Madras. Irrigation Series.
Red Hills Tank Project

NO-J-48

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No. 149. Read the following letter from W. FRASER, Esq., C. E., Special Executive Engineer, to the Secretary to Government, Public Works Department, dated Mount Road, 26th February 1866, No. 50 :—

1. I have the honor to forward my first Report on the Madras Water Works, with one volume of detailed plans, and an abstract of the estimate. I trust that these papers will be found satisfactory.

2. A detailed specification and estimate will be furnished when required. The other volumes are being bound.

3. I send this volume in a deal case, as it is large and easily injured.

FIRST REPORT ON THE MADRAS WATER WORKS

By William Fraser, Esq., C. E.

1. The supplying of Madras with an abundance of pure water is a question which has occupied the attention of the Government for many years; and numerous reports and suggestions have been submitted by professional Engineers and others, either under the direct orders of Government, or from having their attention directed to the subject by the repeated complaints of the gradually increasing impurity of the water drawn from the wells, which, at present, form the only source of supply.

The gradual deterioration of the Madras wells is so notorious that it is unnecessary to enlarge on this part of the subject, for the purpose of establishing the necessity for obtaining a supply of water from some other source. Many reasons have been assigned for this deterioration of the Black Town wells, but there is no occasion to search for obscure causes, when we are familiar with the fact that Madras is built upon a portion of the belt of silicious sand which runs along the Coromandel Coast; and which, in its uncontaminated state, yields, nearly every where, a very pure fresh water. At Black Town and other parts of Madras it has been thickly covered with human habitations, the surface has rarely been in any but a filthy state, and, considering the porous nature of the soil, it is but reasonable to suppose that during every monsoon a portion of the surface impurities is washed down to the water-bearing strata; and there can be no doubt, too, but that the very efforts recently made to keep the town clean by flushing the drains with water from Cochrane's Canal, has hastened the deterioration of the wells; for these drains were too uneven and broken to be successfully flushed, and the diluting of the sewage only enabled the porous sub-soil to absorb it the more readily. The result has been that many of the wells, which were slowly becoming impure, have, of late, rapidly become not only unfit for use but offensive.

2. The troops in Fort Saint George are supplied with water through pipes from the "Seven Wells," which are in an open piece of ground at the north side of Black Town, about two miles from the fort.

The waters of these wells, and of several others throughout Madras been analyzed by Doctor Wyndowe, the Government Chemical Examiner. following copy of his analyses has been kindly placed at my disposal Madras Sanitary Commission.

The work on which Dr. Wyndowe is engaged, "*The Analyses of the of Madras,*" is not yet completed. In writing of the wells of the 1st, 2nd, 4th Police Divisions, he says :—"The results show that, with very few exce "the drinking water in Madras is as bad as it possibly can be. I am also in "that the poorest only make use of these wells for drinking purposes, "obtaining their supply from the few good wells, and paying for the same." remark quite coincides with the result of my own enquiries amongst the those who can afford to do so send for water to the wells north of Tond where the belt of sand has been either not at all, or only partially built upon

Tabular Statement of the results of Analyses of the following Drinking Waters in use at the Presidency, arranged according to the Police Divisions.

Number.	Locality.	Sensible Properties.			Re-action to test Paper.	Solid ingredients in one Imperial Gallon.			Chemical Properties.														Remarks.
		Appearance.	Odour.	Taste.		Organic.	Inorganic.	Total.	Hardness to soap test. Temporary.	Hardness to soap test. Permanent.	Hardness to soap test. Total.	Chlorides determined as Chloride of Sodium in one Imperial Gallon.	Bases in solution by Carbonic Acid. Iron.	Bases in solution by Carbonic Acid. Lime.	Bases in solution by Carbonic Acid. Magnesia.	In solution after boiling. Lime.	In solution after boiling. Magnesia.	In solution after boiling. Chlorides.	In solution after boiling. Sulphates.	In solution after boiling. Nitrates.			
	1st Police Division.					Grains.	Grains.	Grains.															
1	*Well.*—In China Bazaar Street, Monument Esplanade, China Bazaar Tannah.	Not clear from particles of dust, &c., suspended, clear after filtration.	None.	Slightly brackish.	Neutral.	4	79	83	2°	14°	16°	60·21380 grains.	Fair...	Fair...	Fair...	Large	Much above average.	Very large.	Large.	None.			
2	*Well.*—One of the two wells on the North Glacis of the Fort, near the Windmill.	Clear ...	do.	Not unpleasant.	do.	3	75	78	3½°	14°	17½°	52·90630	do.	do.	Above average.	Much above average.	do.	Small.	do.	do.	do.			
3	*Well.*—One of the two wells in Cunnee Covil Street, near the Water Gate Tannah.	do. ...	do.	No particular taste, if any, a very faint brackish taste.	do.	4	60	64	5½°	15°	20½°	40·62970	do.	Average.	do.	Traces.	do.	do.	do.	do.	do.			
4	*Well.*—Inside Darmarajah Covil, Linga Chetty Street, Royapooram Gate Tannah.	do. ...	do.	Agreeable, not unpleasant.	do.	5	62	67	2½°	16°	18½°	40·92200	do.	do.	Average.	Average.	do.	Average.	do.	do.	do.			
5	*Well.*—Thumboo Chetty Street, Royapooram Gate Tannah.	do. ...	do.	Slightly brackish.	do.	4	75	79	3°	16°	19°	52·61400	do.	do.	do.	do	do.	do.	do.	do.	do.			
	2nd Division.																						
1	*Well.*—Old Jail Street, near the Mint Gate Tannah.	do. ...	do.	Agreeable, not brackish.	do.	5	28	33	3½°	7°	10½°	13·10350	do.	A little above average.	Average.	Average.	Little above average.	Traces.	Fair.	Fair.	do.			
2	*Well.*—Googely Bazaar road, in Durmarajah Covil compound.	do. ...	do.	Brackish.	Alkaline.	6	150	156	6°	24°	30°	102·30500	do.	Average.	Considerable.	Above average.	Large.	Much above average.	Very large.	Large.	do.			
3	*Well.*—Narrainen Street... ...	do. ...	do.	Very brackish.	do.	9	242·1	251·1	8°	19°	27°	180·64140	do.	Under average.	do.	Large.	Considerable.	Large.	Considerable.	Very large.	do.			
	Well.—Ramalingen Street, (private property.)	Before & after filtration opaque.	do.	Rather sweetish.	Neutral.	3	27·30	30·3	2½°	8°	10½°	9·06130	do.	Above.	Small average.	Average.	Small average.	Average.	Fair.	Fair.	do.			
	—Old Jail Street, the Cotton Go-wn. (Mr. Barrow's.)	Clear ...	do.	Agreeable, not brackish.	do.	6·5	27·8	34·30	2°	7°	9°	7·30750	do.	Little above average.	do.	do.	do.	do.	do.	do.	do.			
	l.—Seven Wells' treet, Big Parcherry annah.	do. ...	do.	Slightly brackish.	Faintly alkaline.	5	38·3	43·30	5°	10°	15°	22·50710	do.	Under.	Large (not very.)	Little above average.	Large.	Little above average.	Large.	Large.	do.			
	ll.—Within the rracks, east of "Se-n Wells" compound, onegar Choultry Tan-h.	do. ...	do.	do.	do.	7	39·30	46·30	4½°	14°	18½°	21·63120	do.	do.	Fair...	Average.	do.	Average.	do.	do.	do.			

Tabular Statement of the results of Analyses of the following Drinking Waters in use at the Presidency, arranged according to the Police Divisions.

Number.	Locality.	Sensible Properties.			Re-action to test Paper.	Solid ingredients in one Imperial Gallon.			Chemical Properties.															Remarks.
		Appearance	Odour.	Taste.		Organic.	Inorganic.	Total.	Hardness to soap test. Temporary.	Permanent.	Total.	Chlorides determined as Chloride of Sodium in one Imperial Gallon.	Bases in solution by Carbonic Acid. Iron.	Lime.	Magnesia.	In solution after boiling. Lime.	Magnesia.	Chlorides.	Sulphates.	Nitrates.	
	2nd Division—(Concluded).					Grains.	Grains.	Grains.																
8	*Well.*—Googely Bazaar Esplanade, Googely Bazaar Tannah.	Clear ...	None.	Brackish ...	Alkaline.	3	122	125·0	13°	25°	38°	90·90530 grains.	Under.	Very large considerable.	Large.	Considerable.	Above average.	Very large.	Very large.	None.		
	3rd Division.																							
1	*Well.*—Ice House road, West of Hindu burial ground, Ice House Tannah.	do.	do.	Slightly brackish.	Very faintly alkaline.	9	39·00	48·00	5°	18°	23°	21·04560 do.	Average.	Fair.	Small.	Fair.	Much above average. (large)	Large.	Large.	do.		
2	*Well.*—Ice House road, inside the Hindu burial ground.	do. ...	do.	do.	do.	5	31·30	36·30	3°	13°	16°	17·53800 do.	Under.	Average.	Average.	do.	do.	do.	Fair.	Distinct evidence obtained.		
3	*Well.*—Hall's garden, near the Market Tannah.	Before and after filtration opalescent.	do.	Rather sweetish astringent.	Neutral.	4	34·30	38·30	4½°	14°	18½°	19·58450 do.	Average.	Fair.	Small.	do.	Large.	do.	Not too large	None.		
4	*Well.*—Baboo or Bo-Begum street, North gate of Patter's garden, Club-House Tannah.	Clear.	do.	Slightly brackish.	Faintly alkaline.	7	44·30	51·30	8½°	15°	23½°	27·18390 do.	do.	Rather large.	Average.	do.	do.	do.	Rather large.	do.		
5	*Well.*—Soopary Goontah street, Club-House Tannah.	do.	do.	Not unpleasant.	Neutral.		31·30	36·30	3½°	13°	16½°	14·61500 do.	do.	Fair about average.	Small.	do.	do.	Fair.	Fair.	do.		
6	*Well.*—Adjoining the tank in Isan Moolk's garden, south of the Royapettah Police compound.	After filtration clear.	do.	Very faintly brackish.	Faintly alkaline.	5	34·30	39·30	3½°	10°	13½°	22·21480 do.	do.	do.	do.	do.	Fair.	Large.	do.	do.		
7	*Well.*—Wood's road, Patter's garden.	Clear.	do.	Agreeable.	Neutral.	4	24·30	28·30	3½°	9°	12½°	9·93820 do.	do.	do.	Average.	do.	do.	Fair.	Not very large.	do.		
8	*Well.*—Chepauk Palace compound, used by the inhabitants south of Chepauk.	do.	do.	None.	Very faintly alkaline.	4·5	36·30	40·80	6°	12°	18°	19·29180 do.	Small.	Rather large.	Fair above average.	Not too large.	do. above.	Large.	do.	do.		
9	*Well.*—Chepauk Palace compound, used by the inhabitants north of Chepauk.	do.	do.	Rather brackish.	Alkaline.	5	48·30	53·30	5½°	18°	23½°	24·55320 do.	Average.	do.	do.	Large.	Large rather.	do.	Large.	do.		
	4th Division.																							
1	*Well.*—Cabalisparawan Covil Maday Street, Brodie's road, Ayatoray Pillay Tannah, (used by Hindoos only.)	Opalescent both before and after filtration.	Rather muddy.	Earthy like tank water, or water kept in a new pot.	Faintly acid.	2	10·	12	½°	5½°	6°	4·38450 do.	Above.	Under.	Under.	Under.	Little above.	Small.	Average.	do.		

Tabular Statement of the results of Analyses of the following Drinking Waters

Number.	Locality.	Sensible Properties.			Re-action to test Paper.	Solid ingredients in one Imperial Gallon.		
		Appearance.	Odour.	Taste.		Organic.	Inorganic.	Total.
	4th Division.—(Conclud.)					Grains.	Grains.	Grains.
2	*Well.*—In the same locality used by all other castes except Hindoos.	Turbid suspended matters large, iron and alumina, after filtration clear.	Earthy or muddy smell.	Earthy of the unfiltered, of the filtered brisk, pleasant.	Acid.	3	12	15
3	*Well*—Behind Ayatoray Pilliar Covil.	Clear.	None.	None.	Very faintly alkaline.	3	23	26
4	*Well.*—Daberood Dowlah's ground in Coonoor Mothia Moodelly's street, Meer Saib Pettah Tannah.	do.	do.	Faint brackish.	Alkaline.	5	33	38
5	*Well.*—In Abdool Cawder's garden, Cossapet Tannah.	do.	do.	Agreeable, not unpleasant.	Very faintly alkaline.	3	29	32
6	*Well.*—Cundasawmy Moodelly's ground, Peter's road, Royapettah Tannah.	do.	do.	Tasteless.	Faint alkaline.	6	37	43
7	*Well.*—Camalooddeen Saib's garden, Royapet Tannah.	do.	do.	Sharp, very pleasant.	Acid.	4	17	21
8	*Well.*—Mowbray's road, Mowbray Tannah in Rungiah Naik's garden.	Turbid, suspended matters large, clear after filtration.	do.	Earthy, after filtration agreeable.	do.	3	18	21
9	*Well.*—Kistnampett Venkata Rungapillay street, Aroonachella Chetty's ground.	Clear.	do.	Sharp brisk.	do.	4	48	52
10	Do. do. do. in the garden of Parthasarathy's Pagoda.	Opalescent.	do.	Agreeable.	Faintly acid.	6	53	59
11	*Well.*—Edward Elliot's road near its junction with Meeran Saib's street.	do.	do.	None.	Very faint acid.	5	52	57
12	*Well.*—Beemana Moodelly Pettah, Sawmynada Moodelly's ground.	Clear.	do.	do.	do.	5	38	43
13	*Well.*—Vellala Tanampetta Moottiah Moodelly's street, Calatha Moodelly's garden.	do.	do.	Agreeable.	Faintly acid.	5	25·8	30·8
14	*Well.*—Saint George's Cathedral road, in Mr. Sim's compound.	do.	do.	Brackish.	Neutral.	4	61·43	65·43
	5th Division.							
1	*Well.*—Narrain Moodelly's garden near Nungumbaukum Tannah.	do.	do.	Rather brackish.	Faintly alkaline.	5	48	53
2	*Well.*—Nungumbaukum tank road, Nungumbaukum Tannah.	do.	do.	Agreeable.	Neutral.	5·1	29·40	34·5

in use at the Presidency, arranged according to the Police Divisions.

Chemical Properties.													Remarks.
Hardness to soap test.			Chlorides determined as Chloride of Sodium in one Imperial Gallon.	Bases in solution by Carbonic Acid.			In solution after boiling.						
Temporary.	Permanent.	Total.		Iron.	Lime.	Magnesia.	Lime.	Magnesia.	Chlorides.	Sulphates.	Nitrates.		
5°	6°	11°	4·38450 grains.	Large.	Above.	Traces.	Average.	Small.	Small.	Average.	None.		
6°	7½°	13½°	12·27660	do.	Under.	do. large.	Average.	Fair.	Average.	Fair.	Fair.	do.	
4°	17°	21°	17·83030	do.	Average.	Average.	do.	Large.	Little above.	Large.	Large	do.	
7°	11°	18°	12·86120	do.	do.	Large.	do.	Not too large.	do.	Fair.	do.	do.	
6½°	11½°	18°	18·70720	do.	do.	do.	Above.	do.	Large.	Large.	do.	do.	
5°	6½°	11½°	6·13830	do.	do.	Large above.	Average.	Fair.	Average.	Average.	Fair.	do.	
3½°	5°	8½°	8·47670	do.	Above.	About average.	do.	Small. average.	do.	do.	do.	do	
2½°	14°	16½°	24·84550	do.	Large.	Small.	Fair.	Not too large.	Large.	Large.	Large.	do.	
3°	20°	23°	36·82980	do.	Above	Above average.	Above	Large.	do.	Very large.	do.	do.	
3°	17°	20°	34·78370	do.	Much above.	do.	Average.	do.	do.	do.	do.	do.	
5°	10°	15°	16·95340	do.	Average.	Large above.	do.	Fair.	Above average.	Not too large.	Fair.	do.	
4½°	14°	18½°	18·99950	do.	do.	do.	do.	do.	Much above average.	do.	Not very large.	do.	
5°	17°	22°	38·58360	do.	do.	Large.	Little above.	Large	Above	Considerable.	Large.	do.	
5°	15°	20°	27·47620	do.	Under.	do.	Average.	Fair.	Much above average.	Large.	Fair.	do.	
4½°	10°	14½°	20·46100	do.	Small.	Fair.	Small.	Not too large.	Average.	do.	Not too large.	do.	

Tabular Statement of the results of Analyses of the following Drinking Waters from the "Seven Wells" enclosure.

Number.	Locality.	Sensible Properties.			Re-action to test Paper.	Solid ingredients in one Imperial Gallon.			Chemical Properties.										
		Appearance.	Odour.	Taste.		Organic.	Inorganic.	Total.	Hardness to soap test. Temporary.	Permanent.	Total.	Chlorides determined as Chloride of Sodium in one Imperial Gallon.	Bases in solution by Carbonic Acid. Iron.	Lime.	Magnesia.	In solution after b. Lime.	Magnesia.	Chlorides.
1	Well No. I ...	To the unassisted sight, clear, transparent.	Distinct, reminding one of water which has stood some days in a goblet.	There is an absence of that grateful and pleasant briskness that good water should impart to taste.	Perfectly neutral.	7·25	28·90	36·15	3°	11°	14°	12·86 grains.	Traces.	Average quantity.	In quantity rather more than the average of waters.	In rather large quantity.	In rather large quantity.	Shown above quantitatively.
2	Do. ,, II ...	Clear transparent.	Void of ...	Not so fresh as good pure water should be; but in this respect it is better than No. 1.	Decidedly acid, becoming alkaline after boiling some time.	6·90	24·70	31·60	35°	9·5°	13°	11·1 do....	do.	Average in fair quantity.	Rather above the average quantity.	Rather large amount	Rather large amount	Already determined quantity.
3	Do. ,, III ...	Perfectly clear and transparent.	Free from odour.	Has a taste slightly saline.	Decidedly acid in the cold.	5·00	33·00	38·65	3°	10°	13°	14·615 do....	do.	Average.	Average.	Average.	Large	Not determined.
4	Do. ,, IV ..	Clear & transparent.	do. ...	Slightly unpleasant.	Neutral ...	5·90	45·05	59·95	17°	11°	18°	19·461 do....	More than traces.	Large.	do.	do.	Very large.	do.
5	Do. ,, V ...	Clear ...	Not free from.	Not pleasant after swallowing.	Slight acid ...	3·90	19·20	23·10	2°	6°	8°	4·38450 do....	Traces.	Small (average.)	Under average.	do.	Small.	Not determined here.
6	Do. ,, VI ...	do. ...	do. ...	do. ...	do. ...	7·10	26·90	34·00	2°	11½°	13½°	9·35360 do...	do.	do.	do.	Large.	do.	do.
7	Do. ,, VII ...	do. ...	None. ...	Faintly acid ...	Acid	7·85	21·65	29·50	2½°	13°	15°	8·47670= 14·5°	do.	Average.	Traces.	Average.	do.	Not determined.
8	Do. ,, VIII ...	do. ...	do. ...	None.	Neutral ...	6·70	28·30	35·00	3°	12°	15°	9·06130 grains	do.	do.	Small.	do.	do.	do.
9	Do. ,, IX ...	Not clear from numerous minute particles.	Free from ...	Not remarkable ...	Acid ...	5·25	22·95	28·20	3°	15°	145°	9·93820 do.	do.	do.	About average.	Small.	do.	do.
10	Do. ,, X ...	Clear, but impurity still present.	do. ...	Brackish ...	do. ...	5·70	64·40	70·10	9.5°	17°	26·5°	26·95160 do.	do.	Very large.	Rather large above.	Not too large.	Above average.	do.

3. Almost every one who has suggested a plan for supplying Madras with water, more especially the portion lying to the north of the Kuam river, has recommended the use of the Red Hill Lake, as a storage reservoir; but it was not until 1854, when the Government placed the investigation of the subject in the hands of Colonel (then Lieutenant) O'Connell of the Madras Engineers, that plans or sections were prepared. Colonel O'Connell's plans and reports were published in 1855; but no action was taken upon them, and the matter was allowed to drop, until October 1861, when the Municipal Commissioners drew attention to, and recommended a project put forward by Mr. Peter Orr of Madras. The Government in their Proceedings of the 20th December 1861, referred the subject for the consideration of the Public Works Department, and in May 1862, Mr. Roberts, Civil Engineer, was appointed to re-investigate the whole project.

As, with the exception of one trial line of levels, Mr. Roberts confined his observations to the ground previously examined by Colonel O'Connell, it will be sufficient to describe briefly the plan proposed by the latter Officer.

Colonel O'Connell's plan.

4. Colonel O'Connell proposed to put an anicut or dam across the Cortilliar river at Pushali, some distance above the crossing of the Madras Railway, and three or four miles below the Kassavaram dam, which now turns the surplus water of the Cortilliar into the Kuam river. The supply channel, which was to be about 28 miles in length, was, on its course to the Red Hill Lake, to supply the following eight tanks: Senji, Pudumvalungie, Kadambatoor, Puttiloor, Taneerkolam, Pakkam, Palvadee, and Mettanamallee.

After supplying these irrigation tanks the surplus water, for the supply of Madras, was to be stored in the Red Hill Lake, which was to be raised nine feet. An open channel was to convey the water from the lake to two basins in Madras, where it was to be pumped up into settling reservoirs, filtered, and passed into the mains for distribution. No detailed plans of this scheme were prepared.

5. To Colonel O'Connell's plan there are two vital objections, namely, making the storing of water for Madras a secondary matter to that of filling the eight irrigation tanks; and taking off the supply channel from the Cortilliar so close under the Kassavaram dam, which is supposed to turn most of the flood, and all the summer water of the Cortilliar into the Kuam river for the supply of the Chembrambakkam and other tanks. I am aware that Colonel O'Connell did not intend to make the supplying of Madras the secondary question, but it would have come practically to that by the arrangement he adopted. Besides, the quantity of water obtained at that point, would have been insufficient for either purpose.

It was proposed to raise the Red Hill Lake nine feet, but as this was calculated from the crown of the calingulah (surplus weir), it would have been practically only an increase of 4½ feet, as the Mirassidars (land owners) have a right to raise the water, and do so when there is sufficient rain, to the tops of the dam stones which stand 4½ feet above the crown.

Plan now proposed.

6. In a matter so important as that of supplying Madras with water, the extension of irrigation should be considered as of little importance compared with securing an abundant supply for the city, and to accomplish this it is evident that the supply channel should be taken off the river at the lowest point which would give sufficient fall into the storage reservoirs. But it so happens that, in this case, the two objects of water supply and irrigation can be combined without endangering the success of the former; because, between the reservoirs now proposed and the sea there are from 20,000 to 25,000 acres of land lying waste for want of water, and there could be no more convenient places for storing it than Cholavaram and Red Hill Lakes; but by filling them first, the quantity required for Madras is made secure.

7. With these objects in view, I examined frequently and carefully the country between Madras and the Cortilliar, and many trial lines were surveyed and levelled. It was soon ascertained that besides the *Red Hill* another artificial lake,

Cholavaram, could be made available for storage, as it lay in the best line for the supply channel, and was fifteen feet higher than the former.

General design.

8. The general design then, which I now submit, is simply this—*See the portions marked in red on Sheet No.* 1.

I. To place a dam across the Cortilliar at the point marked A., which is just high enough to give a fall of two feet per mile to Cholavaram Lake,

II. To cut a supply channel 8½ miles in length from the dam to Cholavaram Lake.

III. To enlarge this lake by raising its level six yards above the present calingulah or surplus weir.

IV. To connect Cholavaram with the Red Hill Lake by a channel 2¾ miles in length, and with an inclination of three feet in a mile.

V. To enlarge the Red Hill Lake by raising its level to five yards above the present calingulah.

VI. To cut a delivery channel from this lake to the Spur Tank in Madras, a portion of which tank would be converted into the last settling reservoir.

Here we propose to stop for the present. The works connected with the filtering, raising, and distribution of the water will form the subject of another report. The observations for which have been partly made.

Detailed drawings furnished.

9. The volume of plans furnished with this Report contains the following detailed drawings:—

Sheet No. 1.—Index plan, and section, is appended to this Report.
Do. ,, 2.—Plan, longitudinal section, and cross sections of the Cortilliar river, for some distance above and below the site of the proposed anicut.
Do. ,, 3.—Plan showing details of anicut, and head works of supply channel.
Do. ,, 4.—Details of head sluice.
Do. ,, 5.—Plan and longitudinal section, of supply channel.
Do. ,, 6.—Continuation of do.
Do. ,, 7.—Do. do.
Do. ,, 8.—Do. up to Cholavaram Lake.
Do. ,, 9.—Plan, longitudinal section, and cross section of the Katenkal drainage channel.
Do. ,, 10.—Do. do. of the Boosykal drainage channel.
Do. ,, 11.—Details of the proposed aqueduct across the Boosykal.
Do. ,, 12.—Map of Cholavaram Lake, with details of the proposed calingulah or surplus weir.
Do. ,, 13.—*Cholavaram Lake.* Longitudinal and cross sections of the present and proposed bunds.
Do. ,, 14.—Do. Details of head sluice, also design for cart bridges in brick and stone.
Do. ,, 15.—Do. Details of proposed irrigation sluices.
Do. ,, 16.—Plan and longitudinal section of the channel from Cholavaram to the Red Hill Lake.
Do. ,, 17.—Map of the Red Hill Lake.
Do. ,, 18.—*Red Hill Lake.* Longitudinal and cross sections of the bund.
Do. ,, 19.—Do. Cross sections of the bund.
Do. ,, 20.—Do. Detailed plan showing the present calingulah and details of the proposed one.

Sheet No. 21.—*Red Hill Lake.* Details of proposed alterations to Polal irrigation sluice.
Do. ,, 22.—Do. Details of proposed alterations to the northern sluice.
Do. ,, 23.—Do. Plan and details of proposed head sluice.
Do. ,, 24.—*Delivery channel.* Plan and longitudinal section.
Do. ,, 25.—Do. Continued.
Do. ,, 26.—Do. do. up to the Spur Tank in Madras.
Do. ,, 27.—Map and longitudinal section of the Otary nulla, with details of the proposed aqueduct.
Do. ,, 28.—Details of the design for cattle and foot timber bridges on the supply channel.
Do. ,, 29.—Do. of brick cart bridges, and timber foot and cattle bridges on the delivery channel.
Do. ,, 30.—Design for irrigation and drainage under-tunnels.
Do. ,, 31.—Do for culverts for road crossings in Madras.

Quantity of water required for the supply of Madras.

10. The population of Madras is supposed to be about 170,000, but for our purposes we may assume it to be half a million.

It has been generally allowed that for such a class of people 20 gallons a head per day, on the gross population, is a very liberal allowance, this would amount to 21,692,085 cubic yards per annum; but to make allowance for waste, evaporation, special cases of consumption, &c., &c., I propose that forty millions of cubic yards be stored, per annum, for the supply of the city.

Capability of the Cortilliar.

11. Of the capability of the Cortilliar to supply this quantity during average years there can, I think, be no doubt. I have had the river gauged during two monsoons, and have obtained much information regarding its floods from personal observation, and from inquiries amongst those who live upon its banks, and the result is, that at the site of the proposed dam, the average discharged during thirty or forty days of the north-east monsoon within the last ten years, was between four and five hundred millions of cubic yards.*

The floods keep up to their maximum height for four or five days, and run about three feet deep for thirty or forty days more, when the river gradually retires to its small summer channel which runs full all the year round.

The south-west monsoon is scarcely felt in this river.

12. By placing the dam at the lowest possible point we secure the discharge due to 30 miles of the Cortilliar proper, that is, from the proposed dam to the Kasavaram dam, and also that from the Trittani and Nagiri rivers.

The area of the catchment basin of the Cortilliar would be no aid in calculating the quantity of water discharged at any point below the Kasavaram dam, which turns its surplus into the Kuam; besides, the Cortilliar occasionally receives an addition from the Palar river through the Cauverypak tank. The basins of the Trittani and Nagiri rivers, however, discharge their surplus water by the site of the proposed dam, and we must depend principally on them for a constant supply, as they include within their area the greater portion of the Nagiri mountains.

* Note.—The actual result of the observations is 444,842,640 cubic yards; but I consider it unnecessary to perplex the reader with elaborate calculations of this kind.

These basins are about 770 square miles in extent, and over this area the quantity observed to flow through the Cortilliar during the north-east monsoon, would be only 6½ inches in depth, probably not one-fifth of the whole depth which falls upon the Nagiri hills.

Katenkal and Boosykal.

13. It will be observed that the supply channel crosses two drainage streams, the *Katenkal* and the *Boosykal*, which carry to the Cortilliar the surplus waters from a large number of tanks which lie on the north of the railway.

Observations on these channels show that they discharge about 20 millions of cubic yards per annum, and it is proposed to divert them into the supply channel.

Cholavaram and Red Hill Lakes.

14. Cholavaram and Red Hill Lakes were both formed centuries ago, by bunding across valleys surrounded by low hills of laterite rock and gravel.

The Red Hill Lake had formerly a supply channel (see Index Plan), but for many years both lakes have been dependent for their supply on the surface drainage during the monsoons. Each has a calingulah or surplus weir, but the dam stones (stone-uprights built into the weir) enable the land-owners to raise the water; in the case of Cholavaram, 3 feet; and in that of the Red Hill Lake, 4½ feet above the crown of the weir. For eight or ten years past, however, (with the exception of last year,) the water has rarely risen above the level of the weirs.

15. On sheets 12 and 17 in the volume of plans, are actual surveys of these two lakes, and of the adjoining villages, carefully contoured by lines at every yard in height, up to seven or eight yards above the level of their respective calingulahs.

These contours will show the extent to which the surrounding land will be swamped, and the villages affected in each case by the proposed enlargements.

The red contours show the level of the present calingulahs, and the contours shaded red or purple, show the level of the proposed calingulahs.

The following tables show the capacities, areas, and circumferences at each contour:—

CHOLAVARAM LAKE.

Contour 1 yard	Area at each contour in yards.	Area in acres and decimals.	Area in miles and decimals.	Circumference in miles.	Cubical contents between each two contours.	Total cubical contents up to each contour.	Remarks.
8	10,381,220	2144·088	3·35	.....		55,207,929	
					9,873,208		
7	9,368,196	1935·577	3·023	.....		45,334,721	
					8,907,248		
6	8,449,300	1745·072	2·726	9 nearly		36,427,473	Level of proposed calingulah.
					7,958,504		
5	7,467,708	1542·894	2·409	.....		28,468,969	
					6,944,687		
4	6,421,667	1326·790	2·071	.....		21,524,282	
					5,891,049		
3	5,360,431	1107·527	1·729	.....		15,633,233	
					4,948,279		
2	4,536,128	937·216	1·464	.....		10,684,954	
					4,103,623		
1	3,671,118	758·392	1·184	.....		6,581,331	Level of the top of the dam stones.
					3,215,928		
0	2,760,738	570·400	0·890	4·644		3,365,403	Level of calingulah.
					2,397,886		
1	1,935,035	399·800	0·623	.....		967,517	
					967,517		
2	Take half	199·900	0·310	.....			

RED HILL LAKE.

Contour 1 yard each.	Area at each contour in yards.	Area in acres and decimals.	Area in miles and decimals.	Circumference in miles.	Cubical contents between each two contours	Total cubical contents up to each contour.	Remarks.
					Cubic yards.	Cubic yards.	
7	28,594,962	5908·050	9·231	.....		154,061,302	
					27,298,204		
6	26,001,446	5372·200	8·393	.....		126,763,098	Orakadam summit.
					24,781,283		
5	23,567,120	4869·239	7·607	17·333		101,981,815	Seitapet summit and level of proposed calingulah.
					21,580,199		
4	19,599,278	4049·437	6·310	.....		80,401,616	
					18,633,617		
3	17,667,956	3650·404	5·703	.....		61,767,999	
					16,449,949		
2	15,231,942	3147·094	4·917	.....		45,318,050	Soorapodu summit at head sluice.
$1\frac{1}{2}$					13,775,136		
1	12,318,330	2545·109	3·967	.....		38,430,482	Top of dam stones.
					11,065,880		
0	9,813,430	2027·818	3·167	10·767		31,542,914	
					8,587,077		
1	7,360,725	1520·810	2·375	.....		20,477,034	Level of calingulah.
					6,604,515		
2	5,848,306	1212·460	1·893	.....		11,889,957	
					4,340,928		
3	2,833,544	585·442	0·914	.....		5,285,442	
					944,514		
4	$\frac{1}{3}$ to be taken	195·147	0·304	.....		0,904,514	

Height to which the lakes should be raised.

16. It is probable that differences of opinion will exist as to the heights to which these lakes should be raised; but as the water is plentiful, and as there is an abundance of waste land which can be irrigated from these lakes, it seems to be desirable to enlarge them to the fullest extent to which they can be enlarged, without incurring any extraordinary expenditure.

17. It is proposed to raise Cholavaram 18 feet above the crown of the calingulah, because if raised higher it would involve the cost of embanking along a considerable portion of the supply channel.

The Red Hill Lake is proposed to be raised 15 feet above its calingulah, because a greater height would place Cholavaram head sluice inconveniently in back-water, and occasion the cost of constructing a large embankment across the valley at Seitapet, and at one or two other places.

18. The capacity of the two lakes up to these proposed heights is 138,409,288 cubic yards. If from this quantity we deduct the capacity at the level of the dam stones, to which the Mirassidars have a right to raise the water, the difference will be 93,397,475 cubic yards; but if we deduct only the quantity to the level of the calingulahs, beyond which they have rarely had the power to raise the water, the balance will be 114,566,851 cubic yards.

We may safely assume that, in addition to the quantity to which the Mirassidars have a right, we can store 100 millions of cubic yards, leaving 60 millions for irrigation after supplying Madras.

This quantity, it is calculated, will be thrown into the reservoirs in only thirty or forty days of the monsoon, nothing being allowed for the constant run there will be in the summer channel for the greater part of the year; but neither do I take evaporation nor absorption into account, and until we have had experience of the actual working of the reservoirs, I am disposed to let one stand against the other.

19. Most of the waste land under these lakes is of an unusually fruitful character, being, for the most part, alluvial deposit; it is also well suited for irrigation, as it descends in a slightly inclined plane towards the sea.

Area of land that may be irrigated.

20. There are various opinions as to the quantity of water required to bring to maturity an acre of rice, but most people allow that if carefully husbanded it would go much farther than it does. Colonel Sir Arthur Cotton takes 7,000 cubic yards as sufficient, (see "*Public Works of India*," page 171,) and if this be correct, 60 millions of cubic yards would be sufficient for 8,571 acres, which is not one-half of the waste land available.

The general difference between the assessment on dry and wet cultivation in the vicinity of Madras is 5 Rupees an acre, but as the land to which this water could be applied pays nothing now, we may take the increase at 7 Rupees an acre, which on 8,571 acres would amount to nearly 60,000 Rupees a year. If this calculation is even nearly correct, the return on the irrigation part of the project alone would yield a fair per-centage on the entire amount proposed to be expended. I may here mention that of course the irrigation sluices, as well as those on the supply channels, would be under the control of Officers appointed for the purpose, so that the water could not be wasted as it is now.

Proposed works.

21. I now come to the description of the proposed works, and which I shall make as brief as possible.

Anicut or dam on the Cortilliar.

Where the Cortilliar flows between its ordinary banks, its width, at the flood level, is about 500 feet. I propose to put the dam right across, and to make it 600 feet in length, and to raise it to the flood level of the last ten years.

The water may rise nine feet over this height without injury to the lands above, as the banks, either immediate or remote, are high; but the highest flood observed in 1863 and in 1864 if discharged over the dam, would have a depth of only $3\frac{1}{2}$ feet. As this flood, however, was rather under the average, (yielding only 840,000 cubic feet a minute,) and as the Cortilliar is subject to sudden inundations from the breaching of the Kasavaram dam, as happened last year, I consider it best to give a safe length to the dam.*

Site of the dam.

22. The site of the dam was originally fixed lower down the river, but on boring there we found over 40 feet of sand.

This led to an examination of the bed of the river for three or four miles, and the site now proposed was found to be the only place where, *in that distance, the clay approached.*

From what I have seen I believe that, at the present rate of destruction, the jungles will soon disappear altogether from the Nagiri hills, and I believe that one effect of this will be to shorten the period of floods, and to increase the time of minimum discharge, although perhaps the rain-fall may not be seriously diminished.

About seven years ago I drew the attention of the Government to this subject in my reports on the Coimbatore jungles, and I still think that the question is deserving of serious consideration.

The surface: whether this clay underlies all the sand, or is only a stratum within it, I do not know, as we had no means of boring into it, but it is compact and indurated, and is the best foundation we could get. The detailed drawings on sheet No. 3 will show that it is proposed to carry the concrete retaining walls of the dam into this clay substratum.

* Note.—To those acquainted with the phenomena of rivers, the present condition of the Cortilliar, the height of its floods compared with its cross section, &c., &c., must seem abnormal, but this is explained by the fact that the channel is now what it was made many years ago, before its waters were turned into other courses, or tanks upon its tributaries were so numerous as they now are. It is quite evident that within a recent period its floods rose 12 to 15 feet higher than they do now.

This diminution is said by the people, to be caused by the cutting of the jungles from the slopes of the Nagiri hills, and no trees being planted in their stead.

Cortilliar Head Sluice.

23. The general plan of the head sluice is shown on sheet No. 3, and the details on No. 4. The sill of the sluice is to be six feet below the crown of the dam, and ten openings of five feet each in the clear are proposed.

The whole space within the cut waters, and the faces of the openings are to be in dressed gneiss; all the rest of the work, as also the stone work of the dam, to be in laterite.

Supply channel to Cholavaram Lake.

24. On sheets 5, 6, 7, and 8, the detailed plan and section of the supply channel are shown.

The inclination is two feet in a mile. The bottom breadth thirty feet, and the side slopes one and a half to one.

The berms are to be 15 feet each, so as to admit of any future widening if necessary; and the excavated material is to be formed into embankments at the low places.

25. It is unnecessary to give here the calculations by which these dimensions were obtained. I need only state that the channel is intended to supply, at least, 100 millions of cubic yards in about thirty-five days. The dimensions and, of course, the cost would be diminished if a longer time were taken, but I do not think it would be right to estimate for a smaller channel than that now proposed, although the power of a smaller one might be tried for a season or two; for it is only by long experience that we can obtain any actual knowledge of the floods of a river like the Cortilliar, whose principal source is in a mountain country close at hand.

26. The excavation of this channel will be in ordinary soil, with occasional bits through laterite gravel.

In making it out advantage was taken of natural lines of drainage, and it was kept as much as possible out of irrigated or other valuable land.

The Katenkal—See sheet No. 9.

27. This drainage channel is proposed to be crossed on the level; but about 120 yards higher up, the stream will be diverted into the supply channel as shown on sheet No. 9.

The Boosykal—See Nos. 10 and 11.

28. This drainage stream is so low at the place of crossing, and it must be diverted so far up from the supply channel, that it must be crossed by an aqueduct. The general plan and section, and the details of the acqueduct, are shown on sheets Nos. 10 and 11.

Cholavaram Lake—Sheets 12 and 13.

29. The present bund is about one mile in length, and is proposed to be extended and raised as shown on sheets 12 and 13. At the south end the extension will be very short as the ground rises rapidly.

At the north end the extension must be longer, but advantage is taken of the remains of an old bund which, in consequence of a dispute about a supply channel, became disused about 120 years ago.

30. Most of the land to be swamped by the raising of this lake is waste, and is covered with low, scrubby jungle; and even that portion which is under cultivation, either wet or dry, is of very little value, as the soil is poor and the supply of water precarious.

One village, *Allamady*, will be nearly altogether swamped, and must be purchased; but it is of little value.

31. The facilities afforded for the proposed enlargement of the bund are very great.

At both ends the extension will rest upon hills of laterite rock and gravel, from which almost any quantity of material required can be obtained.

Cholavaram Calingulah.

32. The new calingulah is proposed to be placed at the north end, where the extension of the bund runs out in laterite rock; the fall will thus not exceed 3 feet; the details are shown on sheet No. 12.

The length of this calingulah or surplus weir has been fixed at 200 feet.

As the safety of the reservoir and of the country lying under it very much depends on the length of the surplus weir, it is important that it should be accurately determined.

I have ascertained by enquiring amongst the people, that both Cholavaram and Red Hill Lakes have, by a sudden burst of the north-east monsoon, been filled to the level of their calingulahs by twenty-four hours' rain.

Such a heavy rain-fall is of rare occurrence; but as it might happen when the reservoirs were full, we must make ample provision for its discharge. In a matter of this kind the safety of the works must be beyond suspicion.

33. The capacity of Cholavaram Lake to the level of the calingulah is about 3½ millions of cubic yards. The proposed surplus weir would discharge this quantity in 24 hours without allowing the water to rise more than 12 inches over it.

Red Hill Lake Calingulah.

The capacity of the Red Hill Lake to the level of the calingulah is about 20½ millions of cubic yards. The length of the surplus weir proposed for this lake is 400 feet, which would keep the surface down to about 2¾ feet above its own level; but in this case the action of the weir would be aided not only by the two large irrigation sluices, but by the head sluice, which would draw off a large body of water which could be diverted into some of the lower tanks.

Cholavaram Head Sluice.

34. This head sluice is shown on sheet 14. It is to correspond in all respects, except in height, with the head sluice at the Cortilliar.

Cholavaram Irrigation Sluices.

The existing sluices are of a very rude description, and would be too small for the enlarged conditions of the lake. Two new sluices are proposed to be built according to the detailed plan on sheet 15. The head or nut will be worked with a lever not shown on the drawing.

Channel from Cholavaram to Red Hill Lake.

This channel will be 2¾ miles in length, with a fall of three feet per mile. The other dimensions are proposed to be the same as those of the channel from the Cortilliar, as it is desirable that Cholavaram Lake should be drawn from rapidly during the early part of the floods.

The greater part of this channel must be excavated through laterite rock, but this will be rather a convenience, as we shall want the material for building purposes.

Red Hill Lake.

35. The remarks already made about the map of Cholavaram apply to the Red Hill Lake. The length of the present bund is about 3,000 yards, and as there is rapidly rising ground at each end, the extension, consequent on the proposed raising, will be very short.—*See the longitudinal section on sheet* 18. In this case, as in that of Cholavaram, the required material is very convenient, laterite, gravel, and rock being had in the hills at each end of the bund.

Houses at the Red Hills.

36. Some years ago the Red Hill Lake was a favorite retreat for Europeans, and some nine or ten houses were built for their accommodation. The opening of the railway to the Shevaroy Hills and to Bangalore has, however, led to almost the total abandonment of the place, and not one of the houses is, I believe, now tenanted, and some of them are falling into ruin.

Three small ones which are built upon the bund, and four others which are upon a promontory inside the line of bund, will be swamped by the proposed raising of the lake; ample compensation for these houses is included in the estimate. Portions of three or four villages will be swamped, but they are of little value.

Red Hill Lake Irrigation Sluices.

37. There are two very good irrigation sluices in the bund of this tank. Under the altered circumstances of the lake they cannot be worked, with plugs, as they now are; they are therefore proposed to be altered as shown on sheets 21 and 22; the details of the sluice gates will be the same as those of the Cholavaram irrigation sluices.

Reservoir Bunds.

38. The mode of raising the bunds of these two lakes is shown on sheets 13, 18, and 19. The old revetment is proposed to be removed, the old work stepped out where the slope is quick, and the new earth laid in thin layers sloping inwards; a puddle wall, on the lake side, to be carried up at the same time; outside the puddle a layer of gravel and stones, 12 inches thick; and outside that, the stone pitching 18 inches in thickness.

Red Hill Lake Head Sluice.

39. This will be placed in the low bund which must be constructed along the summit at Soorapoddoo tank, at the south-east side of the lake—See sheet 24 for the general position, and sheet 23 for the details of the sluice.

Delivery channel of Madras.

40. On sheets 24, 25, 26, are shown the plan and longitudinal section of the delivery channel to the Spur Tank in Madras. The dimensions of the channel are shown on the section. It is calculated to deliver considerably more than will be required daily for the use of Madras.

Otary Nulla.

41. Where the delivery channel crosses the Otary nulla the banks are very low. It had been proposed to shut up this nulla altogether, but as some land is irrigated from it lower down, I propose to cross it by an aqueduct. A map and longitudinal section of the nulla, and the details of the aqueduct are shown on sheet 27.

Bridges.

42. On the supply channel from the Cortilliar to the Red Hill Lake it is proposed to construct nine cart bridges and five foot and cattle bridges.

The design for the former is shown on sheet No. 14, and that for the latter on sheet 28.

On the delivery channel between the Red Hill Lake and Madras five cart bridges and two foot and cattle bridges are proposed to be erected: the details of these are shown on sheet 29.

For the details of the bridges required in Madras see sheet 31.

Tunnels.

43. On the supply channel two under-tunnels will be required both for irrigation and drainage purposes. The design for these is shown on sheet No. 30. On the delivery channel ten under-tunnels will be required. These will be similar in design, but much smaller than those on the supply channel.

Estimate.

44. The following is an abstract of the estimate for the works enumerated above:—

Abstract Estimate for Madras Water Works.

No.	Description of works.	No.	Amount of each work.	Total.
			RS. A. P.	RS. A. P.
1	Cortilliar anicut	1	30,709 14 0	30,709 14 0
2	Do. head sluice	1	10,928 12 3	10,928 12 3
3	Channel from Cortilliar to Cholavaram Lake	1	75,637 2 1	75,637 2 1
4	Diversion of Katenkal, including dam across channel	1	657 8 0	657 8 0
5	Boosykal aqueduct	1	3,738 8 6	3,738 8 6
6	Do. diversion and dam across channel...	1	3,339 15 0	3,339 15 0
7	Cart bridges for main channel crossings...	6	2,029 10 6	12,177 15 0
8	Foot do. do. do. 3½ feet road-way ..	4	837 10 0	3,350 8 0
9	Irrigation under-sluices do. do. ...	11	1,111 4 9	12,224 4 3
10	Cholavaram Lake bund	1	1,24,515 4 6	1,24,515 4 6
11	Head sluice for supply channel to Red Hill Lake	1	11,121 13 4	11,121 13 4
12	Irrigation sluices to Cholavaram Lake...	2	851 10 0	1,703 4 0
13	Cholavaram Lake calingulah	1	1,411 10 0	1,411 10 0
14	Channel between lakes	1	56,815 3 4	56,815 3 4
15	Cart bridges for supply channel crossings	3	2,029 10 6	6,088 15 6
16	Foot do. do. do. ...	1	837 10 0	837 10 0
17	Irrigation under-sluices do. do. ...	2	1,111 4 9	2,222 9 6
18	Red Hill Lake bund	1	96,791 1 6	96,791 1 6
19	Bunds across the valleys around the Red Hill Lake	3	13,876 8 0 2,911 14 0 704 7 9	17,492 13 9
20	Red Hill Lake irrigation sluices	2	426 1 6 620 7 6	1,046 9 0
21	Do. calingulah	1	2,603 2 0	2,603 2 0
22	Head sluice of delivery channel to Madras	1	2,898 2 1	2,898 2 1
23	Delivery channel to Madras	1	10,497 13 3	10,497 13 3
24	Cart bridges for delivery channel crossings	5	331 11 0	1,658 7 0
25	Foot bridges do. do.	2	251 10 2	503 4 4
26	Irrigation under-sluices for delivery channel crossings	10	832 11 0	8,326 14 0
27	Otary nullah aqueduct	1	1,392 6 6	1,392 6 6
28	Railway culvert	1	... .	.....
29	Poonamallee road bridge	1	742 13 0	742 13 0
30	Road bridge from Aminjicary to Chetput	1	421 11 0	421 11 0
31	Harrington's road culvert	1	594 11 0	594 11 0
32	Nabob's garden culvert	1	421 11 0	421 11 0
33	Macknical's road do.	1	574 9 0	574 9 0
				5,03,446 13 8
	Contingence, superintendence, and sundries	...	.. ..	50,343 2 4
	Compensation for damage to land, &c ...	...	.....	83,140 0 0
	Total estimate ...	...	.....	6,36,930 0 0

Compensation for damage to land.

45. In this estimate is included a sum of 83,140 Rupees for compensation for damage to land, villages, &c. This includes compensation for the houses at the Red Hill Lake.

As regards the land to be swamped by raising the lakes, much of it would still be available for cultivation every year as the water subsided, and the remain-

der would be valuable as pasturage: this would be an important set off against the sum to be paid for damages, but I have not considered it necessary to take it into account.

The Red Hill houses were valued by the Municipal Commissioner's Assessor; the villages and lands by a Revenue Inspector. My own opinion is that if these works are ever carried out, the amount to be paid for compensation for damages will not exceed 60,000 Rupees.

Quality of the Red Hill and Cortilliar water.

46. Dr. Wyndowe has analyzed the water of the Red Hill Lake, and has made the following observations about it:—

Paragraph 3. "As regards sensible properties, the water was free from odour "or taste, but cloudy (even after filtration) from suspended impurities. This no "doubt will subside after some time if the water be left at rest. Chemically "speaking, *this is by far the best specimen of drinking* water I have yet examined in "Madras. The salts are very small in amount, viz., 6·98 grains in one gallon, and "the amount of organic impurity is not great, and would be still further diminished "by care and proper storage.

"The tank abounds in a species of chara; although this plant acts bene-"ficially by precipitating the carbonate of lime, its presence is objectionable by "adding to the organic impurity, and also from its tendency to generate a noxious "gas, which still further deteriorates the water."

47. With regard to these remarks of Dr. Wyndowe I have to observe—

First.—That the italics are mine.

Second.—That the Red Hill Lake is now solely supplied from the surface drainage of the land laying around it.

Third.—That being now comparatively shallow, vegetation is more vigorous than it would be if increased in depth as proposed.

Fourth.—The water which is proposed to be supplied to Madras, is the rain which falls upon the Nagiri hills, which are almost wholly composed of gneiss, and the channels through which it flows consist nearly altogether of pure silicious sand.

48. The grosser particles held in suspension by the water would be deposited in Cholavaram Lake, the finer particles in the Red Hill Lake, so that water comparatively pure would be delivered to the Spur Tank, where it would pass through properly prepared filter beds into the pure water basin, which would be covered in from light and dust. From this basin, which would hold three or four days' supply, the water would pass to the pump well, placed at some central point where it would be raised, probably into an elevated cistern, and thence distributed, through iron pipes, to the several parts of the city.

Taking into account the purity of the source from which the water would be drawn, the process sketched above would probably give to Madras a purer water than is supplied to any city in the world.

49. The works, if gone about actively, might be completed in two years.

No. 150. Minute by the Honorable the President.
(Here enter 5th March 1866.)

No. 151. Minute by the Honorable T. PYCROFT.
(Here enter 5th March 1866.)

No. 152. Minute by the Honorable H. D. PHILLIPS.
(Here enter 5th March 1866.)

13.

No. 153. ORDER THEREON, 11th April 1866, No. 1,102.

CIVIL WORKS, No. 24.

1. Attention has long been directed to the Red Hill Lake as the source from which an ample supply of wholesome water might be derived for the use of the Town of Madras, and Lieutenant (now Lieutenant-Colonel) O'Connell of the Royal Engineers having been deputed to investigate the subject, submitted a report with plans and estimates in 1855, showing that the scheme was perfectly feasible of execution at a cost of Rs. 43,39,476. No action was, however, taken on his proposals, nor on those subsequently put forward by other parties, till Mr. Fraser, Civil Engineer, suggested the probability of improving upon Colonel O'Connell's designs, and was forthwith directed to undertake the re-investigation of the whole project.

2nd July 1863, No. 1,741.

2. His scheme consists of—

		RS.	A.	P.
I.	The construction of a dam across the Cortilliar...	30,709	14	0
II.	The construction of a channel with head and other sluices, bridges, and all requisite works from the anicut to the Cholaveram tank, a distance of 8½ miles	1,22,054	9	1
III.	The enlargement of the capacity of this tank by raising its bund six yards	1,38,751	15	10
IV.	The construction of a channel with sluices, bridges, &c., from the Cholaveram to the Red Hill Tank, 2¾ miles in length.	65,964	6	4
V.	The enlargement of the capacity of this tank by raising its bund five yards...	1,17,933	10	3
VI.	The construction of a channel with its sluices, accommodation bridges, &c., from the Red Hill Tank to the Spur Tank in Madras	28,032	6	2
	Sundries, compensation for lands and houses, superintendence, &c.	1,33,483	2	4
		6,36,930	0	0

3. Mr. Fraser shows clearly that instead of taking off the head of supply from the Cortilliar at Pushali, a distance of 28 miles from the Red Hills, and raising the bund of the tank at that place only nine feet as proposed by Colonel O'Connell, it will be better to place the anicut across the Cortilliar much lower down at a spot about 12 miles from the Red Hills, and having an elevation just sufficient to give an average fall per mile of from two to three feet.

4. The advantages of this site for the anicut are, that the discharge due to the greatest possible length of the Cortilliar below the Kasaveram dam, which turns all the ordinary freshes of that river into the Cooum, is gained; that it is situated below the confluence of the Trittani and Nagari rivers, which are streams draining large tracts of a hilly wooded country, and therefore to be relied on; and that the natural configuration of the country favors the excavation of a channel in the required direction, filling, in its course to the Red Hill Tank, an intermediate reservoir at Cholaveram, the capacity of which, as well as of the Red Hill Tank, could be readily enlarged to the required extent by raising the bund of the former six yards, and of the latter five yards.

5. The works, so far as they are now laid before Government, appear to be projected in a careful manner, and the Government have no doubt of their perfect practicability. The anicut across the Cortilliar, 600 feet in length, will not differ from other works of the kind which have been successfully constructed in this Presidency, and no difficulty seems likely to beset the execution of the other portions of the proposed scheme.

6. By the enlargement of the two tanks in which Mr. Fraser proposes to store the water conveyed into them by a channel from the Cortilliar, he calculates that their joint capacity will be in round numbers 140 millions of cubic yards. Of this quantity the Meerassidars owning exisiting wet lands have a right to about 40 millions of cubic yards, leaving for the supply of Madras, and for extension of wet cultivation, 100 millions of cubic yards. Assuming the population of Madras to be half a million, and allowing each individual twenty gallons per day, the total quantity required for the use of the population will be less than 22 millions of cubic yards, and, making all allowances, there seems no reason to doubt that if 40 millions be reserved for Madras, an ample residue would remain for distribution for increasing the area of wet cultivation under the two tanks. Mr. Fraser states that there are from 20,000 to 25,000 acres of suitable waste land that might be irrigated between Cholaveram and Madras, and he shows that if the 60 millions of cubic yards of water, which will be available after reserving 40 millions for Madras, are used for irrigation, they will suffice for between 8,000 and 9,000 acres, and yield a return of some Rupees 60,000 per annum.

7. The Government do not question the correctness of these calculations, and as, by actual close observation of the Cortilliar during the three years in which he has been engaged on his investigations, Mr. Fraser has ascertained that the quantity of water which is required will be readily obtained from that river during the 30 or 40 days that it is filled by the north-east monsoon, without taking into consideration the much longer periods that a diminished stream continues to flow, the Government are satisfied that, as far as can be judged without detailed specifications and estimates, the project will prove a remunerative one, irrespective of its value as a means of improving the comfort and sanitary condition of the inhabitants of Madras.

8. If the cost of the works be taken at seven lacs of Rupees, instead of the Rupees 6,36,930 estimated by Mr. Fraser, the interest on the outlay will be Rs. 35,000 per annum, or Rupees 25,000 less than the revenue to be derived from irrigation by the surplus water stored in the two tanks. As an irrigation project, therefore, the portion of the scheme now brought under the consideration of Government is likely to be very profitable; and the works remaining to be designed and estimated being the least expensive and at the same time the most remunerative, it is very desirable that, by carrying out what is now ready for execution, the Government should be able to secure a balance of returns with which to meet the interest of such monies as it may be necessary to raise to complete the scheme for providing a full supply of water to the inhabitants of Madras.

9. Mr. Fraser will lose no time in submitting the detailed specifications and estimates, and, on their receipt, His Excellency in Council will propose to the Government of India and the Secretary of State, that the money required for carrying out the works should be borrowed on the responsibility of Government, with a view to the works being given out on contract, and completed as rapidly as possible.

10. Mr. Fraser will be requested also to expedite the preparation of the remainder of the project in communication with Captain Tulloch, and to submit as early as practicable that portion of the general scheme which provides for the supply of water to the Southern Districts of Madras from the Adyar and the Cooum, as well as for the formation of a high level canal to connect these rivers and the Northern and Southern Coast Canals.

(True Extract.)

(Signed) CHARLES A. ORR, Colonel, R. E.,
Secretary to Government.

To W. Fraser, Esq., Special Executive Engineer.
,, Captain H. Tulloch, R. E.,
To the Superintending Engineer, 4th Division.

14

PUBLIC WORKS DEPARTMENT,
FORT SAINT GEORGE,
30th April 1866.

No. 728.

No. 1,376.

To

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

SIR,

ACCOUNT, No. 103.

1. I am directed by the Governor in Council to acknowledge the receipt of your letter No. 344 A, dated 27th March 1866, communicating the orders of the Government of India on the Public Works Budget Estimate for 1866-67.

2. On full consideration, this Government have resolved, subject to the approval of the Government of India, on appropriating the additional sum of Rupees 1,10,800 which is made available in paragraphs 3, 13, and 19 to the project for the storage of water in the Sholaveram and Red Hill tanks, with a view of increasing the capacity of those reservoirs for irrigation, as well as of providing the city of Madras, its garrison and public establishments, with an abundant and wholesome supply of water, according to the plans and estimates which have been prepared in full detail by Mr. Fraser, Civil Engineer, and have recently received the approval of this Government.

3. The Government think it scarcely necessary to urge the expediency of the immediate execution of a project which, so far as it is now proposed to carry it out, being a complete and promising irrigation work, similar in all respects to many of those which have proved so highly remunerative in this Presidency, is likewise of much value in a sanitary point of view, as it will, when completed, provide a source from whence an abundant supply of wholesome water will be procurable for distribution to Madras. It is probably known to the Government of India that Madras is exclusively supplied with water from wells; that the progressive deterioration of the water thence obtained has been attested by popular experience and official analysis, and that its impurity has formed for some time a very serious cause of complaint on the part not only of the general public, but also of the Military and Sanitary authorities, and of the Medical Officers in whose charge the health of the Troops in garrison is placed. The cause of that deterioration is readily traceable to the percolation into the springs of the decomposed animal and vegetable organic matters with which the earth overlying the water-bearing strata is saturated; and, as that deterioration can only be arrested by sanitary works for improving drainage and disposing of sewage at a cost which appears at present beyond the means of the Government or the Municipality, there is little hope of the quality of the water in the wells being improved. Even could it be restored to its former purity, the quantity of it raised and distributed by a laborious and costly process would still be insufficient for cleanliness and salubrity, and the introduction of a free flow of wholesome water from the country is therefore admitted to be the one indispensable basis of sanitary improvement for Madras.

4. Fortunately the remedy is easily accessible. Successive surveys have shown the perfect practicability of collecting the rain-fall in the river basins adjacent to Madras, by diverting it, by means of a dam across the river Cortilliar, into existing tanks, and there, by the enlargement of their embankments, storing it in ample quantities for the extension of irrigation to a large area of land which is conveniently situated for wet cultivation, leaving a sufficient residue for conveyance into Madras, in readiness for distribution hereafter throughout the city. The plans for carrying this into effect originated with the investigations of Colonel O'Connell, and, after revision by subsequent projectors, have now been remodelled on such a scale as to render the execution of the necessary works both easy and comparatively inexpensive.

5. Mr. Fraser's scheme may be thus briefly described:—

		Rs.	A.	P.
I.	The construction of a dam across the Cortilliar	30,709	14	0
II.	The construction of a channel with head and other sluices, bridges and all requisite works, from the anicut to the Cholaveram tank, a distance of 8½ miles...	1,22,054	9	1
III.	The enlargement of the capacity of this tank by raising its bund six yards	1,38,751	15	10
IV.	The construction of a channel with sluices, bridges, &c., from the Cholaveram to the Red Hill tank, 2¾ miles in length...	65,964	6	4
V.	The enlargement of the capacity of this tank by raising its bund five yards	1,17,933	10	3
VI.	The construction of a channel with its sluices, accommodation bridges, &c., from the Red Hill tank to the Spur tank in Madras	28,032	6	2
	Sundries, compensation for lands and houses, superintendence, &c. ...	1,33,483	2	4
		6,36,930	0	0

6. It will be observed that the scheme contemplates the collection and storage of sufficient water for the irrigation of between 8 and 9,000 acres of waste land which is susceptible of being improved to yield an assessment which, though calculated by Mr. Fraser at 7 Rupees, may, in the opinion of this Government, range considerably higher, owing to the proximity of the lands to the Presidency, and yield a return considerably in excess of the 60,000 Rupees at which it has been computed by Mr. Fraser. As an irrigation work alone the returns expected from it will pay a high interest on the 6,36,000 Rupees which it is estimated to cost, leaving a broad margin to be carried to a fund for the re-payment of the capital expended, should it be found desirable, under the recent resolution of the Government of India, to complete the scheme by means of borrowed monies. But as the design further contemplates the delivery of a quantity of water, at a point situated in the Northern District of Madras, sufficient for distribution throughout the city and for the consumption of all its inhabitants, and as water so used must necessarily be more valuable than when applied to the land, the revenue that may be derived from the quantity thus disposed of will ultimately largely supplement the returns. Seeing then that, whether viewed solely as an irrigation work or in its combined character of a very beneficial agricultural and sanitary, as well as a Municipal improvement, it will be very remunerative, the Government are of opinion that the enterprize has been too long delayed, and that the opportunity which is now afforded should not be lost in making a commencement with it.

7. It may be assumed that neither the Home Government nor public opinion will suffer the establishments of Madras to go on much longer without an improved supply of drinking water, even if the Local Government were indifferent to the necessities of those establishments. The Fort, the General Hospital, the Prisons, the Infirmaries, the Asylums, and other Institutions must sooner or later

be furnished with subterranean tanks for storing roof water, after the system adopted at Malta, if water be not introduced from the country. The cost of constructing such a tank for the Fort alone will probably be about Rupees 1,00,000, and the whole expenditure involved in carrying out this system would perhaps equal or exceed the cost of the project now submitted; and it must be remembered that the subterranean tank system is only applicable to drinking water, that it is restricted in amount, uncertain, unprofitable for the land, and unproductive, while the water supply from the country will be abundant for all purposes, reliable, beneficial to the land, and remunerative. The prompt commencement of the work under discussion may therefore prevent other demands and save a wasteful expenditure.

8. On all considerations, financial as well as sanitary, the Government are satisfied that the additional grant of Rupees 1,10,800 which has been placed at their disposal cannot be better applied than in the manner they propose, and, in now transmitting a complete set of plans, with an abstract of the estimate of the work to which they think the money should be appropriated, for the sanction of the Government of India, I am directed to state that all outlay from the beginning will be so arranged as to provide for the execution of the works in such a manner as to bring them into profitable operation in the shortest possible time solely as an irrigational undertaking complete in all respects in itself. Beginning with the construction of the dam across the Cortilliar river, the excavation of the channel to connect it with the nearest tank at Sholaveram, and of its continuation to the Red Hill tank will be simultaneously put in hand. The masonry head works, and those required to pass the channel across drainages, &c., will be furnished as speedily as practicable, and every endeavour will be made to complete the means of diverting improved supplies of water into the two tanks, and thereby increasing cultivation to such an extent under them at once as to obtain immediate returns from the very first outlay.

9. Adverting to paragraph 18 of the Budget Orders, I am to state that there has been no actual increase in the sanctioned Establishments of the Secretariat, the two Clerks referred to by the Government of India having been transferred, with the correspondence of the Railway Branch, from the Departments under the Chief Secretary to the Public Works Department from the 1st October 1865.

10. The item "Public Works Store Purchase," Rupees 30,000, noticed in paragraph 25, represents charges to be incurred by the Public Works Store Department at Madras on account of landing, shipping, setting up and repairing machinery, and in the purchase of articles for store purposes which may be required during the year. The Officer in charge of the Store Department has been requested to provide for these charges, in future estimates, under the proper heads.

11. With reference to paragraph 26, I am to state that, of the sum of Rupees 11,290 which is provided in Part VI. of the Budget on account of the establishments to be employed in making over land to the Madras Irrigation and Canal Company, no less than Rupees 10,130 appertain to the Kurnool District. From the accompanying Proceedings in the Revenue Department, No. 371, dated 12th February 1866, it will be seen that on the Collector's urgent representation of his inability, without special assistance, to accomplish the duties that devolve upon him owing to the increase of work occasioned by the Company's operations, this Government have consented to the continued employment in Kurnool of the additional Deputy Collector until further orders. As regards the Surveyor who is employed under

the Deputy Collector, I am to draw the attention of the Government of India to their Proceedings in the Financial Department, No. 843, dated 19th February 1861, conveying sanction to the entertainment of a subordinate of that class for a period of two years. The sums provided for the Cuddapah and Nellore Districts are very small; but, if possible, a reduction of the establishments engaged in making over land to the Company will be effected during the year.

12. Paragraphs 7, 8, 10, 11, and 30 of the Orders of the Government of India will be separately replied to. I am, however, here to state that the plans and estimates for the Lawrence Asylum buildings are under revision, but that they will be submitted to the Government of India at an early date.

13. I am to add that the Local Fund Budget Estimate of this Presidency for the year 1866-67 was transmitted with my letter, No. 1,065, dated 7th April 1866.

I have the honor to be,

Sir,

Your most obedient servant,

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

Secretary to Government.

Exd. T. O'Connor.

16

SHEET N° 2.

CROSS SECTION N° VII

Highest Flood during the last ten years

High Flood of 1853

Horizontal Scale 300 Feet to an Inch.

Vertical Scale 50 Feet to an Inch.

CROSS SECTION. N° IX.

Highest Flood during the last 10 Years.

High Flood of 1853

50 Feet above Datum.

Datum.

DRAWN BY H.R. CALDER T. DENT & J. SUARES. LITH. BY R.J. HALDREY.

MADRAS WATER WORKS.

DESIGN FOR THE ANNICUT AT THE CORTELIAR.

SEE Nº2 GENERAL PLAN.

FIG. Nº I.

FIG. Nº II.
CROSS SECTION OF ANNICUT A.B.

FIG. Nº III.
CROSS SECTION C.D.

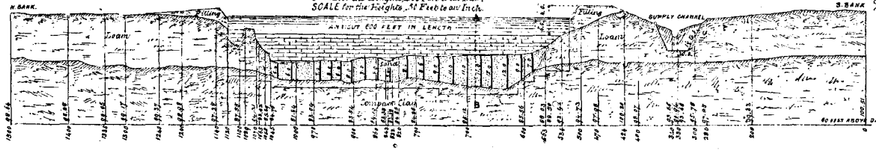
FIG. Nº IV.
CROSS SECTION E.F.

FIG. Nº V.
CROSS SECTION G.H.

FIG. Nº VI.
CROSS SECTION I.K.

Scale for Fig. 1
100 Feet to an Inch.
Scale for Figs. 2.3.4.5.6.
25 Feet to an Inch.

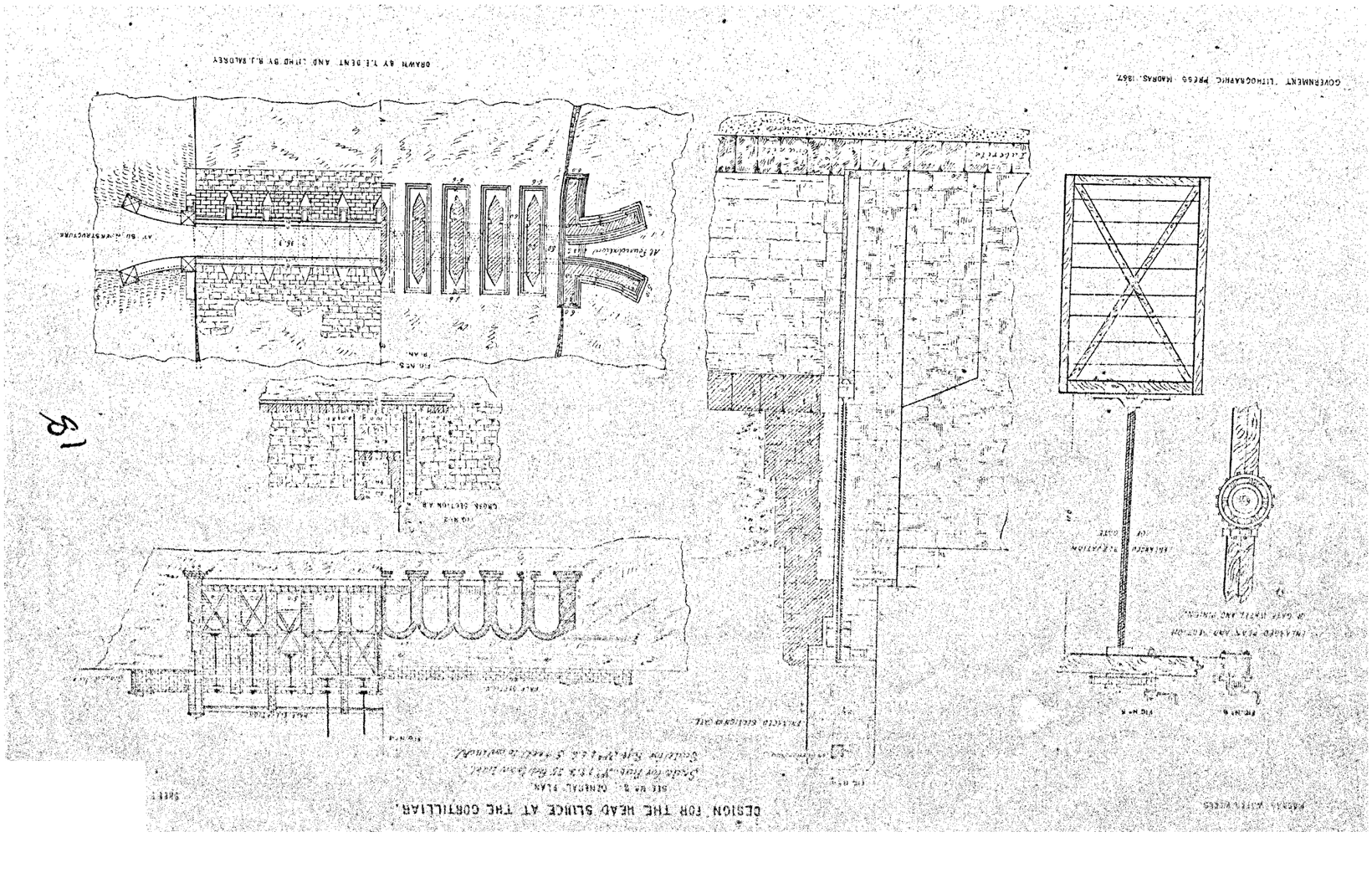
FIG. Nº VII.
CROSS SECTION OF THE CORTELIAR AT THE SITE OF THE ANNICUT
SCALE for the Lengths 250 Feet to an Inch.
SCALE for the Heights 25 Feet to an Inch.



N.B. The heavy black lines on the above Section, indicate the borings that were made to ascertain the nature of the River Bed, as regards the suitability for Foundation.

GOVERNMENT LITHOGRAPHIC PRESS MADRAS 1867.

DRAWN BY H.R.GALLIER AND LITHº BY R.J. BALDREY.


DESIGN FOR THE HEAD SLUICE AT THE CORTTALLAR.
SHEET 1
DRAWN BY T.E.DENT AND LITHO BY R.J.BADDELEY
GOVERNMENT LITHOGRAPHIC PRESS MADRAS 1867

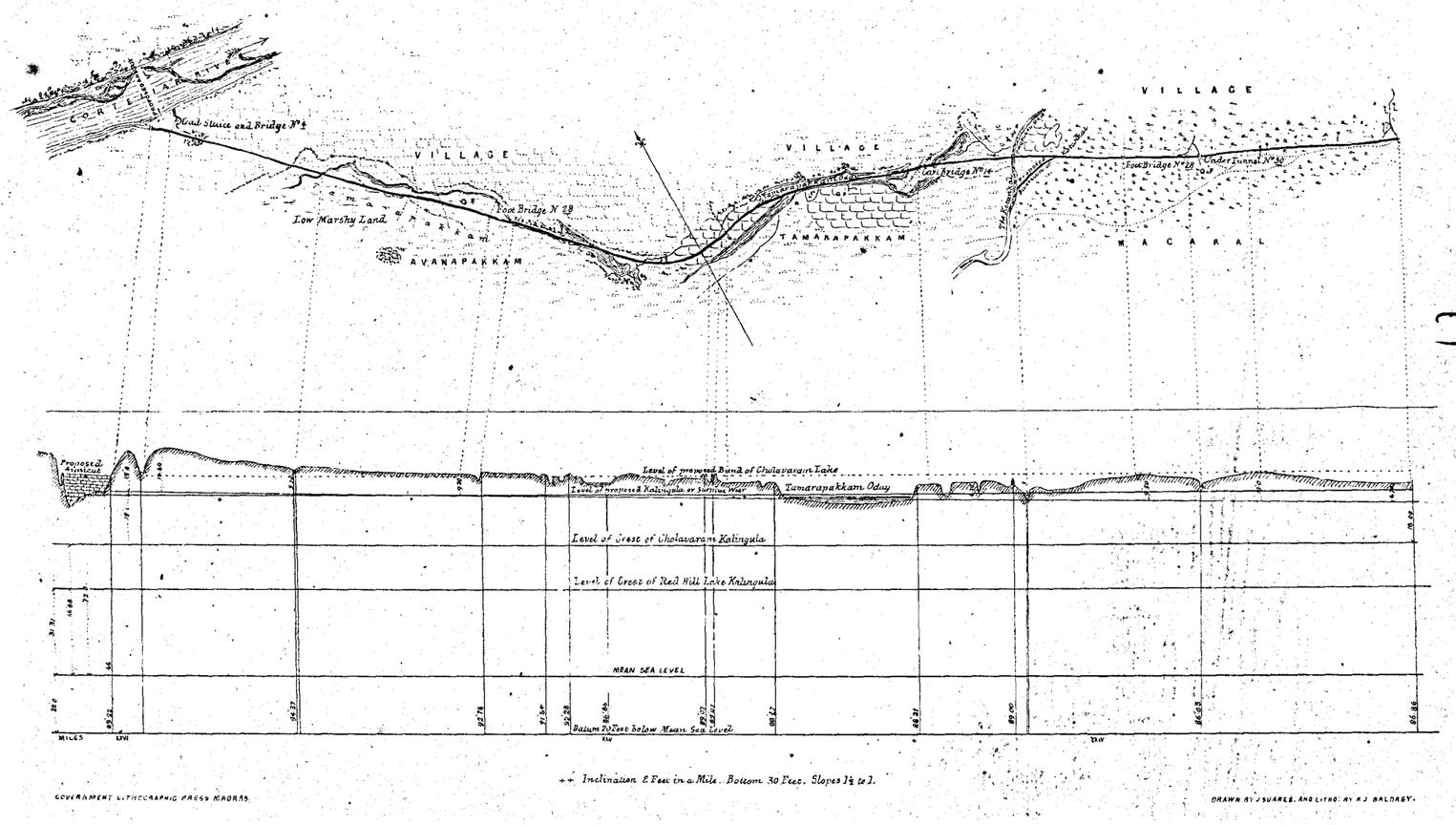
MADRAS WATER WORKS.

PLAN AND SECTION OF SUPPLY CHANNEL.

SHEET Nº 5.

SCALE for the Plan and Lengths of the Section - 1500 Feet to an Inch.
SCALE - for the Heights of the Section - 50 Feet to an Inch.

The numbers underlined refer to those of the Sheets containing the detailed Plans



++ Inclination 2 Feet in a Mile. Bottom 30 Feet. Slopes 1½ to 1.

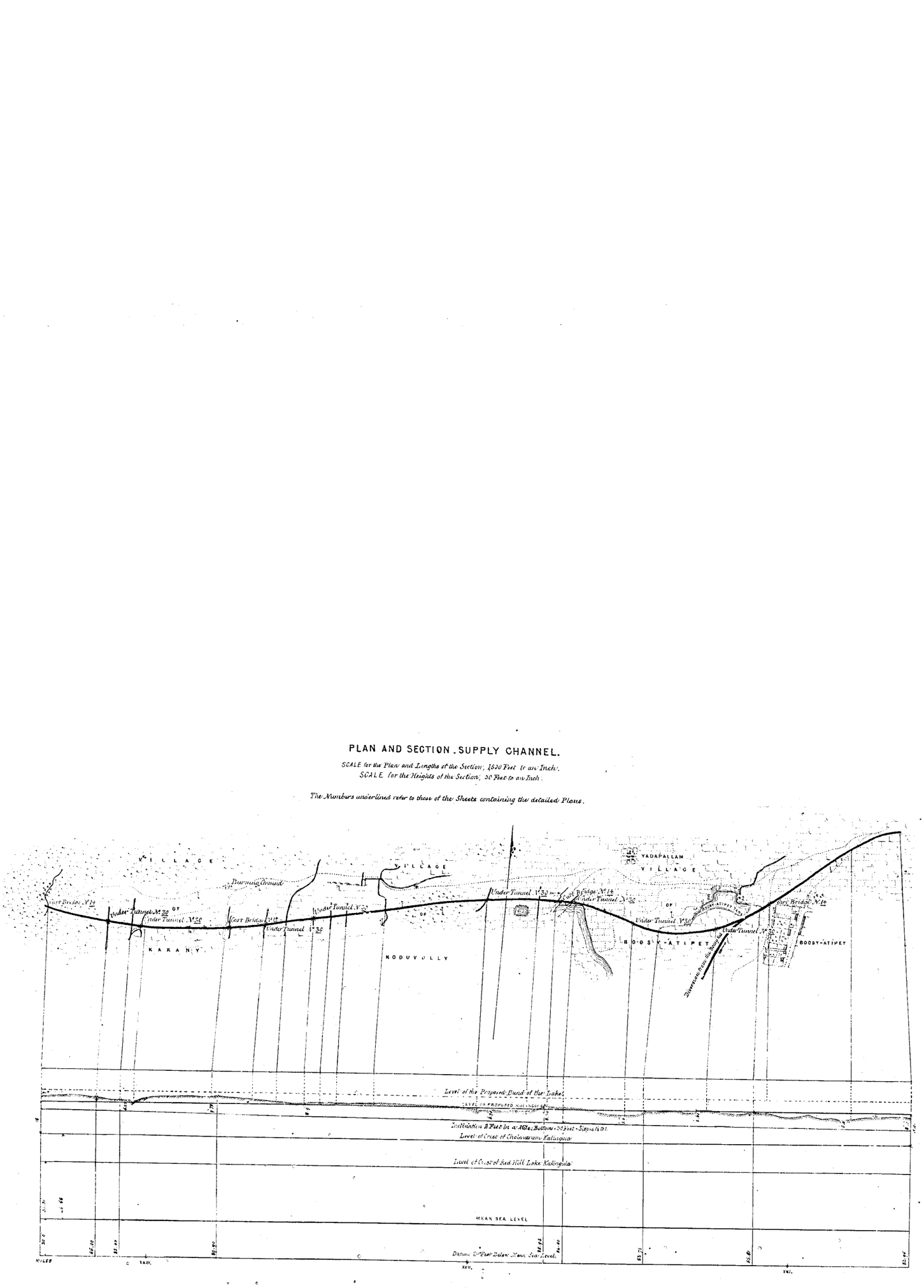
GOVERNMENT LITHOGRAPHIC PRESS MADRAS.

DRAWN BY J SUARES. AND LITHO: BY R J BALDAEY.

PLAN AND SECTION. SUPPLY CHANNEL.

SCALE for the Plan and Lengths of the Section; 1320 Feet to an Inch.
SCALE for the Heights of the Section; 30 Feet to an Inch.

The Numbers underlined refer to those of the Sheets containing the detailed Plans.



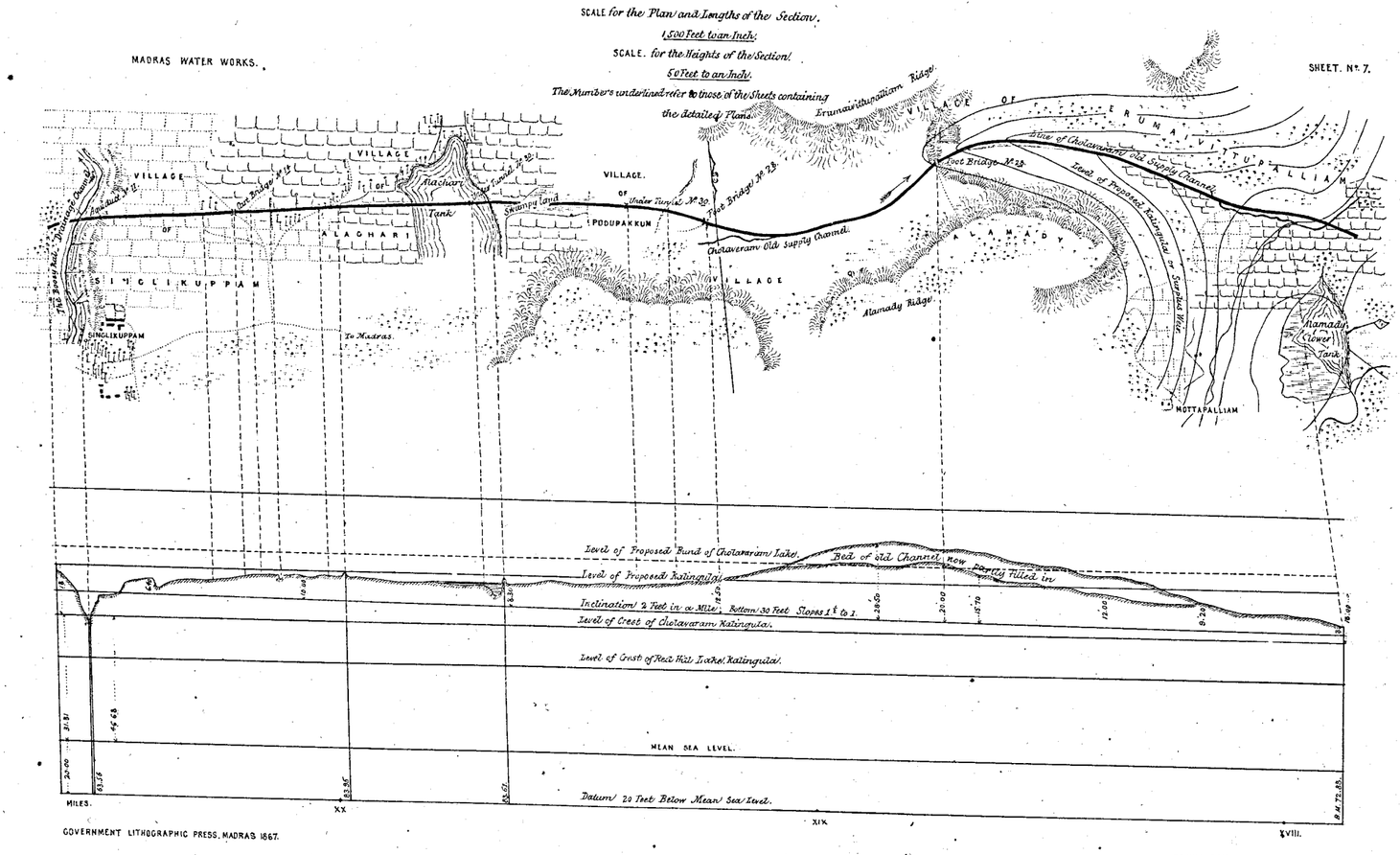
20

PLAN AND SECTION . SUPPLY CHANNEL

SCALE for the Plan and Lengths of the Section.
1,500 Feet to an Inch.
SCALE. for the Heights of the Section.
50 Feet to an Inch.
The Numbers underlined refer to those of the Sheets containing the detailed Plans.

MADRAS WATER WORKS.

SHEET. No. 7.



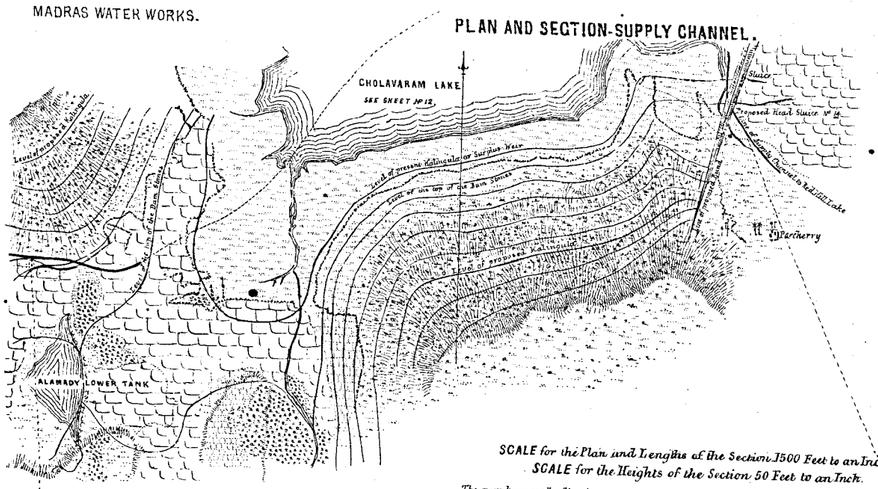
GOVERNMENT LITHOGRAPHIC PRESS, MADRAS 1867.

DRAWN BY T. E. DENT, LITH BY J. DUMPHY.

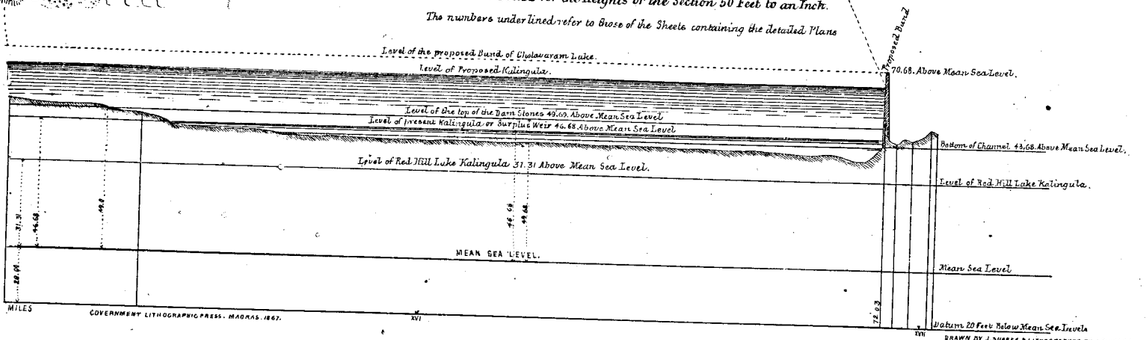
MADRAS WATER WORKS.

PLAN AND SECTION-SUPPLY CHANNEL.

SHEET No 8



SCALE for the Plan and Lengths of the Section 1500 Feet to an Inch.
SCALE for the Heights of the Section 50 Feet to an Inch.
The numbers underlined refer to those of the Sheets containing the detailed Plans



GOVERNMENT LITHOGRAPHIC PRESS - MADRAS 1867.

DRAWN BY J. DUMPHY. LITHOGRAPHED BY J. DUMPHY.

SCALE for the Heights of the Longitudinal Section
20 Feet to an Inch.

SCALE for Fig. 3. 25 Feet to an Inch.

GOVERNMENT LITHOGRAPHIC PRESS, MADRAS 1867.

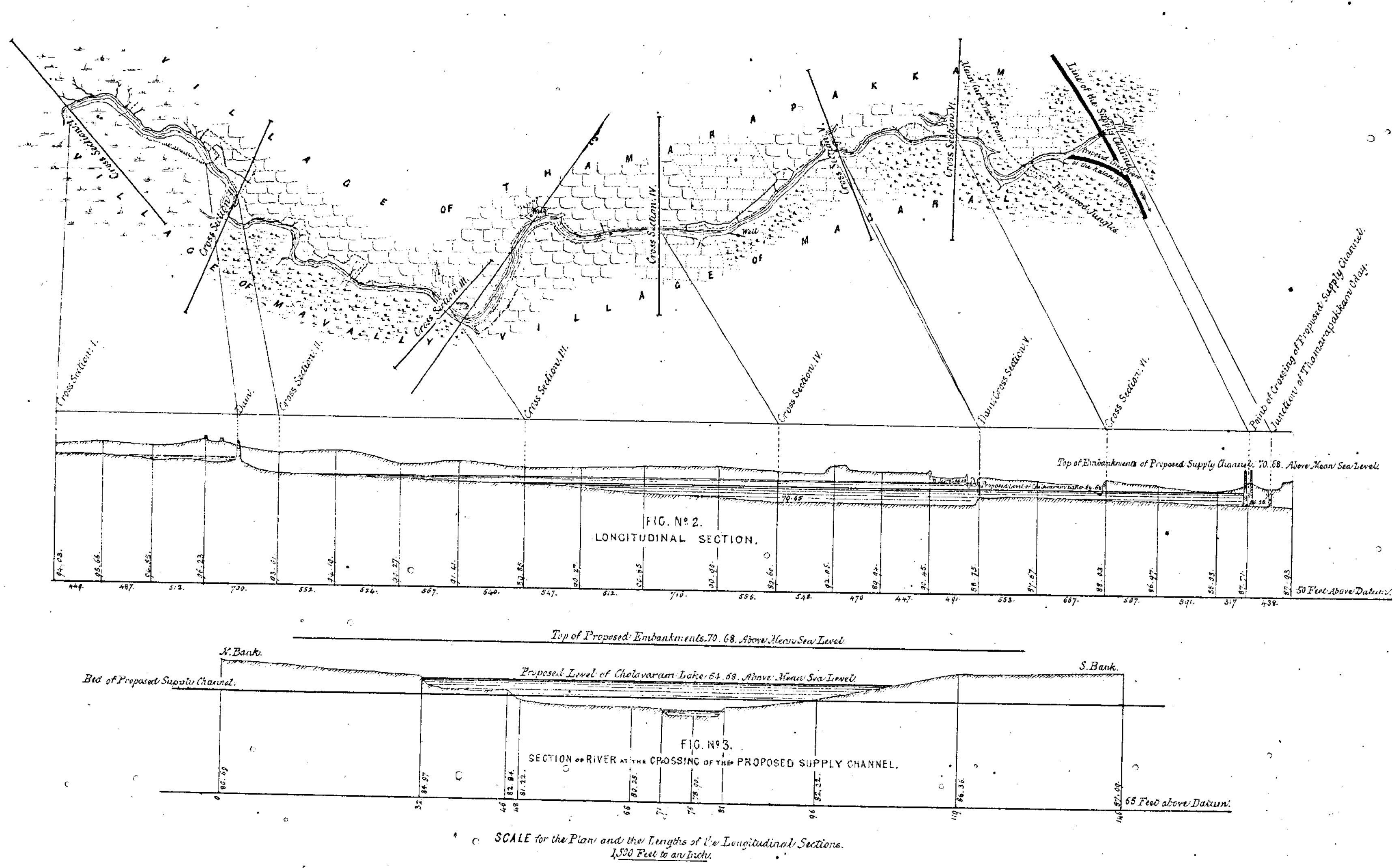
DRAWN BY W.R. CALDER AND LITHT BY J. DUMPHY.

MADRAS WATER WORKS.

PLAN AND SECTIONS OF THE KATAN KAL.

SHEET No. 9.

FIG. No. 1.



SCALE for the Plan and the Lengths of the Longitudinal Sections.
1,500 Feet to an Inch.

SCALE for the Heights of the Longitudinal Section.
50 Feet to an Inch.

SCALE for Fig. 3. 25 Feet to an Inch.

GOVERNMENT LITHOGRAPHIC PRESS, MADRAS 1867.

DRAWN BY H.R.CALDER AND LITHD BY J. DUMPHY.

MADRAS WATER WORKS.

PLAN AND SECTIONS OF THE BOOSY KAL.

SHEET N° 10.

FIG N°I.

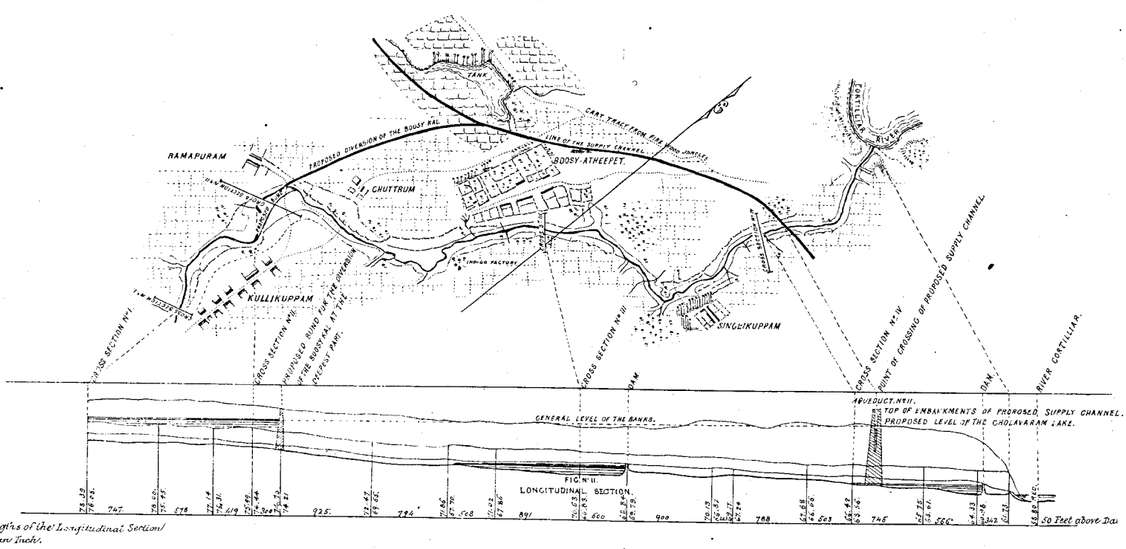


FIG N°II.
LONGITUDINAL SECTION.

SCALE for the Plan and the Lengths of the Longitudinal Section 400 feet to an Inch.

SCALE for the Heights of the Longitudinal Section 50 feet to an Inch.

SCALE for Fig°s III feet to an Inch.

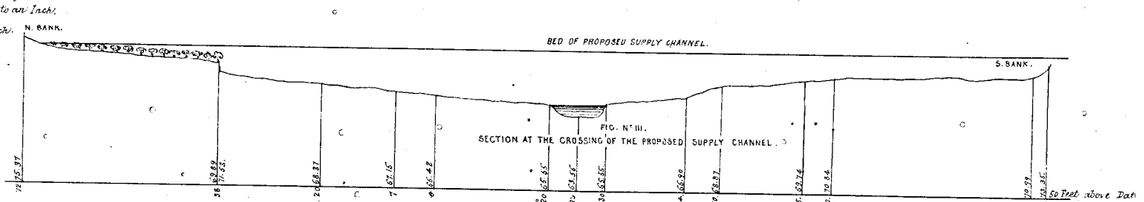


FIG. N°III.
SECTION AT THE CROSSING OF THE PROPOSED SUPPLY CHANNEL.

GOVERNMENT LITHOGRAPHIC PRESS, MADRAS. 1867.

DRAWN BY T. E. DENT AND LITH° BY R. J. BALDREY

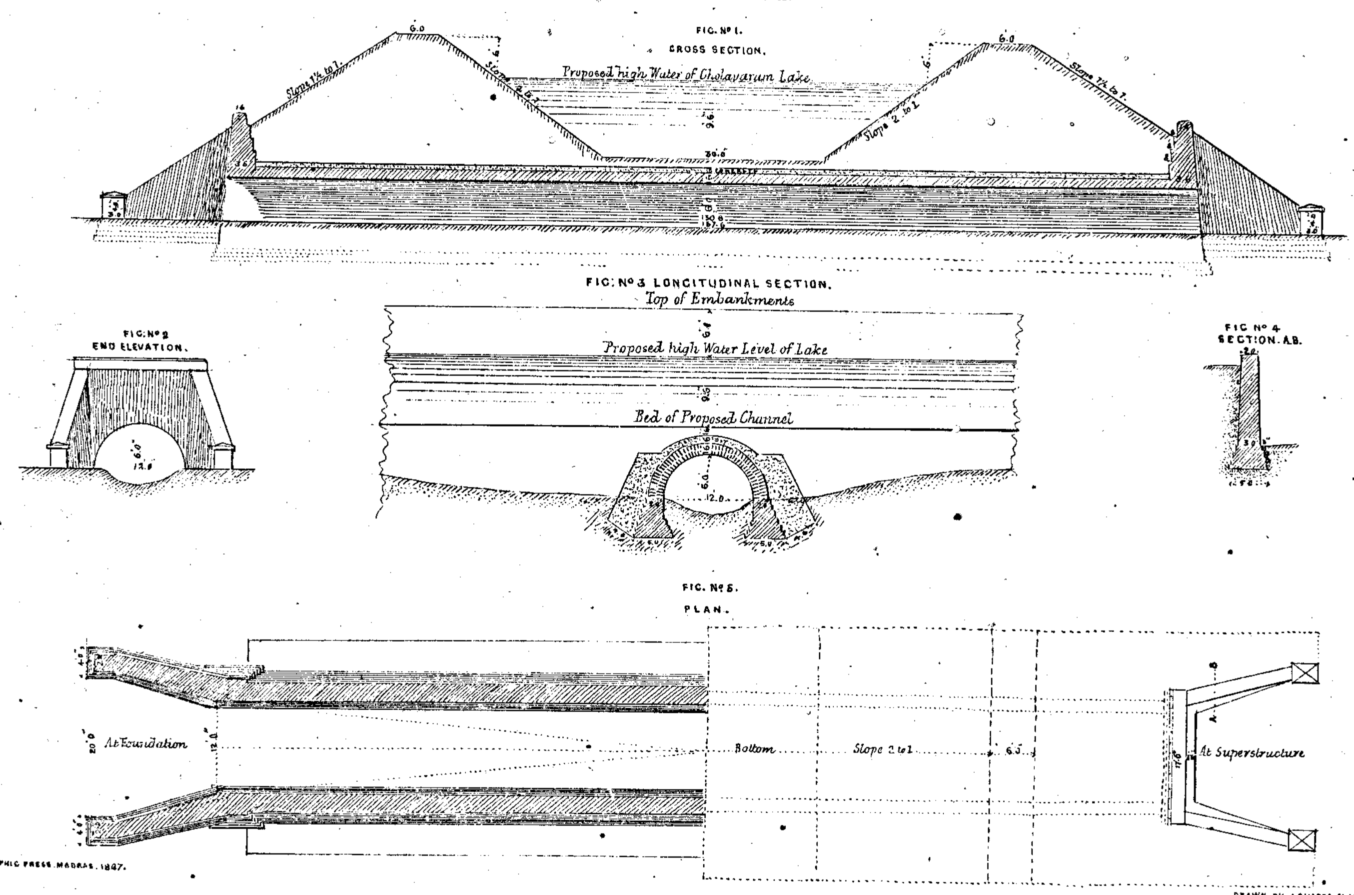
MADRAS WATER WORKS

DESIGN FOR THE AQUEDUCT AT THE BOOSY-KAL

SHEET. No. 11

SEE No. 7. GENERAL PLAN.

SCALE 25 Feet to an Inch.



GOVERNMENT LITHOGRAPHIC PRESS MADRAS. 1867.

DRAWN BY J. SUARES & LITHO: BY J. DUMPHY.

DRAWN BY T. E. DENT AND LITH. BY R. I. BALDREY.

GOVERNMENT LITH: PRESS CHEPAUK.

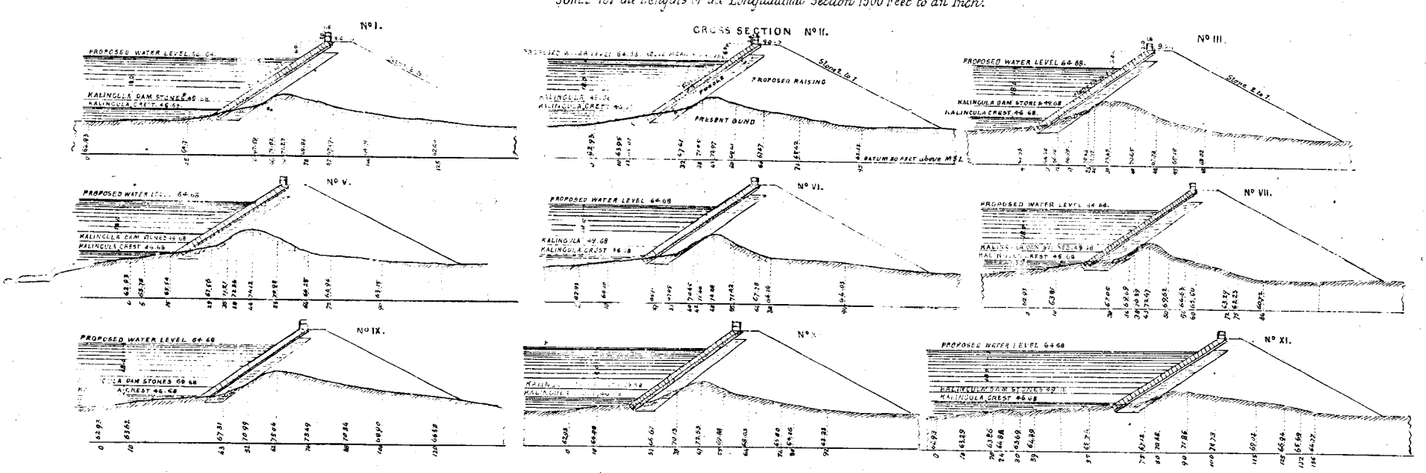
MADRAS WATER WORKS.

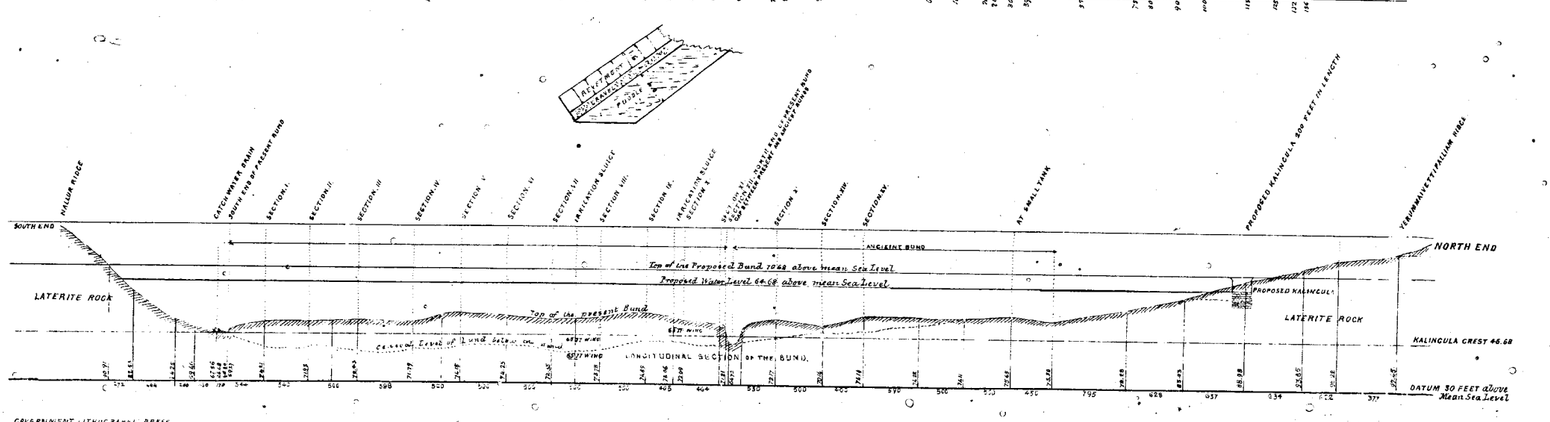
CHOLAVARAM LAKE - SECTIONS OF THE BUND.

SHEET. No13

SCALE for the Cross Sections and Heights of the Longitudinal Section, 50 Feet to an Inch.
SCALE for the Lengths of the Longitudinal Section 1500 Feet to an Inch.

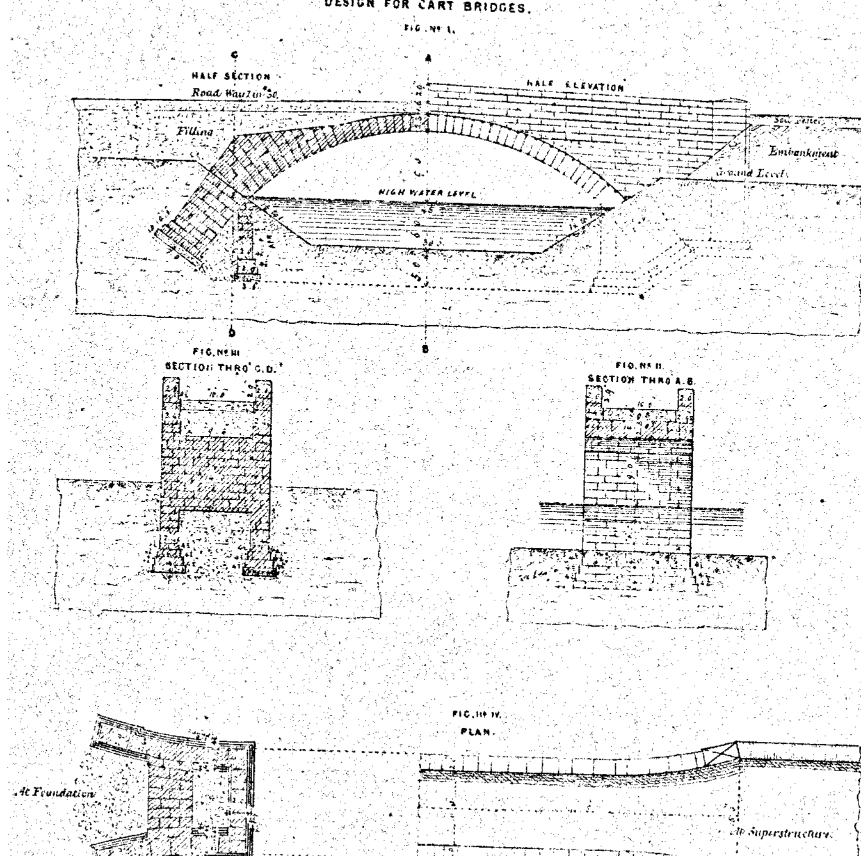
CROSS SECTION No II.





GOVERNMENT LITHOGRAPHIC PRESS

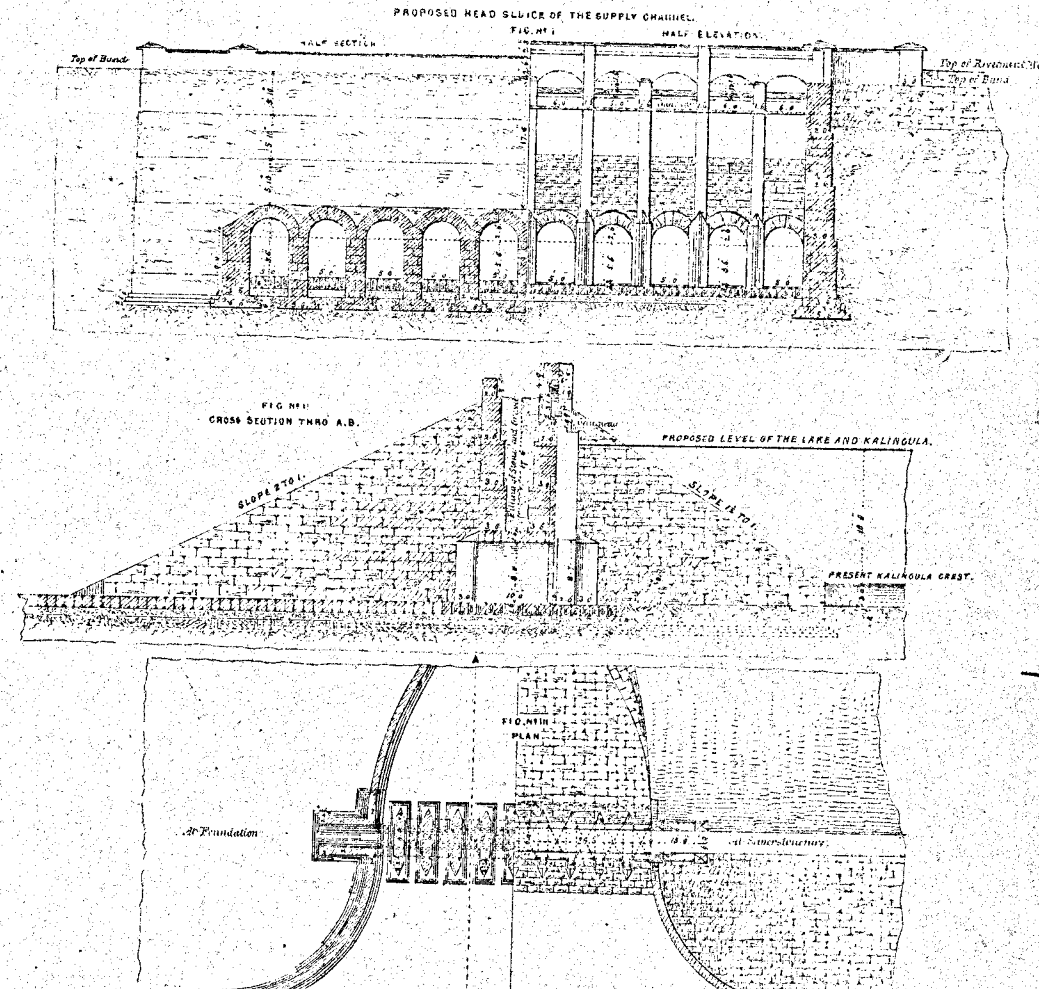
DESIGN FOR CART BRIDGES.



SCALE 25 Feet to an Inch.

CHOLAVARAM LAKE.

PROPOSED HEAD SLUICE OF THE SUPPLY CHANNEL.



For Plan and Details of Sluice Gates, See Plan of Cortelliar Head Sluice Sheet Nº 4, With which these correspond.

SCALE to Figs 1 and 2. 25 Feet to an Inch.
SCALE to Fig: 3. 50 Feet to an Inch.

GOVERNMENT LITHOGRAPHIC PRESS MADRAS 1867.

DRAWN BY H.R. CALDER AND LITHD BY R.J. GALDREY.

CHOLAVARAM LAKE. PROPOSED IRRIGATION SLUICE.

SHEET Nº 15.

SCALE for Figs Nº 1. 2. 3. 25 Feet to an Inch.
SCALE for Figs Nº 4. 5. 5 Feet to the Inch.
SCALE for Figs Nº 6. 7. 8. 2 Feet to the Inch.

FIG. Nº I.
CROSS SECTION A.B.

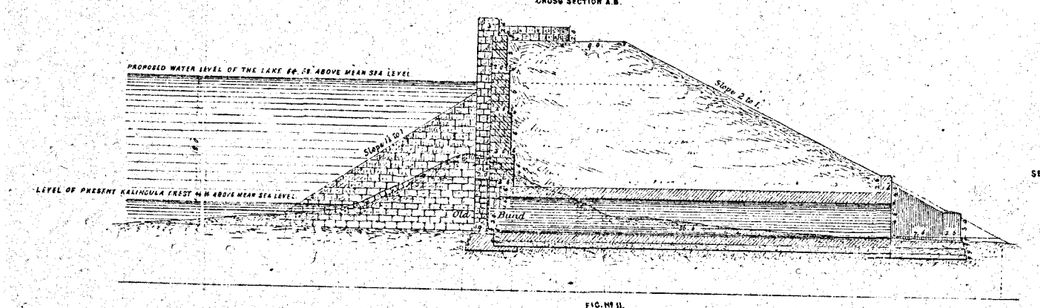


FIG. Nº II.
CROSS SECTION C.D.

FIG. Nº III.
PLAN AT SUPERSTRUCTURE.

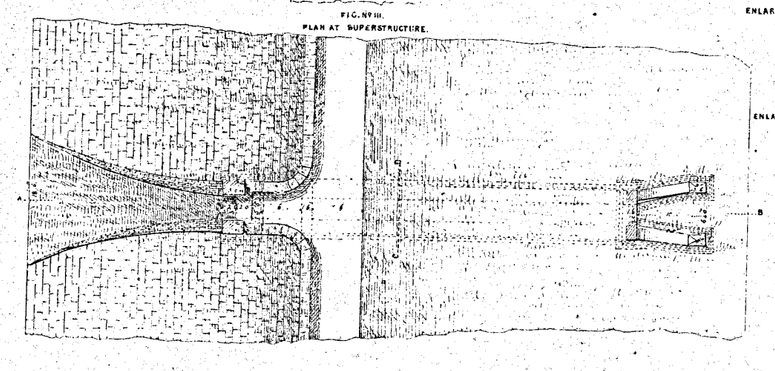


FIG. Nº VI.
SECTION THRO' HEAD.

FIG. Nº VII.
ENLARGED PLAN OF HEAD OF ROD.

FIG. Nº VIII.
ENLARGED ELEVATION OF HEAD OF ROD.

FIG. Nº V.
ENLARGED SECTION OF SLUICE GATE.

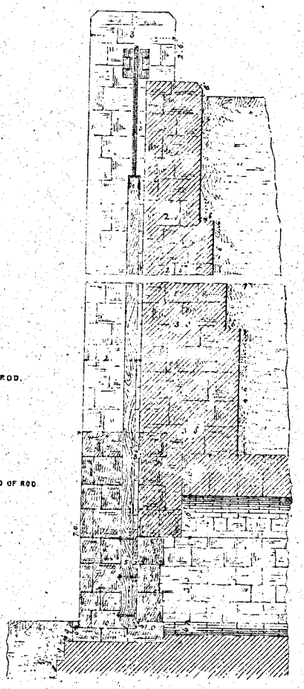
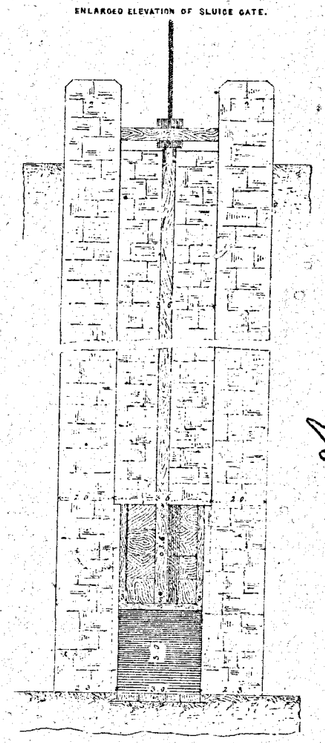


FIG. Nº IV.
ENLARGED ELEVATION OF SLUICE GATE.



85

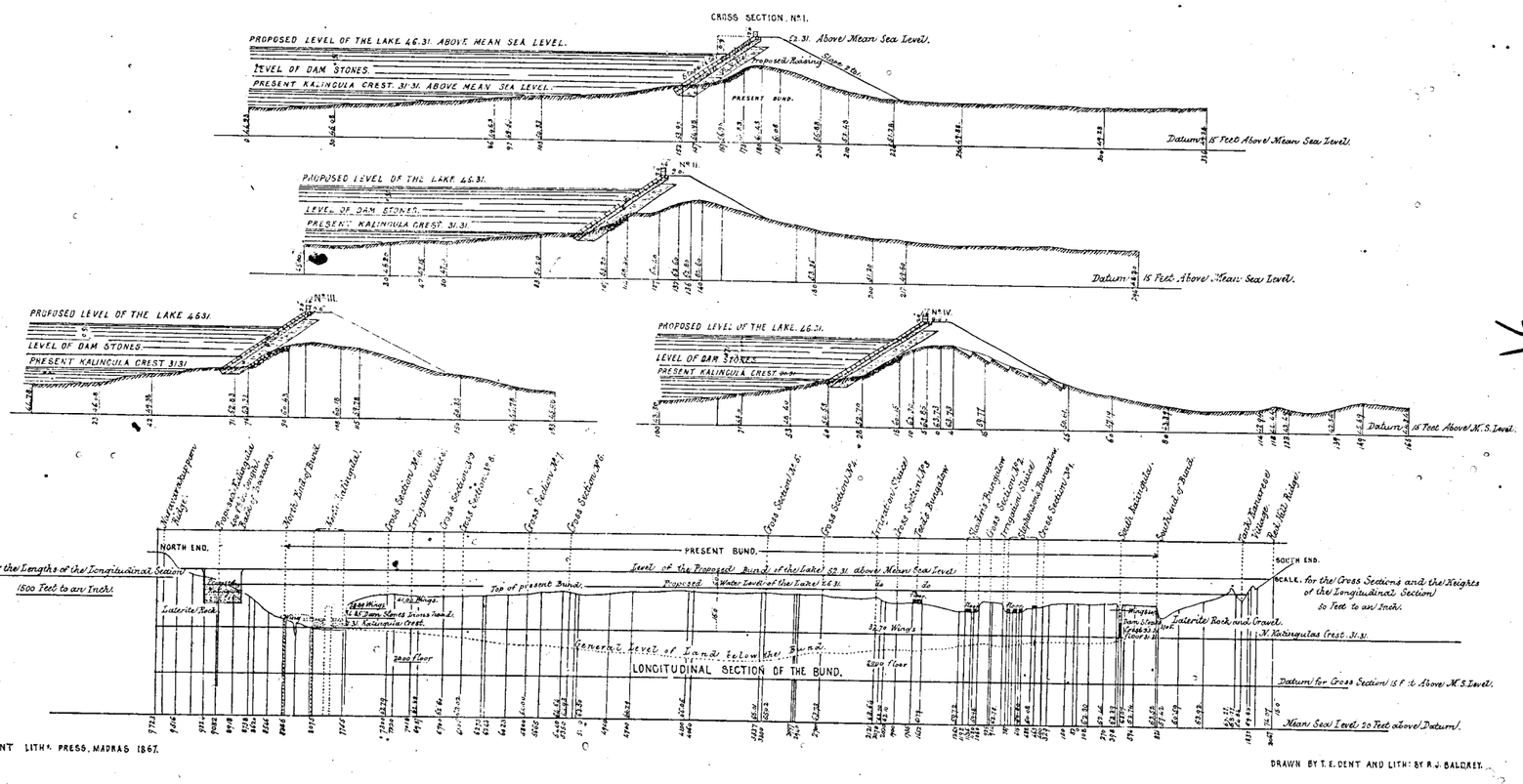
GOVERNMENT LITHOGRAPHIC PRESS MADRAS 1867.

DRAWN BY H.R. CALDER AND LITHº BY R.J. BALDREY.

MADRAS WATER WORKS.

RED HILL LAKE. SECTIONS OF THE BUND.

SHEET Nº. 18.



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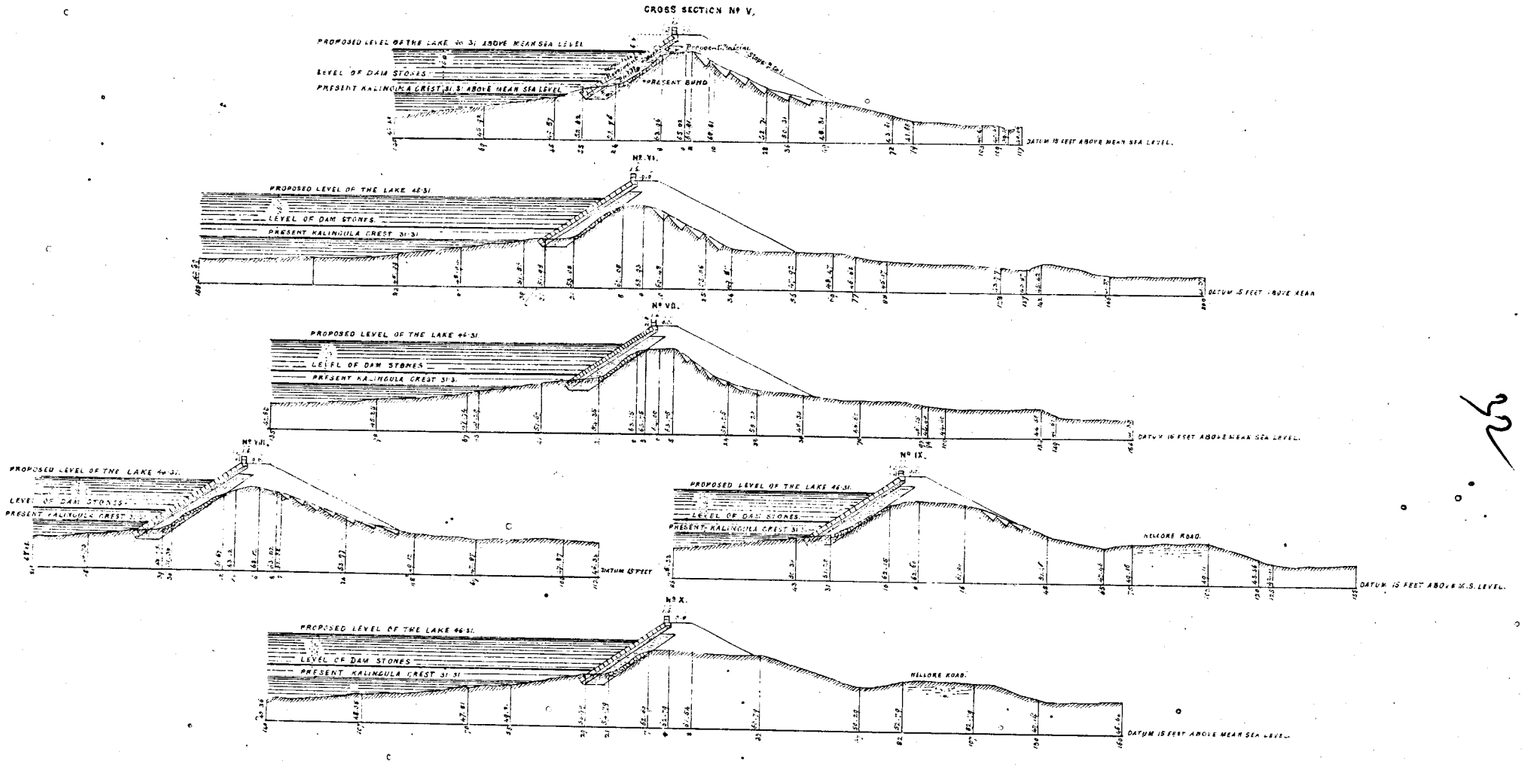
DRAWN BY T. E. DENT AND LITHO BY R. J. BALDREY.

MADRAS WATER WORKS.

RED HILL LAKE. SECTIONS OF THE BUND.

SHEET Nº 19.

SCALE for the Cross Sections, 50 Feet to an Inch.



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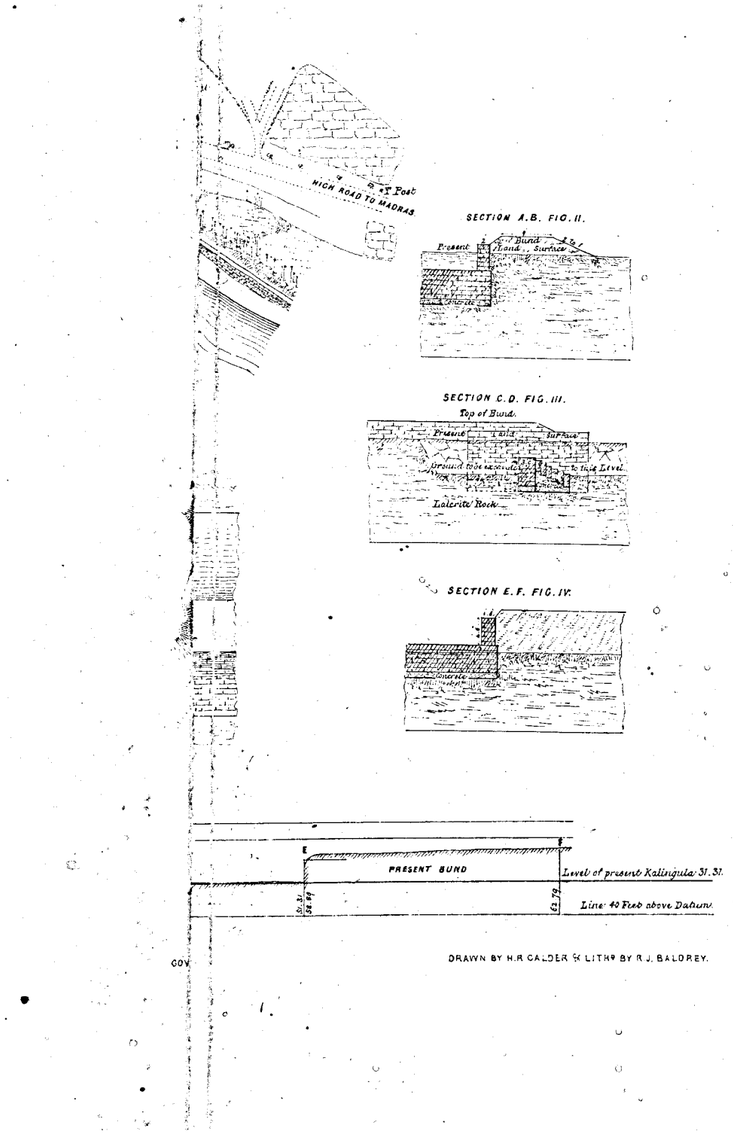
33

SHEET Nº 20



MADRAS WATER WORKS.

RED HILL LAKE. PROPOSED ALTERATION OF POLAL IRRIGATION SLUICE.

SCALE. 20 Feet to an Inch.

FIG. N°I.
SECTION.

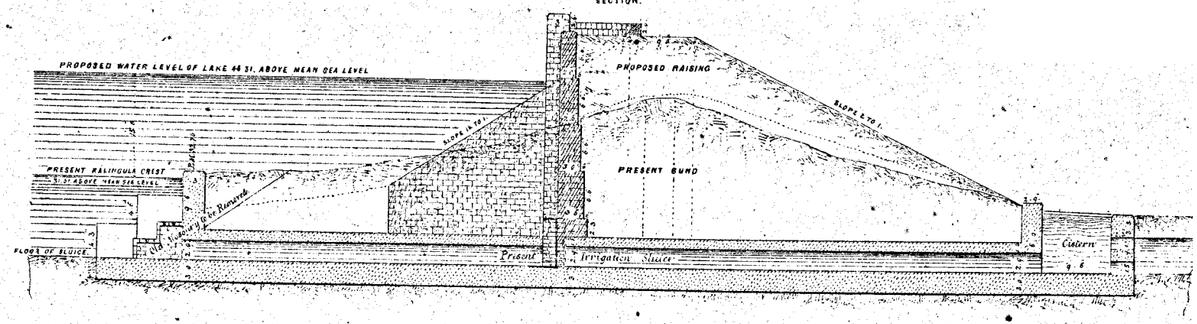
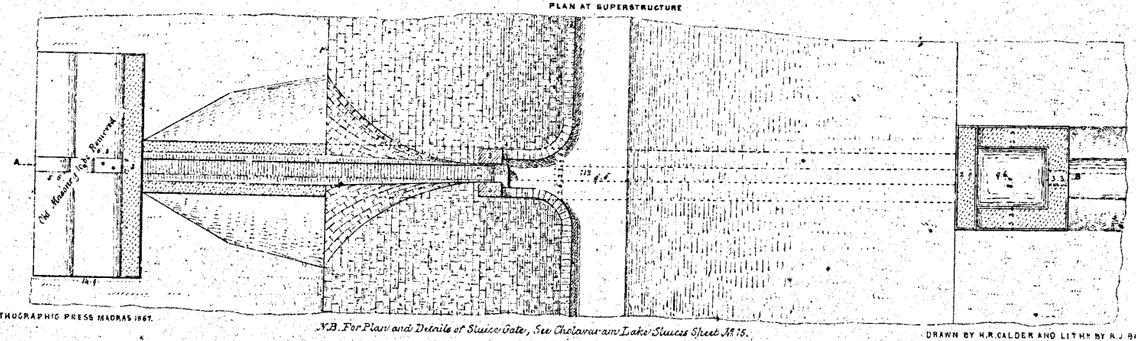


FIG. N°II.
PLAN AT SUPERSTRUCTURE



GOVERNMENT LITHOGRAPHIC PRESS MADRAS 1867.

N.B. For Plan and Details of Sluice Gate, See Cholavaram Lake Sluices Sheet N°15.

DRAWN BY H.R. CALDER AND LITHT BY R.J. B

MADRAS WAT[illegible]ORKS.

RED HILL LAKE.

SHEET, Nº 22.

PLAN SHOWING THE PROPOSED ALTERATIONS OF THE NORTHERN SLUICE.

SCALE. 20 feet to an Inch.

FIG: I. LONGITUDINAL SECTION.

FIG: II. PLAN.

N.B. For Plan and Details of Sluice Gate, See Sheet Nº 15 Design for the Cholavaram Lake Sluices

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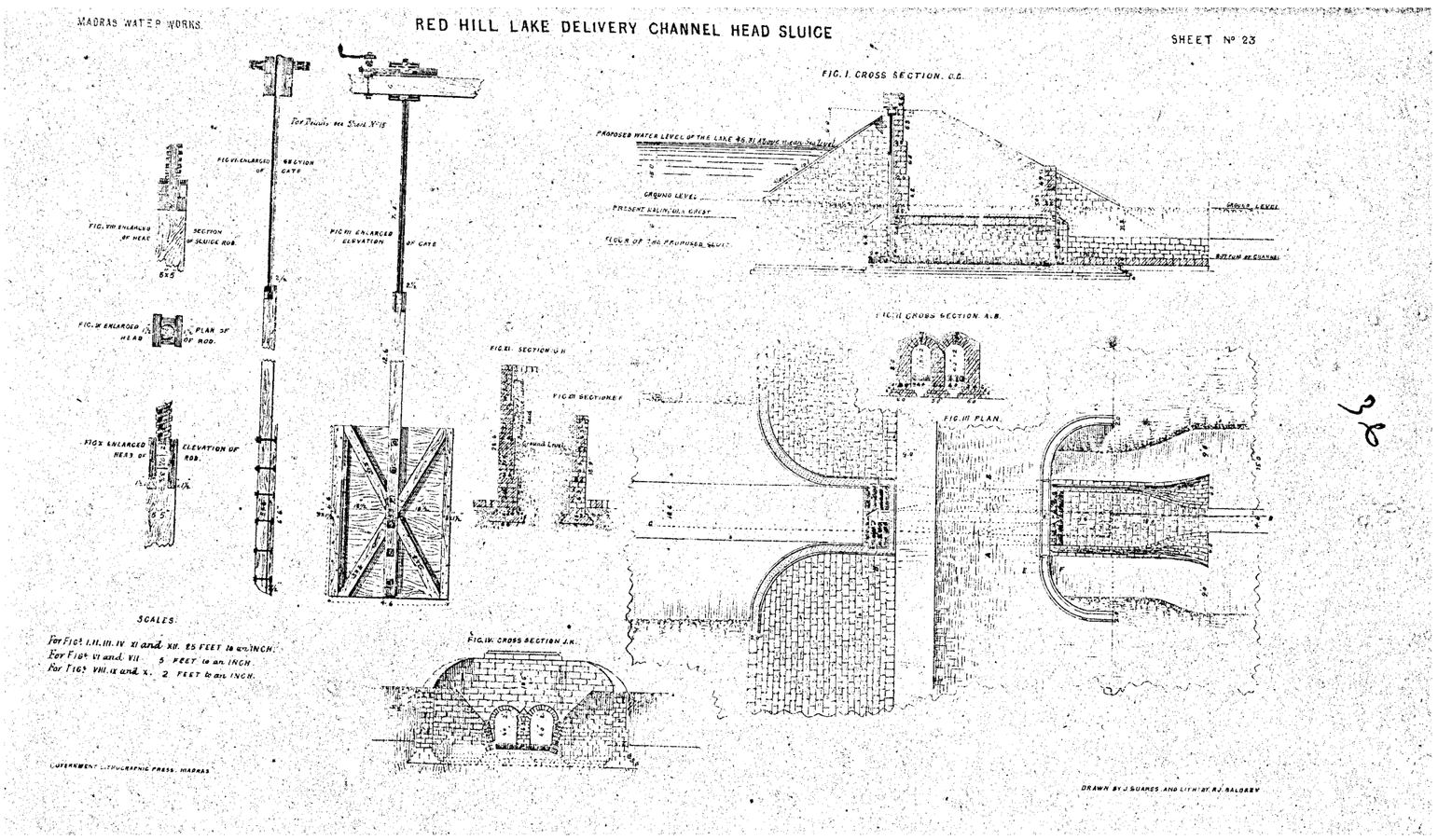
DRAWN BY J. SUARES. & LITH: BY J. DUMPHY.

35

MADRAS WATER WORKS.

RED HILL LAKE DELIVERY CHANNEL HEAD SLUICE

SHEET Nº 23



38

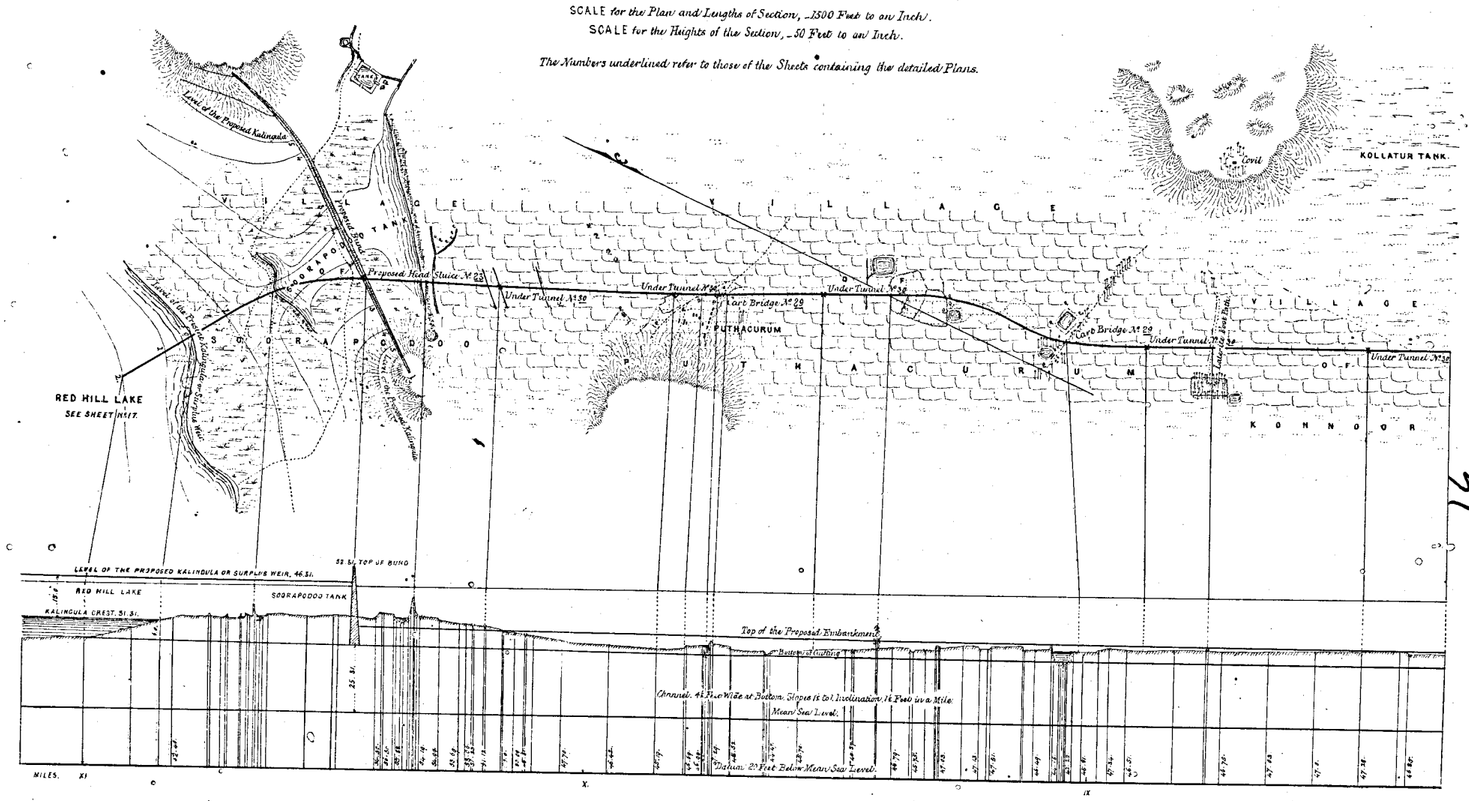
MADRAS WATER WORKS.

PLAN AND SECTION_DELIVERY CHANNEL.

SHEET № 24.

SCALE for the Plan and Lengths of Section, 1500 Feet to an Inch.
SCALE for the Heights of the Section, 50 Feet to an Inch.

The Numbers underlined refer to those of the Sheets containing the detailed Plans.



27

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DRAWN BY H.R.GALDER AND LITHO BY J.DUMPHY

MADRAS WATER WORKS.

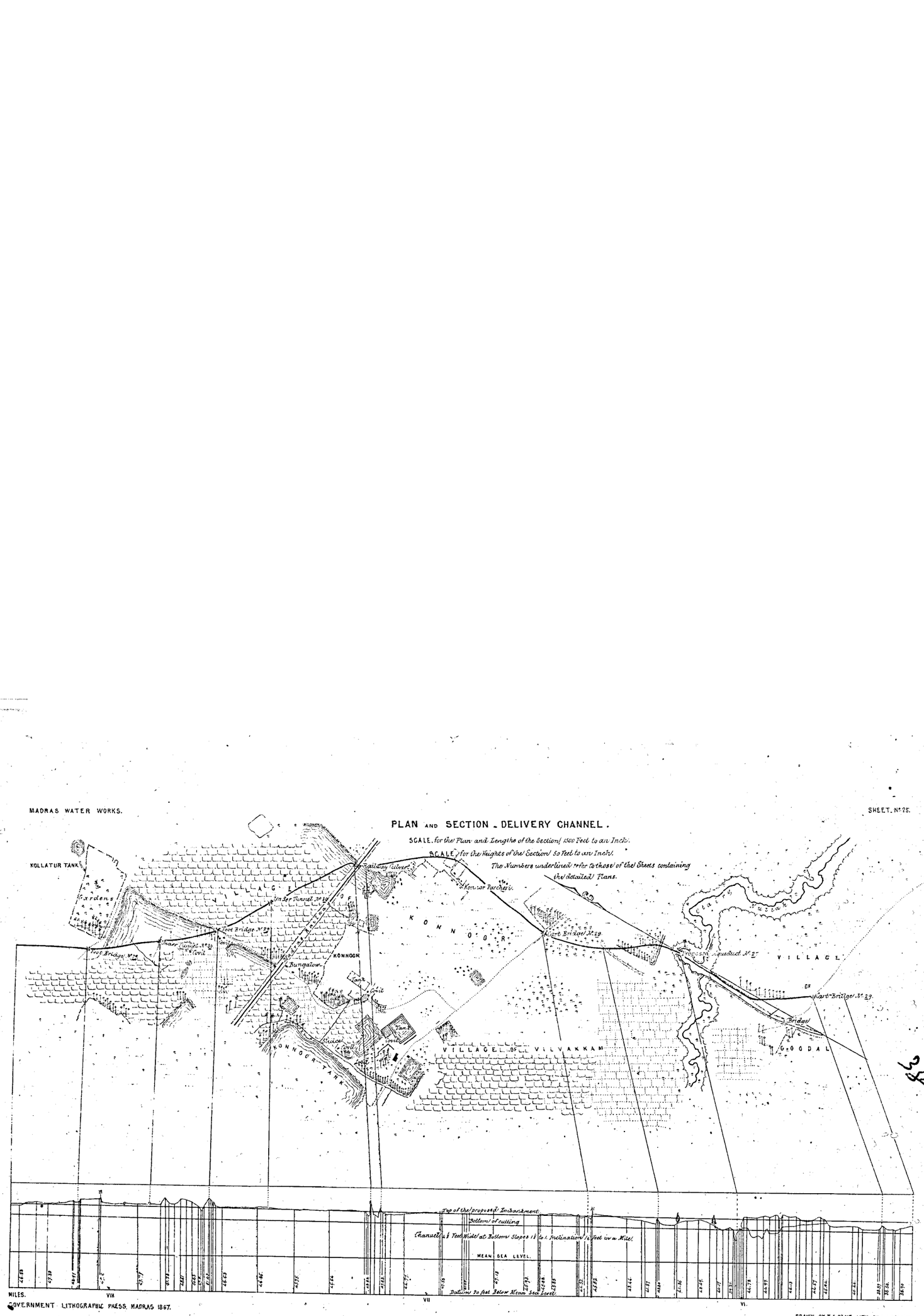
SHEET. No 25.

PLAN AND SECTION - DELIVERY CHANNEL.

SCALE. for the Plan and Lengths of the Section/ 1500 Feet to an Inch.

SCALE / for the Heights of the Section/ 50 Feet to an Inch/.

The Numbers underlined/ refer to those/ of the Sheets containing the detailed/ Plans.



GOVERNMENT LITHOGRAPHIC PRESS, MADRAS 1867.

DRAWN BY T.E.DENT. LITH: BY R.J. BALBEET.

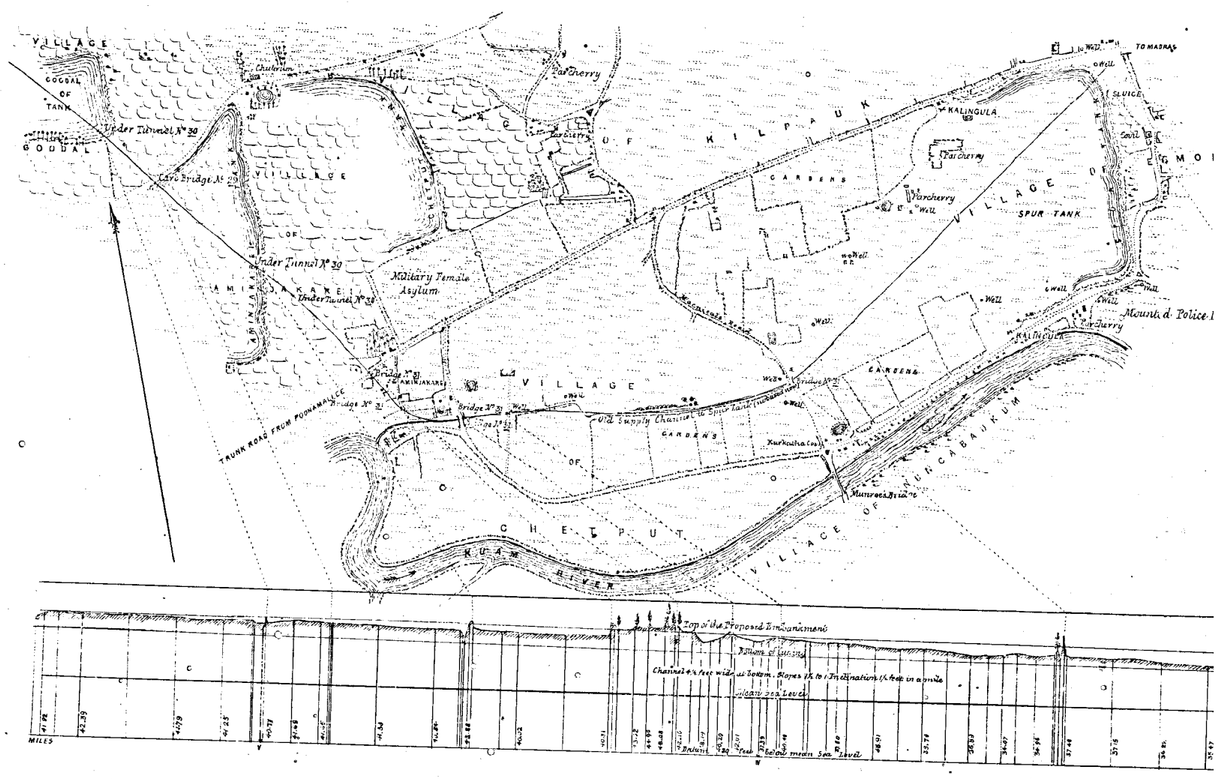
86

MADRAS WATER WORKS.

PLAN AND SECTION-DELIVERY CHANNEL

SCALE for the Plan and Lenghts of the Section 1500 feet to an Inch
SCALE for the Heights of the Section 50 feet to an Inch.

The numbers underlined refer to those of the Sheets containing the detailed Plans.



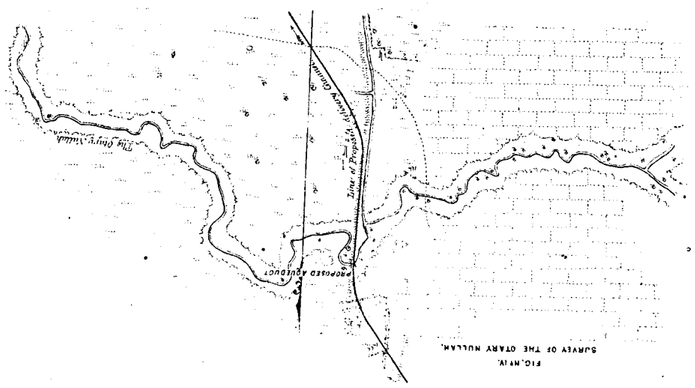
GOVERNMENT LITHOGRAPHIC PRESS, MADRAS. 1867.

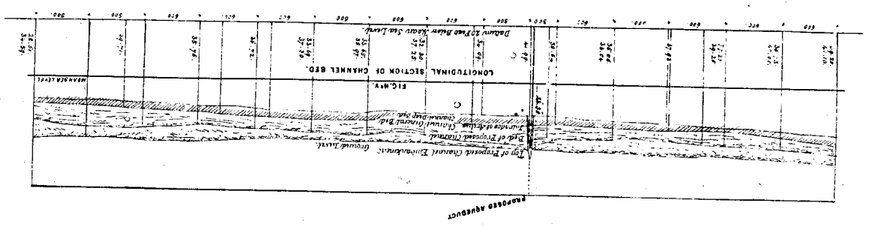
MADRAS WATER WORKS.

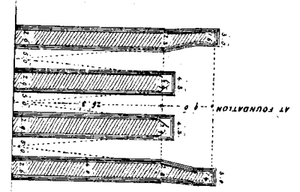
OTARY NULLAH PROPOSED AQUEDUCT

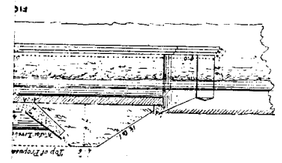
SCALE for Figs I. II. III. 32 Feet to one Inch.
SCALE for Figs IV. V. 1500 Feet to one Inch.

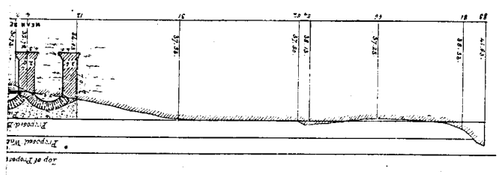
FIG. IV.
SURVEY OF THE OTARY NULLAH.











GOVERNMENT LITHOGRAPHIC PRESS MADRAS 1867.

MADRAS WATER WORKS.

DESIGN FOR BRIDGES.

SHEET No 28.

CATTLE AND FOOT BRIDGES.

FIG. 4.
ENLARGED ELEVATION
STANDARD AND HAND-RAIL.

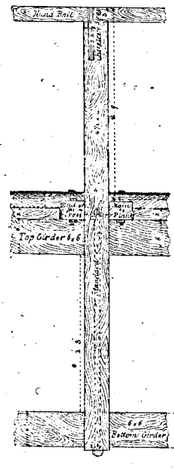
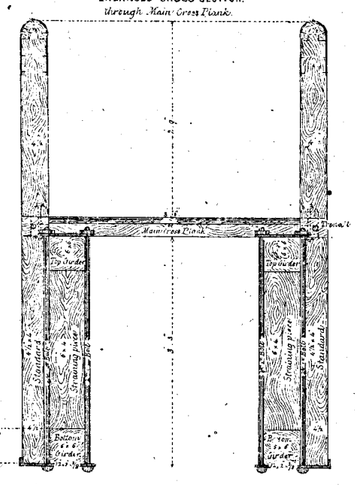


FIG. 5.
ENLARGED CROSS SECTION.
through Main Cross Plank.



SCALE.

For Figs. 1 and 2 - 25 Feet to an Inch.
For Figs. 3. 4. 5 and 6. 2 Feet to the Inch.

FIG. 1.
ELEVATION.

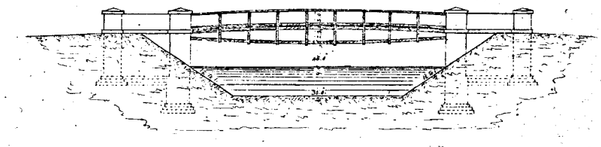


FIG. 6.
Cross Section at E.F.

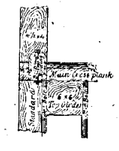


FIG. 2.
PLAN.

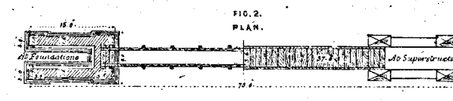
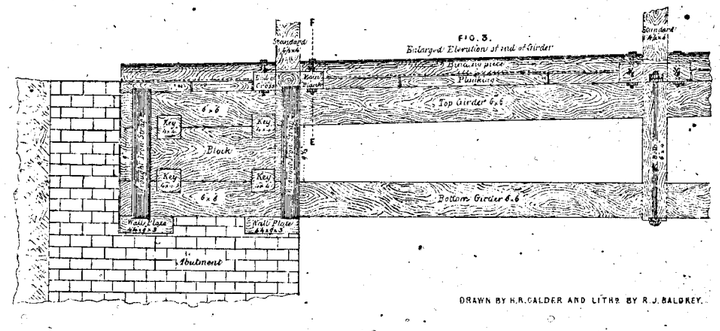


FIG. 3.
Enlarged Elevation at end of Girder



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DELIVERY CHANNEL.

FROM RED HILL LAKE TO MADRAS.

DESIGN FOR TIMBER FOOT BRIDGES

FIG: № 3.
CROSS SECTION. A.B.

FIG: № 2.
PLAN

FIG: № 4.
ENLARGED CROSS SECTION. C.D.

SCALES.
For Figs: 1.2.3. 10 Feet to Inch.
For Figs. 4.5. 2 Feet to the Inch.

DESIGN FOR MASONRY CART BRIDGES.

FIG: № 2
PLAN.

FIG: № 5.
ENLARGED ELEVATION
HANDRAIL AND STANDARD

FIG: № 3.
CROSS SECTION. A.B.

FIG. № 4.
CROSS SECTION. C.D.

FIG. № 5.
CROSS SECTION. E.F.

SCALE. 10 Feet 1 Inch.

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DRAWN BY J SQUARES & LITH. BY J DUMPHY

MADRAS WATER WORKS.

DESIGN FOR IRRIGATION AND DRAINAGE UNDER TUNNELS.

SCALE 25 Feet to an Inch.

SHEET No 30.

FIG I.

SECTION IN THE LINE OF THE TUNNEL.

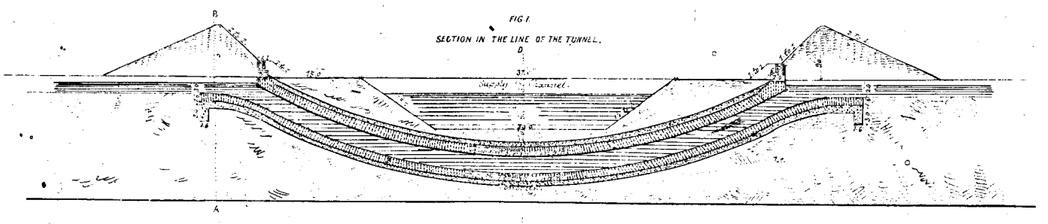


FIG. II.

PLAN.

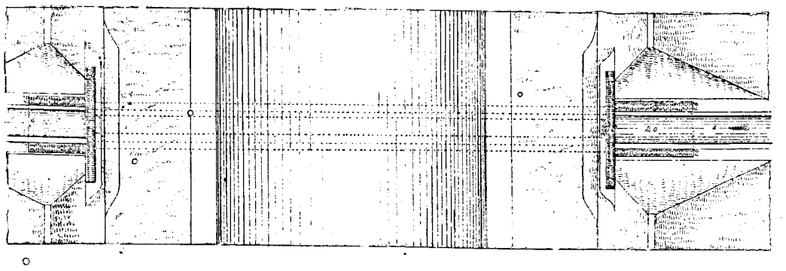


FIG. III.

SECTION THRO. A.B.

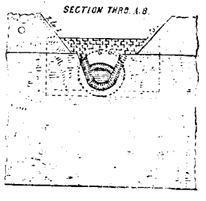
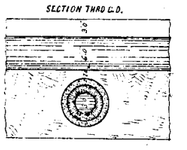


FIG. IV.

SECTION THRO C.D.



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MADRAS WATER WORKS.

SHEET. No 31.

CULVERTS FOR THE ROAD CROSSINGS IN MADRAS.

Scale 20 Feet to 1 Inch.

HARRINGTONS ROAD.

FIG. I.

HALF SECTION | HALF ELEVATION

FIG. II.

LONGITUDINAL SECTION.

AMINJAKARREI VILLAGE AND NOBOSS GARDEN-ROADS.

FIG. I.

HALF SECTION | HALF ELEVATION.

FIG. II

LONGITUDINAL SECTION.

POONAMALLEE ROAD.

FIG. I.

HALF SECTION | HALF ELEVATION.

FIG. II.

LONGITUDINAL SECTION

MACKNIGAL'S ROAD.

FIG. I.

HALF SECTION. | HALF ELEVATION.

FIG. II.

LONGITUDINAL SECTION.

FIG III.

PLAN OF SUPERSTRUCTURE.

FIG III.

PLAN.

GOVERNMENT LITH. PRESS. MADRAS 1867.

DRAWN BY T. E. DENT LITH: R. J. BALDREY.

செப்பனிடுபவர் பெயர்

செப்பனிடுவதற்காக எடுத்துக் கொள்ளப்பட்ட நாள் 3/96

திருப்பப்பட்ட நாள் 7/96

சரிபார்க்கும் மு. பா. ஏ. கையொப்பம்

ஆராய்ச்சி உதவியாளர் கையொப்பம் 31/7/96

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