615	...	
Total ...	37·4	2·8	40·2	42,093	...	...	...	1,56,708	3·72	

PROJECT (YADWAD BRANCH).

of Minors and Distributaries.

No. of distributary.	Length in miles.			Command in acres.	Cost including falls.	Cost of outlet.	Cost of regulator.	Total cost of distributary or minor.	Rate per acre.	Remarks.
	Surveyed.	Unsurveyed.	Total.							
					Rs.	Rs.	Rs.	Rs.		
					Koujalgi East Minor.					
M IV. ...	9·4	...	9·4	9,157	57,733	675	1,000	59,408	1·53	Direct cost and length.
Add D 21*f*	...	0·5	0·5	1,584	...	...	...	**1,650**	...	
„ D 21 *g*	...	0·8	0·8	1,625	...	...	...	**2,150**	...	
„ D 21 *h*	...	1·0	1·0	1,626	...	...	...	**2,650**	...	
„ D 21 *i*	...	2·0	2·0	2,930	...	...	...	**4,525**	...	
„ D22...	4·6	0·8	5·4	9,094	...	...	...	24,615	...	
„ D24...	5·5	1·3	6·8	6,586	...	...	...	25,027	...	
„ D26...	5·2	0·8	6·0	6,259	...	...	...	24,708	...	
Total ...	24·7	7·2	31·9	38,861	...	...	...	1,44,733	3·72	
				Yadwad Minor, unsurveyed.						
M III. ...	1·5	5·0	6·5	4,498	43,910	300	1,000	45,210	1·58	Direct cost and length.
Add D 21 .	1·9	...	1·9	3,091	...	...	...	8,495	...	
„ D 21 *a*	...	3·0	3·0	4,627	...	...	...	**14,375**	...	
„ D 21 *b*	...	3·5	3·5	4,595	...	...	...	**9,225**	...	
„ D 21 *d*	...	1·5	1·5	3,052	...	...	...	**5,450**	...	
„ D 21 *e*	...	5·5	5·5	8,737	...	...	...	**31,150**	...	
Total ...	3·4	18·5	21·9	28,600	...	...	...	1,13,905	3·98	
Abstract of Cost for the whole Yadwad Branch—Excluding cost of field channels.										
Directly under Branch...	...	...	...	6,412	...	...	...	...	...	
D 1 ...	2·2	...	2·2	2,292	...	...	...	3,410	...	
M I ...	32·4	1·5	33·9	29,511	...	...	...	1,21,020	...	
D 9 ...	3·0	...	3·0	4,659	...	...	...	9,025	...	
D 9 *a* ...	...	3·5	3·5	9,402	...	...	...	**18,950**	...	
M II. ...	37·4	2·8	40·2	42,093	...	...	...	1,56,708	...	
D 20 ...	8·5	8·3	16·8	8,467	...	...	...	51,725	...	
M III. ...	3·4	18·5	21·9	28,600	...	...	...	1,13,905	...	
M IV. ...	24·7	7·2	31·9	38,861	...	...	...	1,44,733	...	
Total ...	111·6	41·8	153·4	170,297	...	...	...	6,20,076	3·64	

P. N. NATESAIYER.

Executive Engineer on Special Duty,
Gokak Survey.

GHATPRABHA RIGHT BANK CANAL.

(J).—Statement giving details of cost

No. of Distributary.	Name of Distributary.		Command.	Discharge.	Details of Alignments.				
					In contour.		Ridge.	Unsurveyed.	Total.
					In bad ground.	In easy ground.			
1	Madamgeri—								
	1st Section.	Quantity	2,292	12·5	.....	.....	0·3 mile.	.....	0·3 mile.
		Rate	.....	.....	.....	.....	700 Rs.	.....	.....
		Amount	.....	.....	.....	.....	210 „	.....	210 Rs.
	2nd Section.	Quantity	1,428	8·0	.....	.....	1·9 miles.	.....	1·9 miles.
		Rate	.....	.....	.....	.....	500 Rs.	.....	.....
		Amount	.....	.....	.....	.....	950 „	.....	950 Rs.
2	Karabgatti—								
		Quantity	1,805	10·0	.....	.....	1·4 miles.	.....	1·4 miles.
		Rate	.....	.....	.....	.....	600 Rs.	.....	.....
		Amount	.....	.....	.....	.....	840 „	.....	840 Rs.
3	Kodliwal—								
	1st Section.	Quantity	5,133	24·5	.....	.....	2·2 miles.	.....	2·2 miles.
		Rate	.....	.....	.....	.....	1,300 Rs.	.....	.....
		Amount	.....	.....	.....	.....	2,860 „	.....	2,860 Rs.
	2nd Section.	Quantity	2,477	13	.....	.....	2·1 miles.	.....	2·1 miles
		Rate	.....	.....	.....	.....	800 Rs.	.....	.....
		Amount	.....	.....	.....	.....	1,680 „	.....	1,680 Rs.
4	Nandi—								
		Quantity	2,291	12·5	.....	.....	1·1 miles.	.....	1·1 miles.
		Rate	.....	.....	.....	.....	700 Rs.	.....	.....
		Amount	.....	.....	.....	.....	770 „	.....	770 Rs.
5	Shewapur—								
	1st Section.	Quantity	5,799	27	1·7 miles.	.....	1·4 miles.	.....	3·1 miles.
		Rate	.....	.....	3,500 Rs.	.....	1,300 Rs.	.....	.....
		Amount	.....	.....	5,950 „	.....	1,820 „	.....	7,770 Rs.
	2nd Section.	Quantity	3,143	16	.....	.....	1·9 miles.	.....	1·9 miles
		Rate	.....	.....	.....	.....	1,000 Rs.	.....	.....
		Amount	.....	.....	.....	.....	1,900 „	.....	1,900 Rs.
7	Upperhatti—								
	1st Section.	Quantity	2,374	12·5	.....	1 mile.	1·5 miles.	.....	2·5 miles.
		Rate	.....	.....	.....	1,500 Rs.	700 Rs.	.....	.....
		Amount	.....	.....	.....	1,500 „	1,050 „	.....	2,550 Rs.
	2nd Section.	Quantity	1,407	8	.....	.....	1·4 miles.	.....	1·4 miles.
		Rate	.....	.....	.....	.....	500 Rs.	.....	.....
		Amount	.....	.....	.....	.....	700 „	.....	700 Rs.
8	Kallarkop—								
		Quantity	1,190	6·5	.....	.....	1·4 miles.	.....	1·4 miles
		Rate	.....	.....	.....	.....	400 Rs.	.....	.....
		Amount	.....	.....	.....	.....	560 „	.....	560 Rs.
9	Akisagar—								
	1st Section.	Quantity	4,659	22·5	1·4 miles.	.....	0·8 mile.	.....	2·2 miles.
		Rate	.....	.....	3,250 Rs.	.....	1,200 „	.....	.....
		Amount	.....	.....	4,550 „	.....	960 „	.....	5,510 Rs.
	2nd Section.	Quantity	1,824	10	.....	.....	0·8 mile.	.....	·8 mile.
		Rate	.....	.....	.....	.....	600 Rs.	.....	.....
		Amount	.....	.....	.....	.....	480 „	.....	480 Rs.

2 Nos.	.....	.....	.....	2 Nos.	.....	Rate per mile of unsurveyed length taken proportionate to estimated cost of the surveyed portion on the same distributary.
300 Rs.	.....	.....	.....	.....	.....	
600 „	.....	.....	.....	600 Rs.	810 Rs.	
4 Nos.	.....	.....	.....	4 Nos.	.....	
300 Rs.	.....	.....	.....	.....	.....	
1,200 „	.....	.....	.....	1,200 Rs.	2,150 Rs.	
1 No.	.....	.....	.....	1 No.	.....	
300 Rs.	.....	.....	.....	.....	.....	
300 „	.....	.....	.....	300 Rs.	1,140 Rs.	
4 Nos.	1 No.	Nos.*	.....	127 Nos.	.....	* One drop of 3½ and one of 3 feet.
500 Rs.	440 Rs.	370 Rs.	.....	.....	.....	
2,000 „	440 „	740 „	.....	3,180 Rs.	6,040 Rs.	
14 No.	2 Nos.	2 Nos.*	.....	18 Nos.	.....	* One drop of 3½ and one of 3 feet.
300 Rs.	270 Rs.	230 Rs.	.....	.....	.....	
4,200 „	540 „	460 „	.....	5,200 Rs.	6,880 Rs.	
6 Nos.	1 No.†	.....	.....	7 Nos.	.....	† One drop of 4½ feet.
300 Rs.	270 Rs.	.....	.....	.....	.....	
1,800 „	270 „	.....	.....	2,070 Rs.	2,840 Rs.	
3 Nos.	1 No.	.....	No. ‡	5 Nos.	.....	‡ One drop of 2½ feet.
500 Rs.	440 Rs.	.....	300 Rs.	.....	.....	
1,500 „	440 „	.....	300 „	2,240 Rs.	10,010 Rs.	
6 Nos.	4 Nos.	3 Nos.§	1 No.	14 Nos.	.....	§ One drop of 3½ feet and two of 3 feet.
430 Rs.	380 Rs.	330 Rs.	270 Rs.	.....	.....	
2,580 „	1,520 „	990 „	270 „	5,360 Rs.	7,260 Rs.	
.....	.....	.....	1 No.	1 No.	.....	
.....	.....	.....	200 Rs.	.....	.....	
.....	.....	.....	200 „	200 Rs.	2,750 Rs.	
1 No.	.....	3 Nos.	.....	4 Nos.	.....	
300 Rs.	.....	230 Rs.	.....	.....	.....	
300 „	.....	690 „	.....	990 Rs.	1,690 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	560 Rs.	
2 Nos.	.....	.....	.....	2 Nos.	.....	Actual No. 3 on plan but cost of one may be saved by dropping into a Nala going in contour from pick-up weir on same.
500 Rs.	.....	.....	.....	.....	.....	
1,000 „	.....	.....	.....	1,000 Rs.	6,510 Rs.	
5 Nos.	.....	2 No.	.....	7 Nos.	.....	Actual No. 14 on plan but cost of nine may be saved by dropping into a Nala and going in contour from a pick-up weir on same.
300 Rs.	.....	230 Rs.	.....	.....	.....	
1,500 „	.....	460 „	.....	1,960 Rs.	2,440 Rs.	

11	Gosbal—									
	Quantity		2,054	11	0·8 mile.	...	1·4 miles.	.....	2·2 miles.
	Rate		.....	.....	1,900 Rs.	...	700 Rs.	.....	.....
	Amount		.....	.....	1,520 „	...	980 „	.....	2,500 Rs.
12	Kaujalgi—									
	1st Section. Quantity		4,038	20	.....	...	1·8 miles.	.....	1·8 miles.
	1st Section. Rate		.....	.....	.....	...	1,100 Rs.	.....	.....
	1st Section. Amount		.....	.....	.....	...	1,980 „	.....	1,980 Rs.
	2nd Section. Quantity		1,702	9·5	.....	...	0·7 mile.	.....	0·7 mile.
	2nd Section. Rate		.....	.....	.....	...	600 Rs.	.....	.....
	2nd Section. Amount		.....	.....	.....	...	420 „	.....	420 Rs.
14	Lingapur—									
	Quantity		1,978	10·5	1 mile.	...	1·2 miles.	.....	2·2 miles.
	Rate		.....	.....	1,800 Rs.	...	700 Rs.	.....	.....
	Amount		.....	.....	1,800 „	...	840 „	.....	2,640 Rs.
16	Tigadi—									
	1st Section. Quantity		5,338	25	0·2 mile.	...	2·2 miles.	.....	2·4 miles.
	1st Section. Rate		.....	.....	3,500 Rs.	...	1,300 Rs.	.....	.....
	1st Section. Amount		.....	.....	700 „	...	2,860 „	.....	3,560 Rs.
	2nd Section. Quantity		2,925	15	.....	...	1·2 miles.	.....	1·2 miles.
	2nd Section. Rate		.....	.....	.....	...	900 Rs.	.....	.....
	2nd Section. Amount		.....	.....	.....	...	1,080 „	.....	1,080 Rs.
18	Hunkopi—									
	Quantity		1,709	9·5	.....	...	1·1 miles.	.....	1·1 miles.
	Rate		.....	.....	.....	...	600 Rs.	.....	.....
	Amount		.....	.....	.....	...	660 „	.....	660 Rs.
19	Lakshmeshwar—									
	1st Section. Quantity		4,978	24	.....	...	1·5 miles.	.....	1·5 miles.
	1st Section. Rate		.....	.....	.....	...	1,300 Rs.	.....	.....
	1st Section. Amount		.....	.....	.....	...	1,950 „	.....	1,950 Rs.
	2nd Section. Quantity		3,474	17·5	.....	1·[illegible] miles.	1 mile	.....	2·5 miles.
	2nd Section. Rate		.....	.....	.....	2,00 Rs.	1,000 Rs.	.....	.....
	2nd Section. Amount		.....	.....	.....	3,00 „	1,000 „	.....	4,000 Rs.
21	Kalligudi—									
	Quantity		3,091	16	.....	...	1·9 miles.	.....	1·9 miles.
	Rate		.....	.....	.....	...	1,000 Rs.	.....	.....
	Amount		.....	.....	.....	...	1,900 „	.....	1,900 Rs.
23	Kulgod—									
	Quantity		2,304	12·5	.....	...	1·1 miles.	.....	1·1 miles.
	Rate		.....	.....	.....	...	700 Rs.	.....	.....
	Amount		.....	.....	.....	...	770 „	.....	770 Rs.
25	Venktapur—									
	1st Section. Quantity		3,738	19	0·6 mile.	...	0·3 mile.	.....	0·9 mile.
	1st Section. Rate		.....	.....	2,750 Rs.	...	1,100 Rs.	.....	.....
	1st Section. Amount		.....	.....	1,650 „	...	330 „	.....	1,980 Rs.
	2nd Section. Quantity		1,709	9·5	0·3 mile.	...	1·1 miles.	0·75 mile.	2·2 miles.
	2nd Section. Rate		.....	.....	1,600 Rs.	...	600 Rs.	3,550 Rs.	.....
	2nd Section. Amount		.....	.....	480 „	...	660 „	2,662 „	3,802 Rs.

5 Nos.	1 No.	.....	.....	6 Nos.	.....	Actual No. 7 on plan but cost of two may be saved by dropping into a Nala and going in contour from pick-up weir on same.
300 Rs.	270 Rs.	.....	.....	.....	.....	
1,500 „	270 „	.....	.....	1,770 Rs.	4,270 Rs.	
8 Nos.*	.....	.....	.....	8 Nos.	.....	* 3 drops of 5½ feet and 5 of 5 feet.
430 Rs.	.....	.....	.....	.....	.....	
3,440 „	.....	.....	.....	3,440 Rs.	5,420 Rs.	
1 No.	.....	1 No.	.....	2 Nos.	.....	
300 Rs.	.....	230 R.	.....	.....	.....	
300 „	.....	230 „	.....	530 Rs.	950 Rs.	
3 Nos.	1 No.	1 No	.....	5 Nos.	.....	Actual No. 6 on plan but cost of three may be saved by dropping into a Nala and going in contour from a pick-up weir on same.
300 Rs.	270 Rs.	230 Is.	.....	.....	.....	
900 „	270 „	690 „	.....	1,860 Rs.	4,500 Rs.	
5 Nos. ‡	.....	.....	.....	5 Nos.	.....	‡ 2 drops of 5½ feet and 3 of 5 feet.
500 Rs.	.....	.....	.....	.....	.....	
2,500 „	.....	.....	.....	2,500 Rs.	6,060 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	1,080 Rs.	
3 Nos.	3 Nos.¶	1 No.	1 No.	8 Nos.	.....	¶ One drop of 4½ feet and two of 4 feet.
300 Rs.	270 Rs.	230 Rs.	200 Rs.	.....	.....	
900 „	810 „	230 „	200 „	2,140 Rs.	2,800 Rs.	
7 Nos.	1 No.	1 No.	.....	9 Nos.	.....	
500 Rs.	440 Rs.	370 Rs	.....	.....	.....	
3,500 „	440 „	370 „	.....	4,310 Rs.	6,260 Rs.	
1 No. ‖	1 No.§	.....	.....	2 Nos.	.....	‖ Drop of 5½ feet. § Drop of 4½ feet.
430 Rs.	380 Rs.	.....	.....	.....	.....	
430 „	380 „	.....	.....	810 Rs.	4,810 Rs.	
12 Nos. √	1 No.†	1 No. ∴	.....	14 Nos.	.....	√ 3 drops of 5½ feet and 9 of 5 feet. † one drop of 4½ feet ∴ One drop of 3½ feet.
430 Rs.	380 Rs.	330 Rs.	.....	.....	.....	
5,160 „	380 „	330 „	.....	5,870 Rs.	7,770 Rs.	
6 Nos.	.....	.....	1 No.	7 Nos.	.....	
300 Rs.	.....	.....	200 Rs.	.....	.....	
1,800 „	.....	.....	200 „	2,000 Rs.	2,770 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	1,980 Rs.	
12 Nos.	.....	1 No.	.....	13 Nos.	.....	Actual No. 18 on plan but cost of 6 may be saved by dropping into a Nala going in contour from a pick-up weir on same.
300 Rs.	.....	230 Rs.	.....	.....	.....	
3,600 „	.....	230 „	.....	3,830 Rs.	7,632 Rs.	

27	Aurwad—									
	1st Section.	Quantity	2,605	14	.....	.....	2·4 miles.	.....	2·4 miles.
		Rate	.....	.....	.....	.....	800 Rs.	.....	.....
		Amount	.....	.....	.....	.....	1,920 „	.....	1,920 Rs.
	Branch Distributaries.								
10	Bagarual—								
	1st Section.	Quantity	3,104	16	.....	0·4 mile.	.....	.....	0·4 mile.
		Rate	.....	.....	.....	1,900 Rs.	.....	.....	.....
		Amount	.....	.....	.....	760 „	.....	.....	760 Rs.
	2nd Section.	Quantity	1,050	6	.....	.....	1·4 miles.	.....	1·4 miles.
		Rate	.....	.....	.....	.....	400 Rs.	.....	.....
		Amount	.....	.....	.....	.....	560 „	.....	560 Rs.
13	Udgatti—								
	1st Section.	Quantity	11,111	44	.....	.....	0·4 mile.	.....	0·4 mile.
		Rate	.....	.....	.....	.....	1,600 Rs.	.....	.....
		Amount	.....	.....	.....	.....	640 „	.....	640 Rs.
	2nd Section.	Quantity	9,101	37	0·9 mile.	.....	0·1 mile.	.....	1 mile.
		Rate	.....	.....	4,000 Rs.	.....	1,500 Rs.	.....	.....
		Amount	.....	.....	3,600 „	.....	150 „	.....	3,750 Rs.
	3rd Section.	Quantity	6,592	30	0·5 mile.	.....	0·6 mile.	.....	1·1 miles.
		Rate	.....	.....	3,750 Rs.	.....	1,400 Rs.	.....	.....
		Amount	.....	.....	1,875 „	.....	840 „	.....	2,715 Rs.
	4th Section.	Quantity	4,608	22·5	.....	.....	1·8 miles.	.....	1·8 miles.
		Rate	.....	.....	.....	.....	1,200 Rs.	.....	.....
		Amount	.....	.....	.....	.....	2,160 „	.....	2,160 Rs.
	5th Section.	Quantity	2,669	14	.....	.....	0·9 mile.	.....	0·9 mile.
		Rate	.....	.....	.....	.....	800 Rs.	.....	.....
		Amount	.....	.....	.....	.....	720 „	.....	720 Rs.
15	Bilkundi—								
	1st Section.	Quantity	10,254	41	0·7 mile.	.....	0·9 mile.	.....	1·6 miles.
		Rate	.....	.....	4,000 Rs.	.....	1,500 Rs.	.....	.....
		Amount	.....	.....	2,800 „	.....	1,350 „	.....	4,150 Rs.
	2nd Section.	Quantity	4,590	22·5	.....	.....	2·0 miles.	.....	2·0 miles.
		Rate	.....	.....	.....	.....	1,200 Rs.	.....	.....
		Amount	.....	.....	.....	.....	2,400 „	.....	2,400 Rs.
	3rd Section.	Quantity	2,990	15·5	.....	.....	0·9 mile.	.....	0·9 mile.
		Rate	.....	.....	.....	.....	900 Rs.	.....	.....
		Amount	.....	.....	.....	.....	810 „	.....	810 Rs.
20	Hirekop—								
	1st. Section.	Quantity	8,467	36	5·75miles	.....	.....	.....	5·75miles.
		Rate	.....	.....	4,000 Rs.	.....	.....	.....	.....
		Amount	.....	.....	23,000 „	.....	.....	.....	23,000Rs.
	2nd Section.	Quantity	5,973	28	1·25miles	.....	.....	.....	1·25miles.
		Rate	.....	.....	3,600 Rs.	.....	.....	.....	.....
		Amount	.....	.....	4,500 „	.....	.....	.....	4,500 Rs.
	3rd Section.	Quantity	3,452	17·5	0·5 mile.	.....	.....	.....	0·5 mile.
		Rate	.....	.....	2,750 Rs.	.....	.....	.....	.....
		Amount	.....	.....	1,375 „	.....	.....	.....	1,375 Rs.
	4th Section.	Quantity	1,724	9·5	1·0 mile.	.....	.....	2·5 miles.	3·5 miles.
		Rate	.....	.....	1,600 Rs.	.....	.....	1,600 Rs.	.....
		Amount	.....	.....	1,600 „	.....	.....	4,000 „	5,600 Rs.

16 Nos.	1 No.	.....	1 No.	18 Nos.	.....	Actual No. 19 on plan but cost of
430 Rs.	380 Rs.	.....	270 Rs.	.....	.....	3 may be saved by dropping
6,880 „	380 „	.....	270 „	7,530 Rs.	9,450 Rs.	into a Nala and going in contour from a pick-up weir on same.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	760 Rs.	
3 Nos.	.....	.....	1 No.	4 Nos.	.....	Actual No. 5 on plan but cost of
300 Rs.	.....	.....	200 Rs.	.....	.....	two may be saved by dropping
900 „	.....	.....	200 „	1,100 Rs.	1,660 Rs.	into a Nala and going in contour from a pick-up weir on same.
3 Nos.	.....	1 No.	.....	4 Nos.	.....	Actual No. 5 on plan but cost of two
660 Rs.	.....	380 Rs.	.....	.....	.....	may be saved by dropping into a
1,980 „	.....	380 „	.....	2,460 Rs.	3,100 Rs.	Nala and going in contour from a pick-up weir on same.
2 Nos.	1 No.	2 Nos.	.....	5 Nos.	.....	Actual No. 4 do,
620 Rs.	550 Rs.	440 Rs.	.....	.....	.....	
1,240 „	550 „	880 „	.....	2,670 Rs.	6,420 Rs.	
6 Nos.	.....	1 No.	1 No.	8 Nos.	.....	Actual No. 11 on plan but cost of
620 Rs.	.....	440 Rs.	350 Rs.	.....	.....	5 may be saved by dropping
3,720 „	.....	440 „	350 „	4,510 Rs.	7,225 Rs.	into a Nala and going in contour
2 Nos.	4 Nos.	.....	.....	6 Nos.	.....	from a pick-up weir on same.
500 Rs.	440 Rs.	.....	.....	.....	.....	
1,000 „	1760 „	.....	.....	2,760 Rs.	4,920 Rs.	
1 No.	.....	.....	.....	1 No.	.....	
430 Rs.	.....	.....	.....	.....	.....	
430 „	.....	.....	.....	430 Rs.	1,150 Rs.	
*8 Nos.	1 No.	.....	.....	9 Nos.	.....	* 3 drops of 5½ feet and 7 of 5
660 Rs.	580 Rs.	.....	.....	.....	.....	feet. Actual No. 10 on plan but
5,280 „	580 „	.....	.....	5,860 Rs.	10,010 Rs.	cost of two may be saved by dropping into a Nala and going in contour from a pick-up weir on same.
5 Nos.	.....	1 No. †	.....	6 Nos.	.....	† One drop of 3½ feet.
500 Rs.	.....	370 Rs.	.....	.....	.....	
2,500 „	.....	370 „	.....	2,870 Rs.	5,270 Rs.	
2 Nos.	.....	.....	.....	2 Nos.	.....	
430 Rs.	.....	.....	.....	.....	.....	
860 „	.....	.....	.....	860 Rs.	1,670 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	23,000 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	4,500 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	1,375 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	5,600 Rs.	

22	Hunshal—								
	1st Section.	Quantity	9,094	37	.....	0·1 mile.	0·7 mile.	.....	0·8 mile.
		Rate	.....	.....	.....	3,000 Rs.	1,500 Rs	.....	.....
		Amount	.....	.....	.....	300 „	1,050 „	.....	1,350 Rs.
	2nd Section.	Quantity	6,374	29	.....	.....	2·2 miles.	.....	2·2 miles.
		Rate	.....	.....	.....	.....	1,400 Rs.	.....	.....
		Amount	.....	.....	.....	.....	3,080 „	.....	3,080 Rs.
	3rd Section.	Quantity	2,880	15	.....	.....	0·5 mile.	0·75 mile.	1·25miles
		Rate	.....	.....	.....	.....	900 Rs.	5,200 Rs.	.....
		Amount	.....	.....	.....	.....	450 „	3,900 „	4,350 Rs.
24	Bisankop—								
	1st Section.	Quantity	6,586	30	0·7 mile.	.....	.....	.....	0·7 mile.
		Rate	.....	.....	3,750 Rs.	.....	.....	.....	.....
		Amount	.....	.....	2,625 „	.....	.....	.....	2,625 Rs.
	2nd Section.	Quantity	2,624	14	0·5 mile.	.....	2·0 miles.	0·5 mile.	3 miles.
		Rate	.....	.....	2,250 Rs.	.....	800 Rs.	3,820 Rs.	.....
		Amount	.....	.....	1,125 „	.....	1,600 „	1,910 „	4,635 Rs.
26	Yergudri—								
	1st Section.	Quantity	6,259	29	0·3 mile.	.....	1·2 miles.	.....	1·5 miles.
		Rate	.....	.....	3,750 Rs.	.....	1,400 Rs.	.....	.....
		Amount	.....	.....	1,125 „	.....	1,680 „	.....	2,805 Rs.
	2nd Section.	Quantity	3,136	16	0·2 mile.	.....	1·1 miles.	0·75 mile.	2·1 miles.
		Rate	.....	.....	2,500 Rs.	.....	1,000 Rs.	4,210 Rs.	.....
		Amount	.....	.....	500 „	.....	1,100 „	3,158 „	4,758 Rs.
	Main Distributaries.								
6	Mamdapur—								
	1st Section.	Quantity	9,849	40	1·3 miles.	1·4 miles.	2·5 miles.	.....	5·2 miles.
		Rate	.....	.....	4,000 Rs.	3,000 Rs.	1,500 Rs.	.....	.....
		Amount	.....	.....	5,200 „	4,200 „	3,750 „	.....	13,150Rs.
	2nd Section.	Quantity	4,551	22	.....	.....	2·8 miles.	.....	2·8 miles.
		Rate	.....	.....	.....	.....	1,200 Rs.	.....	.....
		Amount	.....	.....	.....	.....	3,360 „	.....	3,360 Rs.
	3rd Section.	Quantity	1,268	7·5	.....	.....	1·6 miles.	.....	1·6 miles.
		Rate	.....	.....	.....	.....	400 Rs.	.....	.....
		Amount	.....	.....	.....	.....	640 „	.....	640 Rs.
17	Kaujalgi West—								
		Quantity	8,549	36	.....	1·1 miles.	1·3 miles.	.....	2·4 miles.
		Rate	.....	.....	.....	3,000 Rs.	1,500 Rs.	.....	.....
		Amount	.....	.....	.....	3,300 „	1,950 „	.....	5,250 Rs.

4 Nos.	1 No.	.....	.....	5 Nos.	.....	
620 Rs.	50 Rs.	.....	.....	.....	.....	
2,480 „	55 „	.....	.....	330 Rs.	4,380 Rs.	
10 Nos.	1 No.	1 No.*	2 Nos.‡	14 Nos.	.....	* Drop of 3½ feet. ‡ One drop of 2½ and one of 2 feet.
500 Rs.	440 Rs.	370 Rs.	300 Rs.	.....	.....	
5,000 „	440 „	370 „	600 „	6,410 Rs.	9,490 Rs.	
5 Nos.	.....	.....	.....	5 Nos.	.....	Actual No. 8 on plan but cost of 3 may be saved by dropping into a Nala and going in contour from a pick-up weir on same.
430 Rs.	.....	.....	.....	.....	.....	
2,150 „	.....	.....	.....	2,150 Rs.	6,500 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	6,252 Rs.	
15 Nos.*	1 No.	.....	.....	16 Nos.	.....	* One drop of 5½ feet and 22 of 5 feet. Actual No. 23 on plan but cost of 8 may be saved by dropping into a Nala and going in contour from a pick-up weir on same.
430 Rs.	380 Rs.	.....	.....	.....	.....	
6,450 „	380 „	.....	.....	6,830 Rs.	11,465 Rs.	
5Nos.††	.....	.....	.....	5 Nos.	.....	†† One drop of 5½ feet and four of 5 feet.
500 Rs.	.....	.....	.....	.....	.....	
2,500 „	.....	.....	.....	2,500 Rs.	5,305 Rs.	
9 Nos.	.....	.....	.....	9 Nos.	.....	
430 Rs.	.....	.....	.....	.....	.....	
3,870 „	.....	.....	.....	3,870 Rs.	8,628 Rs.	
*12 Nos.	4 Nos.	††5 Nos.	.....	21 Nos.	.....	*14 drops of 5 feet and 14 of 5½ feet. ††4 drops of 3½ and 1 of 3 feet. Actual No. 18 on plan but cost of 6 may be saved by dropping into a Nala and going into contour from a pick-up weir on same.
620 Rs.	550 Rs.	440 Rs.	.....	.....	.....	
7,440 „	2,200 „	2,200 „	.....	11,840 Rs.	24,990 Rs.	
.....	1 No.	5 Nos.	1 No.	7 Nos.	.....	
.....	440 Rs.	370 Rs.	300 Rs.	.....	.....	
.....	440 „	1,850 „	300 „	2,590 Rs.	5,950 Rs.	
.....	.....	.....	1 No.	1 No.	.....	
.....	.....	.....	200 Rs.	.....	.....	
.....	.....	.....	200 „	200 Rs.	840 Rs.	
6 Nos. §	.....	.....	.....	6 Nos.	.....	§Four drops of 5½ ft. and 2 of 5 feet.
620 Rs.	.....	.....	.....	.....	.....	
3,720 „	.....	.....	.....	3,720 Rs.	8,970 Rs.	

Minor.

I.	Mamdapur—									
	1st Section.	Quantity			29,511	94	0·6 mile.	0·2 mile.	.....	0·8 mile
		Rate			.....	.....	5,750 Rs.	4,250 Rs.	.....	.....
		Amount			.....	.....	3,450 „	850 „	.....	4,300 Rs.
	2nd Section.	Quantity			27,706	90	.....	0·7 mile.	0·2 mile	0·9 mile
		Rate			.....	.....	.....	4,250 Rs.	2,250 Rs	.....
		Amount			.....	.....	.....	2,975 „	450	3,425 Rs.
	3rd Section.	Quantity			21,926	76	.....	0·9 mile.	1·5 miles.	2·4 miles.
		Rate			.....	.....	.....	4,000 Rs.	2,000 Rs.	.....
		Amount			.....	.....	.....	3,600 „	3,000 „	6,600 Rs.
	4th Section.	Quantity			16,403	60	0·2 mile.	0·2 mile.	1·2 miles.	1·6 miles.
		Rate			.....	.....	4,750 Rs.	3,500 Rs.	1,800 Rs.	.....
		Amount			.....	.....	950 „	700 „	2,16 „	3,810 Rs.
II.	Kaujalgi West—									
	1st Section.	Quantity			42,093	118	1·8 miles.	.....	0·[illegible] mile.	2·0 miles.
		Rate			.....	.....	6,500 Rs.	.....	2,[illegible]00 Rs.	.....
		Amount			.....	.....	11,700 „	.....	[illegible]00 „	12,200Rs.
	2nd Section.	Quantity			40,973	116	.....	.....	15 miles.	1·5 miles.
		Rate			.....	.....	.....	.....	[illegible],500 Rs.	.....
		Amount			.....	.....	.....	.....	3,750 „	3,750 Rs.
	3rd Section.	Quantity			35,725	106	2·7 miles.	.....	.....	2·7 miles.
		Rate			.....	.....	6,000 Rs.	.....	.....	.....
		Amount			.....	.....	16,200 „	.....	.....	16,200Rs
	4th Section.	Quantity			30,362	96	.....	0·5 mile.	0·1 mile.	0·6 mile.
		Rate			.....	.....	.....	4,500 Rs.	2,250 Rs.	.....
		Amount			.....	.....	.....	2,250 „	225 „	2,475 Rs.
	5th Section.	Quantity			19,251	69	.....	0·2 mile.	0·9 mile.	1·1 miles.
		Rate			.....	.....	.....	3,750 Rs.	1,900 Rs.	.....
		Amount			.....	.....	.....	750 „	1,710 „	2,460 Rs.
III.	Yadwad—									
	1st Section.	Quantity			28,600	92	.....	1·[illegible] miles.	0·2mile.	1·25miles
		Rate			.....	.....	.....	4,[illegible]50 Rs.	2,250 Rs.	.....
		Amount			.....	.....	.....	5,525 „	450 „	5,975 Rs.
	2nd Section.	Quantity			24,786	83	.....	.....	.....	0·7 mile. 0·7 mile.
		Rate			.....	.....	.....	.....	.....	8,300 Rs. .....
		Amount			.....	.....	.....	.....	.....	5,810 „ 5,810 Rs.
	3rd Section.	Quantity			20,159	71	.....	.....	.....	0·9 mile. 0·9 mile.
		Rate			.....	.....	.....	.....	.....	7,500 Rs. .....
		Amount			.....	.....	.....	.....	.....	6,750 „ 6,750 Rs.
	4th Section.	Quantity			15,462	58	.....	.....	.....	3·5 miles. 3·5 miles.
		Rate			.....	.....	.....	.....	.....	7,250 Rs. .....
		Amount			.....	.....	.....	.....	.....	25,375 „ 25,375Rs.
IV.	Kaujalgi East—									
	1st Section.	Quantity			38,861	112	1·5 miles.	.....	2·1 miles.	..... 3·6 miles.
		Rate			.....	.....	6,500 Rs.	.....	2,500 Rs.	....
		Amount			.....	.....	9,750 „	.....	5,250 „	..... 15,000Rs.
	2nd Section.	Quantity			33,658	102	.....	1·1 miles.	1·6 miles.	..... 2·7 miles.
		Rate			.....	.....	.....	4,500 Rs.	2,250 Rs.	....
		Amount			.....	.....	.....	4,950 „	3,600 „	..... 8,550 Rs.
	3rd Section.	Quantity			27,392	89	0·6 mile.	.....	1·2 miles.	..... 1·8 miles.
		Rate			.....	.....	5,500 Rs.	.....	2,250 Rs.	....
		Amount			.....	.....	3,300 „	.....	2,700 „	..... 6,000 Rs.

.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	4,300 Rs.	
3 Nos.	.....	.....	.....	3 Nos.	.....	
880 Rs.	.....	.....	.....	.....	.....	
2,640 „	.....	.....	.....	2,640 Rs	3,065 Rs.	
14 Nos.	.....	1 No.*	.....	15 Nos.	.....	* One drop of 3½ feet.
820 Rs.	.....	730 Rs.	.....	.....	.....	
11,480 „	.....	730 „	.....	12,210 Rs.	18,810 Rs.	
6 Nos.	.....	.....	1 No.†	7 Nos.	.....	† One drop of 2½ feet.
760 Rs.	.....	.....	600 Rs.	.....	.....	
4,560 „	.....	.....	600 „	5,160 Rs.	8,970 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	12,200 Rs.	
4 Nos.	2 Nos.§	2 Nos.‡	1 No.	9 Nos.	.....	§ One drop of 4½ feet and one of 4 feet. ‡ One of 3½ feet and one of 3 feet.
1,116 Rs.	997 Rs.	885 Rs.	745 Rs.	.....	.....	
4,464 „	1,994 „	770 „	745 „	8,973 Rs.	12,723 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	16,200 Rs.	
.....	1 No.	.....	.....	1 No.	.....	
.....	870 Rs.	.....	.....	.....	.....	
.....	870 „	.....	.....	870 Rs.	3,345 Rs.	
9 Nos.††	2 Nos.	1 No.	.....	12 Nos.	.....	†† One drop of 5½ feet and eight of 5 feet.
760 Rs.	680 Rs.	600 Rs.	.....	.....	.....	
6,840 „	1,360 „	600	.....	8,800 Rs.	11,260 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	5,975 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	5,810 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	6,750 Rs.	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	25,375 Rs.	
13 Nos.	.....	.....	.....	13 Nos.	.....	
1,116 Rs.	.....	.....	.....	.....	.....	
14,508 „	.....	.....	.....	14,508 Rs.	29,508 Rs.	
3 Nos.	.....	1 No.	.....	4 Nos.	.....	
970 Rs.	.....	770 Rs.	.....	.....	.....	
2,910 „	.....	770 „	.....	3,680 Rs.	12,230 Rs.	
.....	.....	1 No.	No.	2 Nos.	.....	
.....	.....	700 Rs.	590 Rs.	.....	.....	
.....	.....	700 „	590 „	1,290 Rs.	7,290 Rs.	

IV.	Kanjalgi East—*contd.*									
	4th Section. Quantity	15,772	58	0·5 mile	.....	0·8 mile.	.....	1·3 miles.
	4th Section. Rate	.....	.....	4,750 Rs.	.....	1,800 Rs.	.....	.....
	4th Section. Amount	.....	.....	2,375	.....	1,440 „	.....	3,815 Rs.
	Unsurveyed Distributaries.							
D3a	Taralgeri—							
	Quantity	2,166	13·5	.....	.....	.....	1·5 miles.	1·5 miles.
	Rate	.....	.....	.....	.....	.....	3,300 Rs.	.....
	Amount	.....	.....	.....	.....	.....	4,950 „	4,950 Rs.
D9a	Muglihal—							
	1st Section. Quantity	9,402	37	.....	.....	.....	2·0 miles.	2·0 miles.
	1st Section. Rate	.....	.....	.....	.....	.....	7,500 Rs.	.....
	1st Section. Amount	.....	.....	.....	.....	.....	15,000 „	15,000Rs.
	2nd Section. Quantity	2,848	15	.....	.....	.....	1·5 miles.	1·5 miles.
	2nd Section. Rate	.....	.....	.....	.....	.....	1,850 Rs.	.....
	2nd Section. Amount	.....	.....	.....	.....	.....	2,775 „	2,775 Rs.
D9b	Dasnal—							
	Quantity	2,624	14	.....	.....	.....	0·75 mile	0·75 mile.
	Rate	.....	.....	.....	.....	.....	2,000 Rs.	.....
	Amount	.....	.....	.....	.....	.....	1,500 „	1,500 Rs.
D13a	Belgeri—							
	Quantity	2,010	11	.....	.....	.....	1 mile.	1 mile.
	Rate	.....	.....	.....	.....	.....	2,000 Rs.	.....
	Amount	.....	.....	.....	.....	.....	2,000 „	2,000 Rs.
D16a	Talkatnal—							
	Quantity	1,487	8	.....	.....	.....	1·0 mile.	1·0 mile.
	Rate	.....	.....	.....	.....	.....	1,000 Rs.	.....
	Amount	.....	.....	.....	.....	.....	1,000 „	1,000 Rs.
D20a	Hulkund—							
	Quantity	1,112	7·5	.....	.....	.....	3 miles.	3 miles.
	Rate	.....	.....	.....	.....	.....	3,000 Rs.	.....
	Amount	.....	.....	.....	.....	.....	9,000 „	9,000 Rs.
D20b	Chipalkatti—							
	Quantity	2,412	13	.....	.....	.....	2 miles.	2·0 miles.
	Rate	.....	.....	.....	.....	.....	2,600 Rs.	.....
	Amount	.....	.....	.....	.....	.....	5,200 „	5,200 Rs.
D20c	Husaddipura—							
	Quantity	1,728	9·5	.....	.....	.....	0·75 mile.	0·75 mile.
	Rate	.....	.....	.....	.....	.....	1,400 Rs.	.....
	Amount	.....	.....	.....	.....	.....	1,050 „	1,050 Rs.
D21a	Kunual—							
	Quantity	4,627	22·5	.....	.....	.....	3·0 miles.	3·0 miles.
	Rate	.....	.....	.....	.....	.....	4,500 Rs.	.....
	Amount	.....	.....	.....	.....	.....	13,500 „	13,500Rs.

6 Nos.	1 No.	.....	.....	7 Nos	.....	
710 Rs.	630 Rs.	.....	.....	.....	.....	
4,260 „	630 „	.....	.....	4,890 Rs.	8,705 Rs.	
.....	.....	.....	.....	.....	.....	Rate per mile of unsurveyed distributaries assumed to be roughly proportionate to the estimated cost of surveyed lines of about same command and in similar ground.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	4,950 Rs.	Average rate assumed from cost of 2nd Section of D/3.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	15,000 Rs.	Average rate assumed from cost of 1st Section of D/13.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	2,775 Rs.	Average rate assumed from cost of 4th Section of D/13.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	1,500 Rs.	Average rate assumed from cost of 1st Section of D/11.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	2,000 Rs.	Average rate assumed from cost of 1st Section of D/11.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	1,000 Rs.	Average rate assumed from cost of 3rd Section of D/15.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	9,000 Rs.	3,000 per mile lump sum.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	5,200 Rs.	Average rate assumed from cost of 1st Section of D/11.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	1,050 Rs.	Average rate assumed from cost of 6th Section of D/12.
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	13,500 Rs.	Average rate assumed from cost of 2nd Section of D/22.

D21c	Manami—									
	Quantity		1,638	9	.....	.....	.....	0·5 mile.	0·5 mile.
	Rate		.....	.....	.....	.....	.....	1,800 Rs.	.....
	Amount		.....	.....	.....	.....	.....	900 „	900 Rs.
D21d	Yadwad Sub—									
	Quantity		3,052	16	.....	.....	....	1·5 miles.	1·5 miles.
	Rate		.....	.....	.....	.....	....	3,150 Rs.	.....
	Amount		.....	.....	.....	.....	....	4,725 „	4,725 Rs.
D21e	Yadwad—									
	Quantity		8,737	36	.....	.....	...	5·5 miles.	5·5 miles.
	Rate		.....	.....	.....	.....	....	5,450 Rs.	.....
	Amount		.....	.....	.....	.....	....	29,975 „	29,975Rs.
D21f	Kaujalgi East—									
	Quantity		1,584	8·5	.....	.....	....	0·5 mile.	0·5 mile.
	Rate		.....	.....	.....	.....	....	2,000 Rs.	.....
	Amount		.....	.....	.....	.....	....	1,000 „	1,000 Rs.
D21g	Radarhatti—									
	Quantity		1,625	9	.....	.....	....	0·75 mile.	0·8 mile.
	Rate		.....	.....	.....	.....	....	2,000 Rs.	.....
	Amount		.....	.....	.....	.....	....	1,500 „	1,500 Rs.
D21h	Kulgod South—									
	Quantity		1,626	9	.....	.....	....	1·0 mile.	1·0 mile.
	Rate		.....	.....	.....	.....	....	2,000 Rs.	.....
	Amount		.....	.....	.....	.....	....	2,000 „	2,000 Rs.
D21j	Timapur Sub—									
	Quantity		1,299	7	.....	.....	.....	1·0 mile.	1·0 mile.
	Rate		.....	.....	.....	.....	.....	1,500 Rs.	.....
	Amount		.....	.....	.....	.....	.....	1,500 „	1,500 Rs.
	Branch Distributaries.									
D21b	Manami—									
1st Section.	Quantity		4,595	22·5	.....	.....	.....	2·0 miles.	2·0 miles.
	Rate		.....	.....	.....	.....	.....	2,700 Rs.	.....
	Amount		.....	.....	.....	.....	.....	5,400 „	5,400 Rs.
2nd Section.	Quantity		1,472	8·5	.....	.....	.....	1·0 mile.	1·0 mile.
	Rate		.....	.....	.....	.....	.....	1,750 Rs.	.....
	Amount		.....	.....	.....	.....	.....	1,750 „	1,750 Rs.
D21i	Timapur—									
1st Section.	Quantity		2,930	15	.....	.....	.....	0·4 mile.	0·4 mile.
	Rate		.....	.....	.....	.....	.....	2,000 Rs.	.....
	Amount		.....	.....	.....	.....	.....	8 „	800 Rs.
2nd Section.	Quantity		1,574	8	.....	.....	.....	0·6 mile.	0·6 mile.
	Rate		.....	.....	.....	.....	.....	2,000 Rs.	.....
	Amount		.....	.....	.....	.....	.....	1,200 „	1,200 Rs.

PROJECT YADVAD BRANCH.

of Distributaries and Minors.

Details of Falls.				Total.	Total cost of Distributary or Minor.	Remarks.
Height of fall 5 feet.	Height of fall 4 feet.	Height of fall 3 feet.	Height of fall 2 feet.			
					900 Rs.	Average rate assumed from cost of 1st Section of D/14.
					4,725 Rs.	Average rate assumed from cost of 1st Section of D/23.
					29,975 Rs.	
					1,000 Rs.	Average rate assumed from cost of 1st Section of D/23.
					1,500 Rs.	Average rate assumed from cost of 1st Section of D/23.
					2,000 Rs.	Average rate assumed from cost of 1st Section of D/23.
					1,500 Rs.	
					5,400 Rs.	Average rate assumed from cost of 2nd Section of D/15.
					1,750 Rs.	Average rate assumed from cost of 2nd Section of D/10.
					800 Rs.	Average rate assumed from cost of 3rd Section of D/15.
					1,200 Rs.	

85

P. N. NATESAIYER,

Executive Engineer on Special Duty,

Gokak Survey.

REPORT ON
THE MALPRABHA VALLEY SURVEYS.

CONTENTS.

		PAGES.
1.	Report on the Malprabha Valley Surveys	... 342 to 344
2.	Statements of Rain and River Gauges	... 345 to 347

MALPRABHA VALLEY SURVEYS.

Drawings and Tracings accompanying the Report.

NOTE.—The office in which these plans are recorded is named in the list at page 63 following the Chief Engineer's Review.

No. of Drawing.	Title.	No. of Sheets.	Scale.
1	Tracing of index map showing Storages and Canals.	1	4 miles = 1"
2	Index map of Asoga Storage and Right and Left Bank Canals.	1	1 mile = 1"
3	Plan and longitudinal section of proposed dam line at Asoga.	1	H — 400' / V — 20' } = 1"
4	Plan and longitudinal section of proposed dam line for pick-up weir site.	1	Ditto.
5/1 to 5/2	Contour plans for Malprabha Storage at Asoga ...	2	400' = 1"
6	Longitudinal section of proposed pick-up weir at Manoli (tracing).	1	H — 200' / V — 20' } = 1"

One Topo Sheet No. 305.

INDEX TO
Report on the Malprabha Valley Surveys.

Para.	Subject.
1	Position.
2	History, 1853-1871.
3	1873-1878.
4	Scope of the Special Duty Surveys—Directions given regarding.
5	Surveys for Storage Works.
6	Surveys for Canals.
7	Surveys stopped.
8	Irrigation should not be limited to sugarcane.
9	A Right Bank Canal should be surveyed to command land in the Dharwar District.
10	A weir site might be practicable in the Manoli gorge.
11	A weir or dam site at Torgal.
12	Levels noted.
13	Canal lines.
14	Line from Manoli.
15	Line from Torgal.
16	Conclusions drawn from above.
17	Rain and River Gauges.

REPORT ON THE MALPRABHA VALLEY SURVEYS.

Position.

1. The Malprabha River rises near Chorla Ghat in the south-west corner of the Belgaum District, and joins the Krishna River in Bijapur District, 12 miles before it enters the Nizam's Dominions. The rainfall in the Ghat portion of the catchment is heavy, stations as far as 25 miles from the top of the Ghats receiving an average rainfall of 50 inches.

History—1853-1871.

2. From 1853 to 1871 surveys were made for storage works in the upper reaches of the river near Khanapur. Two tank sites were surveyed, one about 1½ mile above Khanapur and the other at Asoga, the storages obtained with a 100 feet dam being about 5,000 and 3,000 million cubic feet, respectively. Trial lines for a canal were run on the right bank of the river, to discover whether it was practicable to cross the main ridge near Karikatti and deliver water in the valley of the Tupari Nala for cotton irrigation in the Nargund and Navalgund Talukas of the Dharwar District. This did not prove satisfactory, as the initial length of the canal required was found to be more than 90 miles, besides a heavy ridge cutting, before any useful command could be obtained. Canal lines were then run on both banks of the river, immediately below the proposed tank, but this scheme came to nothing as it was thought that with the heavy and secure rainfall in the valley, there would not be sufficient demand for water for irrigation.

Weir sites were also examined at Ramdurg and at Khanapur.

1873-1878.

3. From 1873 to 1878 surveys were made in the lower reaches of the river, and a weir site was examined at Govanki in the Bijapur District, but nothing came of this scheme.

Scope of the Special Duty Surveys.

Directions given regarding—

4. In 1906, work was taken up under the Special Duty Division, the officer in charge of the surveys being directed to examine a site for a storage work at Asoga to hold about 6,000 million cubic feet, and to survey for a right and left bank canal from the tank to irrigate 12,000 acres of sugarcane only.

Surveys.

For storage works.

5. A dam site was selected above the junction of the Malprabha with the Halatur Nala at Asoga, as well as a pick-up weir below the junction.

A base line and 7 cross sections were taken up the valley to Ghodadurg, and from these the capacity of the tank was worked out.

Contours were commenced at R. L. 2240 and 2180 (arbitrary datum), but were left incomplete.

No trial pits were dug, but sheet rock is found plentifully in the river bed at many places above Asoga.

The storage capacity as calculated from the cross-sections is as follows :—

River bed R. L. 2132 above arbitrary datum.

Storage at	R. L.	2200	1,349	million cubic feet.
,,	,,	2220	3,468	,, ,,
,,	,,	2240	6,428	,, ,,
,,	,,	2260	10,364	,, ,,
,,	,,	2280	15,171	,, ,,

For the canals.

6. A contour was run on the left bank with a fall of 1·5 feet per mile for 20 miles, yielding a command of 5,000 acres.

The probable command for an additional length of 70 miles up to the Manol gorge on this bank is reported to be 35,000 acres. On the right bank the old survey was made use of, and the command under 115 miles of contour up to the Manoli gorge is estimated at 65,000 acres, giving a total command of 105,000 acres with 205 miles of contour, which is a very poor result.

Surveys stopped.

7. The surveys were stopped owing to the men being required for work on the Ghatprabha Project, but the Executive Engineer in charge of the work made some investigations in the valley and was able to note the following points for consideration, when any further work is taken up in this valley.

Irrigation should not be limited to sugarcane.

8. From local enquiries the cultivators appear to want water, but it does not appear that 12,000 acres of sugarcane will be irrigated out of a command smaller than 100,000 acres.

A Right Bank Canal should be surveyed to command land in the Dharwar District.

9. As irrigation in the Malprabha Valley itself does not seem promising, further investigations are required to judge whether it will be practicable to construct a canal to skirt round high ridge on the right bank below Ramdurg, and irrigate land in the Nargund and Navalgund Talukas of the Dharwar District.

A weir site might be practicable in the Manoli gorge.

10. From levels shown on topo sheet No. 305, the Manoli gorge might serve as an excellent site for a weir. Some difficulty might be found in dealing with floods off a catchment area of 800 square miles, as the gorge is very narrow.

A weir or dam site at Torgal.

11. A weir or a dam might also be constructed at Torgal, but the damage to property at this site would be very great, as 16 villages and 20,000 acres would be submerged, with a dam 140 feet high to store 25,000 million cubic feet. These figures are very rough and should not be taken as final.

Levels noted.

12. The following levels were noted :—

Lowest level of a house in Gurl-Hosur	R. L.	2075
River bed at gorge, 2 miles above Manoli	,,	1905
River bed opposite Manoli	,,	1899
Lowest level of a house in Manoli	,,	1920
River bed 1 mile above Torgal	,,	1864

Canal lines.

13. Canal lines on the right bank have been roughly drawn on the topo sheet in red pencil from Manoli and in blue pencil from Torgal.

Line from Manoli.

14. The former might command 500,000 acres with a length of 200 miles, but the construction of the line for the first 26 miles up to the Jothall River crossing would be extremely difficult.

Line from Torgal.

15. The latter line presents much the same difficulties, and the practicable command is only 80,000 acres with a length of 85 miles.

Conclusions drawn from the above.

16. In view of the engineering difficulties to be faced, it is doubtful whether any really satisfactory scheme can be worked out for this valley.

A few more surveys would, however, settle this point finally.

Rain and River Gauges.

17. Rain gauges were erected in the catchment area at Kankumbi and Jamboti. The discharge of the river has been gauged at the following stations:—

(1). Asoga ... 1907-1908.

(2*a*). Khanapur 1867-1871.

(2*b*). Khanapur 1907-1908.

(3). Gurl-Hosur 1886-1896.

The discharge at 1 and 2*b* is still being gauged.

The attached statement of the gauge observations at Gurl-Hosur for the period 1886 to 1896, was obtained from the Executive Engineer, Belgaum District. The results were originally entered as cusecs, but are evidently million cubic feet.

H. F. BEALE,

Superintending Engineer.

Statement showing the monthly rainfall at Jamboti for the years 1907-1908.

Months.	1907.	1908.
	Inches.	Inches.
June	20·25	14·60
July	39·77	67·67
August	58·12	26·46
September	8·94	2·02
October	.....	2·38
November	.....	0·06
December	.....	.....
Total ...	127·08	113·19

Statement showing the monthly rainfall at Kurkumbi for the years 1907-1908.

Months.	1907.	1908.
	Inches.	Inches.
June	42·90	4·82
July	76·31	123·38
August	109·69	48·45
September	17·19	7·85
October	1·30	2·55
November	0·27	0·07
December	.....	.....
Total ...	247·66	187·12

Tabular Statement showing Average Discharges per month of the River Malprabha at Gurl-Hosur.

Month.	1886	1887	1888	1889	1890	1891	1892	1393	1894	1895	1896	Remarks.
January	384	237	644	442	537	476	280	641	545	286	374	*Note.*—It may be assumed that these figures represent million cubic feet and not cusecs.
February	182	177	361	310	356	373	145	349	321	166	192	
March	71	83	270	224	221	388	77	369	286	87	109	
April	28	555	417	238	770	316	457	576	1,054	243	108	
May	1,380	147	446	1,134	629	1,096	910	1,121	1,372	214	1,022	
June	5,351	12,440	4,028	12,177	2,313	687	4,730	11,582	9,640	7,716	26,881	
July	28,694	45,758	52,676	23,609	45,895	16,865	39,746	11,752	59,236	19,351	40,703	
August	12,238	9,607	46,256	20,705	26,878	44,621	15,195	22,088	23,906	40,770	101,394	
September	4,241	5,550	12,549	13,611	3,255	6,929	39,386	11,372	5,358	6,271	2,361	
October	6,814	9,583	5,766	28,350	6,261	5,373	9,143	13,101	3,480	10,015	742	
November	1,487	4,399	2,459	3,013	7,360	1,957	5,166	4,484	1,057	990	850	
December	909	1,059	668	936	926	552	1,197	1,217	493	664	398	
Total ...	61,779	89,595	126,540	104,749	95,401	79,633	116,432	78,652	106,757	86,773	175,134	
Average ...	5,148	7,466	10,545	8,729	7,950	6,636	9,703	6,546	8,896	7,231	14,595	

Statement showing the monthly discharges of the River Malprabha at Asoga for the years 1907-1908.

Catchment area, 126 square miles.

Months.	1907.	1908.
		Million cubic feet.
June	Gauge sections incorrectly taken. Discharges could not be worked out.	443
July		13,735
August		6,470
September		874
October		210
November		70
December		41
TOTAL ...		21,843
Run-off in inches		74·63

Statement showing the monthly discharges of the River Malprabha at Khanapur.

Catchment area, 179 square miles.

Months.	1907.	1908.
	Million cubic feet.	Million cubic feet.
January	Monthly totals not given in the discharge statement received from the Executive Engineer on Special Duty,	79
February		48
March		29
April		27
May		5
June		251
July		14,382
August		8,129
September		912
October		143
November		164
December		121
TOTAL ...	32,946	24,290
Run-off in inches	78·51	58·16