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ad the following :—

No. 294—W.

No. 554. *Note by the* *ief Engineer for Irrigation.*

KIST A EASTERN DELTA.

PRINCIPAL CANALS.—The w r-supply for the Eastern Delta of the Kistna will be conveyed

1*st*.—By the Main Canal. e length of which is 900 yards only.

2*ndly*.—By the Ellore, R s and Masulipatam Canals which have their heads at the lower end t he main canal.

3*rdly*.—By the Bank Can and the Pulleru, the former of which will have its head at 3½ miles om the head of the Masulipatam Canal on the right bank of the l ter, and the Pulleru will be supplied, as at present, partly from the M ulipatam Canal in the 13th mile and partly, Ryves Canal.

2. AREA OF EASTERN DELT —*Proposed and present Areas of Irrigation.*—T area of the Eastern Delta is 1,16 square miles. The proposed and present areas irrigation are as follow :—

		ACRES.
Area intended to be irrigated	... ...	270,000
„ at present „	... ...	137,723
	Difference ...	132,277

3. SUB-SECTIONS.—For convenience of investigation an estimating the Eastern Delta has been divided into five sub-sections, the leading pa ulars of which a

Nos. of Sub-Sections.	Sources of Supply.	Areas in Square Miles.	Areas to be irrigated.	Acreage per Square Mile.
			ACRES.	
1.	Masulipatam Canal...	345	88,000	255
	Bank „			
2.	Ellore „	140	31,000	221
3.	Ryves „	277	69,000	250
	Pulleru			
4.	Pulleru	201	46,000	229
5.	Pulleru	197	36,000	183
	Masulipatam Canal...			
		1,160	270,000	233

The proportion of irrigated to total area in the Western Delta is estimated at one-third.

$\frac{233}{640} = 0{\cdot}364$, the total area to be irrigated is therefore rather more (by 20 acres per square mile) than one-third of the gross area of the delta.

In Zemindaries the area expected to be irrigated is on the average 159 acres to the square mile. or less (by 1 acre to the square mile) than one-fourth of the gross area of these properties.

4. WATER-SUPPLY.—The most important consideration in connection with the proposed arrangements for irrigation is the water-supply. The quantity of water

supposed to be required is based upon an allowance of 2 cubic yards per acre per hour, or 1 cubic foot a second for every 66⅔ acres; making this quantity 4,050 cubic feet a second.

(1.) *Main Canal.*—The Main Canal has been designed to carry, according to the calculations of the officer who has prepared the estimates, with a depth of 8¼ feet at the head and 8 feet at the lower end 4,268

Proceedings, Madras Government, 19th December 1874.—Note, paragraph 2.

but, as in the case of the Western Delta Main Canal, it is considered that the formula used gives too high a velocity and discharge, and that with this depth the discharge is not likely to exceed 3,853

8¼ feet is to be the ordinary full supply depth in the Main Canal, but it will be feasible whenever necessary to carry a depth of 9 feet, and then the surface fall will be increased and the discharge may be expected to be about 4,815. This canal has been

Sanctioned in 1871-72.

nearly completed to the full dimensions intended, or indeed practicable, for there is no room for further widening on the river (right) side, and on the left side is the town of Bezwadah, between which and the canal there is only the width of a road, which latter is already revetted to economize space. The bottom width of the canal is 200 feet, and, except at the landing quay, the side slopes are 1 to 1 on the left and 1½ to 1 on the right bank.

The supply of 2 cubic yards per acre per hour is fully as much as is needed by the higher lands of the delta, and is more than is required by all but a very small portion of the total area to be irrigated. In the Godavery Western Delta it is considered that on the average not more than 1·8 cubic yards per acre per hour are necessary, and the soil of the Kistna being much more retentive it is improbable that even so much will be required.

Reference was made this subject in reviewing the Kistna Western Delta Estimates.

The quantity of water required at 1·8 cubic yards would be cubic feet a second 3,645

and the dimensions of the Main Canal are adequate to carry this at less than the normal full supply level.

(2.) *Head Sluice.*—The dimensions of the head sluice have next to be considered. This is an old work of fifteen vents of 6 feet each, and though it might be enlarged it is so situated and circumstanced that without very clear necessity it will be well not to attempt any radical alteration. The vents are at present higher than is necessary, but in order to economize head, and also to allow of surface water, which contains less silt, being admitted to the canal when the river is in fresh, it will be advisable to make the vents 9 feet high, corresponding with the maximum water level to be allowed in the canal. By dividing the shutters into three parts, working in parallel grooves, the regulation of large vents has in the Godavery been made easy, and similar arrangements will be introduced at the Kistna in supersession of the inconvenient and extremely difficult system heretofore in use. Shutters 2¼, 3 and 3¾ feet respectively will, with 15 feet on the sill, make the pressures sufficiently equal, and if the groove of the centre shutter be carried down to the sill so that this shutter may be lowered as well as raised, the canal will be able to be supplied with water from a high instead of a low stratum.

(3.) *River.*—The sill of the head sluice being 6 inches higher than that of the Western Delta, the circumstances are less favorable for ensuring an adequate supply. In the Western Delta the average supply available during the season of 184 days was calculated to be 2·13 cubic yards per acre per hour for the nine years from 1864 to 1872. From the similar information compiled for the Eastern Delta the average is estimated to be 1·93 cubic yards per acre per hour. The following is an abstract which is probably a sufficiently close approximation. It has been based upon Appendices A and B of Lieutenant McNeil Campbell's general report with modifications for the co-efficient of discharge through head sluice, and discharge of main canal at various depths.

Dated 5th September 1874.

Years.	Supplies available in Cubic Yards per Acre per Hour						Total days of Irrigation Season.
	1·00	1·25	1·50	1·75	2·00	2·00 to 2·50	
	Days.	Days.	Days.	Days.	Days.	Days.	
1864	31	38	22	11	6	76	
1865	13	23	14	35	7	83	
1866	...	23	33	28	18	82	
1867	3	14	27	32	30	78	
1868	15	18	12	14	24	101	184
1869	3	9	12	25	21	114	
1870	...	7	14	26	22	115	
1871	3	9	25	41	23	83	
1872	...	5	13	12	17	137	
Totals ...	68	146	172	224	168	869	
Average	8	16	19	25	19	97	184
Quantities... ..	8	20	28	44	38	218	= 1·93 C. Yds. per acre per hour.

For 116 days therefore out of 184 the supply is likely to be fully adequate, and for 141 days it will probably be adequate, so that a short supply during 43 or at most 68 days will have to be supplemented by an increase above the normal supply at other times. Taking, however, the most favorable view of the water-supply, it must be admitted that with the crest of the anicut only 5½ feet above the head sluice sill, and with the water level requiring to be nearly 9 feet above the sill to throw a full supply into the Main Canal, there may be times at which, when the area of irrigation has been greatly extended, the cultivation may be placed in jeopardy by the low level of the river during more than a few days. The cultivation can be kept from suffering materially whenever for a not too protracted interval 1 cubic yard an hour per acre may be available, and this necessary minimum during the irrigation season is not, as will be seen above, of frequent occurrence. It will be secured with rather less than 6½ feet in the channel and 1·20 feet going over the anicut.

The remedy, and an effectual one, would be to raise the anicut. This is done temporarily every year after the freshes, and the required purpose is attained at practically little expense, the stone used being afterwards utilized for the annual repairs of the apron, and if the river does not become low during the season of the freshes, the arrangement is efficient and will

Proceedings of the Madras Government, 19th December 1874.—Note, paragraph 3.

suffice for some time to come ; but it is thought that when the area of irrigation in the Eastern Delta has extended to about 200,000 acres* and in the Western to 150,000† it will be necessary either to raise the crest in masonry or to provide shutters capable of being raised and lowered at pleasure. It must not, however, be overlooked that a more favorable state of the water-supply will be secured by providing the under sluices with manageable shutters, and this will be done as soon as some experimental shutters in the Godavery have been tested, and, if necessary, modified in detail. The shutters hitherto used are marked with so much difficulty, that they have had to be removed in anticipation of the freshes, and with rare exceptions kept out until the final cessation of the freshes for the season. Lieutenant Campbell has proposed raising the crest of the anicut 3 feet. It is to be noticed, however, that less than 18 inches passing over the crest of the anicut is of rare occurrence during the irrigation season, and to secure a full supply it has been mentioned that rather less than 9 feet on the head sluice sill are requisite, $5\frac{1}{2} + 1\frac{1}{2} = 7$ feet, and if 2 feet or even $1\frac{3}{4}$ were added to the crest all that is necessary would, it is believed, be obtained. The crest should not be raised an inch higher than is necessary, and before the time for making an alteration comes there will be ample data to go upon. The raising of the anicut will involve a corresponding raising of the head works, including sluices, locks and flood banks, and the scheme will need to be very carefully worked out, and all possibility of a breach into the delta avoided.

* From 138,000.
† „ 75,000.

5. DRAINAGE.—*General arrangements.*—The drainage of the Eastern Delta has been worked out on the principles laid down by this office when the Western Delta drains were planned. A description of these arrangements was given in paragraph 8 of the Note on the Western Delta estimates, and for convenience may here be briefly summarized. A period of six days has been taken as that within which all rainfall drainage accruing within that time is to be got rid of. The maximum drainage in one day of that period has been taken to be equivalent to 10 inches over the area, and 2 inches are supposed to be the drainage of the other five days, so that 12 inches are estimated to be the quantity to be disposed of in the six days. The standard area adopted is 5 square miles, the discharge from which will be 1,314 cubic feet a second, and the corresponding discharge from other areas has been calculated by the formula $D = 450 \sqrt[3]{M^2}$, *e.g.*, the drains for an area of—

Proceedings of the Madras Government, 19th December 1874, No. 3,572.

M = area in square miles.

10	square miles	will discharge	1·60	inches	from that area.
20	„	„	1·27	„	„
30	„	„	1·10	„	„
40	„	„	1·00	„	„
50	„	„	0·90	„	„
75	„	„	0·81	„	„
100	„	„	0·74	„	„
125	„	„	0·69	„	„
150	„	„	0·65	„	„

This arrangement is applicable of course only to drainage within the delta, the area of which will be sub-divided by canals, channels, main and subsidiary drains

into a number of small spaces, on which drainage will accumulate after very heavy falls of rain, and thereafter be carried away as fast as the drains will allow.

Upland or extra delta drainage will have to be disposed of, so far as passing it across the canals is concerned, as fast or nearly as fast as it can come down.

(1.) *Lieutenant McNeil Campbell's views.*—Referring to this subject Lieutenant Campbell in paragraph 42 of his Report on the drainage of the 1st sub-section remarks, "I would here state that I consider the drainage channels a great deal larger than necessary, and I believe they would answer the purpose quite well enough if they were reduced to one-third the size now estimated for, at any rate as regards draining wet cultivation." This Officer has, however, adduced no reason whatever for his opinion ; he has not given the dimensions of any drain natural or artificial which has sufficed to relieve the lands draining into it after heavy rainfall within a reasonable time ; he has not shown that six days is a period shorter than is requisite for the full relief of cultivated lands from accumulated rainfall waters ; and his statement amounts to this, viz., that for areas of 40 to 100 square miles drains which would carry off $\frac{1}{3}$rd to $\frac{1}{4}$th of an inch in the 24 hours, or 2 to $1\frac{1}{2}$ inches in six days would suffice. Now, although reliable data are not available for demonstrating what quantity of drainage will, as a maximum, need to be disposed of, it is, it is thought, certain that this quantity is very much in excess of Lieutenant Campbell's estimate, seeing that falls of rain exceeding 9 or 10 inches in the 24 hours are by no means uncommon on the east coast of this Presidency from one end to the other. The maximum falls are less in the latitude of the Kistna than further south, but 21 inches have been registered at Madras, 13 to 15 inches have several times been measured in its neighbourhood, and $13\frac{1}{2}$ inches were recorded at Nellore, less than 150 miles to the south of the Kistna Delta, in 1859. Such being the case, the provision intended to be made in the Kistna Delta does not appear to be at all excessive.

(2.) *Drains will be carried out gradually and tentatively.*—On the other hand, there is no intention of making these drains of the full size at once. This could not conveniently be done even were the dimensions known to be correct, but the advantage of providing for fairly ample dimensions from the first will be that embankments, infall works of branch drains, inlets, &c., will be placed at a sufficient distance from the centre lines of the main drains, and there will be no waste of money in removing them to a greater distance hereafter. The drains will be cut first to one-fourth then to one-third, then, say, to half their full size, and so on progressively as labor may be available and as observation may show to be desirable. During the interval of some years that will elapse the data required for a correct estimate of the requirements of the country will be accumulating.

(3.) *Data in the Godavery.*—In the Godavery the drains are being gauged annually and the results reviewed, and from a comparison of calculated and actual floodwater levels at various points of each drain reliable data are being obtained. So far there has not been an even heavy fall of rain, much less anything approaching to a maximum, and it will be necessary to wait patiently until the effects of such a fall have been demonstrated before fixing finally the dimensions of the main and primary branch drains. In the Kistna also from the first gauges must be set up at moderate intervals in every considerable drain, and the flood levels recorded on their longitudinal

sections and compared with the registered rainfall, which can be ascertained with accuracy by maintaining rain gauges at all or most of the locks throughout the delta.

(4.) *Conclusions must be based on Observations.*—The importance of the subject is very great, whether the cost of the drains or their efficiency be the point under consideration. No conclusions of any value however can be derived from mere expressions of opinion, they must be based on observation, and Delta officers have the opportunity of making a series of observations, sufficient to allow of a demonstration in due course of the proper dimensions of drains for any given area, from the smallest to the largest which has there to be dealt with. It is to be hoped that Lieutenant Campbell's opinion in the future will be given in connection with facts. He is now in the Godavery Delta, and has an opportunity of ascertaining what facts have been already recorded for drains already partly completed and of continuing the record for every considerable fall of rain.

6. First Sub-Section.—The first sub-section of this Delta (Eastern Section) includes the country lying between the Kistna and the Masulipatam canal together with the island of Divi. The proposed area of irrigation is thus distributed :—

		Acres.
Under Bank Canal	above Divi	15,000
	in Divi	45,000
Under Masulipatam Canal		28,000
	Total ...	88,000

(1.) *Except in Divi lands are Zemindary.*—The lands commanded by the Bank canal above Divi and by the Masulipatam canal in this sub-section are nearly entirely zemindary. There has so far been no opportunity of irrigating these lands except within the area commanded by the Masulipatam canal, but it is tolerably certain that from whatever cause the irrigation there has not been in proportion to the water-supply available. Appendix H of Lieutenant Campbell's report on this sub-section shows that acres 5,185 represent the present extent of irrigation, and imperfect as have been the means of water distribution hitherto there can be no doubt but that a much larger area would have been irrigated had there been any strong desire to make the most of the means available. The opinion of the Revenue authorities is not favorable to the probability of water being demanded for any very large area of these zemindary lands, and accordingly in the order as per margin it was directed that the Bank canal should be constructed to carry water for 8,300* acres only of zemindary land unless the Collector considered this allowance to need revision. Lieutenant Campbell's project for the canal had been worked out previously, and provides for irrigating 15,000 acres of such land, or 168½ acres to the square mile, the area commanded being 89 square miles.

G.O., No. 434, dated 17th February 1876.

* Area supposed to be about 83 square miles.

(2.) *Expenditure for Irrigation and Drainage of Zemindary lands not to be incurred at present.*—In his report (paragraph 7) he says he considers it perfectly safe to assume that the above area will be taken up, but no direct expenditure should be incurred either on the Bank canal, distributaries or drainage works until the demand has actually been made for water, and until the Zemindar or Zemindars

interested have undertaken to pay for the water at such rates as may be fixed by Government.

(3.) *Canals of supply of Sub-Section.*—Lieutenant Campbell states* that it was his intention to have supplied the whole of this sub-section from the Bank canal in preference to supplying the water for the Masulipatam west side channel from the Masulipatam canal at the end of the first reach at Kunkipad. He states that it would be cheaper to make the Bank canal large enough, than to widen the Masulipatam canal to the required extent, and he adds that while obeying the instructions given by the undersigned for the division of the supply between the two canals, he is still of opinion that his intended arrangement was the better of the two "no argument having been advanced against it." The concluding remark is incorrect. The subject was examined and discussed very carefully, and the objection to designing the Bank canal to irrigate the whole sub-section was based chiefly upon the fact that it is at present very doubtful whether any considerable area of the zemindary will want water at all. The widening of the Masulipatam canal up to a certain extent will be as cheap as, or perhaps cheaper than, a corresponding enlargement of the Bank canal, and the undersigned believes that this limited extent need not be exceeded. When that limit has been reached it will be open to the advisers of Government for the time being to indicate what the arrangements thereafter should be, and it will be easy to supplement the supply of the west side channel from the Bank canal if that be then found to be the preferable arrangement. Had Divi been at the upper instead of the lower end of the sub-section, no proposal for a canal through the zemindary would have been brought forward by the undersigned until some very definite and considerable demand for water had risen.

* Report, paragraph 23.

Vide paragraph 41 of Notes of Inspection in Proceedings of the Madras Government, dated 29th September 1874, No. 2,732.

7. Bank Canal.—The general arrangements of this canal have been discussed at length. The course the discussion has taken is recorded in the papers as per margin. It was at first designed as a second-class line of navigation but with a mean velocity of 2,580 yards an hour (2·15 feet a second), and it was considered that the velocity of 2,000 yards an hour (1·66 feet a second) should not be exceeded if the expense of constructing locks (one at head and two others) was to be incurred. Also that if the Puligadda branch of the Kistna was to be crossed by an aqueduct the level of this work would need to be placed much higher than had at first been proposed. Whether or no the canal should be designed as a regular line of navigation, seeing that for half the distance to the Puligadda branch the Masulipatam canal is at a distance of only 2 or 3 miles and the country thence to that branch all zemindary, but little of which was expected to be irrigated, was pointed out to be a matter for consideration. It was ultimately decided not to propose making this canal a regular line of navigation, but for the purpose of conveying materials, and in order to afford water communication of a practicable but inexpensive kind a head lock

Inspection Notes, paragraphs 41 to 45.—Proceedings of Madras Government, No. 2,732, dated 29th September 1874.
General Report on Eastern Delta Section VII, paragraphs 7 to 18.
Appendix No. 3.
Memorandum No. 226, 24th February 1875.
Lieutenant Campbell's No. 3, 1st April 1875.
Memorandum No. 706, dated 30th June 1875.

was to be allowed for, as also a second lock at or about the 24th mile. Navigation was to end at the Puligadda branch of the Kistna. On this basis and on the further instructions which will be found in the same memorandum, Lieutenant Campbell has, with some modifications which will be noticed in due course, worked out the Bank canal project.

No. 706, Appendix No. 3.

8. DESIGN OF BANK CANAL.—The design down to the Puligadda aqueduct is described in paragraph 8 of the Report.* Starting from the Masulipatam canal (right bank) at $3\frac{1}{2}$ miles, and to be supplied therefrom by a head sluice of five vents of 6 feet span each, it will run for a distance of 9 miles at some little distance from the river and thence generally along the line of pits excavated formerly for the river flood bank. The bed and surface fall of the canal down to 21 miles from the head will be 6 inches a mile. Thence to the Puligadda branch of the Kistna in the 36th mile 7 inches a mile. The following points should be attended to in carrying out the work :—

* Appendix No. 2.

(1.) *Alignment.*—The alignment throughout needs careful revision. The canal must be laid out in straight lines, connected by curves of as large radius as may be conveniently practicable. Close proximity to the river is not desirable and must be avoided, especially where, as on Sheet No. 5, 19th mile, such nearness is dangerous, and at the same time gives a bad alignment.

(2.) *Flood bank in relation to Canal.*—From the 13th mile the river flood bank is shown to be separated by a greater or less interval from the right bank of the canal. The latter when properly laid out will be a good alignment for the flood bank also, and either the canal should be shifted to the flood bank where the latter is in a safe and suitable position or the flood bank should be shifted to the canal. Economy of construction and of maintenance will be secured by this arrangement, the latter everywhere, the former generally.

9. DISCHARGE.—The discharge of the canal has been calculated by Lieutenant Campbell by a formula* which is believed to give a velocity in excess of the actual in earthen channels. Using the formula by which the Godavery Delta Canals have been arranged the differences are as follow :—

* $V = 916\sqrt{2f \times \text{H M D}}$.

	Lieutenant Campbell's.		Revised.	
	V	D	V	D
At head	2·09	910·19	1·85	805·67 cubic feet a second.

The revised discharge would allow of water being provided for about 8,700 acres out of the 15,000 acres of zemindary land which Lieutenant Campbell has taken into account. Similarly

	Lieutenant Campbell's.		Revised.	
	V	D	V	D
At 24 miles ...	2·23	884·19	2·00	793 cubic feet a second,

and the zemindary acreage below this would, by the revised calculation, be 8,000 instead of 13,300 acres. It is more likely that the lesser rather than the greater zemindary acreage will be irrigated, and probably the dimensions of the canal as fixed will suffice. But for the aqueduct arrangements in the 36th mile it might have been desirable to diminish the depth of water below the 24th mile to 6 feet.

10. CROSSING OF PULIGADDA BRANCH OF KISTNA.—The information given is by no means as complete as it should have been and as is necessary. Lieutenant Campbell in paragraph 9 of his Report says, "The drawings forwarded with this letter show the present state of the river, but it is advisable that the changes in the bed should be recorded for several years, and, as it will doubtless be sometime before the aqueduct is built, this can easily be done." Towards the end of 1873 the place was inspected by the undersigned and it was then noted that the site was suitable, but that it was evident that the bed of the river had changed since the survey was made two years before, and that the nature and direction of the changes should be recorded. It was added :—"The nose of the island at the bifurcation of the river has been wearing away by erosion for some time past, and a proper salient should be established by nanel planting, as also the proper alignment of the branch from its head to about half a mile below the aqueduct site. Permanent bench-marks should be placed on both sides of the branch near that site. Nothing has been said as to whether these instructions have been carried out, and, if so, with what effect. The information given will be reviewed more in detail in connection with the design for the aqueduct. The Superintending Engineer has been addressed with a view to the requisite information being made available before the time comes, when it will have to be acted upon. Supposing the site noted on the plan* to be correct, the junction with the present Savurnamuki inundation c[illegible] which for a short distance is to be converted into the Bank canal, would not do. Two alignments, either of which would be more suitable, have been marked on the plan.

Appendix No. 2.

The Report is dated October 1875.

Inspection Notes, paragraph 45, in Proceedings, Madras Government, 29th September 1874, No. 2,732.

Memorandum, dated 1st September 1876.

* $\frac{C.1}{No.1}$ Sheet No. 10.

11. GENERAL ARRANGEMENTS IN DIVI FOR IRRIGATION.—The irrigation of Divi is proposed to be effected by three principal channels, having their heads in the 38th mile near Avinagadda, where the Bank canal may be considered to end :—

(1.)—On the east bank of the Kistna.

(2.)—On the south bank of the Puligadda branch of the Kistna.

(3.)—Occupying a nearly central position in the island.

No. 1, the east bank channel, or as it may be more conveniently termed, the Divi west channel, will be $14\frac{1}{2}$ miles long. For rather more than 2 miles it will have a depth of $6\frac{1}{2}$ feet of water, thence to the end just below 52 miles the depth will be 4 feet. The fall throughout will be 6 inches a mile. It is intended to irrigate 21,000 acres.

Down to 41st mile.

No. 2, which may be called* the Divi north channel, will be $15\frac{1}{8}$ miles long The depth of water at the end and for $2\frac{1}{2}$ miles will be $5\frac{1}{2}$ feet. Thence to the end, where it will terminate in the Moodeliar tank, the depth will be 4 feet. The bed fall throughout will be 7 inches a mile.

* The name on the Sketch Map is "Kistna Branch South Bank Channel," and on the Plan $\frac{C.1}{No.1}$ Sheet No. 10, the "Hamsaldivi Branch."

The expected area of irrigation is 17,000 acres.

No. 3.—The Divi central or Suvarnamuki channel will be 10½ miles in length, will carry 4 feet of water to the 8th mile and 3 feet below that, the bed falls being 7 inches a mile. The area of irrigation provided for is 7,000 acres. It is to be noticed—

1st.—That the right and left banks of the Divi west and Divi north channels should be continued with the river flood bank wherever practicable.

2ndly.—That the waterway of all the channels should be confined to the cross section required, and the water should not be allowed to spread over the ground on either side of the channel proper.

3rdly.—That where future widening is not likely to be required there should be no berms, and the banks should be in continuation of the side slopes of the channels.

4thly.—That the termination of the Suvarnamuki channel in ground about 2½ feet above W.L. without any arrangement for the discharge of surplus will not do, and that the channel must be extended to a point where ground and W.L. coincide, so that the proper W.L. may not be exceeded. Surplus may then escape into the swamp to the southward.

5thly.—That in the Divi north channel the alignment involves generally deeper cutting than is desirable or economical and the quantity of excavation required to form the channel banks, and where the left bank is combined with the river flood bank the latter also should be calculated, and the channel so aligned as to provide this quantity as nearly as may be. It is of course unnecessary that the flood bank should follow all the windings of the Puligadda branch.

12. ABSTRACT OF ESTIMATES OF BANK CANAL.—The estimates, though dated October 1875, contain no classified abstract as required by Proceedings of the Madras Government of the 10th July 1875. The following abstract has been prepared in this office:—

Position.	Description.	Sub-heads.	MAIN-HEADS.								Remarks.
			Main Canals and Branches.		Distributaries.		Drainage and Protective Works.		River Embankments.		
			Original.	Revised.	Original.	Revised.	Original.	Revised.	Original.	Revised.	
M. chs.			Rs.	Rs.							
0 0 to 19 2	Compensation	B. Land ..	(a) 13,005	10,000	..	..	..	..	..	..	(a) Rupees 3,005, transferred to Distributaries.
34 7	Constructing canal	L. Earthworks ..	2,20,510	2,20,510	..	..	..	..	..	..	
	Do.	Do. ..	71,740	71,740	..	..	..	..	..	..	
37 58	Do. including turfing ..	Do. ..	(b) 47,160	18,530	..	..	..	..	..	..	(b) Clerical error .. 450
											47,610
											Transferred to distributaries 29,080
											18,530
0 0 to 52 13	rginal bank right side of canal.	Do. ..	35,900	..	..	..	..	..	..	..	
	lood bank	Do. ..	..	..	..	..	..	..	..	..	
	ead sluice	D. Regulators ..	6,940	6,940	..	..	..	..	62,260	*50,000	* See note paragraph 24.
	Do. lock	I. Navigation Works.	11,970	11,970	..	..	..	..	..	..	
7 38	Royur bridge	G. Bridges ..	7,100	7,100	..	..	..	..	..	..	
12 47	Vallur do.	Do. ..	7,380	7,380	..	..	..	..	..	..	
16 0	Escape weir L. B.	H. Escape ..	2,815	(c) 2,815	..	..	..	..	..	..	(c) No plan in book of designs of masonry works.
19 2	Ilur bridge	G. Bridges ..	7,300	7,300	..	..	..	..	..	..	
23 77	Srikakolam bridge	Do. ..	7,570	7,570	..	..	..	..	..	..	
25 0	Papanasanam do.	Do. ..	7,480	7,480	..	..	..	..	..	..	
31 51	Kottrapalem do.	Do. ..	7,820	7,820	..	..	..	..	..	..	
34 15	Escape weir R. B.	H. Escape ..	3,015	(d) 3,015	..	..	..	..	..	..	
35 40	Puligadda aqueduct	F. River and Hill Torrent Works.	3,58,500	3,58,500	..	..	..	..	..	..	(d) No plan do.
	Five works transferred to Distributaries.	....	13,695	..	..	..	..	..	..	..	
..	Bench-mark stones	O. Miscellaneous ..	195	390	..	..	..	..	..	..	
..	Cattle crossings (16)	Do. ..	9,275	9,275	..	..	..	..	..	..	
..	....	P. Maintenance ..	..	32,000	..	..	..	..	..	..	
19 3	Ilur rest-house	K. Buildings ..	2,960	2,960	..	..	..	..	..	..	
35 0	Aqueduct do.	Do. ..	..	3,100	..	..	..	..	..	..	
37 58	Avanigadda do.	Do. ..	3,100	..	..	..	..	..	..	..	
..	Kodur do.	Do. ..	1,150	1,200	..	..	..	..	..	..	
..	Inlets above 11th mile	F. O. C. Drainage Works.	(c) 6,650	6,650	..	..	..	..	..	..	(c) Transferred from drainage estimate.

Distance	Description	Subheads	MAIN-HEADS. Main Canals and Branches. Original.	Main Canals and Branches. Revised.	Distributaries. Original.	Distributaries. Revised.	Drainage and Protective Works. Original.	Drainage and Protective Works. Revised.	River Embankments. Original.	River Embankments. Revised.	Remarks.
M. Fns.											
33 39	Kudaveru channel	B. Land ..	..	..	23.	200	..	..	..	..	
	Head sluice	C. Works ..	..	..	600	350	..	..	..	..	400 acres.
	Fall at 1·0	Do. ..	..	..	295	300	..	..	..	..	
	Tail escape at 1·25	Do. ..	..	..	570	300	..	..	..	..	
	Channel	L. Earthworks ..	..	..	945	450	..	..	..	..	
31 55	Bankapalli channel	B. Land ..	..	..	246	200	..	..	..	..	
	Head sluice	C. Works ..	..	..	450	400	..	..	..	..	
	Fall at 1·0	Do. ..	..	..	355	300	..	..	..	..	500 do.
	Tail escape at 2·15	Do. ..	..	..	580	400	..	..	..	..	
	Channel	L. Earthworks ..	..	..	1,074	700	..	..	..	..	
25 77	Srirakulam channel	B. Land ..	..	..	680	600	..	..	..	..	
	Head sluice	C. Works ..	..	..	550	500	..	..	..	..	800 do.
	Fall at 1·0	Do. ..	..	..	335	300	..	..	..	..	
	Fall at 3·0	Do. ..	..	..	310	300	..	..	..	..	
	Tail escape at 5·40	Do. ..	..	..	615	600	..	..	..	..	
	Channel	L. Earthworks ..	..	..	2,635	1,300	..	..	..	..	
25 77	Gajapati channel	B. Land ..	..	..	850	600	..	..	..	..	
	Head sluice	C. Works ..	..	..	800	600	..	..	..	..	700 do.
	Fall at 3·0	Do. ..	..	..	395	300	..	..	..	..	
	Do. at 5·0	Do. ..	..	..	310	300	..	..	..	..	
	Tail escape 6·70	Do. ..	..	..	360	300	..	..	..	..	
	Channel	L. Earthworks ..	..	..	2,241	1,400	..	..	..	..	
23 48	Vakalaveddia channel ..	B. Land ..	..	..	523	500	..	..	..	..	600 do.
	Head sluice	C. Works ..	..	..	650	500	..	..	..	..	
	Fall at 2·0	Do. ..	..	..	355	..	..	..	..	..	
	Tail escape at 4·20	Do. ..	..	..	630	600	..	..	..	..	
	Channel	L. Earthworks ..	..	..	2,660	1,200	..	..	..	..	
23 48	Pagula channel	B. Land ..	..	..	730	600	..	..	..	..	
	Head sluice	C. Works ..	..	..	600	500	..	..	..	..	
	Fall and bridge at 2·0	Do. ..	..	..	720	500	..	..	..	..	600 do.
	Bridge at 2·0	Do. ..	..	..	815	500	..	..	..	..	
	Tail escape at 6·0	Do. ..	..	..	450	300	..	..	..	..	
	Channel	L. Earthworks ..	..	..	1,900	600	..	..	..	..	
21 29	Lakavaka channel	B. Land ..	..	..	780	600	..	..	..	..	
	Head sluice	C. Works ..	..	..	800	500	..	..	..	..	700 do.
	Bridge at 1·20	Do. ..	..	..	740	350	..	..	..	..	
	Fall at 3·0	Do. ..	..	..	430	..	..	..	..	..	
	Tail escape at 6·18	Do. ..	..	..	455	450	..	..	..	..	
	Channel	L. Earthworks ..	..	..	2,510	1,500	..	..	..	..	
16 7	Wadapalem channel	B. Land ..	..	..	3,910	3,000	..	..	..	..	
	Head sluice	C. Works ..	..	..	3,250	2,000	..	..	..	..	10,000 do.
	Bridge, Mopadivi and fall ..	C. Works ..	..	..	2,925	2,500	..	..	..	..	
	Do. Pedakallipalli	Do. ..	..	..	2,695	2,300	..	..	..	..	
	Do. C. Yadara	Do. ..	..	..	885	800	..	..	..	..	
	Channel	L. Earthworks ..	..	..	20,280	12,600	..	..	..	..	
M. C.											
6 26	Nelakurru branch channel ..	B. Land ..	..	..	480	400	..	..	..	..	
	Head sluice	C. Works ..	..	..	480	450	..	..	..	..	
	Fall, 2nd mile	Do. ..	..	..	320	..	..	..	..	..	(3,000 acres.)
	Channel	L. Earthworks ..	..	..	2,385	1,000	..	..	..	..	
6 3	C. Yadara branch channel ..	B. Land ..	..	..	520	450	..	..	..	..	
	Head sluice	C. Works ..	..	..	490	400	..	..	..	..	
	Fall, 1st mile	Do. ..	..	..	335	..	..	..	..	..	(3,000 acres.)
	Channel	L. Earthworks ..	..	..	3,405	1,700	..	..	..	..	
37 58	Divi West Channel	B. Land ..	..	..	3,005	3,005	..	..	..	..	
	Head sluice (share of) ..	C. Works ..	..	..	3,265	3,500	..	..	..	..	
2 19	Bridge (Vakanur)	Do. ..	..	..	2,730	2,730	..	..	..	..	(21,000 acres.)
5 59	Do. (Nagailunka) ..	Do. ..	..	..	1,855	1,855	..	..	..	..	
9 6	Do. (Kotapalem)	Do. ..	..	..	1,215	1,215	..	..	..	..	
11 47	Do. (Yetimoga)	Do. ..	..	..	895	895	..	..	..	..	
13 72	Tail escape	Do. ..	..	..	..	250	..	..	..	..	
	Channel	L. Earthworks ..	..	..	29,080	29,080	..	..	..	..	
2 17	Bandalai Cheruvu branch channel	B. Land ..	..	..	305	305	..	..	..	..	
	Head sluice	C. Works ..	..	..	515	515	..	..	..	..	(2,000 acres.)
	Tail escape	Do. ..	..	..	380	380	..	..	..	..	
	Channel	L. Earthworks ..	..	..	1,460	1,460	..	..	..	..	
3 15	Vakanur branch channel ..	B. Land ..	..	..	600	600	..	..	..	..	
	Head sluice	C. Works ..	..	..	615	615	..	..	..	..	(4,000 acres.)
	Fall, 2 miles	Do. ..	..	..	390	390	..	..	..	..	
	Tail escape	Do. ..	..	..	330	330	..	..	..	..	
	Channel	L. Earthworks ..	..	..	3,260	3,260	..	..	..	..	
5 59	Chodaveram branch channel.	B. Land ..	..	..	900	900	..	..	..	..	
	Head sluice	C. Works ..	..	..	535	535	..	..	..	..	(4,000 acres.)
	Fall, 3 miles	Do. ..	..	..	360	360	..	..	..	..	
	Tail escape, 6 miles	Do. ..	..	..	475	475	..	..	..	..	
	Channel	L. Earthworks ..	..	..	4,855	4,855	..	..	..	..	
8 78	Talagada, Divi branch channel.	B. Land ..	..	..	820	820	..	..	..	..	
	Head sluice	C. Works ..	..	..	770	770	..	..	..	..	(5,000 acres.)
	Fall at 60 chains	Do. ..	..	..	575	..	..	..	..	..	
	Do. at 3·0	Do. ..	..	..	410	..	..	..	..	..	
	Tail escape 5·10	Do. ..	..	..	340	340	..	..	..	..	
	Channel	L. Earthworks ..	..	..	5,290	5,290	..	..	..	..	
10 68	Yetimoga branch channel ..	B. Land ..	..	..	270	270	..	..	..	..	
	Head sluice	C. Works ..	..	..	445	445	..	..	..	..	(2,000 acres.)
	Fall at 1·0	Do. ..	..	..	340	..	..	..	..	..	(4,000 acres direct irrigation under Divi west channel.)
	Channel	L. Earthworks ..	..	..	2,020	2,020	..	..	..	..	
37 58	Divi North Channel	B. Land ..	..	..	3,407	3,407	..	..	..	..	
	Head sluice (share of) ..	C. Works ..	..	..	2,655	2,800	..	..	..	..	(17,000 acres.)
2 40	Bridge (Machaveram) ..	Do. ..	..	..	1,845	(f) 1,845	..	..	..	..	(f) No plan.)
9 20	Do. (Salempalem) ..	Do. ..	..	..	955	900	..	..	..	..	

Position.	Description.	Sub-heads.	MAIN HEADS. Main Canals and Branches. Original.	Main Canals and Branches. Revised.	Distributaries. Original.	Distributaries. Revised.	Drainage and Protective Works. Original.	Drainage and Protective Works. Revised.	River Embankments. Original.	River Embankments. Revised.	Remarks.
M. CHS.	M. C.		RS.	RS.							
	12 50 Bridge (Haripuram) ..	C. Works ..	..	..	960	900	..	..	..	..	
	Channel	L. Earthworks ..	..	..	2,200	25,000	..	..	..	..	
	2 40 Machaveram branch channel.	B. Land.. ..	..	..	320	300	..	..	..	..	
	Head sluice	C. Works ..	..	..	410	400	..	..	..	..	(2,000 acres.)
	Fall at 1·0	Do. ..	..	..	350	..	..	..	..	..	
	Tail escape at 2·30	Do. ..	..	..	330	330	..	..	..	..	
	Channel	L. Earthworks ..	..	..	1,720	1,700	..	..	..	..	
	4 77 Kaldindivari branch channel.	B. Land.. ..	..	..	640	640	..	..	..	..	
	Head sluice	C. Works ..	..	..	750	750	..	..	..	..	(5,000 acres.)
	Tail escape at 4·0	Do. ..	..	..	475	475	..	..	..	..	
	Channel	L. Earthworks ..	..	..	3,813	3,000	..	..	..	..	
	7 0 Kodur branch channel ..	B. Land.. ..	..	..	800	800	..	..	..	..	
	Head sluice	C. Works ..	..	..	765	765	..	..	..	..	(5,000 acres.)
	Tail escape at 5 0	Do. ..	..	..	340	340	..	..	..	..	
	Channel	L. Earthworks ..	..	..	4,668	4,000	..	..	..	..	(5,000 acres direct under Divi north channel.)
37·52	Suvarnamuki channel ..	B. Land.. ..	..	..	2,020	2,020	..	..	..	..	(7,000 acres.)
	Head sluice (share of) ..	C. Works ..	..	..	1,080	1,200	..	..	..	..	
	1 20 Fall and bridge	Do. ..	..	..	1,485	1,485	..	..	..	..	
	6 0 Bridge and regulator ..	Do. ..	..	..	1,210	1,210	..	..	..	..	
	8 0 Dividing sluice and bridge ..	Do. ..	..	..	1,400	1,600	..	..	..	..	
	Channel	L. Earthworks ..	..	..	10,165	10,000	..	..	..	..	
	6 0 Mandapakala branch channel.	B. Land.. ..	..	..	540	500	..	..	..	..	
	Head sluice	C. Works ..	..	..	425	425	..	..	..	..	
	Channel	L. Earthworks ..	..	..	4,120	2,000	..	..	..	..	(2,000 acres.)
	8 0 Pelagolapalem branch channel.	B. Land.. ..	..	..	200	200	..	..	..	..	
	.....	L. Earthworks ..	..	..	1,612	1,250	..	..	..	..	(1,500 acres)
	8 0 C. Golapalem branch channel.	B. Land.. ..	..	..	260	200	..	..	..	..	(1,500 acres.)
	.....	L. Earthworks ..	..	..	1,666	1,250	..	..	..	..	
6 38	Kanikalamadagu main drain* ..	B. Land.. ..	..	..	..	..	11,450	11,450	..	..	* Including the upper part called in the estimates the Badiapad affluent.
	Inlet	C. Works ..	..	..	..	..	1,320	1,320	..	..	
	Eight Inlets	Do. ..	..	..	..	..	13,270	13,270	..	..	
	Bodapad extension	L. Earthworks ..	..	..	..	..	8,450	8,450	..	..	
	From C. Mojeru drain to Fort creek	Do. ..	..	..	..	..	67,330	67,330	..	..	
	Devarapalli drain	Do. ..	..	..	..	..	1,000	1,000	..	..	
	Inampudi drain	B. Land.. ..	..	..	..	..	7,020		..	..	
	Bridge Bar and Nedamole road ..	C. Works ..	..	..	..	..	7,890		..	..	
	Inlets	Do. ..	..	..	..	..	12,905	(g)	..	..	(g) Appertains to Masulipatam canal.
	Drain	L. Earthworks ..	..	..	..	..	1,81,030		..	..	
	5 Cattle crossings	Do. ..	..	..	..	..	1,940		..	..	
	Talaru drain (Divi)	B. Land.. ..	..	..	..	..	5,110	4,000	..	..	
	3 Inlets	C. Works ..	..	..	..	..	4,160	3,000	..	..	
	Bridge near Mandapakala ..	Do. ..	..	..	..	..	6,830	4,500	..	..	
	Outlet at end	Do. ..	..	..	..	..	6,310	..	..	..	
	Drain	L. Earthworks ..	..	..	..	..	64,250	50,000	..	..	
	Gudirmotu drain (Divi)	B. Land.. ..	..	..	..	..	2,260	2,000	..	..	
	5 Inlets	C. Works ..	..	..	..	..	7,505	5,000	..	..	
	Bridge near Mandapakala ..	Do. ..	..	..	..	..	6,880	4,500	..	..	
	Drain	L. Earthworks ..	..	..	..	..	14,430	13,500	..	..	
	Viranki drain	B. Land.. ..	..	..	..	..	360		..	..	
	Bridge near Viranki lock ..	C. Works ..	..	..	..	..	2,480	(h)	..	..	
	Drain	L. Earthworks ..	..	..	..	..	1,610		..	..	(h) Appertains to Masulipatam Canal.
	Mopedivi drain	Do. ..	..	..	..	..	500	500	..	..	
			8,53,230	8,05,445	2,20,550	1,86,217	4,36,290	1,89,820	62,260	50,000	
	Deduct items also shown under Distributaries.	..	45,780	..	..	..	..	..	..	..	
	Deduct share of Kanikalamadugu drain chargeable to Masulipatam canal—*Vide* note paragraph 19.	..	..	..	..	..	..	43,860	..	..	
	I. Works .. Total ..	..	8,07,450	8,05,445	2,20,550	1,86,217	4,36,290	1,45,960	62,260	50,000	
	II. Establishment, 25 per cent. on I.	..	..	2,01,365	..	46,553	..	36,490	..	12,500	
	Do. Survey do... Past ..	..	..	2,000	..	2,000	..	1,000	..	..	
	Do. Survey do... Future ..	..	..	1,000	..	3,000	..	1,000	..	..	
	III. Tools and Plant, 8 per cent. on I.	..	..	64,400	..	14,300	..	11,680	..	4,000	
			..	10,74,210	..	2,52,370	..	1,96,130	..	66,500	

	RS.
Main Canals and Branches	8,07,450
Distributaries	2,20,550
River Embankments ..	62,260
	10,90,260
Estimates as submitted by District Engineer	10,83,610
Difference due to transfer of inlets above 11th mile from main-head (4) to (2)	6,650
Drainage and protective works	4,36,290
Transferred to Main Canals and Branches	6,650
Amount of estimates as submitted by District Engineer.	4,42,940

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The subjoined remarks will explain the differences shown in the original and revised columns due to transfers from the main-head (2) Main Canal and Branches to main-head (3) Distributaries.

As mentioned in paragraph 3 above the canal should be considered to end at the Avinagadda regulating works. There is no sufficient reason for closing the Divi west channel as a canal and the Divi north channel as a distributary, the former is to irrigate 21,000 and the latter 17,000 acres, and the two channels are of the same class. Consequently the cost of the Divi west channel has been placed under distributaries, and as there is no information as to the land required for it, an arbitrary division* of the total entry in the "original" column has been made. The inlets on the Bank canal above 11th mile have also been transferred to (2) Main Canals and Branches from (4) Drainage and Protective Works.

* 10,000 to canal 3,005 to Divi West channel.

13. Total of Original Estimates.—After deducting the items amounting to Rupees 45,780† transferred to distribution, the total of the original estimates for the Bank canal from the head to its termination at 37 miles 58 chains becomes Rupees 8,07,450, or at the rate of Rupees 21,227 a mile; this high average is due to the cost of the aqueduct for crossing the Puligadda branch of the Kistna, the item for which is Rupees 3,58,500, and represents a charge per mile of Rupees 9,503; consequently the cost, exclusive of the aqueduct, is Rupees 11,724 a mile. Similarly the cost of distributaries amounts to Rupees 2,20,550, and the acreage to be irrigated being 60,000, the cost per acre is Rupees 3,676. The estimated cost of distribution, however, varies very considerably.

†		Rs.
	Divi West channel	... 42,045
	" North do. head sluice	... 2,655
	Suvarnamuki do. do. ...	... 1,080
		45,780

The area to be irrigated above the aqueduct in the 36th mile is ... ... Acres 15,000
The distribution is estimated to cost ... ... Rupees 73,599
Rate per acre " 4·90

The area to be irrigated below the aqueduct is ... ... Acres 45,000
Cost of distribution ... ... Rupees 1,46,951
Rate per acre 3·27

or the former is just half as much again per acre as the latter, and it is somewhat remarkable that in the former case it is the narrow strip of ground between the and the drainage which limits the area to be irrigated, which is costly to supply,

	Length. M.	Chs.	Rate per Acre. Rs.
Kuderu Channel	1	75	6·36
Lankapalli do.	2	15	5·41
Srikakolam do.	5	40	6·47
Chittur do.	6	70	7·12
Vakalagadda Channel	4	20	8·63
Pagole do.	6	6	13·24
Pedaprolu do.	6	17	8·16
Wadapalem do.	12	60	
Nelakarru branch	3	50	3·69
C. Yadara do.	4	0	

on the other hand, if the total cost of the irrigation above and below the Puligadda branch be considered, the following approximate results will be obtained :—

Above the Puligadda branch M. C. and B. ...		* 98,607
Distributaries		73,599
		1,72,206
	Per Acre...	1,148
Below the do. do. M. C and B. ...		6,54,323
Distributaries		1,46,951
		8,01,274
	Per Acre...	17·81

* One-fourth of the sum of the estimates, less amount transferred to distributaries (45,780) marginal bank (35,900) lock (11,970) and aqueduct.

Three-fourths of do. do., but with aqueduct added.

The subject will be further noticed in connection with the revision of the estimates.

14. Works, Main Canals and Branches.—The following remarks on the items of this main-head explain the alterations made in the original estimates not noted on the abstract. Alterations of details not involving material modification of cost have been shown in remarks on the plans.

(1.) *Marginal bank right side of Canal.*—This bank estimated to cost Rupees 35,900 is unnecessary. The canal can be placed alongside the river flood bank generally or otherwise the flood can be adjusted to the line of the canal in bringing the former to section. Only occasionally therefore will any marginal bank, to confine the water when above ground level to its proper section, be necessary.

(2.) *Puligadda Aqueduct.*—This is by far the most important masonry work on the canal, and is estimated to cost Rupees 3,58,500. The design as regards the arrangements generally of the floors and aprons has been prepared on instructions issued from this office, but there will be several important matters to be considered before the working drawings can be prepared.

1*st.*—The information that is available regarding the changes which have taken place at and near the site selected is at present inadequate.

2*nd.*—It is probable that the lower or river floor of the aqueduct will have to be placed lower than H.W.D. 2·66.

3*rd.*—The information regarding the flood level of 1874 is not as complete as is necessary, and there are discrepancies in the information given which have to be examined into, and regarding which the Superintending Engineer has been addressed.

4*th.*—The flood level must be deemed to be at about the same height at both ends of the aqueduct, but in the design the top of the side walls is at the upper end 1·38 feet higher than at the lower end. The margin at the former is 5·23 feet, and at the latter therefore 3·85 feet. It will probably be desirable to raise the right front and rear wings to 4½ feet above the flood level of 1874.

11·36	
9·98	
1·38	

5*th.*—There should be a hand rail on both sides of the aqueduct.

6*th.*—The water wings are the main wings, and inside these are supplemental wings founded at the upper end at 11·20. It would be difficult, if not impracticable, to prevent a separation of these supplemental wings from the abutments which are to be founded at 15·66. The better arrangement will be to construct the main wings on

the alignment laid down for the interior wings, and the returns of these should not be carried up above 6 feet below canal bed level. The water wings need not then be higher at their junction with the abutments than the springing line of the arches; the returns of these may then be 30 feet in length. The earthwork slopes from the end of the main to the water wings should be revetted. The canal bank at full height should overlap the main wings 6 feet, from which point the slopes towards the water wings should commence.

7*th*.—The cut waters of all the piers should be struck with radii equal to the thickness of the piers, the centre being on the line of the face wall if there be no pilasters: the cut waters of the piers in the design are segments of semi-circles.

8*th*.—Ground level and an accurate cross section of the river require to be shown on the longitudinal section and elevation (small scale) as also the M.F.L.

(3.) *Maintenance chargeable to Capital*.—No provision has been made in the original estimate under this sub-head (P), Rupees 32,000 have been allowed in the revised estimate.

(4.) *Rest-houses*.—First-class rest-houses are provided for at Ilur about 19 miles 3 chains and at Avimagadda about 38 miles. The site for the latter should be selected as near to the aqueduct site as possible, and if suitable ground can be found to the north of the aqueduct so much the better because there rather than on the island of Divi all materials brought from Bezwada will have to be dragged, as the Executive Engineer in charge should reside there for the two or three years that the aqueduct will be under construction. Afterwards also this position will be a convenient one. An additional second-class rest-house may be allowed for Avimagadda, near which all the heads of the principal distributaries of Divi will be kept. The designs for these rest-houses will be supplied by [illegible]

Rupees, and Rupees 50 have been added to the estimate on this account.

15. Works Distributaries.—It has already been noted that the proposed arrangements for the distributaries above Divi are on the whole unusually expensive and a few remarks on those of the several branches will therefore be desirable.

(1.) *Kuderu Channel*.—The levels on the earthwork and [illegible] agree. The difference between the bed

C,1—No. 6. Plans, Earthwork and Masonry.
No. 31 } Do. do.
" 32 }

of the canal and of the distributary is stated to be 4 feet (27·13 + 23·13), but the full supply level in the latter is to be 25·13 and corresponds with 27·13 of the canal bed—[illegible] of the head sluice and of the earthworks are unnecessarily increased by this difference. The bed of the distributary on so low a level; again the water in the channel for half a length would be entirely below ground level and much of the length will generally be below the depth, or in this case 1 foot above ground level. It is believed that Rupees 4 an acre will be ample to meet the cost of distribution, especially as this will be made to approximate more nearly to that of the country.

(2.) *Lankapalli Channel*.—In this case also the canal beds on the head sluice

C,1—No. 7. Plans, Earthwork and Masonry.

[illegible] do not agree with the [illegible] and the channel bed is [illegible] feet below canal bed it will save expense.

1*st*.—To raise the former 2 feet at the head.

2*nd*.—To increase the bed fall.

(3.) *Srikakolam Channel*.—Here again the cost of earthworks may be much reduced by placing the bed of the channel higher and by increasing the bed fall.

C,1—No. 9.

There are mistakes in the levels noted on the head sluice plan.

When a drop is required at a head sluice it should be effected immediately behind the sill, and then the length or width of apron can be much reduced.

(4.) *Chittur Channel*.—The bed is placed on much too low a level at the head and generally the channel is in too deep cutting in the 2nd and 3rd reaches by at least a foot. It is not clear why so low a bed fall as 8 inches a mile for these small channels has been adopted. Two feet a mile would not give too high a velocity, and the nearer the fall of a channel approximates to that of the country the cheaper the distribution will be.

C,1—No. 11.

(5.) *Vakalagadda Channel*.—The level of the bed at the second mile on the longitudinal section is about right, and the bed at the head can with advantage and economy be placed $2\frac{2}{3}$ feet higher than there shown, and, if the fall of 2 feet a mile be continued, no drop at 2 miles will be necessary.

C,1—No. 12.

(6.) *Pagole Channel*.—The arrangements should be recast. Ground level at head is shown at 18·51, and at lower end 4 miles at 10·88. The bed of the channel at head should be about 17·25 and at tail about 9·25, the bed fall being 2 feet a mile.

C,1—No. 13.

(7.) *Pedaprolu Channel*.—The first reach of 3 miles has its bed at about the right level relatively to the ground. No drop is required at 3 miles, but the bed should be laid out from this point to the end with a fall of about 2 feet a mile.

C,1—No. 15.

(8.) *Wadapalam Channel*.—This channel as shown in the longitudinal section starts with a cutting 7·69 feet deep, the proper cutting, with banks 2 feet above water level and 4 feet wide at top, being under 3 feet; consequently the bed at head should be placed at about 16·00 instead of 10·78. The bed fall was intended to be 6 inches a mile, but 15 inches a mile will not occasion a velocity in excess of that in the canal, and a bottom width of 12 feet instead of 20 feet will then suffice. The channel arrangements should be entirely recast so as to place it in somewhat less than 3 feet of cutting generally and to carry the water at a velocity of 2 to 2·25 feet a second.

C,1—No. 16.

(9.) *Nelakurru Branch Channel*.—If the bed be placed on the average $2\frac{1}{2}$ feet below ground surface and the fall be made to correspond with that of the ground, the cost of earthworks will be reduced to less than one-half.

51 of C,1—No. 16.

(10.) *C. Yadara Branch Channel*.—The bed should be at about $2\frac{1}{2}$ feet below ground level. The length is 7,040 yards, and $2\frac{2}{3}$ cubic yards to the yard run will represent the cutting required which will also nearly suffice for banks 2 feet above

53 of C,1—No. 16.

water level. Altogether 3½ cubic yards to the yard run will be enough. Consequently about 24,640 cubic yards will be required instead of the 51,575 cubic yards of the estimate. The fall should approximate closely to that of the country or about 1 foot a mile. No masonry drop will be required.

(11.) *Divi West Channel.*—This to irrigate 21,000 acres, and the estimated cost of the primary distribution is ... ... Rs. 42,045
Secondary do. ,, 26,290
Total .. 68,335

C.I—No. 1. Sheets 11 to 14, longitudinal and cross sections.

This will give Rupees 3¼ an acre which is reasonable and about sufficient ordinarily.

The channel is to carry 6½ feet of water for 3½ miles and thereafter 4 feet. The proposed bed levels appear to be generally suitable, but it is doubtful whether the drop in the 6th mile is necessary, and probably a greater bed fall below the third mile will be desirable. The disposal of surplus water at the lower end will have to be provided for in some way by an escape which will also regulate the level of water surface. The arrangements can be temporary in the first instance and a dry stone escape will suffice, for which Rs. 250 [illegible]

(12.) *Dead Sluice.*—The designs for the Divi west, Divi north and Suvarnamuki channels may with advantage be revised. It is much too cramped for convenience, and should be placed a few yards below the bifurcation, where there will be room for the convenient disposition of the dividing banks between the three channels and for a good alignment of the heads of the west and north channels.

(13.) *Disposal of difference between discharge of Channel in successive miles.*—This matter will need consideration. 31½ cubic feet a second will be admitted at the head when the Bank canal is running full; the last part of the channel is designed to carry 60 cubic feet a second, and the disposal of the difference must not be left to chance. There are several old inundation channels which will be superseded and will be available for carrying surplus into the drainage or into the old tanks. Some remarks have been noted on the plans of the masonry works.

(14.) *Bundalakkeruvu Valavur Chellaperu Branch Channels.*—These have been designed with the beds on too low a level and with too slight a bed fall. The sums provided for them have not been altered, but a reduction in earthworks will be practicable, and the money may be wanted for regulating the heads of field channels. Masonry falls are not likely to be required.

(15.) *Talagadutti Branch Channel Pettayan, &c.*—The bed fall should be increased and the drops superseded.

(16.) *Divi North Channel Hamsalivi.*—Where the left bank of this channel is not also a flood bank, its height above F.S.L. should be 2 feet as the normal level. The bed fall 7 inches a mile is somewhat small where the depth of water, as in the upper 2½ miles is 5½ feet, below where the depth is 4 feet it is less than is desirable. The bed at the head may with advantage to economy be placed higher. The water way where the channel is to be carried alongside the flood bank should be confined to the proper section. On the whole the bed at head will be better if placed at the same

level as that of the end of the Bank canal, and a fall of 8 inches a mile for the first 2½ miles and 1 foot a mile thereafter, at any rate to 7 miles, will be about right. The alignment in the 14th mile runs too close to the river, and it is not clear that it will be advantageous to carry the channel through the pits of the old flood bank as a rule. The Puligadda branch flood levels have not been marked.

A temporary escape for the discharge of surplus into the small tank at which the channel ends should be provided.

(17.) *Machaveram Branch Channel.*—The head as shown in No. 56 C 1—No. 21 is not in the most favorable position available. All the heavy cutting could be avoided by putting it about 300 yards higher up the Divi north channel. The bed fall should be about 1 foot a mile, and no drop will be necessary.

(18.) *Kaldindivari Branch Channel.*—The head of this channel would apparently be better if placed higher up the Divi north channel.

The alignment shown starts in deep cutting, and if placed 1 mile higher up would be no longer and would run through ground better suited as regards level.

The bedfall also would be the better for being increased by adopting a higher offtake.

(19.) *Kodur Branch Channel.*—The ground levels on the section of the Divi north channel and on that of the branch do not agree. It seems probable that the alignment throughout could be improved.

(20.) *Suvarnamuki Channel.*—Apparently the only advantage of utilizing the old inundation channel of this name for the first 2¼ miles will be the avoidance of the necessity for taking up fresh land, and the advantage is questionable. It is proposed to make the channel bed at its head at 10·00 or 1·43 feet below that of the Bank canal, and at the lower end 8⅜ miles 0·13, the fall of the channel will therefore be 9·87 feet. A more satisfactory distributary would be obtained by starting at 11·43, carrying the channel in a nearly direct line to the point at 2¼ miles where the new alignment commences, with a bedfall of 1 foot a mile down to 2½ miles, and below that 1½ feet a mile.

(21.) *Mandapakala Branch Channel.*—The earthworks of this channel 4 miles in length and with 1½ feet of water the bed width at the head being 6 feet, are estimated to cost Rupees 4,120. The channel should be in 1 foot cutting; the banks should be 1 foot wide at top and 3 feet above channel bed, and then about 2 cubic yards to the yard run will be required, or say 1,000 Rupees. 2,000 Rupees should suffice for earthworks, and the regulation of the heads of field channels, minor distributaries, &c.

(22.) *P. Golapalem Branch Channel C. Golapalem Branch Channel.*—These petty channels may be much reduced in cost by adapting the arrangements to the circumstances. Very small banks will suffice and a large part of the earthworks is for these. The original estimate contains no items for regulation at their heads though such works appear to have been designed. The provision for the channels will, however, be more than ample.

16. General Remarks on Distributaries.—There is no advantage in a small bedfall supplemented by masonry drops. The nearer the bedfall coincides with the fall of the ground the better, and a velocity of about 2 feet a second in such channels is none too much. The water surface should as far as possible be somewhat above

ound level; from one-third to one-half the depth is convenient for distribution by field channels. Berms are not desirable unless enlargement be probable: they render the maintenance of the channels more difficult and involve the taking up of much additional land. Banks should not have a greater margin above water level than is really necessary. High banks add greatly to the expense. A margin of half the depth of water is usually ample.

17. Expenditure on Distribution above 35th mile, Bank Canal.—No expenditure on distributaries above the aqueduct will be required until a demand for water arises. The land is all Zemindary, and there is no immediate prospect of much irrigation in this part of the delta.

18. Drainage.—The estimates for drains are heavy. They, as submitted by the District Engineer, amount to Rupees 4,36,290 for works, and represent rather a possible future and ultimate outlay than any present requirement to be met. No drainage of Zemindary land will be undertaken until a large and steady demand for water for irrigation may be made and then only such improvements to existing means of drainage as may be shown to be necessary will be carried out. Moreover, the basis on which the drains have been designed is only probably correct, and it has yet to be settled what capacity the drains for any given area of delta country must be to be effective, consequently the dimensions to be at first given to any drains that may be required will be much less than those provided for in the estimates. This is a necessity as regards the execution of the work, and it is requisite further in order that no unnecessary work may be done. A width of one-third for small to one-half for large areas will generally suffice, not for a season's work which will usually be much less, but for the work to be done until discharges from recorded rainfall have been ascertained and the ultimate requirements deduced therefrom.

19. Kanakalamadugu Drain.—This will be the main drain of the tract of country between the Kistna on the west, the Masulipatam canal on the north, the Puligadda branch of the Kistna on the south, and the sea on the east. For some 26 miles the existing drain (Madugu) is of ample capacity; its extension northwards to Bodlapad and its improvement in the last 10 miles are the requirements provided for. In the papers different parts are called by different names, but there appears to be no good reason for more than one name throughout from near Bodlapad to the fort creek. The ultimate area to be relieved by this drain is 235 square miles, and the dimensions have been arranged to carry off 0·56 inch of drainage from the whole area. The formation of a regular drain as regards the lower 10 miles is intended to commence at the infall of the C Majeru drain with a bottom width of 152 feet and a depth of water of 6 feet. In the third mile the Inampudi drain falls in and the bottom width below the junction is to be 246 feet. The bed level at the infall of the C Majeru drain is at H.W.L. + 0·34, and at the fort creek 4·60 or 4·94 feet fall in a little less than 10 miles, being at the rate of 6 inches a mile. The bed of the creek is however at 6·01, and it will be advisable to lay out the drain bed with a uniform slope to this lower level, if the soil be such as to allow of the excavation being carried the 1·40 feet deeper at the lower end, where the ground is not already below that level. The berms are to be 30 feet wide on each side of the drain at the C Majeru

0·69 inch from area of 122·61 square miles 2,275 cubic feet a second.

Area 225 square miles.

Drainage 0·56 inch from that area 3,391 cubic feet a second.

infall and 100 feet wide at the lower end. Probably but little work will need to be done so far as Government interests are concerned, except in the lower 4 miles where a free outfall for the Inampudi drainage will perhaps be found requisite, but only on a small scale at first and enough to form the embankments on their proper alignment.

The Bodlapad extension northwards of the Kanakalamadugu it may be necessary to carry out at an early date to dispose of surplus from the Masulipatam canal discharged at Kunkipad of the total estimated cost Rupees 1,01,820 of this drain Rupees 10,350 for the Bodlapad extension, Rupees 1,990 for earthworks above station 20, Rupees 1,760 for one inlet plan No. 6, and half the rest of the estimate, or altogether Rupees 57,960 appertain to the Bank canal, and Rupees 43,860 to the Masulipatam canal, the areas in connection with these canals drained being approximately equal, so that the cost below station 20 should be divided between them. Any general sanction which may be given to the estimates should not be deemed to convey authority to carry out any part of the Kanakalamadagu drain without the special sanction of Government.

20. Design for Inlets.—The designs for inlets to the drains are generally suitable. Some modifications in the wings and wing returns may be made without affecting their efficiency and at some saving of expense.

21. Inampudi Drain, Virunki Drain.—These will be considered in connection with the Masulipatam canal the lands under which they are to relieve.

22. Divi Drainage.—It is intended to improve the drainage of the island of Divi by two principal drains, the Taleru and the Gudumotu.

(1.) *Taleru Drain.*—The Taleru drain is to start from the lower end of the Machaveram channel, a branch of the Divi north channel, the drainage area above being 2·86 square miles, and the discharge required 186 cubic feet a second will run alongside the Savurnamuki channel for about $2\frac{1}{2}$ miles, and then turn off and follow a low line through a swamp discharging ultimately at $11\frac{7}{8}$ miles into the Puligadda branch of the Kistna near Hamsaldivi. The total area drained is estimated to be 33 square miles. The drainage to be discharged 1·08 inches over whole area in twenty-four hours, or 960 cubic feet a second. The fall available is from + 4·44 to — 4·00 at the outfall; the latter level being approximately M.S.L.; the drain has been arranged throughout with a bedfall of $8\frac{1}{2}$ inches a mile, the dimensions have been fixed with reference to a depth of 4 feet of water throughout, and at this depth the water will be carried almost entirely within soil. As the waterway is all provided in the drain itself, and as a greater depth of water than 4 feet may at times without inconvenience be allowed, there appears to be no need for leaving berms between the drain and the spoil banks. If these latter be placed on the edge of the drains, as shown in the sections, there will be ample waterway for even a liberal estimate of ultimate discharge, and if the drain be cut to one-third of the full section to begin with, widening can subsequently be carried out as may be found necessary. The rates vary from 1 to $1\frac{1}{2}$ Annas a cubic yard. Judging from Godavery Delta rates an average of 1 Anna should suffice. Looking to the description of land, principally swamp, through which the drain will run the provision for land compensation, Rupees 5,110, seems large. It will be considerably reduced by the omission of berms.

About one-fourth.

(2.) *Mandapakala Bridge.*—The proposed height of this bridge 13½ feet to roadway for a drain carrying 4 feet of water with possibly 6 feet as a maximum, is excessive; abutments 4½ feet high and a rise of 3 feet for the arches will be ample. The abutments can be reduced to 4 feet in thickness at the springing line, and 4½ feet at floor level, and the piers to 3 feet. The wings also can be considerably shortened, viz., to 17 feet instead of 25 feet.

(3.) *Outlet Sluice at end of Drain.*—The lineal waterway of this sluice is only 18 feet, the bottom width of the drain being 103 feet. The spoil banks of the drain can easily be made higher than flood level in the river, and then probably the necessity for any self-acting sluice at the end of the drain will be obviated. At any rate the design would need material alteration were any work of this kind considered necessary.

(4.) *Gudumotu Drain.*—This drain will commence at the lower end of the Bandalaicheru branch of the Divi west channel and run parallel to the Suvarnamuki channel for 3 miles, it will then take a south-east course and fall into an existing drainage at 6½ miles. The total area drained above this outfall will be just under 21 square miles, the drainage provided for being 1¼ inches from that area or 703 cubic feet a second. The fall available is 1·09 feet a mile and the depth of water 4 feet. The comparative cheapness of this drain is due to ground level being from one-third to one-half the depth of water below the surface of the latter. The berms shown in the sections are much smaller than those proposed for the Taleru drain, but they may be omitted with advantage.

(5.) *Bridge near Mandapakala.*—The remarks on the corresponding bridge for the Taleru drain apply to this bridge also.

23. Incidence of Cost of Drainage.—There has been discussion extending over a considerable period as to the way in which the cost of drainage works in the deltas should be distributed, and no decision has yet been arrived at by Government. That the disposal of surplus irrigation water should be provided for as part of the cost of the delta system of irrigation is clear, and were that all that is required to meet the wants of the country, the arrangements would be simple enough. Practically, however, the provision of drains equal to the discharge of surplus irrigation water would leave the country as badly off as ever for drainage, because these delta tracts suffer chiefly from rainfall drainage which has no proper outlet.

The Bank canal and the country connected with it will serve as well as any other example to show how the case stands.

The total quantity of water which this canal has been designed to carry is 918 cubic feet a second, of which only one-fourth or 205, say, cubic feet a second is to be utilized above the Puligadda branch of the Kistna. There are no data available to show the exact proportion between the quantity of water supplied to the fields and that discharged therefrom as surplus, but it will probably be safe to assume that this surplus is not more than one-fourth of the total, or in the case of the country to be drained by the Kanakalamadagu about 50 cubic feet a second.

This drain as designed is to discharge 3,512 cubic feet a second, of which about one-half, or say 1,800 cubic feet a second, appertains to the country connected with the Bank canal. It has already been mentioned that the capacity of this drain has been arranged to carry off 0·56 of an inch in 24 hours from the whole area drained, and whatever may be shown ultimately to be the capacity required, there can hardly

be any doubt but that at least half the above capacity will be needed. If so, the drainage from rainfall will be to that from irrigation as 900, 50 to 50, or as 850 to 50, or 17 to 1. Supposing that the land had been all Government instead of all Zemindary the proportion would have been different, because the area of irrigation per square mile of gross area would have been probably much greater; but even then the proportion between rainfall and irrigation drainage would perhaps not have been less than 900, 80 to 80, or say 10 to 1. Such being the case it would seem to be out of the question to charge the whole cost of main drainage to the delta system, and, if so, some practical arrangement for its distribution, if it is to be undertaken at all appears to be requisite, and this distribution can evidently be most easily effected in relation to the area of the intended irrigation to the total area. It is altogether impracticable to determine in any given case what part of a general system of drainage is necessary in the interests of irrigation, and if only net financial results be looked to it might probably be safely assumed that, except in a few particular localities, no drainage whatever would directly repay its cost, but it has at any rate of late years been assumed that rich alluvial country like that of the deltas will be rendered more favorable for agriculture generally if its drainage be attended to, and that in one way or another such improvements will be beneficial to the revenue as well as to the people. If this assumption be correct, the drainage should be undertaken, but if it be decided that such drainage is not required or that funds for it cannot be found, the drainage to be provided for in connection with the requirements of irrigation alone will be on a very limited scale, and most of it will consist in the connection of the irrigated tracts with the natural water-courses of the country. These minor drains will cost but little. Of late it has been arranged that on the upper side of every distributary which in any way crosses the fall of the country, a drain is to be cut to receive the surplus of the fields above and conduct it to a suitable outfall into a natural water-course, and then, if main drainage is to be given up, the arrangements will end. That they will render the country generally better fitted for agriculture is of course out of the question, for the natural water-courses as a rule are altogether inadequate to carry off within a reasonable time the waters which they receive, and the result at present is—first, that in all seasons of heavy rainfall crops are destroyed and the loss sustained is only in part represented by the remissions granted; 2ndly, that much low-lying land remains altogether unfit for cultivation and consequently is left waste and yields no revenue.

24. River Embankments.—The cost of embanking the Kistna on its left side or rather of completing the present flood bank, which has on several occasions recently, and in 1874 and 1876 particularly, failed to prevent inundation is, apart from that portion of this work which can be done without extra expense from the spoil of the Bank canal and Divi west and north channels, Rupees 62,260. It is proposed to make the flood bank 5 feet above Kistna flood level in the upper part, and this margin may without risk be decreased to 3 feet at the lower end of the Divi west and north channels which will reduce the cost of the work to some material extent and probably make the total not more than 50,000 Rupees. The question of incidence of cost arises in this case also, and widely differing opinions have been expressed upon it. It has been argued that the canals and irrigation works generally are principally interested in these flood banks and in the protection they afford, and it may readily be admitted that such works are very much interested in this subject. That they are the only works or interests involved is however certainly not the case now, whatever

That the land cultivated wet ... ... Acres. 15,944
„ the average revenue of do. ... ... Rupees. 40,876
Dry acres 869 quit-rent ... ... „ 269
„ the Inams are wet acres 2,211 do. ... ... „ 474

The calculation of results of introduction of anicut water might be made in several ways. There is first the consideration that the delta lands already irrigated yield a revenue of about 6 Rupees an acre, and if 5 Rupees be taken as the average for Divi, the result would be—

			RS.
45,000 Acres at	5 Rupees		2,25,000
22,084 Do. unirrigated	1 Rupee		22,084
			2,47,084
Deduct present average revenue			67,174
		Total ...	1,79,910

Secondly, the water-rate being Rupees 4 an acre, the receipts on 45,000 acres would be Rupees 1,80,000, which corresponds very nearly with the previous calculation. But at present acres 15,944 of Government land pay Rupees 40,876, or about $2\frac{1}{2}$ Rupees an acre, and a more correct calculation might be therefore—

			RS.
29,000 Acres at	4 Rupees		1,16,000
16,000 „ at (5—$2\frac{1}{2}$)	$2\frac{1}{2}$ „		40,000
		Total ...	1,56,000

Thirdly, the revenue derivable from Zemindary lands to be irrigated under the first 35 miles of the canal has to be taken into account. The area provided for is acres 15,000, but from paragraph 6 of this note it will be seen that it will be prudent to take 8,000 acres as the probable area of Zemindary irrigation within a time which need now be taken into consideration. The diminution of outlay on distributaries involved in this reduction may be however neglected, as no accurate estimate of it can at the moment be formed. With a water-rate of 4 Rupees an acre this item of the revenue will be Rupees 32,000. Taking, then, the lower figures in the second method of calculation above, the gross revenue will be Rupees 1,88,000. The deductions to find net revenue will be—

	RS.
Maintenance charges at 10 Annas an acre on 60,000 acres	37,500
Establishment charges on do. 25 per cent.	9,375
Loss of revenue on lands occupied by works 2,800 acres at 2 Rupees an acre	5,600
This is Lieutenant Campbell's calculation, but it is probably excessive because a large part of the land will be Zemindary and the loss of revenue on its occupation will be very small.	
Cost of revenue collections at 9 per cent.	16,920
Total Deductions ...	69,395
Net Revenue ...	1,18,605

supposing the drainage works to cost the amount estimated, and one-fourth of that cost to be charged to the Bank canal; also one half the estimate for the river embankment,

the Capital outlay will be about as follows :—

		Rs.
Main supply and distribution		13,24,880
Drainage		98,065
River flood banks		33,250
		14,56,195
To which should be added loss of revenue during construction on lands taken up	Rs. 22,400	
Huts for laborers	10,000	
Unforeseen expenditure	20,000	
		52,400
		15,08,595

1,45,960	9,91,662	
4	36,490	
50,000	25,000	
2	10,53,152	Simple interest on 11 lakhs expended at the rate of 2 lakhs a year 1,80,000
Say 11 lakhs.		
		Total ... 16,88,595
		Say ... 17,00,000

on which sum the net return will be 7 per cent. The simple interest charge has been calculated on the supposition that the canal will be completed in six years, but the actual time will depend upon circumstances, many of which may not be within the control of the Irrigation Department. If then the approximate general abstract of financial results of the Kistna Delta system dated 19th June 1876, which shows a net return of 15·48 per cent. on past expenditure on the Delta system up to the end of 1874-75 be of any value, it would seem to be reasonable to expect that the Bank canal will not be unremunerative.

Proceedings, Madras Government, No. 1,923, dated 28th July 1876.

27. Masulipatam Canal.—The west side channel of this canal will irrigate the part of sub-section one lying between the canal and the Kanakalamadugu drain, and the proposals in regard to this canal have now to be noticed. In paragraph 23 of his report on the first sub-section Lieutenant McNeil Campbell refers to his proposal to supply the west side channel from the Bank canal instead of from the Masulipatam canal at Kunkipad and to the greater economy and advantage of the former arrangement. He notices also that his arguments in favor of the arrangement proposed by him had not been answered, but he appears to have lost sight of the discussion which took place when the undersigned visited the delta at the end of 1873, and what the subject was fully considered, as also of the remarks made in the notes of inspection of that tour. The reasons for using the Masulipatam canal as the source of supply for about 12 miles instead of 3½ miles are—

Appendix No. 2.

Proceedings, Madras Government, 29th September 1874, No. 2,792. Notes paragraph 41.

1*st*.—That it is by no means clear that it would be cheaper to make the Bank canal the source of supply;

2*ndly*.—That by taking off the W.S. channel from the Masulipatam canal no expenditure need be incurred until the demand for water exceeds the supply which the canal can carry without widening; and the land being all Zemindary the ultimate demand is problematical, while the present demand is much below the supply available;

3*rdly*.—That it is desirable to arrange for this canal carrying as much water as it can be conveniently adapted to convey.

It is necessary to remark that it is because the spoil banks of the Masulipatam canal are somewhat close to the canal margin, widening beyond a certain limit would be expensive, and that Lieutenant Campbell was mistaken in his views as to the arrangements necessary to enable this canal to carry the supply required.

28. Area commanded.—The area commanded is 399·35 square miles or say 256,000 acres. Of this area 96·92 square miles or 62,029 acres are commanded by the west side channel.

29. Present and proposed ultimate extent of Irrigation.—The present (1873-74) area of —

	Acres.
Irrigation is	38,012
Of which the area under the west side channel is	6,838
The proposed ultimate area is	127,500
Of which that under the west side channel will be...	28,000

30. General arrangements.—The general arrangements of the canal are described in Lieutenant Campbell's letter, No. 65, of the 7th September 1875, and it will be seen that it is intended to carry water for irrigation only as far as the Kunkipad lock at the beginning of the 13th mile, the rest of the canal to Masulipatam being converted into a still water navigation.

(1.) *Required Capacity*.—The required capacity of the canal above Kunkipad would be 1,912·50 cubic feet a second, distributed as follows :—

Bank canal	60,000 acres	900	Cubic feet a second
Pulleru	33,500 „	502·5	„
West side channel	28,000 „	420	„
Direct irrigation	6,000 „	90	„

The water distribution statement shows 2,001 cubic feet a second as the discharge of the canal in this reach, but the formula used is believed to give a higher velocity than the true.

Appendix 4-A.

(2.) *Particulars of Fall and Dimensions of first Reach*.—For the first 3½ miles to head of Bank canal the surface and bed falls will be 0·33 foot per mile, the bottom width 100 feet at head and 115 immediately above the offtake of the Bank canal, the depth of water being 8 feet. Below this point the bottom width will be 61 feet, the surface fall will be continued at 0·33 foot a mile, but the bed fall will be reduced to 0·215 foot a mile, and the depth at the lock will be 7 feet, the bottom width being 76 feet.

(3.) *Reaches below Kunkipad*.—The desired bottom width of canal below Kunkipad lock is 25 feet, which would give a minimum width at water surface of 40 feet, but a considerably greater width in the lower parts of each reach. Practically little or nothing will need to be done in this part of the canal in the way of earthworks beyond raising the banks in places, for though the canal bed is shown in the section as running from the lower sill of one lock to the upper sill of the next, all that will be necessary will be to keep the bed not higher than from the lower sill of one lock to 6 feet below water surface at the upper end of the next lock.

31. WORK TO BE DONE IN FIRST REACH HEAD TO 12 MILES 13½ CHAINS.—The work to be done here is entirely earthwork—

		Rs.	A.	P.
The estimate shows that the cost of widening to the head of the Bank canal will be		1,16,745	12	0
	Sundries ...	5,831	4	0
		1,22,576	0	0
And thence to the end...		52,060	0	0
	Total ...	1,74,660	0	0

It further appears that of this latter sum the proportion appertaining to the canal, Pulleru, and west side channel respectively may be taken to be according to the intended increase of irrigation under each, and this will be approximately as follows :—

	Present.	Intended	Increase
	Rs.	Rs.	Rs.
Masulipatam canal	*3,000	6,000	3,000
Pulleru	28,174	93,500	65,326
West side channel	6,838	28,000	21,162
Total ...	38,012	1,27,500	89,488

* Assumed not stated in the papers.

Consequently the share of the west side channel will be say one-fourth, or Rupees 13,000 in round numbers, and it would seem therefore that there could have been but little room for effecting any material saving by adopting the Bank canal as at first proposed by Lieutenant Campbell as the source of supply of the west side channel.

(1.) *Rates for Earthworks.*—The rates entered in the estimate are 3 Annas a cubic yard for the 3½ miles to the head of the Bank canal and 2½ Annas below that point. Looking to the depth of the cutting and to the height of the present spoil banks these rates may not be excessive, but it is believed that similar work on the Ryves' canal new head close by has been done at lower rates.

32. SECOND TO FIFTH REACHES 12 MILES 16 CHAINS TO 49 MILES 13 CHAINS.—The proposal is to convert this part of the canal into a still water navigation, the cost of so doing being estimated as follows :—

	Rs.
Earthwork	12,000
Alteration of Viranki lock	800
New lock at Nedamole	22,500
Alterations to Ankumarru lock	240
Raising Chintaguntapalem bridge	150

The object is to improve the navigation by ensuring a minimum depth of water of 5 feet, and to reduce cost of maintenance by ceasing to carry irrigation water at a low velocity which in this delta involves the deposit of much silt. The present Nedamole lock is reported to be in very bad repair, and the chamber walls cracked, so it is not considered advisable to retain it and to subject it to the pressure of an increased

head of water of about 3½ feet. Before however finally deciding on its demolition it will be well for the Superintending Engineer to ascertain whether the cracks are of any real importance, and whether, were it opened out and strengthened by a backing of concrete or otherwise, its retention might not be arranged for without risk. As already mentioned, unless to find earth for the banks, it will not be necessary to lower the present bed below 6 feet from the revised water surface.

(1.) *Canal may still be used for Irrigation.*—The proposed conversion of the canal into a still-water navigation will not prevent its use as a duct for the supply of irrigation water to the west side channel and its branches either temporarily or permanently. When there is no water wanted for irrigation the surface may be held up to a dead level, but at any rate until the demand for water under the west side channel becomes such as to make it desirable to introduce the revised arrangements for its supply, it will be economical to convey water for that irrigation by the canal, and the existing lock weirs which are to be retained will, with slight alterations, enable water to be passed down in sufficient quantities for probably a good many years to come.

(2.) *Viranki Lock alterations.*—It is questionable whether it will be practicable to scarf the heel-posts of the gates effectually. At any rate the arrangement shown in the drawing would not do.

(3.) *Nedumole new Lock.*—Before the working drawings are prepared the designs of some of the more successful locks recently constructed in the Godavery Delta may with advantage be studied. The following details require further consideration :—

Plan No. 14 of B.

(*a.*) The side walls of the chamber are too slight, the depth of water above the springing of the invert will be 16 feet, and the mean thickness is 4·7½, whereas 5½ feet is as little as is safe.

(*b.*) The thickness, 3 and 2½ feet, of the side walls of the side culverts is too small. On the other hand, the thickness of the wall above the lower culverts can be reduced materially by giving a more abrupt batter to the back of this wall from about 2 feet above the crown of the arch.

(*c.*) The invert to be of value must have a greater versed sine than ⅛th the springing line might be placed 1 foot higher which would make the versed sine ⅛th. Inverts are not now generally found requisite.

(*d.*) Wooden sill bars should be provided for the gates.

Circular No. 33, drawing No. 3. *Vide* also Circular No. 44.

(*e.*) The gates of the lower culverts should be worked by double purchase rack and pinion gear.

(*f.*) Lock gates have in the Godavery been of late made much lighter than formerly, and without any diminution of efficiency; drawings can be obtained from the Dowlaishweram workshops.

(4.) *Nedumole Lock site Plan.*—The lower wing returns of the new lock will be about 108 feet above the upper wing returns of the old lock, it will therefore be practicable, if the new lock cannot be completed during the closure of the canal for one season, to arrange for making the old lock available for all boats which commonly use the canals of this delta, and their convenience should be seen to.

(5.) *Chintaguntapalem Bridge.*—It has been found in the Godavery Delta that the minimum prescribed headway of 11 feet is inconvenient, and as the cost of altering this bridge will be extremely small it will be better to raise the roadway 2 feet instead of only 1 foot as proposed. Including approaches 400 Rupees may be taken to be required.

33. ABSTRACT ESTIMATE CLASSIFIED.—The following is a classified abstract of the estimates for the Masulipatam canal :—

Position. Miles.	Position. Chains.	Particulars.	Sub-heads.	Main-head. Main Canal and Branches.	Totals of Sub-heads
				Rs.	Rs.
0 to 3	0 40	Widening canal	I. Earthworks.	1,22,580	
12 to 12	13½ 16	Do.	Do. ...	52,080	1,74,660
49 to 24	13 6	Improving canal	I. Navigation Works ...		
36	50	Altering Viranki lock	Do. ...	12,000	
42	73	Nedumole lock (new)	Do. ...	830	
46	16	Altering Ankumarru lock	Do. ...	25,330	
		Raising Chintaguntapalem bridge ...	Do. ...	210	
			...	400	38,860
		Establishment 25 per cent	...		2,13,520
		Tools and Plant 8 do.	...	...	53,380
			...	...	17,080
					2,83,980

34. PROBABLE RETURNS ON OUTLAY.—It is almost impracticable to estimate the returns on the outlay proposed on this canal for the following reasons :—

1*st*.—This canal will supply the Bank canal entirely, as also the west side channel irrigation.

2*ndly*.—It will supply in part the Pulleru, the other source of supply of which is Ryves canal.

The several items of cost might be distributed were it known what the present water carrying capacity of the several canals is with any precision, but they are in the first place, irregular, and, secondly, the distribution is so incomplete that the water-supply now afforded is by no means in direct proportion to the acreage. There will be, it is expected, 68,326 acres of additional irrigation under the Masulipatam canal apart from the Bank canal and the west side channel, but even if the cost of widening due to the water to be carried for that canal and distributary were to be calculated and deducted, the revenue on the increased area could not be compared with the outlay on the Masulipatam canal after such deduction, because most of the water will be turned into the Pulleru, and will subsequently be used to supply many canals and distributaries, and the estimates for these in part, but not wholly, must be taken into account. It will be better, therefore, to postpone consideration of the returns from the Masulipatam canal until the estimates for the 3rd, 4th, and 5th sub-sections have been reviewed ; but in order that conclusions may then be arrived at the estimate for the Masulipatam canal may be divided between it and the Bank canal and the Masulipatam canal as follows.

(1.) *Distribution of Estimate to several Canals supplied.*—Cost of canal to 3½ miles—

Rupees 1,22,580

Divisible between—

Bank canal	60,000 acres.
Masulipatam canal including Pulleru ...	68,326 „ (increase.)
West side channel	21,162 „ („)
	1,49,488

	Rs.
Shares Bank canal $\frac{60}{149}$ = $\frac{40}{100}$	49,032
* Including Pulleru. „ Masulipatam* canal $\frac{68}{149}$ = $\frac{46}{100}$	56,387
„ West side channel $\frac{21}{149}$ = $\frac{14}{100}$	17,161
Cost of canal from 3½ miles to end of first reach	52,080

Divisible between—

Masulipatam canal	68,326 acres
West side channel	21,162 „
	89,488

	Rs.
Shares Masulipatam canal $\frac{68}{89}$ = $\frac{46}{100}$	39,928
„ West side channel $\frac{21}{89}$ = $\frac{14}{100}$	12,152
Cost of canal below first reach	38,860

This is a navigation charge, but the navigation receipts from any particular canal are not determinable, the licenses being issued for the navigation of the whole of the canals of the delta. It will be necessary, therefore, to consider it as a debit to the Masulipatam canal in connection with the 3rd, 4th, and 5th sub-sections. It follows then that the proposed outlay on the Masulipatam canal amounting for—

	Rs.
Works to	2,13,520

is distributable to—

1st Sub-section Bank Canal	49,032
3rd, 4th, and 5th Sub-sections, Masulipatam Canal...	1,35,175
1st Sub-section, west side channel	29,313

35. WEST SIDE CHANNEL OF MASULIPATAM CANAL.—The review of the estimates for this channel will complete the notice of the irrigation of the 1st sub-section. Its head will be as at present just above the Kunkipad lock at the end of the first reach of the Masulipatam canal.

(1.) *Area commanded.*—The area commanded is 96·92 square miles, of which 96 square miles are reported to be Zemindary.

(2.) *Present and proposed extent of Irrigation.*—The present area of irrigation (1873-74) is acres 6,838, and the expected ultimate area provided for in the estimates is acres 28,000 or 289 acres to the square mile.

36. ANTICIPATED EXTENSION OF IRRIGATION IMPROBABLE.—Lieutenant Campbell gives in paragraph 20 of his report on the 1st sub-section a sketch of the present sources of irrigation and shows that they are very defective, and he notices also the want of drainage; but there is no room for doubting the capability of the Masulipatam canal and of the partially completed side channel to supply a far larger acreage than that for which water has hitherto been demanded. From paragraph 21 of the same report it will be seen that in 1866 an estimate, amounting to Rupees 49,860, for the construction of this side channel was sanctioned, and that the work was stopped in 1871 and a revised estimate called for; that

Appendix No. 2.

G.O., 19th October 1866, No. 3,342.

the whole of the excavation, as far as Arkamarru, 13½ miles, was done in a sort of way," but that silting and the growth of weeds have about obliterated parts of the channel; that the original estimate did not allow for any branch channel and provided only Rupees 1,500 for sluices; that three vents of the lock weir at Kunkipad were converted in 1869 into a head sluice for the channel, and that some materials were obtained for some minor masonry works, the expenditure on these two last items having been apparently provided for from the sanction for earthwork. It further appears that originally 12,000 acres were expected to be irrigated under this channel, but that the village accounts showed only 12,[illegible] acres with a possible addition of 4,000 more, or together 16,000 acres; it is to be noticed, however, that the whole of this tract of country was then supposed to be only 65 square miles, and probably a large number of villages are interested in the project as now drawn up. In short Campbell's report is silent as to the data on which he has arrived that there is a probability of 24,000 acres being irrigated.

For particulars of expenditure see Appendix No. 2—I.

Vide also Notes of Inspection, Paragraphs 23 and 24 in Proceedings, Madras Government, 10th March 1871, No. 722.

Appendix No. 2—E.

There is, for instance, no allowance for [illegible] that given for the Divi irrigation, and in the case of subsidiary [illegible] such information is even more necessary than for Government [illegible].

37. Particulars of Channel Earthworks.—The [illegible] channel when completed have had to be adapted to the work already [illegible] sanction of 1866. The following are the principal [illegible] the longitudinal section:—

Positions.		Reaches.	Fall per Mile.	Bottom width.	Depth.	Slopes.	Remarks.
From	To						
M. ch.	M. ch.						
0 0	2 23½	1st Reach.	7	35	6		
2 23½	9 77	2nd "	10	33	6		
9 77	13 4	3rd "	7	33	6		
13 4	24 34	4th "	7	33	5½		
24 34	30 34	5th "	7	33	5		
30 34	34 24½	6th "	4	33	3		

The fourth reach is noted as having been already excavated. It would [illegible] See remark on Sketch No. 4. [illegible] no drop at the lower end would have been required. The actual [illegible] channel, as excavated, would if no alteration of [illegible] parts greatly exceed the quantity required, and [illegible] reach the depth will manifestly be less than 5 feet [illegible] therefore is—

1*st*.—That a depth approaching to that required for the [illegible] should be fixed.

2*nd*.—That this depth, and not that shown on the longitudinal section, should be taken into account in arranging for the supply of the branch channels.

3*rd*.—That the waterway should be restricted to the proper cross section.

With attention to such details the channel, notwithstanding the irregularities of construction which it exhibits, may be made fairly effective.

38. Arrangements in connection with limited Acreage.—During the probably long time which will elapse before anything like the contemplated ultimate area will be irrigated, it will be necessary to provide for the effective irrigation of smaller areas without sending an excessive supply down the channel.

(1.) *Width to be restricted to what is necessary.*—Where the channel is now of less width than the full section, no widening should be carried out until required.

(2.) *Masonry Works.*—The drops or falls, the bridges, &c., must be built of the dimensions suited to the full section of the channel, but the crests of the former should be contracted with brickwork built on the permanent crests, so as to reduce the waterway and maintain the desired water surface level above. Enlargements can then be made from time to time without difficulty and at a nominal expense.

39. Water levels in Masulipatam Canal and in W. S. Channel.—In order to see how far the Masulipatam canal can for the present be made to supply the irrigation under the west side channel, and to provide for its extension at least until the demand becomes much increased, it will be useful to compare the water levels at a few points. First there are the two principal branches of the side channel:—

	Water levels in W. S. Channel.	Masulipatam Canal.	
Medur branch channel	30·60	33·00	4,000 acres.
Bhimanadi do.	26·00	21·00	6,000 do.

The Medur channel can be therefore effectively supplied from the Masulipatam canal in the 22nd mile, but the Bhimanadi channel if supplied from that canal must be so supplied through the side channel from a point above the Viranki lock which is at the beginning of the 25th mile, or about 1,000 yards above the proposed head of the Bhimanadi channel.

Similarly, the Chinna Mutevi branch needs a water level of 16·70 at its head, and the canal water level is 21·00, so there is plenty of command.

Such being the case the reality of the demand for water can be tested before any considerable expenditure is incurred in adapting the side channel for a large acreage.

40. Masonry Works, W. S. Channel.—The proposed masonry works are:—

(1.) *Head Sluice.*—Lieutenant Campbell shows that the present sluice of nine vents of $2\frac{3}{4}$ by $2\frac{3}{4}$ feet is inadequate, and he proposes to adapt an additional part of the old lock weir to the supply of the side channel at a cost of 3,580 Rupees. All however that seems to be necessary is to make the nine vents of the present sluice 5 feet high instead of $2\frac{3}{4}$ feet. A comparatively small sum will suffice for this alteration, but it is difficult to make out from the drawing what the present sluice is like. Probably 1,500 Rupees will do all that is needed.

(2.) *Rough stone Drop at end of 1st Reach.*—The design of this work is not suited to a discharge of 420 cubic feet a second with a depth of 6 feet of water. The drop should be of masonry, and the level and length of crest should be adapted to the maintenance of the water surface in the first reach at the proper level. The cost of a suitable fall will probably be 1,200 Rupees.

(3.) *Vullur Road Bridge*, 6 *miles* 12 *chains*.—The waterway of the bridge is 120 square feet against 174 square feet in the channel. With a full supply in the channel there would be a head of $1\frac{3}{4}$ inches and erosion of the banks below would probably follow. Looking, however, to the improbability of the full discharge being required the design may be accepted; otherwise a span of 24 feet instead of 20 feet would have been necessary. A slight addition to the weight on the lower part of the arch will be desirable.

(4.) *Drop and Bridge end of Second Reach*, 9 *miles* 77 *chains*.—The waterway is too great, viz., 775 cubic feet a second against 342 cubic feet required. The works should not demand special regulation with a normal discharge of the channel. Either the crest should be raised or its length shortened. The latter is the cheaper arrangement, but would involve a high velocity below. The front wings are short, allowing slopes of barely 1 to 1 which must be revetted to be stable. The rear wing curves should be rather flat and should be struck from a centre on the outer line of the rear retaining wall.

(5.) *Bridge Viranki*, 12 *miles* 6 *chains*.—The wings are considerably longer than Ten or 12 feet than is necessary, and it will be more economical to set the wings back from 6 feet on either side of the centre of the bridge. The estimate may be reduced to Rupees 3,000.

(6.) *Regulating Bridge*, 13 *miles* 4 *chains*.—The design is that of Plan No. 14 and requires material modification, as that bridge has been designed for a different width of channel.

(7.) *Bridge Panurru*, 18 *miles* 30 *chains*.—The design provides only 84 feet of waterway against $162\frac{1}{2}$ feet in the channel, and this reduction is too great; two spans of 15 feet each would do, and would probably not cost more, or but a trifle more, than the estimate, as the masonry taken out of the abutments would suffice nearly for the pier, and the roadway would be 18 inches lower. The wings should not be made longer than is needful for $1\frac{1}{2}$ to 1 slopes with, say, $2\frac{1}{2}$ feet a bed.

(8.) *Bridges, Plans Nos.* 16 *and* 18, 21 *miles* 31 *chains*, 24 *miles* 31 *chains*, and 26 *miles* 74 *chains*.—Somewhat similar remarks apply to these bridges.

41. BRANCH CHANNELS.—The branch channels from the main channel will be numerous. They are as follow:—

(1.) *Vullur Channel*, 5 *miles* 65 *chains*.—Area 1,200 [illegible] works Rupees 360. Apparently the subsidiary arrangements for supplying water to the fields will exceed in extent the masonry distributing [illegible] to be watered being it would seem a strip about 2½ miles long between the Kanikalamadiga drain and the west side channel. It is doubtful whether the ryots will be prepared to make the long field channels which will be required, and it will be advisable therefore to provide Rupees [illegible] for such channels.

(2.) *Modur Channel*, 9 *miles* 40 *chains*.—From the [illegible] that at the heavy cutting shown in the longitudinal section on the first mile and quarter there is an old channel of dimensions [illegible] is 12 miles 20 chains. The bed level at head [illegible] the tail is shown as 7·0 [illegible] and the velocity 1·43 feet a second in the upper part and 1·26 at the lower end. Considerable saving in earthwork and probably in masonry also will result from [illegible] the bed fall a little and to [illegible]

* Appendix 2—G.

a velocity of 2 feet a second, and by placing the bed at a level which will make the cutting about provide the banking. The depth of water is to be 3 feet, and if the tops of the banks be made 18 inches above water level, instead of 3 feet as shown on the sections, a further saving will be effected. The banks should be placed so as to confine the waterway to the proper section.

(2*a*.) *Masonry Works.*—Such remarks as are necessary have been noted on the plans. The modifications needed will not affect materially the cost of the works.

(2*b*.) *Kistnapuram Branch Channel.*—The banks should be placed so as to afford the proper waterway only. There is no need to make them 3 feet above W.L., 1 foot or $1\frac{1}{2}$ feet at most will suffice.

(2*c*.) *Gudupad Branch Channel.*—The depth of cutting shown on longitudinal section indicates that it would be better to place the head somewhat lower down on Medur channel. For position and height of banks see (2*b*).

(2*d*.) *Vemallamada Branch Channel.*—The bed-fall might be somewhat increased with advantage from $1\frac{1}{4}$ miles. For position and height of banks see (2*b*).

(3.) *Bhimanadi Channel*, 10 *miles* 20 *chains*.—This channel directly and by its branches is to irrigate 6,000 acres. The bed level at head is to be at 20·5 and at tail 4·53, the length being 15 miles 30 chains. The bed-fall shown in the section is 7 inches a mile throughout, and the mean velocities are 1·43 to 1·26 feet a second. The cost of earthworks may be much reduced by—

1*stly*.—Revising the bed-fall so as to obtain a velocity of about 2 feet a second.

2*ndly*.—Reducing height of banks from 3 feet above W.L. to 2 feet in the first 8 miles, and to $1\frac{1}{2}$ feet below that.

3*rdly*.—By placing the banks close to the channel.

These alterations will also reduce the cost of masonry works and of land.

(3*a*.) *Masonry Works.*—The necessary remarks have been noted on the plans.

(3*b*.) *Agakodu Branch Channel.*—The ground levels noted on the section of this channel and on that of the Bhimanadi channel differ materially. There appears to be no reason for dropping the bed at the head, and the bed-fall should be about 2 feet a mile, which will give a velocity of 2 feet a second. No drop at 1 mile will then be required.

(3*c*.) *Kosar North Branch Channel.*—Ground levels differ. A bed-fall of 2 feet a mile should be substituted for 7 inches; the bed at head should correspond with that of the channel of supply, and the banks should be altered as noted in (2*b*) above.

(3*d*.) *Kosar South Branch Channel.*—The bed fall is very small, and at any rate the drop of 18 inches should be omitted and the bed fall increased by 6 inches a mile, but, seeing that water level in the Inampudi drain will be liable to be considerably above that in the channel, no further lowering of the bed would perhaps be convenient, though in the lower part of second and beginning of third mile it would be better somewhat lower. The design for the tail escape is that given on Plan $\frac{D1}{No.\ 23}$, and it will be necessary to add a swing shutter to exclude drain water.

(3*e*.) *Mallampalli Branch Channel.*—Similar remarks to those in (3*d*) apply to this distributary.

(3*f*.) *Pusudam Branch Channel.*—The bed-fall of this channel, 7 inches a mile, cannot be conveniently increased. The position and height of banks should be revised as noted in (2*b*.), except that the banks in the lower part should be horizontal and

3 feet above W.L. at end, which corresponds very closely with W.L. in Inampadi drain into which the channel tails.

(3*g*.) *Vendakuduru Branch Channel.*—The drain water is higher than channel water at the tail, but so slightly as to be unimportant. The remarks on banks of (3*f*.) apply.

(3*h*.) *Lankapalli Branch Channel.*—Acreage 250. Earthworks ... Rs. 565
Land ... „ 170

on both a reduction will be feasible—1st, by selecting an off-take somewhat higher* up the Bhimanadi channel and running the branch in 2 feet cutting, with banks 18 inches† above W.L and 2 feet wide at top. The quantity of earthwork will then be about 3,430 cubic yards against 8,610 cubic yards in the estimate; 2nd ly, the land provided for in the estimate is 8·5 acres or 17 yards in width on the average: the channel should be about 9 feet, and the banks 6½ feet wide each or 22 feet altogether, add 2 or 3 feet for side cutting for making up banks, and the total width would be 25 feet, so that 30 feet at most would be ample as an estimate provision, and 100 Rupees instead of 170 will be sufficient. Twelve feet in width will be rendered unnecessary by the omission of berms. Rupees 350 instead of 735 should suffice for this channel, but to this about Rupees 75 will need to be added for regulating the heads of field channels, so the entry may be 425 Rupees.

* One-eighth of a mile would seem suitable.
† This gives a thickness of 6½ feet of bank at W.L.

(4.) *Batlapanumaru Channel*, 12 *Miles* 55 *Chains*.—The omission of berms and the reduction of the height and width of banks are points requiring attention. The length of the channel is 57/8 miles; bed level at head 20·5, and bed and ground level at tail 12·09 and 12·06, and may be lowered to 11·00. Then the fall will be 9·5 feet, which will give an average of 1·61 feet a mile, and this may be distributed so as to make the fall in the upper miles about 1½ feet a mile. No drops will be needed.

(5.) *Peddasanagullu Channel*, 14 *Miles* 61 *Chains*; *Wuculur Channel*, 16 *Miles* 65 *Chains*; *Chinna Mutevi Channel*, 19 *Miles* 15 *Chains*; *Nellapalli Channel*, 20 *Miles* 15 *Chains*; *Nemmakur Channel*, 23 *Miles* 35 *Chains*; *Ramanapettah Channel* 26 *Miles* 15 *Chains*; *Polaveram Channel*, 28 *Miles* 5 *Chains*; *Akumaccu Channel*, 31 *Miles* 25 *Chains*; *Rudvaram Channel*, 32 *Miles* 15 *Chains*; *Gundigalam Channel*, 33 *Miles* 15 *Chains*.—It is not necessary to notice for each of these channels the modifications needed. The foregoing remarks will have indicated sufficiently clearly what alterations are desirable or necessary and in all some material saving can be secured. It is not at all apparent why generally a bed fall of 7 inches a mile has been adopted seeing that frequently this small slope would render drops necessary as well as place the bed on an inconveniently high level from an economical point of view, and this has been done even where there is an existing channel with a better fall than that proposed. The reduction of the estimates may be taken as about one-fifth; it will probably be more.

42. Masonry Works.—On a sufficient number of the plans of the masonry works notes have been made to indicate the scope of the modifications required.

43. Abstract of Estimate.—A classified abstract of the estimate for the west side channel and its branches is subjoined.

Proceedings of the Madras Government, Public Works Department,
22nd December 1876. *No.* 3,528.*A.*

Position.	Particulars.	Sub-heads.	MAIN HEADS. Distributaries. Original.	Distributaries. Revised.	Distributaries. Totals of Sub-heads and Channels.	Drainage and Protective Works. Original.	Drainage and Protective Works. Revised.	Drainage and Protective Works. Totals of Drains.	Remarks.
M. CHS.			RS.	RS.	RS.	RS.	RS.	RS.	
		B. Land ..	9,050	9,000	9,000	..	..	..	
.. ..	Head sluice ..	C. Works ..	3,580	1,500					
2 26	Drop Bodlapad ..	Do. ..	330	1,200					
6 12	Bridge, Vallur road ..	Do. ..	2,410	2,410					
9 77	Do. and drop ..	Do. ..	2,800	2,800					
12 6	Do. Viranki ..	Do. ..	3,555	3,000					The mileage of these bridges given in the book of earthwork estimates is incorrect.
15 4	Do. regulating ..	Do. ..	2,320	3,000					
18 30	Do. Pamurru ..	Do. ..	2,410	2,450					
21 31	Do. Tugbaveram ..	Do. ..	2,400	2,400					
24 34	Do. Nedumole ..	Do. ..	2,045	2,045					
25 74	Do. Tarakatur ..	Do. ..	1,800	1,800					
34 25	Tail escape ..	Do. ..	565	565	23,176	..	..	..	
	Channel ..	L. Earthworks.	65,040	65,040	65,040	..	..	..	
	10 Cattle crossings ..	O. Miscellaneous ..	3,790	3,790					
	Bench mark stones ..	Do. ..	173	346	4,136	..	..	..	28,000 acres.
	Total, west side channel.	....	1,02,268	..	1,01,346	..	..	..	
	Vallur channel ..	B. Land ..	150	150	150	..	..	..	
5 65	Head sluice ..	C. Works ..	365	365	..	..	..	..	
	Tail escape ..	Do. ..	550	550	915	..	..	..	
	Channel ..	L. Earthworks.	210	210	..	..	..	..	
	Minor channels ..	Do. ..	..	500	710	..	..	..	1,200 acres.
	Total, Vallur channel..	....	1,275	..	1,775	..	..	..	
9 40	Medur channel ..	B. Land. ..	1,700	1,500	1,500	..	..	..	
	Head sluice ..	C. Works ..	575	580					
	Drop (No. 25) 2nd mile	Do. ..	460	460					
	Do. (No. 26) ..	Do. ..	495	..					
	Bridge (No. 27) ..	Do. ..	1,570	1,570					
	Drop (No. 29) ..	Do. ..	450						
	Do. (No. 30) ..	Do. ..	465	1,000					Two drops with an increased bed fall will probably suffice instead of five.
	Do. (No. 32) ..	Do. ..	445						
	Do. (No. 34) ..	Do. ..	430	640					
	Tail escape (No. 35) ..	Do. ..	640		4,250	..	..	..	
	Channel ..	L. Earthworks.	11,490	9,190	9,190	..	..	..	
	Kistnapuram branch channel ..	B. Land ..	330	200	200	..	..	..	
	Head sluice ..	C. Works ..	450	450					
	Tail escape ..	Do. ..	370	370	820	..	..	..	
	Channel ..	L. Earthworks.	1,500	1,200	1,200	..	..	..	
	Gundapad branch channel ..	B. Land ..	570	250	250	..	..	..	
	Head sluice ..	C. Works ..	495	495					
	Tail escape ..	Do. ..	390	390	885	..	..	..	
	Channel ..	L. Earthworks.	1,850	1,500	1,500	..	..	..	
	Vemallamada branch channel ..	B. Land ..	420	210	210	..	..	..	
	Head sluice ..	C. Works ..	530	630					
	Tail escape ..	Do. ..	550	550	1080	..	..	..	
	Channel ..	L. Earthworks.	1,870	1,500	1,500	..	..	..	4,000 acres.
	Total, Medur channel..	....	28,015	..	22,585	..	..	..	
10 20	Bhimanadi channel ..	B. Land ..	2,960	2,500	2,500	..	..	..	

Position.	Particulars.	Sub-heads.	MAIN HEADS. Distributaries. Original.	Revised.	Totals of Sub-heads and Channels.	Drainage and Protective Works. Original.	Revised.	Totals of Drains.	Remarks.
M. CHS.			RS.	RS.	RS.	RS.	RS.	RS.	
10 20	Head sluice ..	C. Works ..	1,120	1,120					
	Drop at 2 miles ..	Do. ..	570	..					
	Bridge 5th mile ..	Do. ..	1,950	1,700					
10 20	Drop, 6th mile ..	Do. ..	595	..					
	Do. at 8 miles ..	Do. ..	570	..					
	Tail escape ..	Do. ..	530	530					
	Channel ..	L. Earthworks.	13,870	11,000	3,350	..	..	..	
					11,000	..	..	..	
	Agakodu branch channel ..	B. Land ..	..	..					
	Head sluice ..	C. Works ..	520	400	..	..	..	..	
	Drop at 1 mile ..	Do. ..	380	..					
	Tail escape ..	Do. ..	650	650					
	Channel ..	L. Earthworks.	1,226	1,000	1,050	..	..	..	
					1,000	..	..	..	
	Kosur, north branch channel ..	B. Land ..	150	100					
	Head sluice ..	C. Works ..	515	400	100	..	..	..	
	Drop at 1 mile ..	Do. ..	395	..					
	Tail escape ..	Do. ..	520	520					
	Channel ..	L. Earthworks.	800	640	920	..	..	..	
					640	..	..	..	
	Kosur, south branch channel ..	B. Land ..	710	300					
	Head sluice ..	C. Works ..	520	520	300	..	..	..	
	Drop at 1 mile ..	Do. ..	485	..					
	Tail escape ..	Do. ..	515	525					
	Channel ..	L. Earthworks.	2,510	2,000	1,045	..	..	..	
	Mallampalli branch channel ..	B. Land ..	710	400	2,000	..	..	..	
	Head sluice ..	C. Works ..	505	505	400	..	..	..	
	Drop at 1·40 ..	Do. ..	465	..					
	Tail escape ..	Do. ..	460	470					
	Channel ..	L. Earthworks.	3,360	2,700	975	..	..	..	
					2,700	..	..	..	
	Pusadam branch channel ..	B. Land ..	670	400					
	Head sluice ..	C. Works ..	540	540	400	..	..	..	
	Tail escape ..	Do. ..	600	600					
	Channel ..	L. Earthworks.	3,060	2,460	1,140	..	..	..	
					2,460	..	..	..	
	Yendakuduru branch channel ..	B. Land ..	670	350					
	Head sluice ..	C. Works ..	450	450	350	..	..	..	
	Tail escape ..	Do. ..	420	420					
	Channel ..	L. Earthworks.	3,280	2,630	870	..	..	..	
					2,630	..	..	..	
	Lunkapalli branch channel ..	B. Land ..	170	100					
	Head sluice ..	C. Works ..	470	470	100	..	..	..	
	Tail escape ..	Do. ..	450	450	..				
	Channel ..	L. Earthworks.	565	220	920	..	..	..	
	Total, Bhinanadi channel ..	....			220	..	..	..	
12 55	Batlupanamaru channel ..	B. Land ..	48,806	..	37,070	..	..	..	6,350 A. ps included in above for Bhinanadi channel.
			..	..	..	..	..	..	

Position.	Particulars.	Sub-heads.	MAIN HEADS. Distributaries. Original.	Revised.	Totals of Sub-heads and Channels.	Drainage and Protective Works. Original.	Revised.	Totals of Drains.	Remarks.
M. CHS.			RS.	RS.	RS.	RS.	RS.	RS.	
	Head sluice ..	C. Works ..	..	..	..	..	..	..	
	Drop at 1 mile ..	Do. ..	410	..	..	..	..	..	
	Do. at 3 miles ..	Do. ..	365	..	..	..	..	..	
	Do. at 4 miles ..	Do. ..	405						
	Tail escape ..	Do. ..	370	370					
	Channel ..	E. Earthworks.	3,860	3,000	370 3,000	..	..	..	
	Total, Batlupanamaru channel ..	....	5,410	..	3,370	..	..	..	2,000 acres.
14 61	Pedasanagullu channel	B. Land ..	260	250	250	..	..	..	
	Head sluice ..	C. Works ..	475	450					
	Drop at 1 mile ..	Do. ..	340	..					
	Tail escape ..	Do. ..	330	330					
	Channel ..	L. Earthworks.	1,195	900	780 900	..	..	..	
	Total, Pedasanagullu Channel ..	....	2,600	..	1,930	..	..	..	850 acres.
16 65	Wurutur channel ..	B. Land ..	305	230	230	..	..	..	
	Head sluice ..	C. Works ..	475	450					
	Drop at 1 mile ..	Do. ..	360	..					
	Tail escape ..	Do. ..	625	500					
	Channel ..	L. Earthworks.	1,795	1,430	950 1,430	..	..	..	
	Total, Wurutur channel.	....	3,560	..	2,610	..	..	..	1,000 acres.
19 15	Chinna Mutevi channel	B. Land ..	770	460	460	..	..	..	
	Head sluice ..	C. Works ..	580	500					
	Drop at 1 mile ..	Do. ..	385	..					
	Do. 2·30 ..	Do. ..	375	..					
	Tail escape ..	Do. ..	645	550					
	Channel ..	L. Earthworks.	3,530	2,500	1,050 2,500	..	..	..	
	Total, Chinna Mutevi channel ..	....	6,285	..	4,010	..	..	..	1,750 acres.
20 15	Nebhanpudi channel..	B. Land ..	820	535	535	..	..	..	
	Head sluice ..	C. Works ..	545	450					
	Drop at 1 mile ..	Do. ..	360	..					
	Do. at 3 do. ..	Do. ..	350	..					
	Tail escape ..	Do. ..	490	500					
	Channel ..	L. Earthworks.	3,730	..	950 2,600	..	..	..	
	Total, Nebhandpudi channel ..	....	6,295	..	4,085	..	..	..	1,200 acres.
23 35	Nemmakur channel..	B. Land. ..	200	150	150	..	..	..	
	Head sluice ..	C. Works ..	530	450					
	Drop at 2 miles ..	Do. ..	465	..					
	Tail escape ..	Do. ..	540	540					
	Channel ..	L. Earthworks.	3,830	2,750	990 2,750	..	..	..	
	Total ..	....	5,625	..	3,890	..	..	..	2,500 acres.
26 15	Ramanapettah channel.	B. Land ..	780	500	500	..	..	..	
	Head sluice ..	C. Works..	375	..	..	..	..	..	
	Drop at 3·30 ..	Do. ..	360	..	..	..	..	..	
	Tail escape ..	Do. ..	600	600	975	..	..	..	

Position.	Particulars.	Sub-heads.	MAIN HEADS. DISTRIBUTARIES. Original	Revised.	Totals of Sub-heads and Channels	DRAINAGE AND PROTECTIVE WORKS. Original	Revised.	Totals of Items	Remarks.
M. CHS.	Channel								
	Total, Ramanapettah channel ..	L. Earthworks.	Rs. 4,246	Rs. 3,050	Rs. 3,050	Rs. ..	Rs. ..	Rs. ..	
28 5	Polaveram channel ..	....							
	Head sluice ..	B. Land ..	6,361	200	4,525	..	..	..	
	Channel ..	C. Works ..	350	250	250	..	..	..	
		L. Earthworks.	355	355	355	..	..	..	
	Total, Polaveram channel ..		2,260	1,500	1,500	..	..	..	
31 25	Akumarru channel ..	....				..	..	..	
	Head sluice ..	B. Land ..	2,935	..	2,165	..	..	..	
	Channel ..	C. Works ..	280	150		..	..	..	
	Total, Akamur channel ..	L. Earthworks.	400	250	150	..	..	..	
32 15	Rudraram channel ..	....	1,990	1,500	1,000	..	..	..	1,000 acres.
	Head sluice ..	B. Land ..	2,640	..	1,500	..	..	..	
	Tail escape ..	C. Works ..	280	150		..	..	..	
	Channel ..	Do. ..	435	300	150	..	..	..	500 acres.
		L. Earthworks.	490	450		..	..	..	
35 15	Gunnipudi channel ..	....	2,030	1,500	1,000	..	..	..	
	Head sluice ..	B. Land ..	3,295	..	1,000	..	..	..	
	Tail escape ..	C. Works ..				..	..	..	
	Channel ..	Do. ..				..	..	..	
1 0	Viranki drain ..	L. Earthworks.	435	400	150	..	..	..	
	Bridge ..	....	435	435		..	..	..	
	Drain ..	B. Land ..	1,286	1,000	665	..	..	..	
		C. Works ..	2,27,500	..	1,000	..	..	..	
	Total, Viranki drain ..	L. Earthworks.	..	..	..	..	..	..	
	Inampudi drain ..	....	..	..	1,94,786	..	..	..	
3 54	Bridge, Inur road ..	B. Land ..	..	..	..	..	..	..	
5 10	Inlet Chinnamutevi ..		..	..	..	2,500	2,000	2,000	
6 40	Do. Nelbhanpudi ..	C. Works ..	..	..	..	1,500	1,500	1,500	
7 70	Do. Nemalur (L.B.) ..	Do. ..	..	..	..	6,450	..	6,450	
10 0	Do. Konur (R.B.) ..	Do. ..	..	..	..	7,000	5,800	5,800	
11 30	Do. Mallampalli ..	Do. ..	..	..	..	2,500	..	..	
13 0	Do. Ramanapettah ..	Do. ..	..	..	..	1,500	1,500	1,500	
13 20	Do. Pasadum ..	Do. ..	..	..	..	1,500	1,500	1,500	
	Do. Agakodu ..	Do. ..	..	..	..	1,500	1,500	1,500	
	Drain ..	Do. ..	..	..	..	1,500	1,500	1,500	
	5 Cattle crossings ..	Do. ..	..	..	..	1,500	1,500	1,500	
		L. Earthworks.	..	..	..	1,500	1,500	1,500	
	Total, Inampudi drain ..	C. Miscellaneous	..	..	..	1,679	1,500	1,500	
			..	..	..	1,500	1,500	1,500	
	Total, Works ..	....	..	..	..	4,636	4,636	4,636	
		....	..	..	..	1,81,050	11,000	11,000	
	Establishment at 25 per cent. ..	....	..	..	..	1,500	1,500	1,500	
	Do. survey ..	....	2,27,500	..	..	2,10,750	1,810	1,810	
	Tools and Plant, 8 per cent. ..	....	..	..	1,94,786	2,15,250	..	2,15,250	
		....	..	..	48,696	..	..	53,803	
		....	..	..	3,000	..	..	3,000	
		....	..	..	15,500	..	..	16,500	
					2,62,000	..	..	2,82,000	

44. Cost of Distribution.—The total of the estimates for the west side channel and its distributaries as submitted by the District Engineer is it, will be ... ... Rupees 2,27,800
seen ... ...

system. The roadway of the bridge in connection with the road crossing at the Viranki lock may apparently be lowered several feet which with the [illegible] ing of the wings will reduce materially the cost of this item.

46. Inampudi Drain.—The head of this drain is at the Masulipatam canal at a recently constructed aqueduct which passes the drainage of 31 square miles of country lying to the north of the canal. The depth of water through the drain will be 6 feet. The bed level at head is to be at 6·5 [illegible] the bed of the aqueduct, that at the junction with the Kanakadurgah drain 0·91, and the fall is 7·41 and the length is 14 miles 66 chains, giving a fall of 6 inches a mile throughout. The following are the principal [illegible]

Position	Bed width	Discharge	Area [illegible]	Inches of [illegible]
M. chs. Head.				
2 30	63			
5 0	68	[illegible]	·21	
5 10	70	[illegible]	[illegible]	
6 40	85	1,125	35	1 1·5
7 70	95	1,236	12	1 1·5
10 0	108	1,348	44	0·53
11 30	114	1,456	55	0·65
12 60	120	1,565	·91	0·91
13 20	124	1,673	71	0·84
14 66	140	1,781	77	0·93
	140	1,891	81	0·81
		1,951	56	0·56
			97	0·76
				0·71

As has already been noticed in reviewing the arrangements of other main drains, the actual requirements of the country can be ascertained only by [illegible] of comparatively small dimensions, say one-third of those estimated for in the first instance, and then enlarging it as experience may show to be necessary. It would be unnecessary certainly to provide 20 feet bottom in the upper 10 or 12 miles where the water level will be below ground, and it is improbable that the extra width which they will afford will be wanted in the lower 2 or 3 miles. The saving will [illegible] 1,200 Rupees on land compensation.

(1.) *Masonry Works. Illur road bridge.*—The height of the roadway may be reduced about 2½ feet. The gradients of the approaches may [illegible] from the centre line of the side arches, which will bear the [illegible] 2 feet and shorten them 9 feet.

(2.) *Incidence of Cost.*—The quantity of surplus irrigation water to be disposed of may be assumed to [illegible] the total supply* of the west side channel or 105 cubic feet a second, and this will be tolerably equally distributed throughout the drain. Consequently supposing the drain to be ultimately made of the full dimensions the cost of conveying away the surplus water artificially [illegible] into this tract of country will be about one-nineteenth of the whole cost. Apparently therefore and seeing that the country is all Zemindary it would seem to be impracticable to charge the remaining eleven-twelfths to Ordinary Agricultural, for Government have probably no direct revenue interest in the improvement of this Zemindary. It is

* Cubic feet a second 420.

indeed more than doubtful whether improved drainage would tend directly to develop a demand for water for irrigation. It would do so in the case of low-lying lands which are now unfit for cultivation at all, and which when drained would still be unfit for dry cultivation, but, on the other hand, much land would be fitted by good drainage for bearing dry crops and for such land probably no water would be taken.

(3.) *Sanction of Drainage Scheme not recommended.*—On the whole it would seem to be advisable that no general drainage scheme should be sanctioned, but that within the limits of the scheme which has been planned any special work, which can be demonstrated to be necessary and to be likely to yield some direct return, should be submitted to Government for orders.

47. Ellore Canal.—The estimates for this canal provide for improvements which, after much discussion as to the best way of removing the many defects of its original construction, have been considered to be the best which at a reasonable cost can be devised. There are at present two great defects. One the nominal bed and surface fall due to the level of the Tammileru aqueduct in the 38th mile and of other masonry works near this end. The upper floor of the aqueduct is at 36·58, the bed of the canal at its head being at 37·50; there is therefore a fall of less than 1 foot in rather more than 37 miles. Moreover, the upper sill of the Ellore lock at 40 miles is at 31·95, or 4·63 feet lower than canal bed nearly 3 miles higher up. In order to provide a sufficient depth of water to pass boats over the aqueduct, the water level at the lock has had to be kept up and thereby many inconveniences, including grave interference with the discharge of the east branch of the Tammileru, have resulted. The other great defect is the altogether inadequate provision for passing upland drainage across the canal. This has led to numerous breeches the cost of repairing which has not been very great, the greatest expenditure on repairs in any one year having been Rupees 7,235, but on the average of 17 years Rupees 763 only yearly. On the other hand, the resulting inconvenience by the stoppage of navigation has been very considerable and the trade with Cocanada is on the increase, so that it is very necessary to prevent such accidents for the future. The subject was gone into at the end of 1873, and the present estimates have been based upon the arrangements then ascertained to be necessary.

Appendix No. 5 A.—*Vide* Appendix F to Lieut. Campbell's No. 369.

Inspection Notes, paragraphs 13 to. 20.—Proceedings of Madras Government, 29th September 1874, No. 2,732.

48. General Arrangements.—The canal as revised will have a depth of 8 feet and a bed and surface fall of 0·08 feet per mile from the head to the 11th mile; thence to the 20th mile the bed will be horizontal and the surface fall will be 0·228 feet a mile, the depth being thus diminished to 6 feet; from this point to the end at the Ellore lock the depth will be 6 feet and the bed and surface fall 0·228 a mile. There will necessarily be some practical adjustment of water-level and surface fall to equalize the discharges which, as will be seen from Appendix B to the Report,* as calculated, vary considerably. The water surface is to be 60 feet in width as a minimum in the interests of the navigation, with however some diminution at old masonry works, which are serviceable and which it has not therefore been considered

* Appendix No. 5 A.

necessary to reconstruct. The details will be found in the general longitudinal section and in the detailed longitudinal and cross sections, Plan E J, Sheets Nos. 1 to 10, and 1 to 8, respectively. The deepening is inconsiderable down to the 30th mile, and the maximum cutting required is about 3½ feet in the 39th mile. The upper 35 miles of the canal are for the most part wider than is necessary; the sections are very irregular, and adjustment and the restriction of the water to its proper width, instead of allowing it to spread over the sometimes extensive berms on either side, are the alterations needed. In the lower few miles the lowering of the canal bed materially involves more earthwork. As regards distribution, it is proposed to treat separately each part of the ground into which the area is divided by the cross drainages.

49. PRESENT AND INTENDED AREA OF IRRIGATION.—The area of land commanded by the canal is 140 square miles, and the intended area of irrigation for which water will be provided is 31,000 acres, or 221½ acres to the square mile. The greater part of the land is zemindary, and there will therefore be much uncertainty as to when and to what extent a demand for water will arise. The present extent of irrigation is stated* to be—

Appendix No. 5 A.
* Report Appendix C.

In the Kistna District	...	Acres 4,561, assessment Rupees 1,819.
Godavery District...	...	„ 13,631
		18,192

leaving only 12,808 acres as the additional area to be irrigated.

As regards the irrigation in the Godavery District the latest information on record is contained in Proceedings of Madras Government, No. 3,219, of the 13th November 1874, and it is there shown that for 1872-73 the

area was ... ... Acres 13,111
water-tax was ... ... Rupees 34,228

or at the rate of 2·61 Rupees an acre, while for the two years, 1871-72 and 1872-73, the average area was 12,445 acres, the water-tax Rupees 31,115, and the rate 2·74 Rupees an acre. It has not been practicable to check the area given as the present extent of irrigation in the Kistna District under this canal. The particulars given in the statements printed in the Proceedings as per margin are—

No. 2,844, 7th October 1874.

Year.	Taluq.	Description.	Extent.	Quit-rent	Water-tax	Total	Water-tax per acre.
1871-72 ..	Gudivada ..	Zemindary and Inam lands charged as irrigated .. Do. .. .. do.	Acres. 147	Rs. 45	Rs. 1	Rs. 46	
	Nuzvid Division. Do. ..	Do. actually irrigated free of water-tax and quit-rent	6,738 1,753	45 324	12,362 ..	12,731 ..	1·73 3·42
			8,638	369	12,363	12,732	1·47
1872-73 ..	Gudivada ..	Zemindary and Inam lands charged as irrigated .. Do. .. .. do.	147	45	1	46	0·31
	Nuzvid Division. Do. ..	Do. actually irrigated free of water-tax and quit-rent	1,956 552	25 ..	2,749 ..	2,774 ..	1·41 5·02
			2,653	70	2,750	2,820	1·06

There was no Government land under irrigation in the Kistna District under this canal, and there is no information on record as to the variations in area and rate of water-tax in the two years to which the statements appertain.

The following are the particulars for the irrigation in the Godavery District under this canal:—

Year.	Taluq.	Description.	Extent.	Assessment or Quit-rent, &c.	Water-tax.	Total.	Water-tax per acre.	
			ACRES.	RS.	RS.	RS.	RS.	
1872-73 ..	Ellore ..	Government land charged as irrigated with wet crops	9,519	9,030	33,415	42,445	3 51	
		Do. do. 2nd crops	27	..	..	..	..	
		Do. do. with dry crops	2	2½	3	5½	1·50	
		Zemindary and Inam lands charged as irrigated with wet crops ..	206	15	804	..	3·90	
		Do. do. with dry crops ..	2	..	5	..	1·97	Area 2·30. Water-tax, Rs. 4-8-5.
		Do. do. free 1st crop	3,340	..	..	..	..	
		Do. do. 2nd „	18	..	..	..	..	
			13,114	9,048	34,227	42,451	..	

50. ABSTRACT OF ESTIMATE.—The estimates have been submitted not only without a classified abstract, but without any general abstract. The subjoined abstract has been prepared from the estimates for individual works, and it must be noticed that the works for passing cross drainage across the canal have, under the instructions given in Proceedings, Madras Government, 10th July 1875, No. 1,968, been shown under the main head (4) drainage and protective works. This seems to be a very arbitrary arrangement as such works are an integral portion of the canal, and their omission in the first instance should, it is thought, not cause them to be placed under a different main head. Moreover, it is doubtful whether the instructions are intended to apply to such circumstances as those of the Ellore canal. The cross drainage is natural drainage from the uplands and not artificial drainage, and as placing the cost of dealing with it under main head (4) would give an erroneous idea of the outlay on the drainage proper of the delta, an alternative abstract has been prepared, placing all the cross drainage works and outfall channels under main head (2). No explanation has been given of the reasons for including in the second sub-section drainage estimates the cost of embanking the south side of the Budemair in the 3rd sub-section. This is a natural river or drainage. Nothing that has been done or will be done in the 2nd sub-section will affect in any material degree the conditions under which this river will have to dispose of the drainage which it receives, and the item* for flood banks should therefore be transferred to the 3rd sub-section, to which it properly belongs.

Government of India Circular No. 38 P.W., paragraph 10 F, 2nd sentence.

24 Rupees 18,680.

Position.	Description.	Sub-heads.	MAIN HEADS. Main Canals and Branches.	Distributaries. Original.	Distributaries. Revised.	Drainage and Protective Works. Original.	Drainage and Protective Works. Revised.	Remarks.
M. CH.								
0 0	Improving Canal	L. Earthworks..	29,640	..	..	..	..	The [illegible] remains down to the 26th mile have been considered as irrigation and from thence to end as Navigation Works.
to								
40 0	Do	I. Navigation Works.	26,870	..	..	..	..	
32 63	Kalapurru bridge, tow-path..	Do. ..	430	..	..	..	..	
38 55	Ellore do. do. ..	Do. ..	455	..	..	..	..	
11 70	Kasarapalli channel ..	B. Land ..	..	..	..	..	..	
		C. Works ..	..	..	200	..	..	
		L. Earthworks.	..	..	350	..	..	
14 50	Butumalli channel ..	B. Land ..	..	..	650	..	..	300 acres at 4 Rs. an acre.
		C. Works ..	..	..	600	..	..	
		L. Earthworks.	..	..	750	..	..	
17 26	Panukamad channel ..	B. Land ..	..	..	2,250	..	..	900 do. at do.
		C. Works ..	..	..	900	..	..	
		L. Earthworks.	..	..	1,000	..	..	1,353 do. at do.
20 20	Cherivada do. ..	B. Land ..	..	..	3,500	..	..	
		C. Works ..	..	..	500	..	..	
		L. Earthworks.	..	50,000	650	..	..	
21 47	Puttagunta do. ..	B. Land ..	..	..	1,930	..	..	770 do. at do.
		C. Works ..	..	..	670	..	..	
		L. Earthworks.	..	..	850	..	..	
26 2	Kakulapad do. ..	B. Land ..	..	..	2,480	..	..	1,000 do. at do.
		C. Works ..	..	..	650	..	..	
		L. Earthworks.	..	..	650	..	..	
27 40	Gogunta do. ..	B. Land ..	..	..	2,000	..	..	800 do. at do.
		C. Works ..	..	..	800	..	..	
		L. Earthworks.	..	..	1,000	..	..	
36 20	Muparru do. ..	B. Land ..	..	..	3,000	..	..	1,200 do. at do
	Head sluice	C. Works ..	..	1,370	1,370	..	..	
	1·20 fall	Do.	..	850	1,000	..	..	
	2·20 ,, ...	Do.	..	400	756	..	..	
	3·20 ,, ...	Do.	..	390	735	..	..	
	Tail escape	Do.	..	400	755	..	..	
	Channel	L. Earthworks.	..	455	860	..	..	5,439 acres.
37 10	Madapalli channel ..	B. Land ..	..	4,320	4,320	..	..	
	Head sluice	C. Works ..	..	1,410	1,410	..	..	
	2·5 Fall		..	*420	500	..	..	* No plan furnished.
	3·40 ,, ...	Do.	..	430	810	..	..	
	4·35 ,, ...	Do.	..	700	1,320	..	..	
	5·15 ,, ...	Do.	..	400	755	..	..	3,500 acres.
	Channel	L. Earthworks.	..	490	925	..	..	
7 16	Budemair aqueduct improvements.	C. Works ..	..	5,320	5,320	..	..	
9	Nakalam drain	B. Land ..	..	..	..	880	1,880	
10 21	Kasarapalli aqueduct ..	L. Earthworks.	..	..	..	120	120	
	Kesarapalli drain	C. Works ..	..	..	..	670	670	
		L. Earthworks.	..	..	..	31,690	28,000	
16	Avitapalli do. ..	B. Land ..	..	..	..	300	300	
		L. Earthworks.	..	..	..	300	300	
17	Athkur do. ..	B. Land ..	..	..	..	400	400	
		L. Earthworks.	..	..	..	80	80	
19	Potipad do. ..	B. Land ..	..	..	..	490	* 490	
		L. Earthworks.	..	..	..	50	50	
20 54	Ampapuram outlet ..	C. Works ..	..	..	..	150	150	
..	Do. inlet ..	Do.	..	..	..	1,235	1,235	
..	Do. drain ..	B. Land ..	..	..	..	1,280	1,280	
		L. Earthworks.	..	..	..	710	710	
22 20	Viravalli drain	B. Land ..	..	..	..	1,690	1,690	
	Do. outlet	L. Earthworks.	..	..	..	50	50	
0 50	Nellivagu outlet ..	C. Works ..	..	..	..	350	350	
..	Do. drain ..	Do.	..	..	..	350	350	
23 0	Narsanapalem drain ..	L. Earthworks.	..	..	..	255	255	
24	Canamole do. ..	B. Land ..	..	..	..	830	830	
27 00	Perikud outlet	L. Earthworks.	..	..	..	300	300	
		B. Land ..	..	..	..	1,875	1,875	
		C. Works ..	..	..	..	225	225	
			..	..	..	1,465	1,465	
			..	..	..	15,060	6,720	

Position.	Description.	Sub-Heads.	MAIN HEADS. Main Canals and Branches.	Distributaries. Original.	Distributaries. Revised.	Drainage and Protective Works. Original.	Drainage and Protective Works. Revised.	Remarks.
M. CH.								
..	Perikud drain ..	B. Land ..	..	..	..	170	170	
		L. Earthworks.	..	..	..	300	300	
23 0	Rameleru drain	B. Land ..	..	..	..	80	80	
		L. Earthworks.	..	..	..	60	60	
31 0	Punnukollu drain ..	B. Land ..	..	..	..	40	40	
		L. Earthworks.	..	..	..	20	20	
33 20	Peddapad outlet	C. Works ..	..	..	..	8,770	2,765	
33 20	Do. drain	B. Land ..	..	..	..	1,480	1,480	
		L. Earthworks.	..	..	..	6,780	6,780	
35 77	Wutlur outlet	C. Works ..	..	..	..	21,840	4,900	
..	Do. drain	B. Land ..	..	..	..	70	70	
		L. Earthworks.	..	..	..	300	300	
37 7	West Tammileru outlet ..	C. Works ..	..	..	..	8,180	2,520	
0 10	Do. aqueduct	....	..	..	..	19,080	13,000	
..	Do. drain	B. Land ..	..	..	..	300	300	
		L. Earthworks.	..	..	..	14,830	2,500	No particulars furnished.
39 5	Jolipudi drain	B. Land ..	..	..	..	100	100	
		L. Earthworks.	..	..	..	300	300	
39 60	East Tammileru out and additional outlet.	C. Works ..	..	..	..	17,230	17,230	
..	Do. drain ..	L. Earthworks.	..	..	..	2,160	2,165	
..	Minor drains	O. Miscellaneous.	..	..	..	1,845	1,845	
	Minor improvements to old masonry works.	Do. ..	..	..	..	10,120	10,120	
	Surveys and estimates ..	A. Preliminary Expenses.	..	..	..	..	..	
	I. Works, Total ..	..	57,395	67,775	46,915	1,79,000	1,16,960	
	II. Establishment 25 per cent. on I. ..	..	14,349	..	11,729	..	29,240	
	Do. Survey ..	..	..	..	1,000	..	1,000	
	III. Tools and Plant 8 per cent. on I. ..	..	4,590	..	3,753	..	9,357	
		..	76,334	..	63,397	..	1,56,557	

Position.	Description.	Sub-heads.	MAIN HEADS. Main Canals and Branches. Original.	Main Canals and Branches. Revised.	Distributaries. Original.	Distributaries. Revised.	Drainage and Protective Works. Original.	Drainage and Protective Works. Revised.	Remarks.
M. CH.									
0 0	Improving Canal.. ..	L. Earthworks..	29,640	29,640	..	..	..	..	Alternative abstract.
to									
40 0	Do.	I. Navigation Works.	26,870	26,870	..	..	..	..	
7 16	Budemair aqueduct improvements.	F. River and Hill Torrent Works.	880	1,880	..	..	..	..	
10 21	Kasarapalli aqueduct ..	Do. ..	31,690	28,000	..	..	..	..	
20 54	Ampapuram outlet ..	Do. ..	1,235	1,235	..	..	..	..	
..	Do. inlet ..	Do. ..	1,280	1,280	..	..	..	..	
22 20	Viravalli outlet	Do. ..	380	380	..	..	..	..	
0 50	Nellivagu do.	Do. ..	255	255	..	..	..	..	
27 10	Perisced do.	Do. ..	19,060	6,720	..	..	..	..	
32 63	Kalapurru bridge, tow-path.	I. Navigation Works.	430	430	..	..	..	..	
33 20	Peddapad outlet	F. River and Hill Torrent Works.	8,770	2,765	..	..	..	..	
35 77	Wutlur outlet	Do. ..	21,840	4,900	..	..	..	..	
37 7	West Tammileru do. ..	Do. ..	8,180	2,520	..	..	..	..	
0 10	Do aqueduct alterations..	Do. ..	19,080	13,000	..	..	..	..	
38 55	Ellore bridge, tow-path ..	I. Navigation Works.	455	455	..	..	..	..	
39 60	East Tammileru outlet and additional outlet.	F. River and Hill Torrent Works.	17,230	17,230	..	..	..	..	
11 70	Kasarapalli channel ..	B. Land ..	..	..	}	200	..	..	300 acres at 4 Rs. an acre.
		C. Works ..	..	..		350	..	..	
		L. Earthworks..	..	..		650	..	..	

Position.	Description.	Sub-heads.	MAIN HEADS						Remarks
			Main Canals and Branches		Distributaries		Drainage and Protective Works		
M. ch.			Original.	Revised.	Original.	Revised.	Original.	Revised.	
			Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
14 50	Butumalli channel	B. Land							
		C. Works							
		L. Earthworks							
17 26	Panukamad do.	B. Land							
		C. Works							
		L. Earthworks							
20 20	Cherivada do.	B. Land							
		C. Works							
		L. Earthworks							
21 47	Puttagunta do.	B. Land							
		C. Works							
		L. Earthworks							
26 2	Kakulapad do.	B. Land							
		C. Works							
		L. Earthworks							
27 40	Gogunta do.	B. Land							
		C. Works							
		L. Earthworks							
36 20	Muparru do.	B. Land							
	Head sluice	C. Works							
	1·20 fall	Do.							
	2·20 ,,	Do.							
	3·20 ,,	Do.							
	Tail escape	Do.							
	Channel	L. Earthworks							
37 10	Madapalli channel	B. Land							
	Head sluice	C. Works							
	2·5 fall	Do.							
	3·40 ,,	Do.							
	4·35 ,,	Do.							
	5·15 ,,	Do.							
	Tail escape	Do.							
	Channel	L. Earthworks							
9 0	Nakalam drain	B. Land							
10 21	Kesarapalli do.	C. Works							
16 9	Avitapalli do.	Do.							
17 0	Athkur do.	Do.							
19 0	Potipad do.	Do.							
20 54	Ampapuram do.	L. Earthworks							
		B. Land							
	Viravalli do.	L. Earthworks							
22 50	Nelligavu do.	B. Land							
23 0	Narsanapalem do.	L. Earthworks							
		Do.							
24 0	Canomule do.	B. Land							
27 50	Perikeet do.	L. Earthworks							
28 0	Kancheru do.	B. Land							
31 0	Punerkolla do.	L. Earthworks							
33 20	Peddapad do.	B. Land							
35 77	Wadlur do.	L. Earthworks							
37 10	West Tummalur do.	B. Land							
38 5	Jellipalli do.	L. Earthworks							
	East Tummalur drain	B. Land							
	Main drains	L. Earthworks							
	Main irrigation channels to fill								
	Temporary works								
	Surveys and Establishments								
	I. Works Total								
	II. Establishments								
	III. Tools and plant								

51. RETURNS FROM PROPOSED EXPENDITURE.—The figures above given afford no data for an estimate of returns from extension of cultivation, and it would be unprofitable to attempt any such calculation in detail. The only material increase of water-supply, which will be available for extended irrigation, will be the water which is now taken off by the old head of Ryves canal in the 7th mile, which canal has now a separate head at the lower end of the main canal in course of construction and nearly completed, together with a share of the more ample supply which the main canal will carry now that it has been enlarged. Except as regards new works of distribution, which will not be carried out until the demand for water for particular areas arises, and indeed not until a demand is made for a fair proportion of the area under each distributary, the whole of the proposed expenditure may be deemed to be necessary for rendering the canal fairly efficient to meet the requirements of its circumstances, and of existing irrigation and navigation. If the area of irrigation be extended to the area contemplated, and for which water will be available, and if the water-rate be 3 Rupees an acre on the average; and apparently even supposing that a considerable proportion of the area be dry crops irrigated, this rate would seem not to be excessive, there will be a gross return of about 38,000 Rupees. The expenditure on maintenance of the canal will certainly not be greater than in the past, and will probably be much less when the contemplated improvements have been carried out, and there are therefore grounds for supposing that ultimately a return of about 11 per cent. will be obtained from the further proposed outlay on this canal, after allowing for the maintenance of the additional distributaries, drains, &c.

	Rs.
Budget provision for repairs in 1876-77	13,950
Supposed future	17,500
Difference additional	3,550

52. PROVISION FOR DISTRIBUTARIES.—In Lieutenant Campbell's report, paragraph 8, it is shown that Rupees 50,000 have been allowed in his estimates for seven distributaries which are to water 6,323 acres, and for which detailed estimates have not been prepared. This allowance of 8 Rupees an acre appears to be very unnecessarily high, and as no reason for it has been given, as no instance of such a rate being necessary is on record, and as the average rates for the two channels which have been estimated for are $1\frac{1}{2}$ Rupees and $2\frac{3}{4}$ Rupees respectively, it is believed that 4 Rupees an acre, which have been entered in the above abstract* in each case, and divided arbitrarily under the three sub-heads shown, will suffice. The entry for surveys and estimates under A Preliminary Expenses is a share, in proportion to the additional acreage to be irrigated, of the total outlay up to date with an addition for probable future outlay. No entry had been made under Class VI. As regards (23) capitalization of abatement of land revenue the amount, if any, will be nominal, the land to be acquired being nearly all private property (24). It is not possible to say whether there will be any, and, if so, what payments in England (25). The leave and pension allowances are $\frac{1}{4}$th of Class II, Establishments. The canal being already in operation there will be no simple interest chargeable to Capital under Class VII.

* Revised Estimate column.

Vide memorandum of Distribution of Preliminary Expenses.—Appendix No.

53. Details of Masonry Works, &c.—The following remarks on the designs of the masonry works, &c., should be attended to in carrying out the estimates. When the alterations considered necessary will make no material difference in the amount of the estimates for individual works, the amount has been left as in the original estimate, otherwise an approximate revised amount has been allowed.

54. Distributaries.—*Muparru Head Sluice.*—The design of this work is inappropriate, the roadway being below M.W.L. in the canal, which will be 2 feet above ordinary full supply level owing to the admission of upland drainage. The roadway of the sluice should be on the level of the top of canal banks. The floor of the shutter and its groove should be advanced 1 foot. The bed of the distributary is to be 4 feet below canal bed level, and the water should be dropped at the front wall. All the foundations of the body wall and of the walls and flooring in front that should be laid on an all-over bed of concrete, and the flooring should be laid throughout with Cyclopean stone for a length of 9 feet and 2 feet thick. The alterations have been sketched on the plan and will add about Rupees 150 to the estimate, making the total Rupees 1,000.

Plan 5 of E½.

55. Falls or Rapids.—Rapids are objectionable because the water passing down them acquires a high velocity and would [illegible] below. The design is defective also in having no wing [illegible] not desirable that shutters should be used at such [illegible] under ordinary conditions of supply [illegible] tuted, and the length and level of their crests should [illegible] normal water level above them with a full supply in the [illegible] water level considered requisite as a minimum with [illegible] any minor distribution channels taking off in the [illegible] be provided for occasional use, but in that case the [illegible] height above waters to leave 1 foot [illegible] there is a full supply going down channel. A [illegible] this office for the fall at 1½ miles on the Muparru [illegible] as the general form of work for all falls on this [illegible] approximate amounts required for all the falls on the [illegible] above in the column "revised estimate."

Plans Nos. 9 and 19 of E½.

56. Muparru Channel.—Certain points in the [illegible] have been noted on the plan E½ as needing attention. The [illegible] slightly less section than is necessary for the discharge [illegible] second required, but as a very slight increase of [illegible] water be found insufficient, no alteration of dimensions [illegible] in earthworks may be effected by raising the bed level [illegible]

57. Madapalli Channel.—The alignment of this [illegible] regards the details, supposing the general direction [illegible] and, secondly, it would seem that this line has been [illegible] Probably a much less quantity of earthwork would be required [illegible] the general alignment placed south of the line shown. The [illegible] Sheet No. 1, should receive attention.

58. Cross Drainage Works. Budemair Aqueduct.—The alterations to this work are small though not unimportant. They provide for a slight adjustment of the height of the side walls and the raising of the wings to 3 feet above maximum water level, which may at times be 2 feet above ordinary full supply level in the canal. Iron railings are essential, the tow-path being but 4 feet wide. They will cost about Rupees 1,000, thereby raising the estimate from Rupees 880 to Rupees 1,880.

59. Kasarapalli Aqueduct.—Some modifications of the design are desirable and they have been shown on the plan.* This work also will require iron railings on both sides. It is believed that this aqueduct can be built for much less than the estimate, the rates being very ample. The alterations in quantities have been taken into account in the entry in revised column of abstract.

* No. 6 of E—1.

60. Ampapuram Outlet.—The work provided for is the lengthening of the outlet from 50 to 190 feet. The cross section of the extension corresponds with that of the present outlet, and, if the latter has been found suitable to the soil and circumstances, the extension may be carried out as designed, otherwise the modifications noted on the plan as desirable should be attended to. The estimate will, it is thought, cover the alterations if found necessary, the rate for rubble masonry complete* being nearly 6 Rupees.

Plan No. 12 of E—5.

* Including facing and pointing.

61. Ampapuram Inlet.—This work also provides for lengthening an existing inlet to 190 feet. The design corresponds with the old work, and probably a more satisfactory arrangement may be secured. In any case the wings should correspond with the earthworks as far as ordinary full supply level in the canal, and it is thought that a crest wall with 2½ feet of dry rubble apron 12 feet wide and 4 feet below the crest will be a cheaper and better arrangement. Most hydraulic works founded on alluvial soil are the better for being placed on a bed of concrete 2 feet wide than the walls built thereon. The crest wall, if run into the centre of the bank stepped for the tow-path and with revetments for the overlapping ends of the bank, make an efficient and cheap arrangement, and an entirely new work of this pattern would probably cost less than the extension of the old inlet.

Plan No. 13 of E—5.

Design No. 5, Circular 67.

62. Perikeed Outlet.—The design for this outlet is inappropriate. A very inexpensive work will do very well, ground level being only 1·37 feet below full supply level in the canal. The description of weir shown in design No. 5, circular 67 should be adopted, and it will cost but little more than one-third of the estimate submitted. The Superintending Engineer has noted on the plan the absence of any necessity for a drop of 9 feet as shown, but he apparently contemplated wing walls of the same description as in the plan, whereas a prolongation of the crest wall, which may be founded 4 or 4½ feet below ground level, will suffice with substantial and well backed revetments for the slopes of the connection of the banks with the masonry

Plan No. 23 E—9.

Care must be taken that the surplus discharged from this outlet is not allowed to fall into any low le[illegible] out-fall channel except at a considerable distance from the canal. Apparently there is no risk of this occurring if the Goguata channel right bank be kept in order, as it must be kept to prevent surplus running into that irrigation channel.

63. Peddapad Outle Wutlur Oulet, West Tummileru Outlet.—Similar remarks apply to these works for which the same general design was intended, though the estimate for the Wutlur outlet differs materially in cost per foot run, viz.:—

Perikeed outlet	960 feet	... ...	Rupees 19,060,	per foot 20 nearly.—
Peddapad	„ 395	„	„ 8,770,	„ 22 „
Wutlur	„ 700	„	„ 21,840,	„ 31 „
West Tummileru outlet	360 feet	...	„ 8,180,	„ 22 „

The proximity of the Wutlur outlet to an under tunnel has probably induced Lieutenant Campbell to place the apron* of the former on nearly the same level as the floort of the tunnel, but a training bank will prevent the weir surplus falling into the outfall from the tunnel, and ground level here is somewhat higher than water surface in canal, so a very inexpensive work will answer the purpose. In the revised estimate the entries made are—

* 29·85.
† 28·62.

Peddapad outlet	... ...	395×7=Rupees 2,765
Wutlur „	... ...	700×7= „ 4,900
West Tummileru outlet	... ...	360×7= „ 2,520

64. Tummileru Aqueduct.—It has been considered desirable to revise the arrangements for the conversion of this aqueduct into a set of sluices, and to place the sills of the latter at the floor level instead of as was originally intended at 3 feet thereabove; also to limit the height of the sluices to that required to secure the necessary discharge. The estimate for the design prepared by Lieutenant Campbell amounts to Rupees 19,080, and it is thought that the required alterations can be carried out for a much smaller sum and in a way which will probably be more effective. The revised arrangements have been shown on the plan, and it is hoped that there will be no difficulty in preparing working drawings and carrying them out. All the aqueduct, except the parts shown as required in connection with the sluices, will be demolished, and a set of 24 sluices 6 feet wide and 5½ feet high will be substituted, the sills of the sluices being placed on the floor of the aqueduct, viz., at 27·58. The shutters when fully raised will then be just flush with water surface in canal. The revised estimate, after deducting value of materials of aqueduct which, if not to any great extent required on these alterations, can be utilized at the outlets close by, amounts to Rupees 13,000, and an approximate abstract has been given on the plan.

Plan No. 33 of E—14.

65. West Tummileru Drain.—The estimate contains the following entries for this work:—

Land	... ...	Rupees 300
Earthworks	... ...	„ 11,820

There is no specification or estimate of the work to be done.

This drain is really the west branch of a river. The canal works will not increase the discharge down it, and whenever there is a fresh and the sluices noticed in the

preceding paragraph are opened, the water will pass through them by the artificial cut in which the aqueduct was built into the natural bed of the river. Some small improvements may be necessary, and for these Rupees 2,800 have been entered in the revised estimate column, but no heavy outlay is, it is considered, needed.

66. East Tummileru Escape.—The existing work is a weir with self-acting (intended) shutters 200 feet in length. The crest is 2½ feet below revised water surface in canal. It is intended to bridge this weir and furnish the bays with shutters worked by screws and to extend it so as to allow of seventeen vents of 6 feet with the sills at canal bed level. A few remarks for guidance in carrying out the alterations have been noted on the plan. This is the last of the cross drainage works.

Plan No. 35 of E—15.

67. Data for Cross Drainage Works.—The arrangements have been designed throughout so as to afford the waterway determined to be necessary or desirable when the subject was examined into at the end of 1873—*Vide* Inspection Notes, paragraphs 13 to 20 in Proceedings, Madras Government, No. 2,732, of the 29th September 1874. The considerations affecting the disposal of cross drainage after it has passed the canal will be found noticed in the correspondence as per margin.

From Kistna, No. 106, 17th December 1875.
To do., „ 1, 1st January 1876.
Vide Appendix No.

68. Rates for Masonry Works.—When the works of the Kistna Delta come to be carried out, the rates for the several descriptions of work should not exceed those at which similar work can be done in the Western Delta of the Godavery under similar circumstances. The Superintending Engineer to this end will do well to take measures to inform himself as to what the latter rates are and as to the variations in rates caused by distance over which materials have to be carried. The Bezwada stone is a more easily worked sandstone than is the Dowlaishweram sandstone, and it is quarried under more favorable circumstances. The cost of getting the stone in each locality should be first attended to, and then all subsequent charges for the finished masonry, &c. The following are the rates at works in the two deltas on the same canal, viz., the Ellore—

The mileages are from Bezwada in the one case and from Vijeshweram in the other, or from the respective heads of main canals.

	Kistna Outlet 360 feet 37th mile.	Godavery Outlet 150 feet 43rd mile.
Concrete per 100 cubic feet	Rs. 15·97	10·00
Rubble masonry „	„ 17·82	18·00
Cutstone do. „	„ 44·44	50·00
Dressing facework, 100 square feet ...	„ 12·50	10·00
Rough stone revetment and apron, 100 cubic feet	„ 9·26	8·00

The rates for concrete, roughstone in apron and revetments and face dressing in the Kistna need inquiry. The other rates appear to indicate that a considerable reduction is feasible. In such extensive works as are provided for in the Kistna Delta completion estimates rates are of very great importance, and the experience gained in the neighbouring delta where a high class of work at any rate on the locks and other large masonry works has been carried out should be utilized fully. The cost of the 150 feet outlet on the Godavery Ellore canal appears to have been Rupees 1,074 against Rupees 1,050 the estimated amount.

69. Fourth or Kykalur Sub-section.—The importance of making an early commencement with the improvement of this sub-section of the Eastern Delta renders it desirable to review the scheme before taking up the estimates for the third sub-section in order that, if possible, something may be done in 1877-78. One principal reason for losing no time is that Ryves' canal which through the Pulleru will supply a large part of the water for the Kykalur sub-section has been nearly completed, and unless the means of utilizing this water be provided much of the benefit to be derived from that canal will not be secured. This part of the delta is at present in a very unfavorable condition. The lands are generally not fit for dry cultivation, and the water-supply is very inadequate and somewhat precarious. The drainage too is greatly in need of improvement, for which however the lie of the ground offers considerable facilities, at least as regards its natural definition by alternate ridges and hollows, though the slight fall available will make effective drainage more costly than elsewhere.

70. General Arrangements.—The three principal canals of irrigation will be the—

	Acres.
1. Polrazkodu canal	
2. Chevurkodu channel	20,000
3. Lower Pulleru do.	14,000
	12,000

(1.) *Navigable Canals.*—The Polrazkodu canal to the north and the Buntumalli canal to the south will be navigable, both will join the Uputeru, the former near Vikrampad and the latter near Dongaypundu, the tail locks being about 14 miles apart. The Uputeru is a good navigable river with which three lines of navigation in the Western Delta of the Godavery are connected, and this sub-section will therefore be placed in complete connection with the whole system of the Godavery Delta Canals.

71. Desire of the people for improvements.—The ryots of this sub-section are very anxious for the improvement of the means of irrigation and communication. They have for a long time past seen the results of the far more advanced state of the irrigation in the Godavery Delta, where what were but a few years ago swamps like those of Kykalur are now fertile fields on which excellent crops are to be seen from the Kykalur side of the Uputeru, and the ryots sometime ago petitioned that an aqueduct might be built on that river to convey Godavery water across to their lands so that they might share in the benefits which they saw their near neighbours to be enjoying while so much of their own land was lying uncultivated.

72. Area of Sub-section.—The area of the sub-section is 201 square miles, and the proposed extent of irrigation will there be nearly 229 acres to the square mile commanded. There is no room for doubting that water for the full area for which water can be supplied will be in demand, and probably a still larger area would be taken up for irrigation were it not that a very considerable extent of the low-lying swampy lands must be reserved to afford adequate outfall for the drainage. At present there is very little cultivation and what there is is chiefly wet.

Appendix No. 6.
Lieutenant Campbell's Report, No. 109.

73. Land now irrigated.—Owing to the circumstance that the existing channels of this sub-section irrigate land in other sub-sections, it is not easy to show accurately

what the present area of irrigation in the fourth sub-section is, but Lieutenant Campbell considers that it may be taken to be as follows:—

—	Present.	Proposed.	Difference.
	Rs.	Rs.	Rs.
Polrazkodu	6,735	20,000	13,265
Do. old		14,000	14,000
Chevurkodu	...	12,000	6,740
Lower Pulleru	5,260		
Buntumalli Canal			
	11,995	46,000	34,005

This was the intention of the estimates as prepared by Lieutenant Campbell, but some modification is now intended.

The Buntumalli canal will cease to irrigate, its level being unsuitable, and it will be used as a line of navigation for the southern part of the fourth and northern part of the fifth sub-sections.

74. Proportion of Irrigation under several Channels to Area commanded.—The following particulars show the proportion between the intended area of irrigation and the total area commanded by each principal channel:—

	Area commanded, Square Miles.	Acreage.	Per Square Mile.
Polrazkodu	74	20,000	270
Chevurkodu	67	14,000	209
Lower Pulleru	60	12,000	200

75. Polrazkodu Canal.—The estimates provide for improving and adjusting the level of the existing canal, for extending it to the Uputeru, for making it navigable (2nd-class) throughout, and for the necessary distribution channels and works.

The head is situated on the left bank of the Pulleru canal at 26 miles 63 chains, and the principal features of the canal will be as follow:—

Length 26 miles 16½ chains.
Level of bed at head + 11·12.
Do. of do. at tail + 1·45.
Bed and surface fall head to miles 18·46—0·33 foot per mile.
Do. 18·46 to tail 0·08 foot per mile.
Depth of water, 5 feet.

76. Alteration of off-take of Chevurkodu Channel.—In paragraph 14 of Lieutenant Campbell's report* on the 4th sub-section this alteration is referred to, but no reason for it is given. The present off-take is at 2 miles 70 chains of the Polrazkodu, and it would seem to be unnecessary and not desirable to change the source of supply. The Polrazkodu in these 2⅞ miles will, including the Chevurkodu, need to carry 510 cubic feet a second, and the sections show that this can be done without at any rate more than a nominal addition to the cost of the arrangements there shown and intended to convey 300 cubic feet a second only. All that is necessary is to place the bed down to the Chevurkodu head sluice 2 feet lower than was proposed, so as to carry a depth of 7 feet of water in this part. The bottom

* Appendix No. 6-A.

G, 4—No. 1, Sheet No. 1.

width, 36 feet, intended will do very well, and the side slopes can be 2 to 1, which will be more suitable to the present section of the channel, the bed of which is generally as low and in places lower than that of the revised arrangement at. Immediately below the Chevurkodu head sluice the bed level may be raised by a wall or revetment corresponding to the intended cross section.

(1.) *Flatter side Slopes desirable.*—It may be noticed that flatter side slopes will generally be better suited to the circumstances, and that the waterway should be confined to that desired.

Waterway to be limited.

(2.) *Arrangements for holding up Water for Navigation.*—These are referred to in paragraph 9 of Lieutenant Campbell's report. He explains that it will be cheaper to raise the banks from the 8th mile to the 19th than to build an intermediate lock, and apparently his proposal is to substitute a surface fall of 1 inch a mile for 4 inches a mile whenever the supply of water may run short, but it is not quite clear what is intended. A fall of 1 inch a mile would, with the full depth at the head, make the water surface at the 19th mile lock ... ... 14·57
And the bank at the lock is to be at ... ... 13·77

Margin which is small ... 1·

* From the lock plan it would appear that maximum water level above the lock is to be 13·58, and how this has been determined has not been explained. Before any decision in this direction is done a definite understanding should be come to as to what the intended arrangements are to be, and it should be shown that an additional lock would cost materially more than the higher embankments for which Rupees 10,[illegible] are entered. It is to be noticed that were a lock built at 11 miles 55 chains there would be lattice bridge there estimated to cost 5,000 Rupees would be saved, and the two items would certainly go far towards building a lock with the small depth required.

3. Preferable Arrangements.—Again, the area below the 11th mile is only 6,000, and the discharge required 90 cubic feet a second. To obtain this a fall of 1¼ inches a mile will suffice. The cutting below 15 miles 40 chains is deeper than desirable, and altogether it would seem that the better arrangement would be to put the lock intended to be built in the 19th mile at 11 miles 55 chains, to give it a fall of 18 inches, which will entail very little cutting and not more than will suffice to properly section the old channel and form tow-paths 1 foot or 15 inches above water level, to make the section of the canal from 5¼ miles 20 feet bottom with 2 to 1 side slopes, to give a fall of 4 inches a mile down to 14 miles where the Kykalur channel takes off, and below that a fall of 1¼ inches a mile only.

The water surface in the Polrazkodu canal at 11 miles will then be ... 2·25
And that in the Kykalur channel ... ... 2·91
The bed level at lower end will be ... ... 2·77
Ground do. do. being ... ... 3·45

a difference which will be immaterial. The irrigation under the former will be [illegible]
and under the latter 7,000 acres, and the regulator at the head of the Kykalur channel
may be of a very simple description as ordinarily no regulation will be required.

With these arrangements the surface fall to 11 miles 55 chains will be 3·90 feet
And if the depth of water at the head of the canal be fixed at 3½ feet as a minimum, the water at the lock may have to be held up 3·90 (5—3½) ... ... 2·40 feet

It will be necessary to make the banks 18 inches higher than the maximum water level, or 3·90 feet above ordinary supply level = 8·90 feet above lock upper sill, but it may be noticed that the water will really never be held up so high, for navigation will come to an end for want of water in the Pulleru if there be not a sufficient supply to produce a surface fall of an inch to an inch and a half a mile. In the second reach the ordinary surface fall will be 2·03 feet, and to secure a minimum of 3½ feet on the 12th mile lock lower sill, the water surface at the tail lock would have to be raised 0·53 foot, which can be done without any departure from the normal arrangements. Where the fall of a canal is greater in the upper part than in the lower, it is better when navigation has to be considered to make the upper reaches short and the lower long.

77. Abstract of Estimate.—The following is a classified abstract of the estimates of the Polrazkodu canal including the Chevur channel as a branch, the other branches and the Upeteru embankments. The latter may be considered to be part of the irrigation arrangements, as they are essential to the protection of some of the land to be cultivated, and their cost being small the other interests which will be benefited may be left out of account.

Position.	Particulars.	Sub-heads.	Main-heads: Main Canals and Branches. Original.	Main-heads: Main Canals and Branches. Revised.	Main-heads: Distributaries. Original.	Main-heads: Distributaries. Revised.	Main-heads: Drainage and Protective Works. Original.	Main-heads: Drainage and Protective Works. Revised.	Remarks.
M. CHS.			Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
..	Compensation	B. Land ..	3,785	3,785	..	..	..	..	
..	Improving head sluice ..	D. Regulators..	795	795	..	..	..	..	
..	Head lock	I. Navigation Works ..	17,875	17,875	..	..	..	..	
..	Bridge, Madinapalli ..	G. Bridges ..	..	..	..	..	..	..	Under construction.
7 0		H. Escapes ..	2,735	..	..	..	..	..	
..	Outlet	G. Bridges ..	5,900	..	..	..	..	..	
..	Bridge, Lingala.. ..	H. Escapes ..	2,965	..	..	..	..	..	
11 50	Outlet into Chinna Kommeleru.								
18 47	Lock	I. Navigation Works ..	21,775	..	..	..	..	..	
..	No. weir	Do. ..	2,935	..	..	..	..	..	
..	Do. tidal	Do. ..	27,205	..	..	..	..	..	
..	Do. weir	Do. ..	3,750	..	..	..	..	..	
26 17				67,325	..	..	..	..	
..	Rest-houses (3)	K. Buildings ..	3,900	3,900	..	..	..	..	
..	Canal	L. Earthworks..	31,660	..	..	..	..	..	
..	Canal raising banks to hold up water for navigation.	I. Navigation Works ..	10,790	..	..	..	..	..	
				42,450	..	..	..	..	
..	Cattle ramps (14) ..	O. Miscellaneous.	5,270	5,270	..	..	150	..	
..	Embanking Upeteru (R. B.)	B. Land ..	..	..	..	..	2,710	..	
..	Do. do. ..	L. Earthworks..	..	..	..	..	..	..	
..		P. Maintenance.	..	..	5,000	5,000	..	..	
..	Minor sluices (23) ..	C. Works ..	..	..	5,000	5,000	..	..	
..	Do. channels (10) ..	L. Earthworks..	..	..	9,560	7,500	..	..	
..	Chevur Kodu channel ..	B. Land ..	..	..	(a) 100	500	..	..	(a) in canal estimate.
2 70	Head sluice	C. Works ..	..	..	(b)1,510	..	..	..	(b) in Chevur Kodu estimate, not required.
..	Do.	Do. ..	..	..					

The omission of a new head will save about 6,000 Rupees in earthwork and at least 800 Rupees on land,* for the greater part of the new head would run through wet cultivation for which the average rate of 20 Rupees an acre would not suffice.

Had a new head been necessary, it must be noted that the alignment of the junction of the new and old channels would have much needed improvement.

(1*a*.) *General Arrangements.*—Omitting the low land the length of the channel will be 27 miles 50 chains

Level at head	...	...	...	...	...	...	...	7·81
" at tail	...	...	...	...	...	...	...	2·19
Fall available	...							5·62
Or per mile	...							0·204

On the longitudinal section the bed-fall is 3 inches a mile, and there is a drop of 1½ feet in the 23rd mile (old) which is not an advantage, as the fall available is already so small as to give a velocity of less than 1 foot a second. At 4 miles from new or 3 miles of the old mileage it was intended to reduce the depth of water from 4 to 3 feet. It will of course not be necessary to make any change of depth at this point, but it is a question whether so long as the channel has to carry water for a large acreage it is desirable to reduce the depth below 4 feet.

(1*b*.) *Further consideration as to position of head.*—It is further very doubtful whether the old head of this channel is not [illegible] than the new. It will be seen that there is very little irrigation under the channel in the first [illegible] miles; that the ground levels in the upper miles are not very favorable; that the Chevurkodu will run very close to the Dakeru channel at about 9 miles from the offtake; that at this point the bed level of the former will be about [illegible] the Polrazkodu at the head of the Dakeru channel will be [illegible], and that the latter from the Dakeru head to a junction with the Chevurkodu would be about 7 miles of which 6 will be occupied by the Dakeru channel in any case. This channel has a existing distributary, to which but trifling additions [illegible] have been given, but it would appear from its circumstances that it will probably a better and cheaper line by which to convey water for the irrigation below the channel would be used only for the small amount of irrigation in the upper or 8 miles.

(1*c*.) *Depth of Water.*—Except in the last 3 miles there is nothing in the bed of the ground to prevent a depth of 4 feet of water being carried [illegible] drop 3 miles from the end can be given. For a discharge of, say, [illegible] second the areas of waterway required with 3 and 4 feet of water respectively would be about 200 and 225, and the bottom widths 41 and 70 feet respectively. If therefore, the depth be made 4 feet, there will be a reduction of cost of [illegible] works, and masonry works. Rupees 70,000 have been allowed in the [illegible] column for the works below the head sluice, and this sum will probably suffice.

(1*d*.) *Branch Channels.*—The estimates for these have been left as submitted, but the amounts are generally too high for tertiary distribution, and there is room for reduction. This is especially the case with the Kalathiperumbedu channel, in which a saving may be secured by increasing the bed-fall considerably by [illegible]

* 40 acres.

drop and lowering the bed slightly at the tail, so as to obtain a fall of 16 inches a mile which, with a depth of only 2 feet of water, will give none too high a velocity.

(2.) *Chigurukota Channel.*—This is the next distributary of the canal on which any considerable expenditure is proposed. Its length will be 10 miles and 73 chains, and it has been arranged to run with a velocity of only 1·18 feet a second. As there is a greater fall available than the 4 inches a mile allowed, the velocity should be increased considerably, which will reduce the cost of all descriptions of work. The bed of the canal at the offtake is at 9·42; that of the channel at 8·19; the bed of the channel at the tail end is at 3·10. At least 9 inches a mile fall can be obtained by starting at 9·42, and the lower part of the channel will be all the better for being lowered. The reduction of depth as the acreage decreases may be conveniently arranged for by reduction of bed-fall, keeping the surface fall about the same throughout.

(3.) *Kykalur Channel.*—The first 5⅞th miles are in use and require very little in the way of improvement. As regards the extension, the longitudinal section shows that the line selected gives heavier cutting than is desirable, and this is especially the case in the 11th, 12th and 13th miles. If practicable the line should be run on ground not so high. The head sluice of this channel will, with the altered arrangements of the Polrazkodu canal, require more waterway than was intended by Lieutenant Campbell. It has three vents of 4 feet span, and as its sill is 0·61 feet below the proper level it can be re-arranged with two vents of 7½ or 8 feet each and 5·11 feet high, which will make the sluice of ample capacity. The only other masonry works are a bridge in the 5th mile, an outlet in the 6th mile, and a tail escape, and flood water in the Uputeru being but slightly above water level in the channel no special arrangements at the latter will be needed. No channels for distribution are shown on the plans in connection with the Kykalur channel, they will be very short and necessarily somewhat numerous. It is not quite clear how they are to be provided for, but it may be intended to construct them from the lump sums for minor channels and sluices, Polrazkodu canal.

80. Lower Pulleru Channel.—This channel is to irrigate 12,000 acres. Its head is close to that of the Polrazkodu and Bantumalli canals at end of the Pulleru canal. Its length will be 18½ miles. The following are the principal particulars as shown on the sections:—

Level of bed, at head	...	...	...	...	9·50
at tail	...	...	...	...	2·25
Total fall					11·75
Width of bed, at head	...	...	...	...	28·0
at tail	...	...	...	...	3·0

From the lower part of the 5th mile it is proposed to be continued down to 7⅞th miles, as a side channel to the Bantumalli canal, the estimate for the improvement of which latter forms a part of those of the 5th sub-section.

It will be seen that the fall available is only 0·635 feet a mile, although the tail end of the channel is intended to be at a very low level. A drop of 1 foot is proposed at 3 miles and one of 1½ feet at 4½ miles, and some such arrangement is necessary perhaps if the Tadicherlakodu, an old course with a section very much greater than is required, be adopted, as intended by Lieutenant Campbell, for this distributary.

78. WORKS—MAIN CANALS AND BRANCHES.—The suggested re-arrangement of the canal will necessitate the alteration of some of the items, but the estimates may be taken to be a sufficiently close approximation to the cost of the canal, and the savings on the navigation banks and lock will be available for enhanced cost of other items which the modifications may entail.

(1.) *Tidal Lock.*—The information on which the level of the lower sill has been fixed does not appear to be as definite as is desirable. A short distance off there is the Yelurpad lock on the Godavery side, from which information of value may be obtained. Then there is the Mogultur lock at the end of the Nursapur canal, in connection with which special observations were made and the level of the sill adjusted. Care should be taken that the sill is placed not less than 3 feet below extreme low water of springs.

(2.) *Rest-houses.*—All the rest-houses have been placed under this head. Three are proposed to be built at Kanukollu, Kykalur and Kaldindi, but as not one of these places is on a navigable canal, the propriety of their selection is more than doubtful. It is advisable to place rest-houses in the neighbourhood of considerable distribution offtakes, or where much work is to be done, and in this view a proper place for one rest-house would be about 3 miles from the head of the Polrazkodu canal. A good site for a second would be on the same canal some 15 miles lower down near Rachapatnam, and perhaps the best place for the third would be as near the end of the Bantumalli canal as ground on a suitable level can be found.

(3.) *Cattle Ramps.*—The gradients should not be flatter than is necessary: 1 in 6 is a very easy gradient for cattle. The width should be ample, herds of cattle cannot be driven along a narrow way unless between strong fences.

(4.) *Uputeru right embankment.*—The specification report for the upper $6\frac{1}{2}$ miles is in parts difficult to be understood; but the general arrangement is a bank $4\frac{1}{2}$ feet wide at top with 2 to 1 slopes and a level $2\frac{1}{2}$ to 3 feet above M.F.L. The lower part of this embankment will be formed by adjusting the level of the left bank of the Chevurkodu channel.

79. DISTRIBUTARIES.—The first and principal distribution channel is the Chevurkodu.

(1.) *Chevurkodu Channel.*—Lieutenant Campbell proposed to give the channel a new head at the Pullern, but for the reasons given in paragraph 76 it is considered better to retain the old head. The levels of the canal of supply and of the channel at the offtake are as follow:—

Polrazkodu Canal	Bed	10·19
	Water	15·19
Chevurkodu Channel	Bed	7·81
	Water	11·81

The sill of the present head sluice is at 8·64. There are four vents 2 feet by 3 feet.

Taking the ordinary working head of water at 3 feet, the area of vents required will be 210 divided by 9 or $23\frac{1}{3}$ square feet, and the present vents are therefore large enough, but were it desirable to increase them this could apparently be easily done, and as it will be necessary to raise the sill of the vents to 10·19 and to provide for dropping the water to the bed, 7·81, of the channel an item of Rupees 500 has been entered for the alterations which may be required.

210 cubic feet a second the discharge required.
9 feet a second velocity through vents.

It is doubtful however whether this plan is a good one, for it will necessarily be a long time before a proper régime would be established by the silting up of the section in excess of the proper waterway, and a better arrangement would seem to be to make the Buntumalli canal carry the irrigation water for the lower Pulleru at any rate as far as the 5th mile. This canal will have to be 25 feet wide at bed and will have a depth of 5 feet. Consequently to carry 225 cubic feet a second a velocity of 1·35 feet a second will be required, which will be moderate and suitable to a sandy canal. The expenditure proposed in the Tadichetla Kodu part of the channel is about 4,000 Rupees, and this would probably more than suffice for all that would be necessary to secure the efficiency of the alternative arrangement. It may be advisable to use the canal as far as the 7⅞th mile where the Lower Pulleru diverges finally from the canal. The bed level of the lower Pulleru channel at 5 miles is shown as 4·50 that of the Buntumalli canal above the first lock at 5½ miles is ... ... 7·13 the fall necessary for a discharge of 180 cubic feet a second would be 2·37 inches and the canal being generally of greater than the normal section, 3 inches a mile will suffice. The bed level at the first lock will then be 6·13, and it would be very much and give more than all the command required. Again, at the 7⅞ mile of the Buntumalli canal the bed level is shown to be ... 5·84 and water do. ... 7·84 while those of the channel are bed ... 7·84 Water ... 3·06 ... 0·63

It is clear therefore that it would be quite practicable to do without the first 7½ miles of the lower Pulleru as a separate channel, and to use the first 7½ miles of the Buntumalli canal in support of the lower Pulleru channel. The propriety of using the first reach of the Buntumalli canal in support of the first 7½ miles of the lower Pulleru channel.

(1.) *Abstract of Estimate.*—The following is a classified abstract of the estimate for the lower Pulleru channel and the revised estimate which will be required for the alteration required:—

Position.	Particulars.	Sub-heads.	MAIN HEADS. DISTRIBUTARIES. Original.	Revised.	Remarks.
	Tail escape	Do. ...	465	465	
	Channel	L. Earthworks...	2,135	2,135	(3,000) a cres.
	Pedda Tummida branch channel.	B. Land ...	1,480	1,100	
	Head sluice...	C. Works ...	710	710	
	Bridge, Argole road ...	Do. ...	1,585	1,500	
	Tail escape	Do. ...	485	485	
	Channel	L. Earthworks ..	6,130	6,130	(2,000) acres.
	Fifteen Minor sluices ...	C. Works ...	5,250	5,250	
	Do. do. channels	L. Earthworks...	7,500	7,500	
			55,655	48,660	(12,000) acr es.
	Establishment 25 per cent ...		...	12,165	
	Do. Survey ...		...	500	
	Tools and Plant 8 per cent.		...	3,895	
				65,220	

A few remarks on the alterations made will be convenient.

(2.) *Land.*—One-fourth has been deducted, berms between the channels and their banks being unnecessary.

(3.) *L. P. Channel Head Sluice.*—As a new work will have to be built on the Buntumalli canal, this item has been increased.

(3*a*.)—*Bridge, Argole Road.*—The bed width of channel being only 8 feet the smaller sum will be quite sufficient if splay wings be adopted, and if the span be made equal to the mean width of the channel.

(3*b*.)—*Regulator, 17th Mile.*—This may be dispensed with, the required discharge and the desired depth being obtained by adjusting the bed and surface falls of the channel.

(3*c*.)—*Earthworks.*—The reduction is due to the upper 4½ miles of the channel not being required with an offtake from the Buntumalli canal.

(4.) *Other Reductions.*—Other reductions will probably be feasible, but as sections of some of the channels and plans of their masonry works have not been furnished the details could not be examined. The rate, Rupees 5, per acre for the Pedda Tummidi branch channel is high and should be reduced if possible.

(5.) *Incidence of cost of Bridges.*—In some cases provision has been made in the estimates for proposed roads. It will perhaps suffice to note that the cost of bridges will be debitable under the rules in force, and the entry of items for them in these estimates will not warrant the debit of the expenditure upon them there to except under those rules.

81. DRAINAGES, FOURTH SUB-SECTION.—The principal drains of the sub-section, commencing from the north, will be as follow:—

	Square Miles of Area Drained.	Discharge	Discharge in 24 hours
Pullava main drain			
Damidi "	15·33	[illegible]	[illegible]
Pedakommeleru main dram	2·41	6·12	1·50
Pedalanka "	41·25	1·15	2·55
	197·31	1,10[illegible]	1·00
		2,[illegible]	0·75

And the drains provide for the artificial relief of 169 out of the 201 square miles of country forming this sub-section. The data on which they have been designed are the same as those adopted for other parts of the delta; and as elsewhere the dimensions of the drains should in the first instance be confined to such as may be sufficient to carry off about one-third of the discharge calculated. Moreover Lieutenant Campbell in the concluding part of his report on this sub-section recommends that in the Appendix No. 6 A. swamps the drainage should not be confined to a regular cross section, but should be allowed to spread, a narrow drain being cut through them, and the spoil-banks being placed sufficiently far apart to allow of ample waterway. Elsewhere and especially where the ground rises near the Uputeru the drains would be cut to such dimensions within the full size estimated for as experience may show to be necessary. Lieutenant Campbell has calculated that the saving which will be effected by this arrangement will amount to 4½ lakhs of Rupees.

The details have not apparently been worked out on the sections, and whatever is done in this direction must to be effective be adapted to the circumstances. To allow the water to spread in the swamps will at any rate for a considerable time to come occasion no inconvenience, and there can be no objection to the omission to form embankments through swamps where the cutting required to allow the water to run off is insufficient to form them, and where the omission will not cause the submergence of land at a distance. In such cases the spoil banks, if there be any cutting, should be placed on the proper alignment, should be made of such height as the soil will allow, and should be of the full dimensions of the base of the section; they will then confine the water within the drain, except when it rises to a considerable level.

82. FIRST REQUIREMENTS.—A great deal of drainage finds its way into the vicinity of the Uputeru and is then blocked by the comparatively high level of the river margin. The first thing to be done will be therefore to cut out the tail ends of all the drains through this low ridge, and this will at once afford much relief to the country, and will moreover make it comparatively easy to ascertain the drainage which is to be next taken up, and the extent to which it should in the first instance be carried out. The right embankment of the river will with the outfall sluices [illegible] the quantity of water to be got rid of, and probably a comparatively small outlay judiciously made will reduce the extent of swamp so materially as to alter [illegible] the circumstances of this part of the delta, and do all that is at present required.

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22nd December 1876. *No.* 3,528-*A.*

83. ABSTRACT OF ESTIMATES.—The following is an abstract of the drainage estimates as submitted:—

Position.	Particulars.	Sub-heads.	MAIN-HEAD. DRAINAGE AND PROTECTIVE WORKS. Original.	Revised.	Totals of Drains.
ms. chs.					
2 40	Pullava main drain	B. Land	5,650	4,500	
11 15	Bridge, 3rd mile..	C. Works ..	3,750	1,500	
	Outlet sluice at end	Do. ..	3,185	3,185	
	Drain	L. Earthworks ..	66,700	40,000	
					49,185
	Vedurava drain	B. Land	975	500	
	Culvert	C. Works ..	860	..	
	Drain	L. Earthworks ..	3,690	3,690	
					4,190
	Annava drain	B. Land	1,335	620	
	Culvert..	C. Works ..	825	..	
	Drain	L. Earthworks ..	6,245	6,245	6,865
	Total, Pullava main drain and affluents ..	....	93,215	60,240	60,240
	Damidi drain	B. Land	2,290	1,500	
	Outlet sluice at end	C. Works ..	2,125	2,125	
7 35	Drain	L. Earthworks ...	15,555	6,000	
	Total, Damidi drain ..	....	19,970	9,625	9,625
	Peddakommeleru main drain	B. Land	15,230	10,000	
0 60	Bridge	C. Works ..	4,790	790	
5 40	Do.	Do. ..	9,580	1,010	
7 75	Do.	Do. ..	8,910	1,090	
	Outlet sluice	Do. ...	5,140	5,140	
	Drain..	L. Earthworks ..	2,05,000	83,520	
			2,48,730	1,01,580	1,01,580
	Chinnakommeleru drain	B. Land	3,760	2,500	
	Bridge	C. Works ..	2,570	815	
	Do.	Do. ..	4,030	940	
	Drain	L. Earthworks ..	21,815	21,223	
	39		32,175	23,478	23,478
	Total, Peddakommeleru and affluent ..	....	2,80,905	1,25,058	1,25,058
	Peddalanka drain	B. Land	15,200	12,000	
	Drain	L. Earthworks ..	4,15,960	2,21,260	
			4,31,160	2,33,260	2,33,260
	Singaraipalem drain	B. Land	2,475	2,000	
.. 71	Road dam	C. Works ..	370	500	
0 4	Bridge	Do. ..	4,400	1,000	
4 33	Do.	Do. ..	6,570	1,200	
7	Drain	L. Earthworks ..	30,480	12,400	
			44,295	17,100	17,100
	Utukur drain	B. Land	1,675	1,700	
0 70	Drain	L. Earthworks ..	8,700	6,220	
			10,375	7,920	7,920
	Kondangi drain	B. Land	1,520	1,250	
2 30		L. Earthworks ..	9,235	4,930	
			10,755	6,180	6,180
	Mattagunta drain	B. Land	1,800	1,600	
5 20	Drain (L.B.)	L. Earthworks ..	13,180	6,890	
			14,980	8,490	8,490

Position.	Particulars.	Sub-head	MAIN-HEAD. Railways and Protective Works. Estimated.	MAIN-HEAD. Railways and Protective Works. Expended.	Total of Detail.
ms. chs. 5 20	Pedda Tumidi drain Drain (R.B.)	B. Land .. L. Earthworks			
6 30	Amudalapalli drain Bridge, Argole road Drain	B. Land C. Works L. Earthworks			
	Total of Peddalanka drain and affluents ..				
	Totals of drains, fourth sub-section	....			
	Establishment at 25 per cent	....			
	Do. survey	....			
	Tools and Plant 8 per cent.	....			
		....			

84. PULLAVA DRAIN.—The length is 11 miles 15 chains. It will start from the Polrazkodu canal near Vinjarampadu. The level of the bed of the drain at the head is shown as 1·07 and as 2·5 at the tail end, so that the total fall over the line is 5·47 feet. Of this however 3·74 feet are allotted to the first mile, and the bed and surface of it thence to the end are only 0·17 foot a mile. This arrangement has entailed a much heavier estimate than is at all necessary. The upper end of the drain will it would seem receive only canal surplus, and this can be carried, partly in a narrow drain where the earth for the banks will be taken, and partly above ground. The fall available should be tolerably equally distributed and may be taken as 6 inches a mile throughout, a much more effective fall than the 2 inches shown in the estimate. At the lower end of the drain where the discharge is expected to be 612 cubic feet a second, the bottom width will be 70 feet instead of 101 feet, and if the slopes of the spoil banks be placed 100 feet apart, there will be plenty of space available, and the drain here may be cut to a width of 30 feet in the first instance. The most important work will be the cutting through the ridges in the 8th, 10th and 11th miles. A road dam instead of a bridge at 2½ miles will meet the requirements of the traffic.

(1.) *Vedurava Drain.*—As this is to occupy swamp land entirely, it is not clear why any compensation should be provided for. The drain starts at ground level and a culvert at the head cannot be a necessity.

(2.) *Estimates.*—There are two estimates for the Pullava main drain, one for Rupees 30,220 and the other 66,760. The smaller estimate refers to the more economical arrangement suggested by Lieutenant Campbell, and provides for a cut 20 feet wide only except at the lower end. The actual cost will, with the modification of slope, be less, as the lower end will be 70 feet instead of 101 feet wide. The sum of Rupees 40,000 entered in the revised estimate column is intended to provide for such enlargements as are likely to be required.

85. DAMIDI DRAIN.—The two estimates for this amount, for the complete arrangement, to ... ... Rupees 19,970
Modified do. ... ... „ 14,875
This drain is intended to carry off the drainage of only 2·41 square miles of country, and the estimated cost is out of all proportion to the area to be benefited. This is due to an erroneous impression as to the discharge. The bed fall is reasonably good, viz., 0·62 foot a mile, but it has been assumed that as the water will have little or no depth at the head and a depth of 4 feet at the tail the surface fall will be nearly 0·082 foot a mile. The bed of the drain will, however, be much below the surface of the country, and there is nothing to prevent the surface fall approximating to the bed fall as the discharge increases. Consequently at the lower end the full section would be about 100 square feet instead of the 246 square feet designed, and a fully efficient drain may be provided at a much less cost than the reduced estimate, for, even at the widest part, the bottom width will be only 17 feet. A drain 3 feet wide at bed level at the head and 17 feet at the tail can be cut for about 6,000 Rupees, and, to begin with, a width of 3 feet at the upper end with 1 foot added for each mile may be cut. The ultimate cost may be about 9,625 Rupees, the first outlay will be about 7,000 Rupees, and, even with this reduction, the cost is heavy for the 1,543 acres drained.

86. PEDDAKOMMELERU MAIN DRAIN.—In this case the estimates are Rs. 2,48,730 and Rupees 96,825 respectively, a very important difference, but the greater part of the drain would with the reduced estimate bear no relation whatever to the area drained. The ground and bed level at head is 3·91, the proposed bed level at the tail 3·50, and the length is 16 miles 35 chains. The bed fall available would therefore be 7·41 feet, or on the average 0·45 foot a mile. The required discharge at the lower end is 1,109 cubic feet a second, the intended depth of water 4 feet. In the longitudinal section a fall of only 0·17 foot a mile is shown, and this greatly adds to the dimensions of the drain and to the amount of the estimate. Bearing in mind that the swamp is on a lower level than the surrounding country, and that the ground level shown on the longitudinal section is therefore one above which flood water may rise occasionally and temporarily without inconvenience, the proper arrangement will be to distribute the fall equally and to make the spoil banks about 6 feet above bed level as a minimum. Then if these banks be placed at a suitable distance apart, and if where the cutting is shallow it be confined to the width necessary for the formation of the banks, a drain will be obtained which if not perfect will probably do all that is necessary and this at a comparatively small expense. The revised levels of this main drain will be about as follow, and it will be assumed that the water level at the infall of the Chinna Kommeleru will govern that of the drain above which may perhaps rise there above, but not more than will be provided for by the margin allowed in the embankments.

	LEVELS.					Width of cut.	EARTHWORK.		Width between Banks.	Remarks.
	Bed.		Ground.	Water.	Bank.					
	Normal.	Actual.					Square yards at Mile.	Cubic yards in Mile.		
1	2	3	4	5	6	7	8	9	10	11
Ms. chs.										
..	3·91	1·35	3 91	4 11	6 11					
1 0	3·46	1·15	2·93	4·11	6·11	145 (1)	4 11			
2 0	3·01	0·95	0·63	4 11	6·11	25	7 52	10,[illegible]	25	
3 0	2·56	0·75	1·06	4·11	6·11	..	16·53	29·[illegible]	30	[illegible]
4 0	2·11	0·55	1·05	4·11	6·11	40	15 52	24·[illegible]	40	[illegible]
5 0	1·66	0·35	1·08	4·11	6·11	50	15 89	27,[illegible]	50	[illegible]
6 0	1·21	0·15	1·27	4·11	6·11	63	15·72	27·[illegible]	60	[illegible]
7 0	0·76	—0 05	1·67	4·11	6·11	70	14 72	26,[illegible]	70	[illegible]
8 0	0·31	—0·25	1·22	4·11	6 11	75	15 77	26,[illegible]	80	[illegible]
8 35	0·11	—0·34	1·16	4 11	6·11	80	14 9[illegible]	27,[illegible]	85	[illegible]
9 0	—0·14	0·14	1·37	3·86	..	92	15·29	11,65[illegible]	90	[illegible]
10 0	—0·59	0·59	1·68	3 66	..	150	25 09			
11 0	—1·04	1·04	0·63	3·21	..	155	25 09	38,245	95	
12 0	—1·49	1·49	0 88	2 86	..	160	40 56	58,[illegible]	160	
13 0	—1·94	1·94	0·60	2 31	..	165	33 62	62,462	..	
14 0	—2·39	2·39	0·81	1 86	..	170	44·77	66,[illegible]	..	
15 0	—2 84	2·84	0·60	1·41	..	175	53 25	86,[illegible]	..	
16 0	—3·29	3·29	1·46	0 96	..	180	57 69	97,[illegible]	..	
16 35	—3·49	3·49	2 06	0·51	..	185	61·92	1·5,[illegible]	..	
						185	87 87	131,[illegible]	..	
						135	114·98	77,[illegible]	..	

N.B.—The width of cut in column 7 is down to actual bed level in column 3.

The pits in column 11 are intended to be cut below actual bed level within the drain.

The outside pits in column 11 are intended to be cut outside the drain banks.

The earthworks above the Chinna Kommeleru junction will then be—

		Rs.
Cubic yards,	207,545 at 1 Anna	12,972
And thence to end,	711,062 „ 1½ „	66,662
Sundries	... ...	3,[illegible]
		83,[illegible]

The above, though taken only from a few depths, will be a sufficiently near approximation, as the ground is tolerably even. The amount is [illegible],000 Rupees or so than Lieutenant Campbell's reduced estimate, but it provides for ultimate requirements, and it may be found that a smaller drain will do.

Practically the hydraulic mean and the actual depths may be taken to be equal at the lower end of this main drain, and the velocity will be about 1¼ feet a second. Consequently the area of drain at the tail end will be 710 feet, the mean width 178 feet, and the bottom width 178 feet instead of 205 feet as shown on the sketch.

The Chinna Kommeleru affluent enters at 8·35 chains, and the discharge here is required is 925 cubic feet a second. The bottom width will be 146 feet against the 216 feet of the section.

The discharge immediately above 8 miles 35 chains appears to be 375 cubic feet a second; the velocity may be taken at 1¼ feet a second, and the area of water-way required 300 square feet, 67 feet would then be the bottom width of the drain instead of 210 feet, but to find soil for the banks a greater width than 67 feet has been allowed. The drain may be cut at first to about half the full dimensions in the lower 8 miles. In the upper part the excavation is only just enough for the banks.

Chinna Kommeleru ...	925	
	550	
	375	

(1.) *Chinna Kommeleru.*—With revised bed fall for the main drain the level of the bed of the latter at the junction with this affluent will be 0·11 instead of 2·16. The level of the bed at the head is shown as 7·08 and the length is 9 miles 68 chains. Consequently the fall available is 6·97 feet or 0·708 foot a mile. The upper part of this drain appears to be what has hitherto been known as the Lingala drain which has been partly carried out. In the upper miles where the drain runs alongside the Polrazkodu canal, it is not an advantage to have berms and banks on both sides. Lastly the water may be allowed to rise in the upper miles until it reaches the full depth of 4 feet intended at the lower end if the banks be made 6 feet above bed level. The arrangements of this drain will then be approximately as follow:—

	LEVELS.				EARTHWORK.		Width between Banks.	Remarks.
	Bed.	Ground.	Water.	Bank.	Square yards at Mile.	Cubic yards in Mile.		
Ms. chs.								
..	7·08	7·08	11·08	13·08	10·66	17,829	..	Right bank only.
1 0	6·38	9·20	10·38	12·38	9·60	13,868	..	Bottom width, 25 feet.
2 0	5·67	7·31	9·67	11·67	6·16	26,787	..	Do., 30 „
3 0	4·96	9 84	8·96	10·96	24·27	38,508	..	Do., 35 „
4 0	4·25	7 95	8·25	10·25	19·49	41,541	..	Do., 40 „
5 0	3·55	9·16	7·55	9·55	35·67	52,800	..	Do., 46 „
6 0	2·83	6·83	6·83	8·83	24·34	44,458	60	Do., 52 „
7 0	2·13	1 39	6·13	8·13	26·18	38,878	60	Do., 58 „
								Double Bank.
8 0	1 42	1·06	5·42	7·42	13·00	29,216	60	Do. 61 „
9 0	0·73	0·87	4·72	6·72	15·20	19,508	65	Do. 64 „
9 0	0·11	1·16	4·11	6·11	10·87		..	Bottom width, 67 „
						323,393		

And the cost of earthworks, Rupees 21,223, which is but little less than Lieutenant Campbell's estimate. At first the cutting may be confined to half the bed width noted wherever this width will provide enough soil for the embankments.

(2.) *Masonry Works.*—The estimates provide for five bridges, three for the main and two for the affluent.. It has first to be noticed that some of these bridges are for

proposed roads, and their cost would therefore appear not to be chargeable to these estimates but to the roads. However the incidence of charge would be determined, at the time when they may be undertaken, under the rules. These drains will, except for a few days at a time, have very little water in them, and [illegible] dams will, it is considered, meet the requirements of the traffic.

87. PEDDALUNKA MAIN DRAIN AND SINGARAIPALEM DRAIN.—What is really in the estimate the Singaraipalem affluent is really the upper part of the main drain and determines the bed levels. They must therefore be considered together.

		Ms.	Chs.	Ms.	Chs.
The length of the Singaraipalem drain is	... ...	9	33	...	
Do. do. Peddalunka do.	... ...	15	0	...	
The level of the head of the affluent is that of the ground, or	... ...				
Do. of tail of	... ...	3	60		
do.	... ...	2	55	0·18	
		4	50	1	62

The level of tail of Peddalunka drain ... ... 2·11

The fall therefore is not equally distributed. The discharges at the several points are as follow:—For the affluent no discharges in the several miles have been noted. The cross sections show that there is an old drain for a little more than 5½ miles.

			Discharge per second.
9·33			
10·23	Utukur drain joins		8·05 C. ft.
11·63	Kondangi do.	... ...	1174
14·53	Mattagunta and Petta Tinnidi drains join	... ...	1445
15·63	Amudalapalli	... ...	1519
19·33	Outfall. do	... ...	1597

It will be desirable to reduce the fall of the upper part of the drain and increase that of the lower part. This will reduce depth of cutting, decrease the width of cutting in the lower half, and make a material difference in the cost. If the upper part of the drain be likely to be found on a somewhat too high level, the cheap remedy will be the cutting of a cunette, say of 6 feet bottom width and about half a yard deep, to carry off the last of the drainage, and such a cut and of any necessary width will be the best way also of providing soil for the banks where the cutting is normal width and bed level may prove insufficient.

The average fall available for the 19 miles 33 chains is 0·117, and there appears to be nothing to prevent its adoption throughout. The following modifications will result, and it will be assumed—

1*st*,—that water level at the head will not exceed that at 9 miles 33 chains by more than about a foot, and that the bank for this part of the drain which will have a margin of 2 feet at the lower end may be horizontal;

2*nd*,—that the velocity at, and immediately above, 9 miles 33 chains will be about 1·35 feet a second;

3*rd*,—that the velocity below 9·33 will be about 1·15 feet a second;

4*th*,—that the width of the drain in the upper 9 miles should increase tolerably regularly from the head to that point.

Position.	BED LEVELS. On Section.	BED LEVELS. Revised. Normal.	BED LEVELS. Revised. Actual.	Ground Levels.	Water levels.	Bank Levels.	Square yards at Miles.	Cubic yards in Miles.	Mean width of Drain.	Quantities and Rates.		Remarks.
Ms. Chs. 0 0	3·60	3·60	2·10	3·60	4·68	5·68	3·77		15			The actual levels of column 4 will be those of the cunette.
								7,524				
1 0	2·97	3·19	1·85	3·25	4·57		4·78		25			
								7,480				
2 0	2·23	2·77	1·60	3·62	4·46		3 72		40			
								9,724				
3 0	1·55	2·36	1·35	3·46	4·35		7·33		60			
								13,165				
4 0	0·86	1·93	1·10	2·58	4·24		7·63		75			
								18,242				
5 0	0·17	1·52	·085	2·83	4·13		13 10		90			
								22,502		78,637 at 1 Anna.	4,915	
6 0	—0·52	1·10	0·60	1·29	4·02		12·47		105			
								23,558				
7 0	—1·21	0·68	0·35	0·92	3·91		14·30		120			
								25,942				
8 0	—1·89	0·27	0·10	0·75	3·80		15·18		140			
								26,858				
9 0	—2·57	—0·15	—0·15	0·72	3·69		15·34		160			
								12,055		88,413 at 1½ Annas.	6,907	
9 33	—2·88	—0·32	..	0·26	3·63	5·68	17·87		166	Sundries.	578	
								31,555				7,485
10 23	—2·98	—0·68	..	0·36	3·32	5·32	23·11		200			
								95,040				12,400
11 63	—3·23	—1·31	..	0·15	2·69	4·69	45·89		250			
								123,609				
13 0	—3·44	—1·82	..	1·07	2·18	4·18	66·95		250			
								226,442		476,637 at 1½ Annas.	44,685	
14 53	—3·71	—2·51	..	—0·04	1·49	3·49	87·82		320			
								210,118				
15 63	—3·89	—2·98	..	0·34	1·02	3·02	125·42		340			
								288,606				
17 0	—4·10	—3·49	..	0·38	0·51	2·51	146·20		340			
								281,283				
18 0	—4·26	—3·90	..	0·56	0·10	2·10	173·44		350			
								501,476		12,81,483 at 2 Annas.	1,60,185	
19 33	—4·50	—4·50	..	1·25	—0·50	1·50	230·00		360			
										Sundries ..	2,04,870 16,390	
											2,21,260	

By these modifications the cost of the main drain will be, if it should require to be carried out to the full dimensions, Rupees 2,50,360 instead of Rupees 4,75,455. It should be remembered that as swamp land is not valuable and as 1 yard of lift is equal to 10 yards of lead, the banks should not be made too high. As this drain will have an open outfall into the Uputeru, the banks in the lower part must be as high as the river embankment as a minimum. The top widths of all banks of drains are calculated for a top width of 4 feet and 2 to 1 slopes.

(1.) *Masonry Works.*—Road dams at 5 Rupees the foot run have been substituted for bridges.

(2.) *Uttukur Drain.*—The level of this drain at its head is to be 2·11, and by the revised arrangements the bed at tail will be ... ... 0·68

Fall ... 2·79

Its length will be 4 miles 5 chains. Fall per mile 0·687.

The water level may be assumed to be 1 foot higher at the head than at the lower end when the main drain is full or at 4·32.

The discharge required is at the lower end cubic feet a second 325.

The velocity at this end may be taken to be 1·45 feet a second, and the mean width must be 103 feet—

Position.	BED LEVELS. On Section.	BED LEVELS. Revised. Normal.	BED LEVELS. Revised. Actual.	Ground Levels.	Water Levels.	Bank Levels.	Square yards at Mile.	Cubic yards in Mile.	Mean width of Drain.	Quantities and Rates.	
MS. CHS.											
..	2·11	2·11	0·02	2 11	4 32	5 32	7 42				
1 0	0 55	1·42	—0 15	2 52	4 67		12·25	12,139	33		
2 0	—0 40	0·74	—0·32	0·26	3 92		12 81	12 853	65		
3 0	7·65	0 04	—0 43	0·21	3 57		12 15	12 015	65		
4 5	2·98	—0·68	—0 68	0·32	3 32	5 32	5 54	5 [illegible]	33		

(3.) *Kondangi Drain.*—The level of this drain at its head is to be ... 1·34
Do. do. tail ... 1·31

Fall ... 3·03

Its length will be 3 miles 55 chains. Fall per mile 0·72 foot. The water level may be assumed to be 0·67 foot higher at the head than at the junction with the main drain when the latter is full or at 3·36. The discharge required is at the lower end 572 cubic feet a second. The velocity may be taken at the lower end as 1·45 feet a second, and the mean width then will be 93 feet.

Position.	BED LEVELS. On Section.	BED LEVELS. Revised. Normal.	BED LEVELS. Revised. Actual.	Ground Levels.	Water Levels.	Bank Levels.	Square yards at Mile.	Cubic yards in Mile.	Mean width of Drain.	Quantities and Rates.	
MS. CHS.											
..	1·34	1·24	—1·31	1 24	2 35	4 69	7 37				
1 0	0·10	0·62		0 54	3 15		12 24	12,002	77		
2 0	—1·14	—0·10		0 14	3 55		12 25	12,013	66		
3 0	—2·38	0 52		0 42	2 82		11 25	11,041	55		
3 35	—3 23	—1·31	—1·31	0 45	2 69	4 69	11 78	11,554	66		
								16,714	44		
									33		

(4.) *Mattagunta Drain.*—The level of this drain at its head is to be ... 1·18
Do. do. tail do. ... 2·31

Fall ... 3·49

The length will be 5 miles 20 chains. Fall per mile ... ...
The discharge required at the end is cubic feet a second ... ...

The velocity will be assumed to be 1·45 feet a second, and the mean width at tail will be 70 feet.

Position.	BED LEVELS. On Sections.	BED LEVELS. Revised. Normal.	BED LEVELS. Revised. Actual.	Ground Levels.	Water Levels.	Bank Levels.	Square yards at Mile.	Cubic yards in Mile.	Mean width of Drain.	Quantities and Rates.	
MS. CHS.											
..	1·18	1·18	—0·82	1·18	2·80	3·80	5·38	12,214	24		
1 0	0·25	0·48	—1·14	1·11	2·55	3·55	8·60	16,790	30		
2 0	—0·68	—0·22	—1·46	1·26	2·40	3·49	10·58	17,565	35		
3 0	—1·61	—0·93	—1·78	0·33	2·15		9·38	20,768	40		
4 0	—2·54	—1·63	—2·11	0·45	1·90		14·22	27,949	50		
5 0	—3·47	—2·33	—2·43	0·20	1·65		17·53	8,083	60	122,455 at 1 A.	6,461
6 20	—3·71	—2·51	—2·51	—0·04	1·49	3·49	19·21		70	Sundries	329
											6,890

(5.) *Pedda Tumidi Drain.*—The level of the drain at the head is to be ... 1·18
Do. do. tail do. ... 2·51

Fall ... 3·69

35

The length will be 5 miles 60 chains. Fall per mile ... ... 0·64
The discharge required at lower end is cubic feet a second 488
The velocity will be assumed to be 1·40 feet a second, and the mean width of the drain will be 87 feet.

Position.	BED LEVELS. On Sections.	BED LEVELS. Revised. Normal.	BED LEVELS. Revised. Actual.	Ground Levels.	Water Levels.	Bank Levels.	Square yards at Mile.	Cubic yards in Mile.	Mean width of Drain.	Quantities and Rates.	
MS. CHS.											
..	1·18	1·18	—0·82	1·18	2·93	3·93	5·81	12,584	26		
1 0	0·33	—0·54	—1·11	0·20	2·68	3·68	8·48	18,392	30		
2 0	—0·52	—0·10	—1·40	—0·89	2·43	3·49	12·42	20,997	35		
3 0	—1·37	—0·74	—1·71	—0·68	2·18		11·44	21,261	50		
4 0	—2·22	—1·38	—2·00	—0·95	1·93		12·71	27,931	65	129,479 at 1 Anna.	8,093
5 0	—3·07	2·02	—2·29	—0·15	1·68		19·02	28,314	80	Sundries.	447
5 60	—3·71	—2·51	—2·51	—0·04	1·49	3·49	23·83		87		8,540

(6.) *Amudalapalli Drain.*—The bed level at the head is shown on the section at ... ... 0·00
The level at tail is to be ... ... 2·98

Fall ... 2·98

The length is 5 miles 45 chains. Fall per mile available ... ... 0·536
The discharge required at end is cubic feet a second 489

The velocity has been assumed to be 1·[illegible] feet a second and the width of drain will be 87 feet. The water surface at the upper end of the drain will be taken to be 1·33 feet above that in the main drain.

Position.	BED LEVELS.											
	On Ref. Pegs.	Surface.		Ground Levels.	Water Surface Levels.	Depth of Water.	Cubic Feet per Second.	Velocity in Feet per Second.	Width of Drain.	Cubic Feet per Second per Foot of Width.	Cubic Feet per Second per Square Foot of Section.	Remarks.
		Normal.	Actual.									
Ms. Chs.												
	0·33	0·00										
1 0	−0·79			4·[illegible]	3·[illegible]	3·[illegible]	[illegible]			4	2[illegible]	
2 0	−1·49	−0·[illegible]	−0·[illegible]	6·[illegible]	5·[illegible]	5·[illegible]	[illegible]	[illegible]		1[illegible]		
3 0	−2·19	−1·[illegible]	−1·[illegible]	9·[illegible]	4·[illegible]	3·[illegible]	[illegible]	[illegible]		8[illegible]		
4 0	−2·89	−2·[illegible]	−1·[illegible]	5·[illegible]	2·[illegible]		[illegible]	[illegible]		1[illegible]		
5 0	−3·59	−2·[illegible]	−1·[illegible]	6·[illegible]	1·[illegible]		[illegible]	[illegible]		4[illegible]		
5 45	3·47	−2·[illegible]	−1·[illegible]	3·[illegible]	1·[illegible]		[illegible]	[illegible]		2[illegible]		
				6·[illegible]	3·[illegible]	3·[illegible]	[illegible]			4[illegible]		

53. Total cost of Drainage [illegible] as thus arranged will be Rupees [illegible], the area included being [illegible] which 43,069 acres are expected to be irrigated. It is clear that the whole [illegible] whatever that may be of drainage [illegible] easy to say what [illegible] of the drain would [illegible] account. In the case of the [illegible] disposal of [illegible] it is [illegible] to irrigate [illegible] to obtain by [illegible] Agriculturist.

54. Present [illegible] [illegible] and the [illegible]

[illegible]

[illegible]

[illegible]

(2.) (23.) *Items of Class VI.*—Capitalization of abatement of land revenue. Lieutenant Campbell (paragraph 43) makes the loss of revenue on lands taken up Rupees 3,197, but by the modifications recommended in this note the area should be considerably diminished and may be taken to be—

		Rs.
250	Acres wet, at 6 Rupees	1,500
500	Do. dry, at 2 „	1,000
	Annual assessment...	2,500
	Capitalized ...	62,500

And as the rates of assessment are much higher than those deducible from the registers furnished by the Board of Revenue, and than those adopted in calculating returns from proposed outlay, it is considered that the capitalized abatement of land revenue will be very fully provided for if assumed to be Rupees 50,000.

e.g. Proceedings, Madras Government, 7th October 1874, No. 2,844.

(3.) (24.) *Exchange.*—This item will affect, if at all, only Tools and Plant, and the provision under this main-head will suffice to cover exchange losses on the English materials which may be required.

(4.) (25.) *Leave and Pension Allowances.*—These have been taken as one-fourth the cost of establishment other than survey.

(5.) *Class VII, Simple Interest.*—There will be no interest on the outlay on Irrigation works to be charged to Capital, as Revenue will be secured directly the improvements are undertaken. It will however be necessary to allow for interest on drainage works expenditure, though it is considered that here also improvements will be rapidly followed by additional revenue. The drainage works will take some ten years to make fairly complete. About half the work will be done in five years, and by that time the ultimate requirements may probably be determinable.

90. Estimates for 3rd and 5th Sub-sections.—It has not been practicable to review at the present time the estimates which have been submitted* by the Superintending Engineer for the 5th sub-section. Their amount will be about as follows, subject to such modifications as may be found necessary :—

* No. 168, 29th March 1875.

		Rs.	Rs.	Rs.
Works.—Irrigation		1,73,550		
Navigation		1,29,680		
Drainage		3,42,060		
			6,45,290	
Establishment*			1,65,010	
Tools and Plant			52,000	
				8,62,300
Other charges				1,72,600
			Total ...	10,34,900

The net increase of revenue is expected to be about 90,000 Rupees or per cent. 8·70.

* Added to Superintending Engineer's estimate.

The 3rd sub-section estimates have also to be reviewed as soon as time will allow. The report of Lieutenant Campbell thereon (last paragraph) shows that the requirements are—

Works.—Navigation	Rs. 10,970	Rs.	Rs.
Irrigation	2,65,215		
Drainage	6,22,980		
to which would have to be added		8,99,175	
Establishment		2,30,823	
Tools and Plant		72,000	
And other charges would be about			12,02,000
		... ...	2,48,000
		Total ...	14,50,000

Probably important modifications, especially of the drainage estimates, will be found desirable.

Superintending Engineer's No. 31, paragraph 3.

The area of the sub-section is ... ... 277 square miles.
" expected area of irrigation ... ... 63,000 acres.
" present area of do. ... ... 49,377 do.
" additional do. ... ... 13,623 do.

It is not likely that an outlay of more than 10 lakhs, chargeable to the Delta System, on this tract of country will be requisite or will be recommended for sanction. At the present moment, however, no information of value on this point can be given. The Superintending Engineer's letter shows that there is much need of the improvements contemplated, and the radical defects of the Ryves' branch channel are specially noticeable.

91. Condensed General Abstract.—The subjoined abstract will show, for the estimates now submitted for the consideration of Government, the general scope of the proposals. In this abstract the totals of the estimates as revised have been entered, and the percentages consequently are, with the addition of the entire cost of drainage and protective works, less considerable than is likely to be the case.

Proceedings of the Madras Government, Public Works Department,
22nd December 1876. *No.* 3,528-*A*.

Estimates.

Nos. of Sub-sections.	Canals.	Class I, Works.	Class II, Establishment.	Class III, Tools and Plant.	Class VI.	Class VII, Simple Interest.	Total.	Area commanded.	Present Irrigation.	Additional Irrigation.	Total Irrigation.	Irrigation per Square mile commanded.	Gross Revenue on Area in Column 11.	Additional Working Expenses.	Net Revenue on Total Column 8.	Percentage on Column 8.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Acres.	Acres.	Acres.	Acres.	Acres.	Rs.	Rs.	Rs.	
1	Dark Canal—															
	Main Canal and Branches	8,05,445	2,04,365	64,400	..	1,85,000	19,95,737	1,58,771	..	60,000	60,000	242	1,88,000	63,795	1,24,205	6·25
	Distributaries	1,86,217	61,553	14,900	..	..	2,97,330	2,56,000	31,174	68,326	99,500	324	2,04,978	42,704	1,62,274	16·21
	Drainage and Protective works ..	1,45,960	38,490	11,680	..	..	3,10,060	..	6,638	21,162	28,000	301	63,486	13,226	50,260	8·16
	River embankments ..	50,000	12,500	4,000	..	..	3,05,650	..	..	..	..	..	..	..	..	
	Total ..	11,87,622	3,06,908	94,980	2,14,227	1,85,000	29,08,777	..	37,812	1,49,488	1,87,300	867	3,76,464	55,930	3,20,534	10·99
2	Mannlipatam Canal—															
	Main Canal and Branches	2,13,520	53,380	17,080	13,350	25,000	5,60,610	89,600	18,192	12,808	31,000	221	38,000	3,550	34,450	13·23
	Distributaries, west side channel	1,94,786	51,694	16,580	23,000	25,000	76,390	..	..	..	..	..	..	..	..	..
	Drainage and protective works	2,10,260	55,566	16,825	23,000	25,000	6,27,000	..	..	..	..	..	..	..	..	..
	Total ..	4,05,046	1,07,259	32,405	46,000	50,000	9,19,620	1,28,640	11,995	34,005	46,000	229	1,02,015	25,505	76,510	12·21
3	Ellore Canal—															
	Main Canal and Branches	1,37,550	47,135	14,767	14,000	53,000	15,46,620	1,28,640	11,995	34,005	46,000	229	1,27,616	30,516	97,000	6·27
	Distributaries	46,915	10,195	2,940	3,890	8,000	2,42,500	..	..	..	..	..	..	..	..	..
	Drainage and protective works	36,795	10,195	2,940	3,890	8,000	2,42,500	..	..	..	..	..	..	..	..	..
	Total ..	2,21,270	67,320	17,697	17,890	61,000	1,81,500	..	..	..	..	..	..	..	..	..
4	Polrazkotu Canal—															
	Main Canal and Branches	1,41,400	36,060	11,310	1,00,000	53,000	5,60,610	89,600	18,192	12,808	31,000	221	38,000	3,550	34,450	13·23
	Distributaries	1,53,012	39,018	12,240		8,000	76,390	..	..	..	..	..	..	..	..	..
	Drainage and protective works	3,655	915	..		61,000	6,27,000	..	..	..	..	..	..	..	..	..
		2,98,067	75,993	23,550	1,00,000	1,81,500	9,19,620	1,28,640	11,995	34,005	46,000	229	1,27,616	30,516	97,000	6·27
	Lower Pulleru Channel ..	48,660	12,665	3,895	3,170	2,42,500	15,46,620	..	..	..	..	..	..	..	..	..
		3,46,727	88,658	27,445	1,03,170	4,24,000	24,66,240	1,28,640	11,995	34,005	46,000	229	1,27,616	30,516	97,000	6·27
	Drainage and protective works	4,89,643	1,27,417	39,200	81,860	1,85,030	24,66,240	..	..	..	..	..	..	..	..	..
		8,36,370	2,16,075	66,645	1,85,030	6,09,030	49,32,480	..	..	..	..	..	..	..	..	..

The preparation of a statement showing the value of each canal as a remunerative work would be a somewhat difficult matter as it would involve a distribution of past expenditure, the proper incidence of which among the Delta canals is not readily ascertainable. The most reliable estimate of the probable results of completing the Delta works is deducible from the effects of past expenditure and from the present state of the present incomplete works, what that revenue is, and what its progress has been, is to be seen in the appended abstract of financial results, dated 11th June 1875, and it is noticeable that at the present

Proceedings, Madras Government, No. 1,923, dated 28th July 1876.

up to the latest year, has remained good, 12 to 15 per cent., although for that there has been a good deal of expenditure in the last seven or eight years on works which by themselves, and without the further works included in the estimates, can have but a very small influence on the extension of irrigation in the delta. There is no reason whatever to doubt the value of the irrigation canals and channels and of those being worth completing. As regards the drainage works, the best has been done that the data available would allow, to show what the requirements of the tract of country forming the delta are, and the probable cost of meeting them, and it is believed that if there has been error it is on the side of a too ample, rather than of a too limited, provision for the disposal of flood water from rainfall. The drains can and should be carried out tentatively in the first instance, on a comparatively small scale. This is necessary in order to secure immediate relief to the country. Afterwards enlargement can go forward as the circumstances may show to be necessary. The ultimate dimensions of these drains will be fixed from recorded rainfall and the corresponding discharges.

92. INCIDENCE OF COST OF DRAINAGE.—The Delta System can afford very well to bear a very full share of the cost of a fairly complete system of drainage, and an endeavour has been made to indicate in the case of each subsection of the delta what that share should be. It seems to be clear that to throw the whole cost of drainage works on the irrigation of the delta would not be just, and it is believed that to do so would virtually postpone for a long time to come improvements which it would be demonstration to show must be much required in a country, much of which is but little above mean sea level, and the soil of which, wherever low, is for the most part rich and well adapted to cultivation.

93. GENERAL REMARKS.—The completion of the Delta works will occupy a considerable many years. The scheme of operations so far as it has been submitted to Government

Proceedings, Madras Government, dated 19th December 1874, No. 3,572.

last in this respect, and in that as in portion of the estimates for the Western Delta, will be within comparatively close limits, the way in which the system of irrigation and navigable canals, of drainage tributaries and of drains, should be carried out, and the cost of these completions. Lieutenant McNeil Campbell has bestowed great labour upon the preparation of the several parts of the scheme, and the undertaking is of opinion that the results are highly creditable to him. It is hoped that his labours will meet with the full approval of Government, and that sanction will be accorded to the early commencement of those portions of the improvements which are most required, and which will lead to an immediate extension of irrigation and in case of necessity, leaving such other parts, *e.g.*, the Masulipatam canal, west side channel, the distributaries under the Bank canal, &c., to be taken up at a future time when such a demand

for water, as would warrant the expenditure on these works being incurred, may have arisen. There is so much immediately remunerative work to be done, or so much work as in the case of the Ellore canal improvements which is necessary to the security of existing canals, and to the development of the trade of the country, that all parts of the scheme of doubtful utility may well be left alone for the present. It will be seen that the Superintending Engineer, in the concluding paragraph of his letter, No. 31, of the 9th June 1876, states the cost of the whole of the improvements of the Eastern Section of the Delta as follows :—

Estimates submitted—*Works*	Rs.	47,12,667
Tools and Plant, 8 per cent.	,,	3,77,008
Loss of Assessment on lands taken up	,,	1,00,000
Repairs of works in progress	,,	1,00,000
	Rs.	52,89,675

The returns he calculates to be—

Acres 1,29,808. Water-tax at 4 Rupees an acre or 9·8 per cent. on the expenditure ... Rs. 5,19,232

This calculation, were the estimates as submitted by him to be accepted, would need some considerable modifications, and to begin with it would be necessary to add to the expenditure side of the account nearly 12 lakhs for establishment charges, and this would be necessary under the orders at present in force, even were the existing establishment of the delta equal to the carrying out of the extensive works contemplated, and this is certainly not the case. This alteration alone would reduce the anticipated returns to 8 per cent. It will be better, however, to take the general abstract above given,

Paragraph 91.

and the particulars of the third and fifth sub-sections noted in paragraph 90 as the basis for a rough calculation, as then the revised *works* estimates, so far as these have been reviewed, and the more complete particulars of other outlay requiring to be taken into account, will be seen. The general results will then be somewhat as follow :—

		Outlay.
Bank canal	Rs.	19,86,737
Masulipatam canal	,,	2,97,330
West side channel	,,	6,16,740
Ellore canal .. .. }	,,	3,15,510
Polrazkodu canal .. .. }	,,	15,70,390
Lower Pulleru channel	,,	10,00,000
Third sub-section	,,	10,34,900
Fifth do.		
	Total Rs.	68,21,607

And on this sum Rupees 5,19,232 would give a return of 7·61 per cent. It may, it is considered, safely be assumed that not more than about 60 lakhs will be spent and charged to the Delta System, and that the net returns will not be less than 8 per cent. The net revenue stated by Major Hasted may not in the form given be capable of being accepted, as it implies an average gross revenue of about 4¼ Rupees an acre; but if, as he mentions, the Revenue officers have informed him that Rupees 6 an acre will be obtainable from irrigated waste lands, that average may very well be reached, as it would require that 40,065 acres out of the total of 129,808 acres should pay the higher rate, or that a smaller number of acres should be so assessed, the balance being made up by reduction of remissions.

FORT ST. GEORGE, (Signed) JOHN MULLINS, Lt.-Col., R.E.,
6th November 1876. *Chief Engineer for Irrigation.*

To the Secretary to Government, Public Works Department.

KISTNA, EASTERN DELTA.

Note on Completion Estimates by the Chief Engineer for Irrigation.

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Do.	„ Seddalunka Main Drain and Singaraipalem drain	87	
Do.	„ masonry works		(1)
Do.	„ Utukur Drain		(2)
Do.	„ Kondangi Drain		(3)
Do.	„ Mettagunta „		(4)
Do.	„ Pedda Tumidi Drain		(5)
Do.	„ Amudalapalli „		(6)
Do.	„ Total cost of	88	
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No. 555.

ORDER THEREON, 22nd December 1876, No. 3,528.

IRRIGATION, No. 43-A.

THE Chief Engineer for Irrigation has in the foregoing Note laid before Government the general scheme for the completion of the works of the Kistna Eastern Delta, and has submitted, for sanction, estimates for a large part of the proposed arrangements.

2. This section of the delta lies on the left bank of the Kistna, and is bounded by the river on the one side, and by the Ellore canal, the Colair lake, the Upputeru and the sea on the other side.

The total area is ... ... 1,160 square miles.
" area at present irrigated is ... ... 137,723 " "
" area proposed to be irrigated is ... ... 22[illegible] "

For convenience of investigation it was found desirable to divide this tract of country into five sub-sections, and the estimates of all have been prepared; but it has not been found practicable to examine in detail more than those of three of the sub-sections, viz., the first, second and fourth in time for entry in the Budget of 1877-78.

The proportion of intended area of irrigation to total area varies from 183 acres to the square mile in the first sub-section to 255 acres to the square mile in the fifth sub-section.

3. Into the all-important question of water-supply the Note has entered at length, and the general conclusion arrived at is that, while the present temporary arrangements, for raising the crest of the anicut annually on the subsidence of the freshes, will suffice until a considerable extension of the irrigated area has been effected, it will within a few years be necessary either to place the masonry crest something less than 3 feet higher, or to provide shutters capable of being raised and lowered at pleasure. Before the time for this alteration arrives the data for determining the exact arrangements required will be ample, and there will be no difficulty in carrying them out, but the details will need to be very carefully considered. The Chief Engineer for Irrigation thinks that when the irrigation in the Eastern Delta has extended from 138,000 to 200,000 acres, and that in the Western Delta from 75,000 to 150,000 acres, the raising of the water level above the ancient for the better supply of the main canals will have to be provided for, and it will be desirable to be prepared at any time to carry out the necessary arrangements, which could be completed as far as would be requisite in one season. There appears to be no reason to doubt the feasibility of providing, with a raised water level, for the supply of the entire proposed area in all but very exceptional seasons. Such a season is now being experienced, and it may be noticed that, with the present very imperfect arrangements, the Superintending Engineer anticipates that from ⅓ths to ⅔ths of the area under irrigation will be adequately supplied.

4. The estimates include provision for the complete drainage of the country on a scale which has been designed to allow of all rainfall drainage being disposed of within a maximum period of six days. The data for deciding on the requisite capacity of drains for the relief of given areas are confessedly imperfect, and consequently it is proposed to cut them at first to from one-third to half of the designed dimensions,

and thus to ascertain experimentally what is necessary for the efficient drainage of each particular locality. Another important point which has to be determined is the proper incidence of the cost of drainage works. It has been shown that the quantity of surplus irrigation water to be disposed of is small compared with the discharge due to rainfall, and, on the other hand, the irrigated area interested in the improvement of the drainage is only about 36 per cent. of the gross area. It will therefore not be proper to charge to the Delta system the whole cost of the drainage works, but at the present moment the Government are not in a position to arrive at a conclusion as to the proper distribution of the charge. The subject has for some time past been engaging attention, and it is thought that the best plan will be —

1stly,—to consider these drainage estimates as an approximate indication of the amount which may ultimately have to be spent for the improvement of the agricultural condition of this tract of country;

2ndly,—to assume that about one-third of the amount of these estimates will require to be laid out concurrently with the extension of irrigation in order, first, to provide for the removal of the more prominent existing obstructions to effective drainage, and, secondly, to prevent all risk of deterioration of the condition of the country from the introduction by the canals of an increased supply of water;

3rdly,—to take sanction for this one-third of these estimates as a lump sum provision for drainage, all proposals for expenditure being subsequently submitted for the specific sanction of this Government, so that improvements which may be shown to be necessary may from time to time be approved for execution;

4thly,—to charge to the Delta system the cost of this partial drainage on the assumption that at least so much will be necessary either in the interests of the irrigated area, or to prevent increase of the inconvenience arising from defective drainage. By judicious arrangements it is anticipated that a good deal of subsidiary drainage will be secured without extra, or at a nominal, expense by forming catch-drains alongside distributaries when outside cutting is required to make up the channel banks to proper section. This arrangement has been provided for in laying out the distribution, and should be carefully borne in mind during the execution of the works.

5. The estimates of the first sub-section of the Eastern Delta contemplate the irrigation of altogether 88,000 acres as follows:—

	ACRES.
Under Bank Canal above Divi...	15,000
Do. in Divi	45,000
Do. the west side channel of the Masulipatam Canal	28,000

The Bank canal will be an entirely new work, and it will traverse zemindary lands until it crosses the Puligadda branch of the Kistna and enters Divi. The experience of the past having shown it to be improbable that for any large proportion of these zemindaries water will be demanded, it was intended that a supply should be provided for only 100 acres to the square mile, or 8,300 acres, but the project having been worked out before this decision was come to, a revision has not been made on this account. It is also to be noticed that the formula used for calculating

G.O., No. 434, of the 17th February 1876.

the discharge of the canal as designed is believed by the Chief Engineer to give a higher than the probable discharge, and that consequently there is not likely to be too much water; in other respects some material alterations have been made by the Chief Engineer for Irrigation, and, as submitted for sanction, the estimates stand as follow:—

Classes.	Main Canals and Branches.	Distributaries.	Drainage and Protective Works.	River Embankments.	Totals.
I.—Works	8,05,445	1,86,217	1,45,960	50,000	11,87,622
II.—Establishment	2,04,365	51,553	38,490	12,500	3,06,908
III.—Tools and Plant	64,400	14,900	11,680	4,000	94,980
	10,74,210	2,52,670	1,96,130	66,500	15,89,410

The Chief Engineer for Irrigation in paragraph 2[illegible] of his Note gives reasons for recommending that the work required, in excess of the spoil from the Bank canal, to complete the river flood bank should not be charged to the Delta system. That system has already been debited with the cost of the existing embankment which has proved on more than one occasion in recent years inadequate, and it may readily be admitted that the irrigation works are not the only works or property interested in the efficiency of these protective works. The Delta system may therefore be deemed to have already contributed its full share to their cost, and the estimate of 50,000 Rupees for further improvements will therefore be sanctioned under Ordinary Agricultural.

6. The estimates for the Bank canal and its subsidiary works will then stand as follows:—

		Rs.
Works—	Main Canals and Branches	8,05,445
	Distributaries	1,86,217
	Drainage and Protective Works, one-third of estimate	48,653
		10,40,315
Establishment		2,70,085
Tools and Plant		83,190
		13,93,590
To which may be added (paragraph 26 of Note)		
Huts	10,000	
Unforeseen outlay	20,000	
		30,000
Total direct charges ...		14,23,590

Note, paragraph 26.

The Chief Engineer for Irrigation has shown that the returns may be estimated in several ways, and that taking the least favorable the net revenue may be expected to amount to Rupees 1,18,605 or 8·32 per cent. on the direct charges. With indirect charges added Lieutenant-Colonel Mullins' figures indicate that the returns are likely to prove satisfactory even on the proposed outlay on this canal by itself, and his

conclusions are supported by the results of past expenditure on the delta works generally.

7. As regards details of the canal arrangements the Note on the estimates has entered so fully into the subject of modifications which should be attended to in carrying out the works, that important as are many of the matters referred to it is unnecessary to notice them in this order further than to direct the careful attention of the Superintending Engineer to them.

8. The Masulipatam canal will, by its west side channel, provide for the irrigation of that part of the first sub-section of the Eastern Delta lying to the east of the Kanakalamadugu drain. After due consideration the Chief Engineer for Irrigation has decided to supply the west side channel from the end* of the first reach of the Masulipatam canal rather than through the Bank canal which has its head at 3½ miles, and the estimates provide for this arrangement. The area commanded by the canal is 399·35 square miles or, say, 256,000 acres, of which 96·92 square miles or 62,029 acres are commanded by the west side channel.

*12 miles.

The area of irrigation in 1873-74 was 38,012 acres, of which the area of irrigation under the west side channel was 6,838.

The proposed ultimate areas are—

Canal	127,500
West side channel	28,000

The greater part of the irrigation supplied by the canal will be under the Pulleru, the particulars being as follow:—

—	Present.	Intended.	Increase.
Masulipatam canal	3,000	6,000	3,000
Pulleru	28,174	93,500	65,326
West side channel	6,838	28,000	21,162
Total ...	38,012	127,500	89,488

The improvements to the Masulipatam canal contemplated provide for its enlargement down to 3½ miles for the supply of the Bank canal, and thence to the end of the first reach for the supply (in part) of the Pulleru and of the west side channel. This reach terminates at the Kunkipad lock, and thence to the Tidal lock at the lower end it is proposed to arrange for still-water navigation, and it was intended not to carry any water for irrigation in this part, but Lieutenant-Colonel Mullins considers that while it is desirable to secure still-water at times, it is not necessary, at any rate for the present, to give up the use of the canal as an irrigation duct, and pending a demand for a greatly increased supply of water for the tract of country, all zemindary, commanded by the west side channel, there appears to be no good or sufficient reason for incurring any considerable expenditure on the introduction of the more complete arrangements which the side channel will ultimately, if necessary, secure.

The estimate for the Masulipatam canal amounts to Rupees 2,83,980 as follows:—

		Rs.	Rs.
Works	Earthworks	1,74,660	
	Navigation works	38,860	
			2,13,520
Establishment			53,080
Tools and Plant			17,080
		Total ...	2,83,980

Of the above Rupees 1,22,580 are for widening the first 3½ miles of the canal and Rupees 52,080 for widening the rest of the first reach down to 12¼ miles. A new lock at Nedumole, 36⅝ miles, is the principal item of the navigation works, and before this is undertaken it is intended to see whether by a much smaller expenditure the old lock cannot be made safe and efficient.

With regard to the direct returns to be anticipated from the above estimated outlay, the Chief Engineer for Irrigation shows that it is difficult to indicate what the results will be apart from those from the several canals supplied from this source, but in paragraph 34 (1) he notes the shares of distribution, and these are for *works*—

	Rs.
Bank canal	42,052
Masulipatam canal (and Pulleru)	96,715
Do. west side channel...	29,313

There will then remain Rupees 28,860 to be considered in connection with the navigation receipts which are obtained from licenses issued not for the navigation of particular canals, but of those of the delta generally.

9. The Masulipatam west side channel commands, with the exception of a few acres, zemindary lands only. The present area of irrigation is acres 6,888, and the proposed ultimate area 28,000 acres. It would be practicable with but a small outlay on distributaries to provide water for a much larger area than that at present watered, were there a demand for water. The side channel has been partly constructed on an estimate of Rupees 49,860 sanctioned in 1866, but this estimate was a very incomplete one, and the work done has varied considerably from that provided for. The proper treatment of the channel and its branches has been noticed by the Chief Engineer for Irrigation, and as the circumstances appear to support his opinion that for some time to come all the water needed may be conveyed by the Masulipatam canal and distributed through the side channel as it is, with only some minor improvements and minor distributaries, for which he thinks a sum of Rupees 30,000 will probably suffice, it will be desirable that the arrangements should be reconsidered especially with reference to the assumed advantages of the side channel system, and economy of maintenance supposed to attend it, and revised proposals submitted at a future time. This will not prevent such works as may from time to time be found necessary to meet demands for water being carried out, and for these estimates may

be separately submitted for sanction when necessary. The estimates, as in part revised by the Chief Engineer, are as follow:—

	Works.	Establishment.	Tools and Plant.	Total.
	Rs.	Rs.	Rs.	Rs.
Distributaries	1,94,786	51,694	15,580	2,62,060
Drainage and Protective Works	2,10,260	55,565	16,825	2,82,650

With regard to drainage works, the land being zemindary, Government could in no case be prepared to incur a larger outlay than would be necessary to secure the efficient cultivation of irrigated lands paying a water-rate, or for which a water-rate would be paid, and then also the financial bearing of the proposals would have to be very clearly demonstrated.

10. The second sub-section is connected with only one, the Ellore, canal, and of the estimates the Chief Engineer for Irrigation says they "provide for improvements which after much discussion as to the best way of removing the many defects of its original construction have been considered to be the best which at a reasonable cost can be devised." One great defect is the smallness of the bed and surface fall, the former being less than 1 foot in 37 miles. Again, the upper sill of the Ellore lock at 40 miles is 4·63 feet lower than the canal bed nearly 3 miles higher up. The other great defect is the inadequate means of passing drainage across the canal. The remedy of these defects has been duly provided for in the estimates.

The area of land commanded by the canal is 140 square miles, and the intended area of irrigation is 31,000 acres or 2,21½ acres to the square mile. The present area of irrigation is reported to be

	Acres.
in Kistna District	4,561
„ Godavery do.	13,631
Total...	18,192

leaving only 12,808 acres as additional area. In the Kistna District all the land irrigated is zemindary, and there is little Government land commanded. As most of the additional area is in the Kistna it is doubtful what increased demand for water will arise and when. The estimates as revised are, according to the alternative abstract, which adopts the apparently more reasonable classification.

	Works.	Establishment.	Tools and Plant.	Totals.
	Rs.	Rs.	Rs.	Rs.
Main Canals and Branches	1,37,560	34,390	11,000	1,82 950
Distributaries	46,915	12,735	3,750	63,400
Drainage and Protective Works	36,795	10,195	2,940	49,930
	2,21,270	57,320	17,690	2,96,280

and on the total of Rupees 2,96,280 a water-rate of 3 Rupees only on 12,808 acres would, after allowing for increased maintenance charges, yield a return 11 per of cent.

The improvements proposed however are shown, independently of the proposal of a direct return, to be necessary for rendering the canal fairly efficient to meet the requirements of its circumstances and of existing irrigation and navigation. Part of the expenditure will therefore be chargeable to the returns already derived from the Delta system, and it can hardly be doubted that in due course a sufficient return will result from the improvements.

The Note contains full information regarding the revision of details which have been made by the Chief Engineer for Irrigation.

11. The estimates of the fourth or Kykalur sub-section have been revised out of the regular order owing to much importance being attached to the early commencement of the improvements, first, to utilize the water-supply which will almost immediately be available from Ryves canal through the Pulleru, and secondly, to ameliorate the condition of the tract of country concerned in which the lands are generally unfit for dry cultivation, the water-supply is at present very inadequate and the drainage greatly in need of improvement. The people are represented to be most anxious for improved means of irrigation and communication which the canal will afford.

The area of the sub-section is 201 square miles, and the proposed extent of irrigation will be 229 acres to the square mile commanded. It is anticipated that all the land which is or can be rendered fit for irrigation and can be supplied will be taken up as fast as the canal and drainage improvements will admit.

The canals and channels of the sub-section will be—

	Present	Proposed	Difference
	Acres.	Acres.	
Polrazkodu	6,735	[illegible]	[illegible]
Chevurkodu	...	[illegible]	[illegible]
Lower Pulleru, Buntumalli canal	5,250	[illegible]	[illegible]
Total ...	11,985	[illegible]	[illegible]

Considerable modifications have been made by the Chief Engineer for Irrigation in the details of the arrangements proposed by Lieutenant McNeil Campbell, which will not, it is anticipated, affect the cost of the Polrazkodu canal materially, and consequently the amount of the original estimate for this canal under main heads has been retained. This canal with its distributaries and the embankment of the Uputeru is estimated to cost as follows:—

	Works	Establishment	Tools and Plant	Total
	Rs.	Rs.	Rs.	Rs.
Polrazkodu canal	[illegible]	[illegible]	[illegible]	[illegible]
Distributaries	[illegible]	[illegible]	[illegible]	[illegible]
Drainage and Protective Works	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

The Chevurkodu instead of having a separate head at the Pulleru is intended to be supplied from the Polrazkodu canal; the reasons for this alteration are stated in paragraph 76 of the Note, and the best position for the offtake should be further considered in connection with the remarks in paragraph 79 (1*b*).

12. Lieutenant Campbell proposed to make the Buntumalli canal a still-water navigation throughout, and to supply the lower Pulleru irrigation through the Tadicherlakodu. This arrangement has not been approved by the Chief Engineer for Irrigation, who points out that the first reach of 5 miles of the Buntumalli canal should be used to convey water for the lower Pulleru channel and that it is feasible and possibly may be desirable, to carry irrigation water in the canal for $2\frac{3}{8}$ miles of the second reach. The revision of the estimate provides for making the channel a distributary of the Buntumalli canal, and the cost will be as follows:—

Lower Pulleru Channel.—Works	Rs.	48,660
Establishment	,,	12,665
Tools and Plant	,,	3,895

The remarks in paragraph 80 (5), on the incidents of the cost of bridges for proposed roads, should be attended to at the proper time, and the rules duly carried out.

13. The estimates of the drains of the fourth sub-section amounted under Works to the very large sum of Rupees 9,47,895, and attention having been given by Lieutenant Campbell to the subject of the reduction of the cost of these works, he suggested a modified arrangement by which an arbitrary and fixed width was to be allowed to all the drains where these run through swamps. This plan having the demerit of not proportioning the capacity of the drains to the area drained, the Chief Engineer for Irrigation has gone into the subject in detail and has worked out arrangements under which the proportions between capacity and drainage area have been maintained, and the estimated cost reduced to Rupees 4,89,643. This too is rather an approximate estimate of possible ultimate requirements, and it will be observed (Note paragraph 82) that a very material alteration in the condition of this tract of country is anticipated from the opening out of only the tail ends of the drains through the ridge separating the swamps and low ground from the Uputeru; and thereafter, this great obstacle to all drainage having been removed, the requirements of the country will be readily ascertainable, and, as elsewhere, comparatively small drains will in the first instance be cut, the obstructions presented by ridges and high ground being first removed.

The drainage estimates as revised are as follow:—

	Rs.
Pullava main drain and affluents	60,240
Damidi drain	9,625
Peddakommeleru drain and affluents...	1,25,058
Peddalanka drain and affluents	2,94,720
Total, *Works* ...	4,89,643
Establishment	1,27,417
Tools and Plant	39,200
	6,56,260

The Chief Engineer for Irrigation (Note paragraph 88) considers that about five-eighths of the cost of the drainage may fairly be deemed chargeable to the Delta system, and for the purpose of obtaining a rough approximation of the probable results of the improvements contemplated this distribution will be accepted. The estimates for the sub-section will then be—

	Rs.
Polrazkodu Canal	
Lower Pulleru Channel	3,57,610
Drainage $\frac{5 \times 6,51,209}{8}$	65,220
	4,07,649
Total of Sub-section ...	8,30,479

The additional area of irrigation will be 34,005 acres, and an average water-rate of Rupees 3 will not be too much to assume.

	Rs.
The gross return will then be	1,02,015
Maintenance, 10 Annas an acre	21,253
Revenue collections, 9 per cent.	9,182
	30,435
Net Return ...	71,580

which will be equivalent to 8·23 per cent. on the outlay. This calculation takes no account of the dry assessment of lands reclaimed by the drainage works or of that of waste land the cultivation of which will be rendered feasible by the supply of water, and it gives therefore a view by no means favorable of the probable results of the improvements. In the first instance it will be best to take sanction for one-third of the whole amount of the drainage estimates, and all expenditure against this reduced amount will be chargeable to the Delta system. The way in which a commencement is to be made has been sufficiently indicated, and generally drains of one-fourth of the capacity which ultimately may be needed should in the first instance be provided throughout the sub-section.

The Government of India will therefore be asked to sanction the following estimates:—

	Works.	Establishment.	Tools and Plant.	Total.
	Rs.	Rs.	Rs.	Rs.
Polrazkodu Canal	2,08,607	25,975	23,550	3,57,610
Buntumalli Canal	45,660	12,675	3,885	65,220
Lower Pulleru Channel	1,63,215	11,805	13,050	2,17,620
Drainage				
Total ...	3,99,942	1,20,453	40,485	6,30,850

14. As already noticed the estimates for the third and fifth sub-sections have been received by the Chief Engineer for Irrigation, but have not yet been

reviewed. As submitted (Note paragraph 90) they would, including all charges, be as follows:—

	Rs.
Third Sub-section	14,50,000
Fifth do.	10,34,900

and it is thought that it is not likely that an outlay of more than 10 lakhs on the third sub-section, chargeable to the Delta system, will be found requisite.

15. In paragraph 91 of the Note is given a general abstract of the proposed outlay and of the charges other than direct, also of the irrigation and revenue particulars for all the canals for which estimates have been submitted. The results are generally satisfactory, and this too though a low rate has been assumed, and no credit has been taken for land assessment. It may be anticipated therefore that the actual results will be more favorable, and in support of this view the actual results of past expenditure may properly be brought forward. The history of the Kistna Delta Works is briefly this, as shown by the approximate financial statement up to the end of 1874-75. The works were commenced in 1852-53, the total capital outlay amounted to the above

Rupees 3 an acre.

Proceedings, Madras Government, No. 1,923, of the 28th July 1876.

date to	Rs. 44,93,902
the direct income had risen from nothing to, for that year	„ 8,90,598
the total income up to end of that year had been	„ 92,16,261
and the net revenue, do. do. ...	„ 68,66,215
also the difference between the net revenue and the charge for interest to	„ 42,19,553

If these figures be verified by the special investigations on which Mr. Wilson is now employed it would follow that nearly all the capital outlay of the past has been recouped. It would appear also that, but for this statement continuing to charge interest on Capital Outlay which had been refunded by revenue receipts in excess of interest, not only would all capital have been refunded, but there would have been a considerable balance to the credit of the works. It may be further noticed that the net increase* of revenue derived from the delta works will more than suffice to provide all the money required for their completion, and ultimately there will be a complete system of irrigation and navigation which will have cost the State nothing, and will secure an addition, after meeting all charges, of about 9 or 10 lakhs annually to the resources of the country. Such are the conclusions to which the figures point, and they are not likely in any case to be so modified as to make the delta works other than highly valuable.

	Rs.
Gross	8,90,598
Charges	1,94,905
	6,95,693

16. His Grace the Governor in Council desires to place on record his appreciation of the great care and ability with which these important papers have been submitted to the Government by the Chief Engineer for Irrigation, and he requests that Colonel Mullins will convey to Lieutenant McNeil Campbell the approval of the Govern-

ment of the manner in which he has performed the difficult and important work confided to him.

(True Extract.)

(Signed) JOHN MULLINS, Lieut.-Colonel, R.E.,
Secretary to Government.

No. 555. (DOCKET, No. 3,528-A, dated 22nd December 1876.)

COPY of the above forwarded to the Government of India.

(True Extract.)

Lieut.- Colonel, R.E.,
Secretary to Government.

Memorandum

A few words in explanation of the concluding part of the draft order on the Kosta Eastern Delta completion estimates may be desirable.

The Chief Engineer for Irrigation has been in communication with the Examiner of Accounts and has ascertained that interest is charged on all expenditure shown as capital outlay, while no interest is credited on surplus receipts.

The contention of the office is that if interest is charged against Irrigation Works upon all withdrawals from the Treasury it is necessary in order to the ascertainment of the true financial position of each work that either

1st. Such revenue receipts as exceed the interest charges on Capital Outlay should be taken in reduction of Capital account

or 2nd. that on such surplus receipts credit

Revenue shows interest on unfunded portion of Capital outlay

interest should be allowed.

The same result would follow in the case of each of the subsidiary projects. The approximate abstract of financial results of the Kistna Project, as it is hoped to be fairly correct, the results would appear to be up to end of 1875 [illegible]

Interest charges ... Rupees 42,14,553

Interest on surplus receipts during the year 1869-70 at 4½ per cent — Rs. 11,20,362

Rs. 53,39,915

Capital outlay — Rs. 44,93,902

Balance to credit of the system Rs. 8,46,013

and towards the cost of the Godavery Project, as well as paid off the Capital outlay and the interest charges, and there would be a balance of 84 lakhs of Rupees and nearly 8 lakhs of surplus annually remaining to credit of the system.

The future expenditure will probably not exceed 4½ lakhs yearly, and the balance to credit of the system

Ref. No. 1920 of 28th Aug 1875

will increase year by year, and when the works are finished the result will be even more favourable than as stated in the draft order.

Lyt. 12/12

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Ex 22 Dec/11 No. 3523

W. 294 - W.

Note by the Chief Engineer for Irrigation

Kistna - Eastern Delta.

Principal Canals.

The water supply for the Eastern Delta of the Kistna will be conveyed

1st By the main canal the length of which is 900 yards only

2ndly By the Ellore, Ryves and Maculipatam canals which have their heads at the lower end of the main canal

3rdly By the Bank Canal and the Pullern the former of which will have its head at 3½ miles from the head of the Maculipatam Canal on the right bank of the latter and the Pullern will be supplied, as at present, partly from the Maculipatam Canal in the 13th mile and partly by Ryves Canal.

The

2. The area of the Eastern Delta is 1160 square miles. The proposed and present areas of irrigation are as follow:- Area of Delta Proposed areas of

Area intended to be irrigated	acres 270,000
— — at present — do — — —	137,723
Difference	132,277

3. For convenience of investigation and estimating the Eastern Delta has been divided into 5 subsections, the leading particulars of which are Sub Sec

No. of Sub Sections	Sources of Supply.	Area in square miles	Area to be irrigated Acres.	Acreage for square mile.
1	Masulipatam Canal Bank	345	85,000	255
2	Ellore Canal	140	31,000	221
3	Ryves canal Pullem	277	69,000	250
4	Pullem	201	46,000	229
5	Pullem Masulipatam Canal	197	36,000	183
		1160	270,000	233

$\frac{233}{640} = 0.364$, the total area to be

portion of ted to total in the Deltem is estimated

is therefore rather more (by 20 acres per square mile) than one third of the gross area of the Delta. In Zemindaris the area proposed to be irrigated is on the average 159 acres to the square mile or less (less 1 acre to the square mile) than one fourth of the gross area of these properties.

Supply 4. The most important consideration in connection with the proposed arrangements for irrigation is the water supply. The quantity of water supposed to be required as stated comprises an allowance of 2 cubic yards per acre per hour or 1 cubic foot a second for every 66⅔ acres, making this quantity 4,050 cubic feet a second.

n Canal 5. The main canal has been designed to carry, according to the calculations of the officer who has prepared the estimates, with a depth of 8¼ feet at the head

and 8 feet at the lower end ——— 4.268

Bnk 19 Decr 1874 Note para 2

bank, as in the case of the Western Delta main Canal, it is considered that the formula used gives too high a velocity and discharge, and that with this depth the discharge is not likely to exceed ——— 3.858

8½ feet is to be the ordinary full supply depth in the main Canal, but it will be feasible whenever necessary to carry a depth of 9 feet, and then the surface fall will be increased and the discharge may be expected to be about ——— 4.845

This canal has been nearly completed to the full dimensions intended, & sanctioned 1871-72
indeed practicable for there is no room for further widening on the river (right) side, and on the left side is the Town of Berriadah between which and the Canal there is only the width of a road, which latter is already pretty to economize space. The bottom width of the canal is 200

3

feet and except at the landing quay the side slopes are 1 to 1 on the left and 1½ to 1 on the right bank.

The supply of 2 cubic yards per acre per hour is fully as much as is needed by the higher lands of the Delta, and is more than is required by all but a very small portion of the total area to be irrigated. In the Godavery Western Delta it is considered that on the average not more than 1.8 cubic yards per acre per hour are necessary, and the soil of the Kistna being much more retentive it is improbable that even so much will be required.

Reference was made to this subject in reviewing the Kistna Western Delta estimates

The quantity of water required at 1.8 cubic yards would be

cubic feet a second ——— 3.645

and the dimensions of the main canal are adequate to carry this at less than the normal full supply level.

Head Sluices (2). The dimensions of the head sluices have next to be considered. This is an

old work of 15 vents of 6 feet each and though it might be enlarged it is so situated and circumstanced that without very clear necessity it will be well not to attempt any radical alteration. The vents are at present higher than is necessary but in order to economize head, and also to allow of surface water, which contains less silt, being admitted to the canal when the river is in fresh it will be advisable to make the vents 9 feet high corresponding with the maximum water level to be allowed in the canal. By dividing the shutters into 3 parts working in parallel grooves the regulation of large vents has in the Godavery been made easy and similar arrangements will be introduced at the Kistna to expedite of the inconvenient and extremely difficult system heretofore in use. Shutters 2¼, 3 and 3¾ feet respectively will with the 15 feet on the sill make

the pressures sufficiently equal, and if the groove of the central shutter be carried down to the sill so that this shutter may be lowered as well as raised the canal will be able to be supplied with water from a high instead of a low stratum.

River (3) The sill of the head sluice being 6 inches higher than that of the Western Delta, the circumstances are less favourable for ensuring an adequate supply. In the Western Delta the average supply available during the season of 184 days was calculated to be 2.13 cubic yards per acre per hour for the 9 years from 1864 to 1872. From the similar information compiled for the Eastern Delta the average is estimated to be 1.93 cubic yards per acre per hour. The following is an abstract which is probably sufficiently close approximation.

It has been based upon appendices A & B of Lt Mc Neill Campbell's General report on the modifications for the coefficient of discharge through head sluice, and discharge of main canal at various depths.

Years	Supplies available in Cubic feet per acre per hour						Total days of irrigation shown
	1.00 days	1.25 days	1.50 days	1.75 days	2.00 days	2.00 to 2.50 days.	
1864	31	36	22	11	6	76	
1865	13	23	14	35	7	83	
1866	0	28	33	26	15	82	
1867	3	14	27	32	30	78	
1868	15	15	12	14	24	107	
1869	3	9	12	25	21	114	184
1870	0	7	14	26	22	115	
1871	3	9	25	41	23	83	
1872	0	5	18	12	17	137	
Totals	68	146	172	224	168	869	
Average quantities	8	16	19	25	19	97	184
	8	20	28	44	38	215	½ 193 Cubic feet per acre per hour

for 116 days therefore out of 184 the supply is likely to be fully adequate and for 141 days it will probably be adequate, so that a shortening during 43 or at most 68 days will have to be supplemented by an increase above the normal supply at other times. Taking however the most favourable view of the water supply it must be admitted that with the crest of the sluice 5½ feet above the head sluice sill, and with the water level beginning to be nearly 9 feet above the sill to throw a full supply into the main canal, there may be times at which when the area of irrigation has been greatly extended the cultivation may be placed in jeopardy by the low level of the river during more than a few days. The cultivation can be kept from suffering materially whenever for a not too protracted interval 1½ cubic yard can how per acre may be available, and this necessary minimum during the irrigation season is not, as will be seen above, of frequent occurrence. It will be secured with rather less than 6½ feet in the channel and 1.20 feet

going over the amicut.

The remedy and an effectual one would be to raise the amicut. This is done temporarily every year after the freshes, and the required purpose is attained at practically little expense, the stone used being afterwards utilized for the annual repairs of the apron; and if the river does not become low during the season of the freshes the arrangement is sufficient and will suffice for some time to come, but it is thought that when the area of irrigation in the Eastern delta has extended to about 200,000 acres, and in the Western to 150,000 it will be necessary either to raise the crest in masonry or to provide shutters capable of being raised and lowered at pleasure. It must not however be overlooked that a more favourable state of the water supply will be secured by

C.M.G. 19 Dec 1/84
Note para 3.

* from 130,000
** " 75,000

providing the under sluices with manageable shutters and this will be done as soon as some experimental shutters on the Godaveny have been tested and if necessary modified in detail. The shutters hitherto used are marked with such difficulty that they should have to be removed in anticipation of the freshes and with rare exceptions kept out until the final cessation of the freshes for the season. Mr Campbell had prepared plans for the crest of the amicut 3 feet. It is to be noticed however that less than 18 inches passing over the crest of the amicut is of rare occurrence during the irrigation season and to secure a full supply it has been mentioned that rather less than 9 feet on the head sluice sill are requisite - 5½ + 1½ = 7 feet, and if 2 feet or even 1¾ were added to the

crest all that is necessary would it is believed be attained. The crest should not be raised an inch higher than is necessary, and before the time for making an alteration arises there will be ample data to go upon. The raising of the crest will involve a corresponding raising of the head works in sluicing sluices, locks, and flood banks, and the scheme will need to be very carefully worked out, and all possibility of a breach into the Delta avoided.

The drainage of the Eastern Delta has been worked out on the principles laid down by this office when the Western Delta drains were planned. A description of these arrangements was given in para 8 of the Note on the Western Delta estimates and for convenience may here be briefly summarised.

Drainage. General arrangement.

Govt. Report 1874 No 3672

A period of 6 days has been taken as that within which all rainfall drainage accruing within that time is to be got rid of. The maximum drainage in one day of that period has been taken to be equivalent to 10 inches over the area, and 2 inches are supposed to be the drainage of the other 5 days, so that 12 inches are estimated to be the quantity to be disposed of in the 6 days. The standard area adopted is 5 square miles, the discharge from which will be 1314 cubic feet a second, and the corresponding discharge from other areas has been calculated by the formula $D = 450 \sqrt[3]{M^2}$, e.g. the drains for an area of

M = area in square miles.

10 square miles will discharge 1.60 inches from the area
20 — do — " — 1.27 do — " — do
30 — do — " — 1.10 do — " — do
40 — do — " — 1.00 do — " — do
50 — do — " — 0.90 do — " — do
75 — do — " — 0.81 do — " — do
100 — do — " — 0.74 do — " — do

125 square miles will discharge 0.69 inches from the area
150 do " " 0.65 do do
This arrangement is applicable of course only to drainage within the Delta, the area of which will be sub-divided by canals, channels, main and subsidiary drains into a number of small spaces, in which drainage will be accumulated after very heavy falls of rain, and thereafter be carried away as fast as the drains will allow.
Upland or extra Delta drainage will have to be dispensed of, so far as passing it across the canals is concerned, as fast as nearly as fast as it can come down.
(1) Referring to this subject Lt Campbell in para 42 of his Report on the drainage of the 1st Subdivision remarks "I would here state that I consider the drainage channels a great deal larger than necessary

Lt McNeil Campbell's views

and I believe they would answer the purpose quite well enough if they were reduced to one third the size now estimated for, at any rate as regards draining wet cultivation. This officer has however adduced no reasons whatever for this opinion he has not given the dimensions of any drain natural or artificial which has sufficed to relieve the lands draining into it after heavy rainfall within a reasonable time - he has not shown that six days is a period shorter than is requisite for the full relief of cultivated land from accumulated rainfall waters and this statement amounts to this viz that for areas of 40 to 100 square miles drains which would carry off 1/3 to 1/4 of an inch in the 24 hours, or 2 to 1½ inches in 6 days, would suffice. However, although reliable data are not available for demonstrating what quantity of drainage will, as a maximum,

need to be disposed of, it is, it is
125 or thought, certain that this quantity
150 is very much in excess of Lt Campbell's
This estimate, seeing that falls of rain
exceeding 9 or 10 inches in the 24 hours
are by no means uncommon in
the East coast of this Presidency
ons from one end to the other, the
of maximum falls are less in the
latitude of the Kistna than further
South but 21 inches have been
registered at Madras, 13 to 15 inches
have several times been measured
in its neighbourhood and 13½ inches
were recorded at Bellary, less than
150 miles to the South of the Kistna
delta, in 1859. Such being the case
the provision intended to be made
in the Kistna delta does not appear
to be at all excessive.

In the plan of the Rond there is an in-
tention of making three drains of
full size alone. This could
commence by the Rond Governors

Drains will be carried out gradually and tentatively.

the dimensions known to be correct,
but the advantage of providing
for fairly ample dimensions from
the first will be that embankments
in all works of branch drains
inlets &c will be placed at a sufficient
distance from the centre lines of the
main drains and there will be no
waste of money in removing them
to a greater distance hereafter.
The drains will be cut first to
¼ then to ½, then say to ¾ their full
size and so on progressively as
labour may be available and as
observation may show to be desirable
during the interval of some years
that will elapse the data required
for a correct estimate of the
requirements of the country will
be accumulating.

Data in the Godavery.

(3). In the Godavery the drains are
being gauged annually and the
results reviewed and from a
comparison of calculated and

actual flood water levels at various
points of each drain reliable
data are being obtained. So far
there has not been an even heavy
fall of rain much less anything
approaching to a maximum and
as it will be necessary to wait patiently
until the effects of such a fall
have been demonstrated before
fixing finally the dimensions of
the main and primary branch
drains. In the Kistna also from
the first gauges must be taken at
moderate intervals in every considerable
drain and the flood levels re-
corded on their longitudinal
sections and compared with the
registered rainfall which can
be ascertained with accuracy
(2) by maintaining rain gauges at
all or most of the locks throughout
the delta.

(4) The importance of the subject is very great whether the lack of the

Conclusions to be based on observation.

drains per thousand efficiency be the
point under consideration, no
conclusions of any value however
can be derived from mere expression
of opinion. They must be based
on observation and Delta officers
have the opportunity of making a
series of observations sufficient
to allow of a demonstration in due
course of the proper dimensions
of drains for any given area
from the smallest to the largest
which has there to be dealt with.
It is to be hoped that Lt Campbell's
opinion in the future will be given
in connection with facts. He is
now in the Godavery delta, and
has an opportunity of ascertaining
what facts have been already
recorded for drains already partly
completed and of continuing the
record for any considerable
fall of rain.

1st Sub Section ... The first subsection of

This Delta (Eastern Section) includes the country lying between the Kistna and the Maenlipatam Canal together with the island of Divi. The proposed area of irrigation is thus distributed.

Under Bank Canals { above Divi 15,000 acres
                  { in Divi 45,000
" Maenlipatam Canal 28,000
Total acres 88,000

(1) The lands commanded by the Bank Canal above Divi and by the Maenlipatam Canal in this subsection are nearly entirely Zemindary. There has so far been no opportunity of irrigating these lands except within the area commanded by the Maenlipatam Canal, but it is tolerably certain that from whatever cause the irrigation there has not been in proportion to the water supply available: Appendix H of Lt Campbell's Report on this subsection shows that acres 5,185 represent the present extent of irrigation and imperfect as have been the means of water distribution hitherto there can be no doubt but that a much larger area would have been irrigated had there been any strong desire to make the most of the means available. The opinion of the Revenue authorities is not favourable to the probability of water being demanded for any very large area of these Zemindary lands and accordingly in the order as per margin it was directed that the Bank Canal should be constructed to carry water for 8300 acres only of Zemindary land. Lt. Campbell's project for this Canal had been worked out previously and provides for irrigating 15,000 acres of such land or 168½ acres to the square mile, the area commanded being 89 square miles.

Except in Divi the lands are Zemindary

G.O. Nr 1434 dy. 17 Feb 1876

× 8,300 multiply the Collector considered this allowance to need revision

× area subsequently to be about 53 Square miles

12 (2) In his report (para 7) he says
15 he considers it perfectly safe to
Ti assume that the above area will
c be taken up, but no direct Expendi-
b ture should be incurred either
d on the Bank Canal, distributaries
n or drainage works until the
p demand has actually been made
er for water and until the Zemindar
T or Zemindars interested have
b undertaken to pay for the water
d at such rates as may be fixed
by Government.

Expenditure for irrigation and drainage of Zemindary lands not to be incurred at present

(3) Lt. Campbell states that it was his intention to have supplied the whole of this embecation from the Bank Canal in preference to supplying the water for the Maenlipatam overhead channel from the Maenlipatam Canal at the end of the first reach at Kunkipadu. He states that it would be cheaper to make the Bank Canal large enough, than to widen the Maenlipatam Canal to the required extent and breadth

Canal to supply Ellore section
v Report para 23

vide para 41 Pb. Notes of Inspection in P.W.D. 29th Sept/14 No. 2732.

that, while obeying the instructions given by the undersigned for the division of the supply between the two canals, he is still of opinion that his intended arrangement was the better of the two "no argument having been advanced against it". The concluding remark is incorrect. The subject was examined and discussed very carefully, and the objection to designing the Bank Canal to irrigate the whole embecation was based chiefly upon the fact that it is at present very doubtful whether any considerable area of the Zemindary will want water at all. The widening of the Maenlipatam Canal up to a certain extent will be as cheap as, or perhaps cheaper than a corresponding enlargement of the Bank Canal, and the undersigned believes that this limited extent need not be exceeded. When that limit

has been reached it will be open to the advices of Government for the time being to indicate what the arrangements thereafter should be, and it will be easy to supplement the supply of the west side channel from the Bank Canal if that be then found to be the preferable arrangement. Had Divi been at the upper instead of the lower end of the subsection, no proposal for a Canal through the Zemindary would have been
13/ brought forward by the undersigned
h until some very definite and
th considerable demand for water
th had been.

to 7/ The general arrangements of this Canal have been discussed
M of at length. The course the discussion
h has taken is recorded in
to the papers as per margin.†
C It was at first designed
as a 2nd class line of navigation

Bank Canal

† Inspection notes paras 41 to 46. P.W.D. No 2732 dated 29th Septr. 1874.
General Report on Eastern Delta Section VII paras 7 to 18.
Appendix No 3 { Memo No 226-26th Feb/75 / Lt. Campbell's No 3-14th April. / Memo No 706-30 June "

but with a mean velocity of 2,580 yards an hour (2.15 feet a second) and it was considered that the velocity of 2,000 yards an hour (1.66 feet a second) should not be exceeded if the expense of constructing locks (1 at head and 2 others) was to be incurred. Also that if the Puligadda branch of the Kistna was to be supplied by an agreeable the level of this mark would need to be placed much higher than had at first been proposed. Whether or no the Canal should be designed as a regular line of navigation seeing that for half the distance to the Puligadda branch the Masulipatam Canal is at a distance of only two or three miles and the country thence to that branch all Zemindary but little of which was expected to be irrigated was pointed out to be a matter for consideration. It was ultimately decided not to propose

making this canal a regular
line of navigation, but for the
purpose of conveying materials,
and in order to afford water
communication of a practicable
but inexpensive kind a head
lock was to be allowed for at
the 24th mile. Navigation was to
end at the Puligadda branch
of the Kistna. On this basis and
on the further instructions which
will be found in the same Memo. dt 706. Appendix
Capt Campbell has with some dt 8
modifications which will be
noticed in due course worked
out the Bank Canal project.

8. The design down to the Puligadda aqueduct is described in para 8 of the Report* starting from the Masulipatam Canal (right bank) at 3½ miles and to be supplied therefrom by a head sluice of 5 vents of 6 feet span each

Design of Bank Canal
*Appendix dt 2

it will run for a distance of
9 miles at some little distance
from the river and thence generally
along the line of pits excavated
formerly for the river flood
bank. The bed and surface fall
of the canal down to 24 miles
from the head will be 6 inches a
mile. Thence to the Puligaddas
branch of the Kistna in the 36th
mile 3 inches a mile. The following
points should be attended to in
carrying out the work.

(1) The alignment throughout needs
careful revision. The canal
must be laid out in straight
lines connected by curves of
as large radius as may be con-
veniently practicable. Close proxi-
mity to the river is not desirable
and must be avoided especially
where as on sheet dt 5 - 19½ mile
such nearness is dangerous and
at the same times gives a bad align-

-ment. ...

1/4 From the 13½ mile the river flood bank is shown to be separated by a greater or less interval from the right bank of the canal. The latter when properly laid out will be a good alignment for the flood bank also and either the canal should be shifted to the flood bank where the latter is in a safe and suitable position or the flood bank should be shifted to the canal. Economy of construction and of maintenance will be secured by this arrangement, the latter everywhere, the former generally.

Flood bank in relation to Canal.

9. The discharge of the canal has been calculated by Mr. Campbell by a formula which is believed to give a velocity in excess of the actual in earthen channels. Using the formula by which the Godavery Delta canals

Discharge

$V = .916\sqrt{2f \times HMD}$

have been arranged the differences are as follow.

	Mr. Campbell's V	D	Revised V	D	
at head.	2.09	910.19	1.85	805.67	cubic feet a second

The revised discharge would allow of water being provided for about 8,700 acres out of the 15,000 acres of Zemindary land which Mr. Campbell has taken into account.

Similarly

	Mr. Campbell's V	D	Revised V	D	
at 24 miles.	2.23	884.19	2.00	793	cubic feet a second

and the Zemindary acreage below this would by the revised calculation be 8000 instead of 13,300 acres. It is more likely that the lesser rather than the greater Zemindary acreage will be irrigated and probably the dimensions of the canal as fixed will suffice. But for the Aqueduct arrangements in the 36th mile it might have been desirable to diminish the depth of water below the 24th mile to 6 feet.

10. The information given is by
on oneans as complete as it should
have been and as is necessary. Lt.
Campbell in para 9 of his Report
says "The drawings forwarded with
this letter show the present state
of the river but it is advisable that
the changes in the bed should be
recorded for several years and as
it will doubtless be some time before
the aqueduct is built this can easily
be done." Towards the end of 1873
the place was inspected by the under-
signed and it was then noted that
the site was suitable, but that it
was evident that the bed of the
river had changed since the
survey was made 2 years before
and that the nature and direction
of the changes should be recorded.
It was added "The nose of the
island at the bifurcation of the
river has been wearing away by
erosion for sometime back

crossing of Puliyadu branch of Mutna

Appendix No 2

The report is dated October 1876.

Inspection notes para 45 in Bnd 29th Septr. 1874, No 2732.

and a proper salient should
be established by raised planting,
as also the proper alignment of
the branch from its head to about
half a mile below the aqueduct site.
Permanent bench marks should
be placed on both sides of the
branch near that site. Nothing
has been said as to whether these
instructions have been carried
out, and if so with what effect.
The information given will be
reviewed more in detail in con-
nection with the design for the
aqueduct. The Superintending
Engineer has been addressed
with a view to the requisite in-
formation being made available
before the time comes when it
will have to be acted upon. Sup-
posing the site noted on the plan
to be correct, the junction with
the present Savurnamuki inundation
Channel which for a short distance

Memo. dy. 1st Septr. 1876.

C.1 / No. 1 Sheet No. 10

is to be converted into the Bank Canal would not do. Two alignments either of which would be more suitable have been marked on the plan.

General arrangements in Divi for irrigation

11. The irrigation of Divi is proposed to be effected by 3 principal channels having their heads in the 38½ mile near Avvinagadda where the Bank Canal may be considered to end.

1- on the East bank of the Kistna
2- on the south bank of the Puligadda branch of the Kistna.
3- occupying a nearly central position in the island.

W.1- the East bank channel or as it may be more conveniently termed the Divi west channel will be 14½ miles long. For rather more than 2 miles it will have a depth of 6½ feet of water, thence to the end just below 52 miles the depth will be 4 feet. The fall throughout will be 6 inches down to 41½ mile a mile. It is intended to irrigate 21,000 acres.

W.2. which may be called the Divi south channel will be 15 1/8 miles long. The depth of water at the end and for 2½ miles will be 5½ feet. Thence to the end where it will terminate in the Moodelias Tank the depth will be 4 feet. The bed fall throughout will be 7 inches a mile. The expected area of irrigation is 17,000 acres.

+The name on the Sketch Map is "Kistna Branch South Bank Channel" and on the Plan C.1 W.1 Sheet W.10 the "Hamsaldiva branch"

W.3. The Divi Central or Suvarnamukhi channel will be 10½ miles in length, will convey 4 feet of water to the 8½ mile and 3 feet below that, the bed falls being 7 inches a mile. The area of irrigation provided for is 7,000 acres.

It is to be noticed

1st That the right and left banks of the Divi west and Divi south channels should be combined

with the river flood banks wherever practicable.

2ndly that the waterway of all the channels should be confined to the cross section required and the water should not be allowed to spread over the ground on either side of the channel proper.

3rdly that where future widening is not likely to be required there should be no berms and the banks should be in continuation of the side slopes of the channels.

4thly that the termination of the Sivaramanuki channel in ground about 3½ feet above W.L. without any arrangement for the discharge of surplus will not do and that the channel must be extended to a point where ground and W.L. coincide, so that the proper W.L may not be exceeded. Surplus may then escape into the swamp to the southward.

5thly that in the Divi north channel the alignment involves generally deeper cutting than is desirable or economical and the quantity of excavation required to form the channel banks, and where the left bank is combined with the river flood bank the latter also, should be calculated and the channel so aligned as to provide this quantity as nearly as may be. It is of course unnecessary that the flood bank should follow all the windings of the Puligadda branch.

Abstract of Estimates of Bank Canal

12. The estimates though dated October 1875 contain no classified abstract as required by P.W.D. of the 10th July 1875. The following abstract has been prepared in this office.

Position Miles Chains	Description	Sub Heads	Main Heads: Main Canals and Branches Original	Main Heads: Main Canals and Branches Revised	Distributaries Original	Distributaries Revised	Drainage and Protective Works Original	Drainage and Protective Works Revised	River Embankments Original	River Embankments Revised	Remarks
0 0	Compensation	B Lands	413005	10000							
0 0 to 19.2	Combinating Canal	L Earthworks	224510	224570							Rs 60 transferred to Distributaries
19.2 to 34.7	do	do	71740	71740							
34.7 to 37.58	do including Tanjore	do	19 47160	16530							Rupees 47160 Rs. clerical error 460 47610 transferred to Distributaries 29080 16530
0 0 to 62 13	Marginal bank right side of canal	do	35900								
	Flood bank L	do									
0 0	Head Sluice	Regulators	6940	6940			6220	50000			see note para 24.
0 0	Head Lock	Navigation Works	11970	11970							
7.38	Koyur Bridge	G Bridges	7100	7100							
12.47	Vallur do	do	7360	7360							
16.0	Escape weir L.B.	H Escapes	2815	12815							R/S no plan in book of designs of masonry works
19.2	Slow Bridge	G Bridges	7300	7300							
23.77	Srikakolam do	do	7570	7570							
25.0	Papanasanam do	do	7480	7480							
31.57	Kottapalem do	do	7820	7820							
34.15	Escape weir R.B	H Escapes	3015	13015							R/S to plan do
35.40	Polizadda Aqueduct	F River & Hill Torrent Works	358500	358500							
	5 Works transferred to Distributaries			13695							

	Stock marks altered	O Miscellaneous	195	390				
	Cattle crossings (16)	do	9275	9275				
		P Maintenance		32000				
19.3	Inspection houses	K Building	2960	2960				
35.0	Aqueduct do	do		3100				
37.58	Avanigadda do	do	3100					
	Kodur do	do	1150	1200				
	Inlets above 11th mile	F&C Drainage Works	16 6650	6650				16 Transferred from Drainage Estimate.
19.28	Kuderu Channel	B Lands			235	200		
	Head Sluice	C Works			500	450		400 acres
	Fall at 1.0	do			295	300		
	Tail Escape at 1.75	do			570	300		
	Channel	L Earthworks			945	450		
21.56	Lankapalli Channel	B. Land			246	200		
	Head Sluice	C. Works			450	400		500 acres
	Fall at 1.0	do			355	300		
	Tail Escape at 2.15	do			580	400		
	Channel	L Earthworks			1075	700		
23.77	Srikakolam Channel	B. Land			680	600		
	Head Sluice	C. Works			550	500		800 acres
	Fall at 1.0	do			335	300		

Position miles chains	Description	Sub heads	Main heads. Main Canals & Branches Original	Main heads. Main Canals & Branches Revised	Main heads. Distributaries Original	Main heads. Distributaries Revised	Drainage & Irrigation Works Original	Drainage & Irrigation Works Revised	Embankments Original	Embankments Revised	Remarks
	Fall at 3.0	C. Works			360				300		
	Tail escape at 5.40	do			815				600		
	Channel	L Earthworks			2,655				1,300		
26.77	Chittur Channel	B. Land			880				800		
	Head sluice	C. Works			500				400		700 acres.
	Fall at 3.0	do			395				300		
	do 5.0	do			540				500		
	Tail escape 6.70	do			360				360		
	Channel	L Earthworks			2,240				1,400		
28.46	Pokalagadda Channel	B Land			725				500		600 acres
	Head sluice	C. Works			572				500		
	Fall at 2.0	do			355				—		
	Tail escape at 4.20	do			630				600		
	Channel	L Earthworks			2,660				1,200		
30.68	Vegole Channel	B Land			730				500		
	Head sluice	C. Works			600				600		
	Fall & bridge at 2.0	do			720				300		400 acres.
	Bridge at 2.60	do			815				300		
	Tail escape at 6.6	do			440				300		
	Channel	L Earthworks			1,990				600		
33.20	Pedanadi Channel	B Land			480				600		
	Head sluice	C. Works			800				500		700 acres.
	Bridge at 1.20	do			740				350		
	Fall at 2.0	do			400				—		
	Tail escape at 6.10	do			455				450		
	Channel	L Earthworks			2,540				1,500		
34.73	Wadapalem Channel	B Land			3,910				3,000		
	Head sluice	C. Works			3,250				2,000		10,900 acres
	Bridge, Mopadivi Fall	do			2,925				2,500		
	do Padakallipalli	do			2,695				2,300		
	do C. Yadara	do			985				800		
	Channel	L Earthworks			20,280				12,600		
M.C. 6.26	Atlakuru branch Channel	B Land			480				400		
	Head sluice	C. Works			480				450		(3000 acres)
	Fall 2nd mile	do			321				—		
	Channel	L Earthwork			2,385				1,000		
8.3	C. Yadara branch Channel	B. Land			520				450		
	Head sluice	C. Works			490				400		(3000 acres
	Fall 1st mile	do			335				—		
	Channel	L Earthworks			3,405				1,700		
37.58	Divi Westchannel	B. Land			3,005				3,005		
	Head sluice (share of)	C. Work			3,265				3,500		2,000 acres

Position miles Chains	Description	Sub heads	Main heads: Main Canals & Bonnches Original	Main heads: Main Canals & Bonnches Revised	Main heads: Distributaries Original	Main heads: Distributaries Revised	River Drainage & Protective Works Original	River Drainage & Protective Works Revised	River Embankments Original	River Embankments Revised	Remarks
3.19	Bridge (Vakanur)	C Works			2730	2730					
5.59	do (Kazailmka)	do			1866	1855					
9.6	do (Kokalalem)	do			1215	1215					
11.47	do (Yetimoga)	do			895	895					
13.72	Tail escape	do			—	250					
	Channel	Earthworks			29080	29080					
2.17	Bandalai cheruvu branch Channel	B. Land			305	305					
	Head sluice	C Works			515	515					(2000 acres)
	Tail escape	do			380	380					
	Channel	Earthworks			1460	1460					
3.15	Vakanur branch Channel	B. Land			600	600					(4000 acres)
	Head sluice	C Works			615	615					
	Fall 2 miles	do			390	390					
	Tail escape	do			350	350					
	Channel	Earthworks			3280	3280					
5.59	Chederevu branch Channel	B. Land			900	900					
	Head sluice	C Works			536	536					(4000 acres)
	Fall 3 miles	do			360	360					
	Tail escape 6 do	do			475	475					
	Channel	Earthwor			4855	4855					

8.76	Talegada div branch Channel	B. Land									
	Head sluice	C Works			770	770					(5000 acres)
	Fall at 6 chains	do			575						
	do at 3.0	do			410						
	Tail escape 5.10	do			340	340					
	Channel	do			5290	5290					
10.68	Yetimoga branch Channel	B. Land			270	270					(2000 acres)
	Head sluice	C. Works			445	445					
	Fall at 1.0	do			540	—					(4000 acres direct irrigation under Divi West channel)
	Channel	Earthworks			2020	2020					
37.58	Divi North channel	B. Land			3407	3407					
	Head sluice (share of)	C. Works			2855	2800					17000 acres
2.40	Pindeo (Mechaveram)	do			1645	1845					(1) No plan
9.20	do (Salempalem)	do			955	900					
12.50	do (Haripuram)	do			960	900					
	Channel	Earthworks			27,200	25,000					
2.40	Mechaveram branch Channel	B. Land			320	300					
	Head sluice	C. Works			410	400					(2000 acres)
	Fall at 1.0	do			350	—					
	Tail escape at 2.30	do			330	330					
	Channel	Earthwork			1720	1700					
4.77	Kaldindivari branch Channel	B. Land			640	640					

Position miles Chains	Description	Sub heads	Main heads: Main Canals & Branches	Distributaries	Drainage & Protective Works	River Embankments	Remarks
Position		Sub heads	Main Canals & Branches	Distributaries	Drainage & Protective Works	River Embankments	
Chains	Description		Original Revised	Original Revised	Original Revised	Original Revised	
	Head Sluice	C Works		750 750			(5000 acres)
	Tail Escape at 4.0	do		475 475			
	Channel	L Earthwork		3813 3800			
	R.B. Rodda branch Channel	B. Land		600 800			(5000 acres)
	Head Sluice	C Works		765 765			
	Tail Escape at 5.0	do		340 340			(5000 acres direct under Main Channel)
	Channel	L Earthwork		4665 4000			
7.56	Suryanarayanka Chan.			2020 2020			7000 acres
	rtl	B. Land		1080 1200			
	Headsluice (3 vents)	C Works		1485 1485			
1.20	Fall & bridge	do		1212 1210			
6.0	Bridge & Regulator	do		1400 1600			
8.0	Uniting Sluice & Bridge	do		10165 10000			
	Channel	L Earthworks					
6.0	Mandapakala			540 500			(2000 acres)
	branch channel	B Land		425 425			
	Head Sluice	C Works		4120 2000			
	Channel	L Earthworks					
2.0	C. Solapalem			260 200			
	Solapalem branch Channel	B. Land					(1500 acres)
8.76		L Earthworks		1612 1250			
8.0	C. Solapalem branch Channel	B. Land		260 200			(1500 acres)
		L Earthworks		1666 1258			
	Kanikalamadugu spare drain	B Land		5000 5200	11450	11450	*including the upper part called in the estimate the Rodlapad affluent
6.38	Inlet	C Works			1320	1320	
	8 Inlets	do			13270	13270	
	Rodlapad Extension	L Earthworks			8450	8450	
	From C. Majeru drain to Fork creek	do			67330	67330	
	Devarapalli drainage	do			1000	1000	
	Inampudi drain	B Land			7020		
	Bridge Short Nedimole road	C Works			7890		(9) Appertains to Masulipatam Canal
	8 Inlets	do			12905		
	Drain	L Earthworks			1620		
	5 Cattle crossings	do			1940		
	Talern drain (Divi)	B. Land			5110	4000	
	3 Inlets	C Works			4160	3000	
	Bridge near Mandapakala	do			6830	4500	
	Outlet at head	do			6810		
	Drain	L Earthworks			64250	50000	

Dist. Sub Main No. 1.

Position Miles	Chains	Description	Sub heads	Drain heads: Main Canals & Branches Original	Drain heads: Main Canals & Branches Revised	Drain heads: Distributaries Original	Drain heads: Distributaries Revised	Drainage & Protective Works Original	Drainage & Protective Works Revised	River Embankments Original	River Embankments Revised	Remarks
		Gudimoktu drain (Divi)	B. Land					2260	2000			
		5 Inlets	C. Works					7505	5000			
		Bridge near Mandapakala	do					6880	4500			
		Drain	L. Earthworks					14430	13500			
		Veeranki drain	B. Land					360				
		Bridge near Veeranki lock	C. Works					2480	(b)			(b) appertains to Masulipatam Canal.
		Drain	L. Earthworks					1680				
		Mopidivi drain	do					580	580			
				853230	805445	220550	186217	436290	189820	62260	50000	
		Deduct items also shown under Distributaries		45760	—							
		Deduct share of Kanika-lamudiga drain chargeable to Masulipatam Canal. vide Note para 19		—	—	—	—		43660			
I		Works Total		807450	805445	220550	186217	436290	145960	62260	50000	
II		Establishment 25 per cent on I			201365		46553		36490		12500	
		do Survey do { Past			2000		2000		1000			
		do Survey do { Future			1000		3000		1000			
III		Tools & Plant 6 per cent on I			64400		14900		11680		4000	
					1074210		252670		196130		66500	

Drainage & Protective Works 436290
Transferred to M C & B — 6650
Amount of Estimates as submitted by D.E. 442940

Remarks

Rs 607450
M C & B — 220550
Distributaries — 62260
River Embankments — 50000
1940260
Estimates as submitted by D.E. 10,63,610
Difference due to transfer of Inlets about 11 miles from Main head (4) to (b) 6650

23

Line submitted remarks will explain the difference between return in the Original and Revised estimates from the Main head to Kanipaka Drain (2) Main Canal and Branches Head (2) Main Canal (3) Distributaries.

In Untitled in para 3 above

No mention of the Original estimates. There is no explanation why the Drainage Works Revised are Rs 145960 and the Canal Channel as a distributary Rs 43660 is to irrigate 2,000 acres and the latter 1,000 acres. The Canal channel are up the Canal class.

Consequently the cost per acre of the Drainage Works Revised estimates, under Distributaries, and as there is no information as to the land required for it, an arbitrary division of the Works has been made. The "Drainage" estimates has been made on the Bank Canal about 11 miles

Canal Divided channel

have also been transferred to [2] main canals and branches from [4] Drainage and Protective Works.

13. After deducting the items amounting to Rupees 45,780 transferred to distribution the total of the original estimates for the Bank Canal from the head to its termination at 37 m. 58 ch. becomes Rupees 8,07,450 at the rate of Rupees 21,229 a mile; this high average is due to the cost of the aqueduct for crossing the Paligadda branch of the Kistna; the item for which is Rupees 3,58,500 and represents a charge per mile of Rupees 9,503; consequently the cost per 1/16th mile of the aqueduct is Rs. 1,724 a mile. Similarly the cost of Distributaries amounts to Rupees 2,20,550 and the acreage to be

Total of first Estimate

Divi west channel 42,845
N. de. bee Sluice 2655
Suvarnamukhi club do 1180
45,780

irrigated being 60,000 the cost per acre is Rupees 3.676. The estimated cost of distribution however varies very considerably

The area to be irrigated above the aqueduct in the 36th mile is - acres 15,000
The distribution is estimated to cost - Rupees 73,599
Rate per acre - " - 4.90

The area to be irrigated below the aqueduct is . . . acres 45,000
Cost of distribution . . Rupees 1,46,951
Rate per acre " 3.27

or the former is just half as much again per acre as the latter, and it is somewhat remarkable that in the former case it is the narrow strip of ground between the canal and the drainage which limits the area to be irrigated, which is exactly to supply e.g.

Kindem channel	length	1.75 m. ch.	rate per acre	6.36 Rupees
Lankapalli do	do	2.15	do	5.41 do
Spitkakolam do	do	5.40	do	6.47 do
Chittur do	do	6.70	do	7.12 do
Vakalagadda do	do	4.20	do	8.03 do

	m. ch		
Pagole channel. length	6.6	rate per acre	13.24 Rs.
Pedaprolu do — do	6.17	— do —	8.16 do
Wadapalem do — do	12.60		
Nalakarru branch	3.50	— do —	3.89 do
C. Yadara — do —	4.00		

On the other hand if the total cost of the irrigation above and below the Puligadda branch be considered, the following approximate results will be obtained

Above the Puligadda branch M.C & B 98,607*

Distributaries 73599

1,72,206

per acre 1148

*one fourth of the sum of the estimates, less amount transferred to Distributaries (45780) marginal bank (35900) dock (11970) & aqueduct.

below the — do — do M.C & B 6,54,323

Distributaries 1,46,951

8,01,274

per acre 17.81

three fourths of do-do- but with aqueduct added.

The subject will be further noticed in connection with the revision of the estimates.

14. The following remarks on the items of this mainhead explain the alterations made in the original estimates, not noted on the abstract. Alterations of details

Works- Main Canals & Branches

not involving material modification of cost have been shown in remarks on the plans.

Marginal bank right side of canal.

(1) This bank estimated to cost Rupees 35,900 is unnecessary. The canal can be placed alongside the river flood bank generally as otherwise the flood bank can be adjusted to the line of the canal in bringing the former to section. Only occasionally therefore will any marginal bank, to confine the water when above ground level to its proper section, be necessary.

Puligadda Aqueduct

(2) This is by far the most important masonry work on the canal, and is estimated to cost Rupees 3,58,500. The design as regards the arrangements generally of the floors and aprons has been prepared on instructions issued from this office, but there will be several important matters to be considered before the working drawings can be prepared.

Pa 1st the information that is
Pe available regarding the changes
W. which have taken place at and
near the site selected is at pre-
sent inadequate.

b 2nd it is probable that the lower
or river floor of the aqueduct will
th have to be placed lower than
A H.W.D - 2.66

3rd the information regarding
a the flood level of 1874 is not as
complete as is necessary and there
are discrepancies in the informa-
tion given which have to be examined
be into and regarding which the
Superintending Engineer has been
addressed.

I, 4th the flood level must be
w deemed to be at about the same
o height at both ends of the aqueduct
H but in the design the top of the
o side walls is at the upper end 1.38 — 11.36
e feet higher than at the lower end. The — 9.98
th margin at the former is 5.23 feet — 1.38
o and at the latter therefore 3.85 feet.

It will probably be desirable to raise the right front and rear wings to 4½ feet above the flood level of 1874.

5th there should be a hand rail on both sides of the aqueduct.

6th the water wings are the main wings, and inside these are supplemental wings founded at the upper end at 11.20. It would be difficult, if not impracticable, to prevent a separation of these supplemental wings from the abutments which are to be founded at 15.66. The better arrangement will be to construct the main wings on the alignment laid down for the interior wings and the returns of these should not be carried up above 6 feet below canal bed level. The water wings need not then be higher, at their junction with the abutments, than the springing line of the arches: the returns of these may then be 30 feet in length. The

earthwork slopes from the end of the main to the waterwings should be permitted. The canal bank at full height should overlap the main wings 6 feet from which point the slopes towards the water wings should commence.

7th The cut waters of all the piers should be struck with radii equal to the thickness of the piers, the centre being on the line of the face wall if there be no pilasters: the cut waters of the piers in the design are segments of semicircles.

8th ground level and an accurate cross section of the river require to be shown on the longitudinal section and elevation (small scale) as also the M.F.L

(3) No provision has been made in the original estimate under this subhead (P) Rupees 32,000 have been allowed in the revised estimate. Maintenance Charges Capital

(4) First class rest houses are provided for at Ilur about 19 miles Road

3 chains and at Avinagadda about 38 miles. The site for the latter should be selected as near to the aqueduct site as possible and if suitable ground can be found to the north of the aqueduct so much the better because there rather than on the island of Divi all materials brought from Bezwada will have to be deposited, so the Executive Engineer in charge should reside there for the 2 or 3 years that the aqueduct will be under construction. Afterwards also this position will be a convenient one. An additional 2nd class rest house may be allowed for Avinagadda, near which all the heads of the principal distributaries of Divi will be located. The design for these rest houses will be improved by enclosing a part of one verandah for a bathroom and Rupees 50 have been added to the estimate on this account

15. It has already been noticed that the proposed arrangements for the distributaries above Divi are on the whole unusually expensive and a few remarks on those of the several branches will therefore be desirable.

Works
Distributaries

(1). The levels on the earthwork and masonry plans do not agree. The difference between the bed of the canal and of the distributary is stated to be 4 feet (27.13 + (23.13) but full supply level in the latter is to be at 25.13 and corresponds with 27.13 of the canal bed vide plan of head sluice. The cost of the head sluice and of the earthworks are unnecessarily increased by placing the bed of the distributary on so low a level, again the water in the channel for half its length would be entirely below ground level and much of the land could not therefore be conveniently

Kudaru Channel
C1 No 6 Plant Earthwork & Masonry
No 31 do Masonry
32

supplied. The water surface in the channel should generally have half the depth or in this case 1 foot above ground level. It is believed that Rupees 4 an acre will be ample to meet the cost of distribution especially if the bed fall can be made to approximate more nearly to that of the country.

Sen Kapalli Channel
C1 No 7 Plant Earthwork & Masonry

(2) In this case also the noted levels on the head sluice plan do not agree with the drawing and if the channel bed is to be 2 feet below the canal bed it will save expense.

(1) to raise the former 2 feet at the head
(2) to increase the bed fall.

Spika Nolam Channel
C1 No 9

(3) Here again the cost of earthworks may be much reduced by placing the bed of the channel higher and by increasing the bed fall. There are mistakes in the levels noted on the head sluice plan.

When a drop is required at a head sluice it should be effected immediately behind the sill, and then the length or width of apron can be much reduced.

[4] The bed is placed on much too low a level at the head and generally the channel is in too deep cutting in the 2nd and 3rd reaches by at least 1 a foot. It is not clear why so low a bed fall as 8 inches a mile for these small channels has been adopted. 2 feet a mile would not give too high a velocity and the nearer the fall of a channel approximates to that of the country the cheaper the distribution will be.

Chittur Channel C1 No 11

[5] The level of the bed at the second mile on the longitudinal section is about right and the bed at the head can with advantage and economy be placed 2 2/3 feet higher than there shown and if the fall of 2 feet a mile be continued no drop at 2 miles will be necessary.

Vakalagadda Channel C1 No 12

[6] The arrangements should be recast. Ground level at head is shown at 18.51 and at lower end, 4 miles, at 10.88. The bed of the channel at head should be about 14.25 and at tail about 9.25 the bed fall being 2 feet a mile.

Pagale channel No C1/13

[7] The first reach of 3 miles has its bed at about the right level relatively to the ground. A drop is required at 3 miles but the bed should be laid out from this point to the end with a fall of about 2 feet a mile.

Vedapuram Channel C1 No 15

[8] This channel as shown in the longitudinal section starts with a cutting 7.69 feet deep the proper cutting, with banks 2 feet above water level and 4 feet wide at top, being under 3 feet. Consequently the bed at head should be placed at about 16.00 instead of 10.78. The bed fall was intended to be 6 inches a mile but 15 inches a mile will not occasion a velocity in excess of that in the canal and a bottom width of 12 feet instead of 20 feet will then suffice. The channel arrangements should be entirely recast so as to place it in somewhat less than 3 feet

Wadapalam Channel C1

14/ The
a level of cutting generally and to carry
deep the water at a velocity of 2 to 2.25
by at feet a second.
why 19/ 2/ The bed be placed on the
a m average 2½ feet below ground
has surface and the fall be made
wants to correspond with that of the
and ground the cost of earthworks
chan will be reduced to less than
of one half.
dict- 10/ The bed should be at about
5/ 2½ feet below ground level. The
mile length is 7040 yards and 2⅔ cubic
is a yards to the yard run will re-
the represent the cutting required
and which will also nearly suffice
high for banks 2 feet above water
the level. Altogether 3½ cubic yards
ns d to the yard run will be enough.
16/ Consequently about 24,640 cubic
re yards will be required instead
is of the 51,875 cubic yards of the
2nd estimate. The fall should ap-
han proximate closely to that of the
14.25 country or about 1 foot a mile.

Sidakpur branch channel. 51 of C1 No.16.

C. Godara branch Channel. 53 of C1 No.16.

Ordal test channel C1 No.1 Sheets 11 to 14 longitudinal and cross sections.

30

No masonry drop will be required.
(11) This is to irrigate 21,000 acres and the estimated cost of the
primary distribution is Rupees 42,045
secondary — do — " — 26,260
Total 68,305

This will give Rupees 3¼ an acre which is reasonable and about sufficient ordinarily.
The channel is to carry 6½ feet of water for 3⅘ miles and thereafter 4 feet. The prepared bed levels appear to be generally suitable, but it is doubtful whether the drop in the 6th mile is necessary and probably a greater bed fall below the 3rd mile will be desirable.
The disposal of surplus water at the lower end will have to be provided for in some way by an escape which will also regulate the level of water surface. The arrangements can be temporary in the first instance and a dry stone escape will suffice

for which 250 Rupees have been allowed in the revised estimate. Some improvements of the alignment of the channel are requisite.

Head Sluice

/2/ The design for the Divi west, Divi north and Savurnamukki Channels may with advantage be revised. It is much too cramped for convenience, and should be placed a few yards below the trifurcation, where there will be room for the convenient disposition of the dividing banks between the 3 channels and for a good alignment of the heads of the west and north channels.

/3/ This matter will need consideration. 315 cubic feet a second will be admitted at the head when the Bank Canal is running full. The last part of the channel is designed to carry 60 cubic feet a second and the disposal of the difference must not be left to chance. There are several old inundation channels

Disposal of differences between discharge of channel in successive miles.

which will be superseded and will be available for carrying surplus into the drains or into the old tanks.

Some remarks have been noted on the plans of the masonry works.

/4/ These have been designed with the beds on too low a level and with too slight a bed fall. The sluices provided for them have not been altered but a reduction in earthworks will be practicable and the money may be wanted for regulating the heads of field channels. Masonry falls are not likely to be required.

Bondalaichenuvu Valavaram Chodavaram branch channels

Talegadadivi branch channel Yetimoga-ds-

/5/ The bed fall should be increased and the drops superseded.

Divi north channel (Kamsaldivi)

/6/ Where the left bank of this channel is not also a flood bank its height above F.S.L should be 2 feet as the normal level. The bed fall 7 inches a mile is somewhat small where the depth of

water, as in the upper 2½ miles is
of for 5½ feet, below where the depth is 4
allo feet it is less than is desirable. The
the bed at the head may with advantage
for to economy be placed higher. The
of waterway where the channel is to
12/ be carried alongside the flood
D bank should be confined to the
m proper section. On the whole the
It bed at head will be better if
(w placed at the same level as that
e of the end of the Bank Canal and
ro a fall of 8 inches a mile for the
co first 2½ miles and 1 foot a mile
di thereafter, at any rate to 7 miles,
t 13/ will be about right. The alignment
an in the 14th mile runs too close to
he the river, and it is not clear that
ch it will be advantageous to carry
1 the channel through the pits of the
to old flood bank as a rule. The
a Puligadda branch flood levels
n have not been marked.

A temporary escape for the dis-

charge of surplus into the small tank at which the channel ends should be provided.

Machaveram branch Channel. 17/ The head as shown in R.P. 66 C1 R.21 is not in the most favourable position available. All the heavy cutting could be avoided by putting it about 300 yards higher up the Divi North channel. The bed fall should be about 1 foot a mile and no drop will be necessary.

Kaldindivari branch Channel. (18) The head of this channel would apparently be better if placed higher up the Divi North Channel. The alignment shown starts in deep cutting and if placed 1 mile higher up would be no longer and would run through ground better suited as regards level. The bed fall also would be the better for being increased by adopting a higher off take.

Kodur branch Channel. (19) The ground levels on the section of the Divi North channel and on

that of the branch do not agree. It seems probable that the alignment throughout could be improved.

(20) Apparently the only advantage of utilising the old inundation channel of this name for the first 2¼ miles will be the avoidance of the necessity for taking up fresh land and the advantage is questionable. It is proposed to make the channel bed at its head at 10.00 or 1.43 feet below that of the Bank Canal and at the lower end 83/8 miles 0.13 the fall of the channel will therefore be 9.87 feet. A more satisfactory distributary would be obtained by starting at 11.43, carrying the channel in a nearly direct line to the point at 2¼ miles where the new alignment commences, with a bed fall of 1 foot a mile down to 2½ miles, and below that 1½

Sawarnamuk Channel

Lopakala W. Channel

(21) The earthworks of this channel 4 miles in length and with 1½ feet of water, the bed width at the head being 6 feet are estimated to cost Rupees 4,120. The channel should be in 1 foot cutting; the banks should be 1 foot wide at top and 3 feet above channel bed and then about 2 cubic yards to the yard run will be required or say 1000 Rupees. 2000 Rupees should suffice for earthworks and the regulation of the heads of field channels, minor distributaries &c

Kalem branch channel — do —

(22) These petty channels may be much reduced in cost by adapting the arrangements to the circumstances. Very small banks will suffice and a large part of the earthworks is for these. The original estimate contains no items for regulation at their heads though such works appear to have been designed. The provision for the channels will however be more than ample.

16. There is no advantage in a small bed fall supplemented by masonry drops. The nearer the bed fall coincides with the fall of the ground the better and a velocity of about 2 fut a second in such channels is none too much. The water surface should as far as possible be somewhat above ground level: from one-third to one half the depth is convenient for distribution by field channels. Berms are not desirable unless enlargement be probable: they render the maintenance of the channels more difficult and involve the taking up of much additional land. Banks should not have a greater margin above water level than is really necessary. Highbanks add greatly to the expense. A margin of half the depth of water is usually ample.

General remarks on Distributaries

17. No expenditure on distributaries above the aqueduct will be required until a demand for water arises. The land is all Zemindary and there is no immediate prospect of much irrigation in this part of the delta.

Expenditure on distributaries above 35th mile Bank Canal

Drainage

18. The estimates for drains are heavy. They, as submitted by the District Engineer, amount to Rupees 4,36,290 for works and represent rather a possible future and ultimate outlay than any present requirement to be met. As drainage of Zemindary land will be undertaken until a large and steady demand for water for irrigation may be made and then only such improvements to existing means of drainage as may be shown to be necessary will be carried out. Moreover the basis on which the drains have been designed is only probably correct and it has yet to be settled what capacity the drains for any given area of delta country must be to be effective

tha Consequently the dimensions to be
dk at first given to any drains that
mes may be required will be much
pr less than those provided for in
(20) the estimates. This is a necessity
of as regards the execution of the
ch work and it is requisite further,
fu in order that no unnecessary
of work may be done. A width
fu of one third for small to one
half for large areas will generally
is suffice not for a season's
in work which will usually be much
he less but for the work to be done
tha until discharges from recorded
the rainfall have been ascertained
of and the ultimate requirements
fe deduced therefrom.

br 19. This will be the main
d drain of the tract of country
ch between the Kistna on the west
to the Masulipatam Canal on the
n north, the Puligadda branch of
a the Kistna on the south and the
2/ sea on the east. For some 26

Kanakalamadugu drain.

0.69 inches from area of 122.61 square miles
2275 cubic feet a second
area 225 square miles.
drainage 0.56 inches from that area
3391 cft. a second

miles the existing drain (Madugu)
is of ample capacity; its extension
northwards to Bodlapad and its
improvement in the last 10 miles
are the requirements provided
for. In the papers different parts
are called by different names
but there appears to be no good
reason for more than one name
throughout from Bodlapad to the
Fort creek. The ultimate area to be
relieved by this drain is 235 square
miles and the dimensions have been
arranged to carry off 0.56 inches
of drainage from the whole area.
The formation of a regular drain
as regards the lower 10 miles is in-
tended to commence at the infall
of the C. Majeru drain with a bottom
width of 152 feet and a depth of
water of 6 feet. In the 3d mile the
Inampudi drain falls in and the
bottom width below the junction is
to be 246 feet. The bed level at the
infall of the C. Majeru drain is at
H.W.L + 0.34 and at the Fort creek - 4.60

or 4.94 feet fall in a little less than 10 miles being at the rate of 6 inches a mile. The bed of the creek is however at - 6.01 and it will be advisable to lay out the drain bed with a uniform slope to this lower level, if the soil be such as to allow of the excavation being carried the 1.40 feet deeper at the lower end, where the ground is not already below that level. The berms are to be 30 feet wide on each side of the drain at the C. Majeru mfall, and 100 feet wide at the lower end. Probably but little work will need to be done so far as Government interests are concerned, except in the lower 4 miles where a free outfall for the Inampudi drainage will perhaps be found requisite but only on a small scale at first and enough to form the embankments on their proper alignment.

The Boddapad extension northwards of the Kanakalamadugu it may be necessary to carry out at an early date to dispose of surplus from the Masulipatam Canal discharged at Kunkipad of the total estimated cost Rupees 1,01,820 of this drain. Rupees 10,350 for the Boddapad extension Rupees 1990 for earthworks above station 20, Rupees 1,760 for one inlet Plan No 6, and half the rest of the estimate or altogether Rupees 57,960 appertain to the Bank Canal and Rupees 43,860 to the Masulipatam Canal the areas in connection with these canals drained being approximately equal so that the cost below station 20 should be divided between them. Any general sanction which may be given to the estimates should not be deemed to convey authority to carry out any part of the Kanakalamadugu drain without the special sanction of Government.

35

Design for Inlets. 20. The designs for inlets to

the drains are generally suitable. Some modification in the wings and wing returns may be made without affecting their efficiency and at some saving of expense.

21 These will be considered in connection with the Masulipatam Canal the lands under which they are to relieve.

Inampudi drain
Vinuntki – do

22 It is intended to improve the drainage of the island of Divi by two principal drains, the Talern and the Gudimotu.

Divi Drainage.

(1) The Talern drain is to start from the lower end of the Machaveram channel, a branch of the Divi north channel, the drainage area above being 2.86 square miles and the discharge required 186 cubic feet a second, will run alongside the Savurnamuki channel for about 2½ miles, and then turn off and follow a low line through a swamp discharging ultimately at 11/8 miles into the Pulejadda branch

Talern drain

of the Kistna near Hamsaldivi. The total area drained is estimated to be 33 square miles – the drainage to be discharged 1.08 inches over the whole area in 24 hours or 960 cubic feet a second. The fall available is from +4.44 to –4.00 at the outfall; the latter level being approximately M.S.L; the drain has been arranged throughout with a bed fall of 6½ inches a mile, the dimensions have been fixed with reference to a depth of 4 feet of water throughout, and at this depth the water will be carried almost entirely within kerb. As the water way is all provided in the drain itself, and as a greater depth of water than 4 feet may at times without inconvenience be allowed, there appears to be no need for leaving berms between the drain and the spoil banks. If these latter be placed on the edge of the drains, as shown on

the sections, there will be ample waterway for even a liberal estimate of ultimate discharge, and if the drain be cut to one third of the full section to begin with, widening can subsequently be carried out as may be found necessary. The rates vary from 1 to 1½ annas a cubic yard. Judging from Godavery delta rates an average of 1 anna should suffice.

Looking to the description of land principally swamp, through which the drain will run the provision for land compensation Rupees 5110 seems large. It will be considerably reduced by the omission of the bridges.

about ¼ ft.

(2) The proposed height of this bridge, 13½ feet to roadway, for a drain carrying 4 feet of water with possibly 6 feet as a maximum, is excessive; abutments 4½ feet high and a piece of 3-feet for the

Mandalaka Kala Bridge

arches will be ample. The abutments can be reduced to 4 feet in thickness at the springing line, and 4½ feet at floor level, and the piers to 3 feet. The wings also can be considerably shortened viz to 17 feet instead of 25 feet.

Outlet sluice at end of drain

(3) The lineal waterway of this sluice is only 18 feet, the bottom width of the drain being 108 feet. The spoil banks of the drain can easily be made higher than flood level in the river and then probably the necessity for any self acting sluice at the end of the drain will be obviated. At any rate the design would need material alteration were any work of this kind considered necessary.

Gudumotu drain

(4) This drain will commence at the lower end of the Bandalaichern branch of the Divi creek channel and run parallel to it Kavarammuki channel for 3 miles it will then take a S.E course and fall into

an existing drainage at 6½ miles.
The total area drained above
this outfall will be just under 21
square miles, the drainage provided
for being 1½ inches from that area
or 703 cubic feet a second. The fall
available is 1.09 feet a mile and
the depth of water 4 feet. The com-
parative cheapness of this drain
is due to ground level being from
⅓ to ½ the depth of water below
the surface of the latter. The berms
shown in the sections are much
smaller than those proposed for
the Salem drain but they may be
permitted with advantage.

(5) The remarks on the cor-
responding bridge for the Salem
drain apply to this bridge also.

Bridge near Mandapeshala

23. There has been discussion
lately extending over a considerable
period as to the way in which the
cost of drainage works in the
deltas should be distributed and
no decision has yet been arrived at

Incidence of cost of drainage

by Government. That the disposal
of surplus irrigation water should
be provided for as part of
the cost of the delta system
of irrigation is clear and were
that all that is required to meet
the wants of the country the arrange-
ments would be simple enough.
Practically however the provision
of drains equal to the discharge
of surplus irrigation water would
leave the country as badly off
as ever for drainage because
these deltas suffer chiefly
from rainfall drainage which
has no proper outlet.
The Bank Canal and the country
connected with it will serve as
well as any other example to show
how the case stands.
The total quantity of water which
this canal has been designed to
carry is 918 cubic feet a second
of which only one fourth or
205, say, cubic feet a second is to

the ri… be utilized above the Poligadda
water… branch of the Kistna. There are
ration… no data available to show the
and i… exact proportion between the quantity
a third … of water supplied to the fields
2 begin… and that discharged therefrom
regn… as surplus but it will probably
Co… may be safe to assume that this surplus
the rate … is not more than ¼th of the total
2 a cu… or in the case of the counting tribe
the Godav… ⅓ drained by the Kanakalamadugu
be of 1 … about 50 cubic feet a second.
look… This drain as designed is to dis-
prim… charge 3542 cubic feet a second of
for which … which about one half, or say 1800
cha… cubic feet a second, appertains to
the Anpu… the country connected with the Band
ar… Canal. It has already been mentioned
conce… that the capacity of this drain
ar… has been arranged to carry off
(2) 2… 0.56 of an inch in 24 hours
abridg… from the whole area drained,
for a dro… and whatever may be shown
of with … ultimately to be the capacity re-
is fo… quired, there can hardly be any
at high…

doubt but that at least half the above capacity will be needed. If so the drainage from rainfall will be to that from irrigation as 900 - 50 to 50 or as 850 to 50 or 17 to 1. Supposing that the land had been all Government instead of all Zemindary the proportion would have been different, because the area of irrigation per square mile of gross area would have been probably much greater, but even then the proportion between rainfall and irrigation drainage would perhaps not have been less than 900 - 50 to 50 or say 10 to 1. Such being the case it would seem to be out of the question to charge the whole cost of main drainage to the Delta system and if so some practical arrangement for its distribution if it is to be undertaken at all appears to be requisite and this distribution can evidently be

most gravely effected in relation
to the area of the intended irrigation
to the total area. It is altogether
impracticable to determine in
any given case what part of a
general system of drainage is
necessary in the interests of irrigation
and if only net financial results
are looked to it might probably
be safely assumed that except in
a few particular localities no
drainage whatever would directly
repay its cost, but it has at
any rate of late years been assumed
that rich alluvial country like
that of the Deltas will be rendered
more favourable for agriculture
generally if its drainage be attended
to and that in one way or another
such improvements will be beneficial
alike to the revenue as well as to the
people. If this assumption be cor-
rect the drainage should be under-
taken, but if it be decided that
such drainage is not required,
on that funds for it cannot
be found the drainage to be
provided for in connection with
the requirements of irrigation
alone will be on a very limited
scale and most of it will consist
in the connection of the irrigated
tracts with the natural water-
courses of the country. These
minor drains will cost but
little. Of late it has been arranged
that on the upper side of every
distributary which in any way
crosses the fall of the country
a drain is to be cut to receive
the surplus of the fields above
and conduct it to a suitable
outfall into a natural watercourse
and then, if main drainage is
to be given up, the arrangements
will end. That they will render
the country generally better fitted
for agriculture is of course
part of the question for the

[illegible] natural water courses as a rule
[illegible] are altogether inadequate to
[illegible] to carry off within a reasonable
[illegible] an in time the waters which they receive
[illegible] and the result at present is
[illegible] 1st That in all seasons of heavy
[illegible] rainfall crops are destroyed
[illegible] and the loss sustained is only
[illegible] in part represented by the
[illegible] remissions granted 2ndly That
[illegible] much low lying land remains
[illegible] altogether unfit for cultivation
[illegible] and consequently is left waste
[illegible] and yields no revenue.

24 The cost of embanking the Kistna on its left side / or rather of completing the present flood bank, which has on several occasions recently, and in 1874 and 1876 particularly, failed to prevent inundation, is, apart from that portion of this work which can be done without extra expense

from the spoil of the Bank Canal and Divi west and north channels, Rupees 62,200. It is proposed to make the flood bank 5 feet above Kistna flood level in the upper part and this margin may without risk be decreased to 3 feet at the lower end of the Divi west and north channels which will reduce the cost of the work to some material extent and probably make the total not more than 5,0,000 Rupees. The question of incidence of cost arises in this case also and widely differing opinions have been expressed upon it. It has been argued that the canals and irrigation works generally are principally interested in these flood banks and in the protection they afford and it may readily be admitted that such works are very much interested in this subject. That they

are the only works or interests involved is however certainly not the case now, whatever it might have been where there were no roads and when the area of cultivation was very limited and its value very small. Irrigation works have in the past contributed far more than their share of the cost of such protective works, for it is believed that nearly all the expense hitherto whether for construction or repair has been borne by them and there appears to be no good reason for continuing to impose upon irrigation the whole charge for works to which exercise an important influence on many interests. Efficient drains for instance cannot be designed, or maintained if an unknown and indeterminable quantity of water from the river be allowed to find its way into them. Similarly the prosperity of the Delta country depends in no small degree upon its communications being maintained in serviceable condition and the same floods which would put a stop to navigation on the canals would render the roads impassable in the tract of country inundated by them.

As in the case of the main drains therefore it appears to be desirable that some principle of distribution of cost of construction and upkeep of flood embankments should be decided upon. The charges cannot be distributed in detail but they may conveniently be divided between the Delta systems and ordinary Agricultural.

Total cost of Bank Canal & of improvements to country under it.

25. According to the revised estimates as given in the classified

abstract shown in para 12 above the probable cost of the canal and subsidiary works will be as follows:—

Main Supply — Works —	Rupees	8,05,445
Distribution — do —	"	1,86,217
		9,91,662
Drainage — do —	"	1,45,960
River floodbanks — do —	"	50,000
	Total	11,87,622

Including other charges for Establishment, Tools and Plant &c the figures become

Main Supply —	Rupees	10,72,210
Distribution —	"	2,52,670
		13,24,880
Drainage —		1,96,130
River floodbanks —		66,500
		15,87,510

Probable results of expenditure Appendix D

26. D. McNeil Campbell in para 17 of his Report and in Appendix E of that report shows what he considers will be the gross revenue derivable from the

Canal. He deduces from information supplied to him by the Tahsildar under orders from the Collector that from the 45,000 acres to be irrigated in Divi a gross increase of Revenue of Rupees 1,89,013 will be obtained and for the 15,000 acres which may ultimately be irrigated in the Zemindaries above Divi he has made no calculation. It appears that the

total area of Divi is —	acres	1,65,467
" arable area — do —	"	67,084
that the waste land fit for cultivation is —	"	36,105
" land cultivated dry —	"	11,955
" average revenue of do	Rupees	25,555
" land cultivated wet —	acres	15,944
" average revenue of do —	Rupees	40,876
" Inams are Dry acres 869 Wet " 2211 —	Assessment Rs.	269
	do — do —	474

The calculation of results of introduction of ancut water might be made in several ways. There is

1st the consideration that the delta lands already irrigated yield a revenue of about 6 Rupees an acre, and if 5 Rupees be taken as the average for Divi the result would be

45,000 acres at — 5 Rupees — 2,25,000
22,084 do irrigated 1 " — 22,084
2,47,084
Deduct present average revenue 67,174
1,79,910

2ndly the water rate being Rupees 4 per acre the receipts on 45,000 acres would be Rupees 1,80,000 which corresponds very nearly with the previous calculation. But at present acres 15,944 of Government land pay Rupees 40,876 or about 2½ Rupees an acre and a more correct calculation might be therefore

29,000 acres at 4 Rupees — Rs 1,16,000
16,000 — do — at (5 — 2½) 2½ do — " — 40,000
1,56,000

3rdly the revenue derivable from Zemindary lands to be irrigated under that first 35 miles of the canal has to be taken into account. The area provided for is acres 15,000 but from para 6 of this Note it will be seen that it will be prudent to take 8,000 acres as the probable area of Zemindary irrigation within a time which need now be taken into consideration. The diminution of outlay on Distributaries involved in this reduction may be however neglected as no accurate estimate of it can at the moment be formed. With a water rate of 4 Rupees an acre this item of Revenue will be Rupees 32,000 Taking then the lower figures in the 2nd method of calculation above the gross revenue will be Rupees 1,88,000 The deductions to find net revenue will be

Maintenance

Maintenance charges at 10 annas
an acre on 60,000 acres Rs. 37,500
Establishment charges on do. 25 per cent " 9,375
Loss of revenue on lands occupied by works 2800 acres
at 2 Rupees an acre —— 5,600.

This is Lt. Campbell's calculation, but it is probably excessive because a large part of the land will be Zemindary and the loss of revenue on its occupation will be very small.

Cost of revenue collections at 9 per cent — 16,920

Total deductions 69,395

Net revenue Rupees — 1,18,605

Supposing the drainage works to cost the amount estimated, and one fourth of that cost to be charged to the Bank Canal; also one half the estimate for the river embankment, the Capital outlay will be about as follows:—

16,0

Main

Main supply and distribution Rs 13,24,680
Drainage —— 98,065
River flood banks —— 33,250
14,56,195

to which should be added
loss of revenue during construction on lands taken up 22,400
Huts for labourers —— 10,000
Unforeseen Expenditure — 20000 52,400
15,08,595

Simple interest on 11 lakhs expended
at the rate of 2 lakhs a year —— 1,80,000
Total 16,88,595
Say 17,00,000

991,662
36,490
25,000
10,53,152
Say 11 lakhs

45960 / 4 / 10000 / 2

on which sum the net return will be 7 per cent. The simple interest charge has been calculated on the supposition that the canal will be completed in 6 years but the actual time will depend upon circumstances many of which may not be within the control of the Irrigation department. If ken the approximate general Abstract of Financial Results of the Kistna Delta System dated 19th June 1876

Pub. G. No. 1926
dt. 28th July 1876.

which shows a net return of 15.48 per cent on past expenditure on the Delta systems up to the end of 1874-75 be of any value, it would seem to be reasonable to expect that the Bank Canal will not be remunerative.

27. The west side channel of this canal will irrigate the part of subsection 1 lying between the canal and the Kanakhlama-dugu drain, and the proposals in regard to this canal have now to be noticed. In para 23 of his report on the 1st subsection Lt. Appendix No 2 Merril Campbell refers to his proposal to supply the westside channel from the Bank Canal instead of from the Masulipatam Canal at Kantipad and to the greater economy and advantage of the former arrangement. He notices also that his arguments in favour of the arrangement pro-

Masulipatam Canal

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passed by him had not been answered but he appears to have lost sight of the discussion which took place when the undersigned visited the Delta at the end of 1873 and when the subject was fully considered, as also of the remarks made in the Notes of Inspection of that tour. The reasons for using the Masulipatam Canal as the source of supply for about 12 miles instead of 3½ miles are

1st That it is by no means clear that it would be cheaper to make the Bank Canal the source of supply

2nd That by taking off the W.S. channel from the Masulipatam Canal no expenditure need be incurred until the demand for water exceeds the supply which this Canal can carry without widening; and the land being all Zemindary the ultimate demand is problematical, while the present demand is much below

the supply available.

3rdly That it is desirable to arrange for this canal carrying as much water as it can be conveniently adapted to convey.

It is necessary to remark that it is because the spoil banks of the Masulipatam Canal are somewhat close to the canal margin, widening beyond a certain limit would be expensive, and that Lt. Campbell was mistaken in his views as to the arrangements necessary to enable this canal to carry the supply required.

Area commanded.

28 The area commanded is 399.35 square miles or say 256,000 acres. Of this area 96.92 square miles or 62,029 acres are commanded by the west side channel.

Present & proposed ultimate extent of Irrigation

29 The present (1873/74) area of irrigation is —— acres — 38,012
of which the area under the west side channel is — " — 6,838
The proposed ultimate area is acres 127,500
of which that under the west side channel will be " 28,000

General arrangements.

30 The general arrangements of the Canal are described in Lt. Campbell's letter dt. 65 of the 7th September 1875, and it will be seen that it is intended to carry water for irrigation only as far as the Kunkipad lock at the beginning of the 13th mile the rest of the canal to Masulipatam being converted into a still water navigation.

Required capacity

(1) The required capacity of the canal above Kunkipad would be 1912.50 cubic feet a second distributed as follows.

Bank canal	60,000 acres	900 C. ft. a second	
Pullern	33,500 — "	502.5 — "	
West Side Channel	28,000 — "	420 — "	
Direct irrigation	6,000 — "	90 — "	

Appendix 4. A

The water distribution statement shows 2001 cubic feet a second as the discharge of the canal in this reach

but the formula used is believed to give a higher velocity than the time.

(2) For the first 3½ miles to head of Bank Canal the surface and bed falls will be 0.33 feet per mile, the bottom width 100 feet at head and 115 immediately above the offtake of the Bank Canal, the depth of water being 8 feet. Below this point the bottom width will be 61 feet, the surface fall will be continued at 0.33 feet a mile, but the bed fall will be reduced to 0.215 feet a mile, and the depth at the lock will be 7 feet; the bottom width being 76 feet.

Particulars of fall & dimensions of 1st reach.

(3) The desired bottom width of canal below Kumkipad lock is 25 feet which would give a minimum width at water surface of 40 feet, but a considerably greater width in the lower parts of each reach. Practically little or nothing

Reaches below Kumkipad

will need to be done in this part of the canal in the way of earthworks beyond raising the banks in places, for though the canal bed is shown in the section as running from the lower sill of one lock to the upper sill of the next, all that will be necessary will be to keep the bed not higher than from the lower sill of one lock to 6 feet below water surface at the upper end of the next lock.

Work to be done in 1st Reach
m. ch.
Head to 12. 13½

31 The work to be done here is entirely earthwork. The estimate shows that the cost of widening to the head of the Bank Canal will be _____ Rupees 1,16,745. 12. 0

Smidries — " — 5834. 4. 0

1,22,580. 0. 0

and thence to the end — 52080. 0. 0

Total Rupees 1,74,660. 0. 0

It further appears that of this latter sum the proportion appertaining to the Canal, Pattern, and

t Westside channel respectively
t may be taken to be according
t to the intended increase of irrigation
under each and this will be ap-
t proximately as follows.—

	Present	Intended	Increase
p Mahtliptam Canal	*3,000	6,000	3,000
a Pillern	28,174	93,500	65,326
th Westside channel	6,838	28,000	21,162
th	38,012	1,27,500	89,488

* assumed - not stated in the papers.

Re Consequently the share of the
w Westside channel will be say
w one fourth, or Rupees 13,000 in
w round numbers, and it would
re seem therefore that there could
th have been but little room for
fu effecting any material saving by
adopting the Bank Canal as at
of can first proposed by Lt. Campbell
is 25 fu as the source of supply of the
minimum Westside channel.
of 40 fut, w
width in the estimate are 3 annas a cubic yard
reach. Spac for the 3½ miles to
Bank Canal and 2½ annas below that point. Looking to the depth of the cutting and to the height of the present spoil banks these rates may not be excessive, but it is believed that similar work on the Ryves Canal new head close by has been done at lower rates.

2nd to 5th Reaches.
2m. 16ch. to 49m. 13ch.

32 The proposal is to convert this part of the canal into a still water navigation, the cost of so doing being estimated as follows.—

Earthwork	—	Rupees 12,000
Alteration of Viranki lock	— " —	890
New lock at Nedaonole	— " —	25,330
Alterations to Anikumaram lock	" —	240
Raising Chintagumtapalem bridge	" —	180

The object is to improve the navigation by ensuring a minimum depth of water of 5 feet, and to reduce cost of maintenance by ceasing to carry irrigation water at a low velocity which in this delta involves

the deposit of much silt. The present tedamole lock is reported to be in very bad repair and the chamber walls cracked so it is not considered advisable to retain it and to subject it to the pressure of an increased head of water of about 3½ feet. Before however finally deciding on its demolition it will be well for the Superintending Engineer to ascertain whether the cracks are of any real importance and whether were it opened out and strengthened by a backing of concrete or otherwise its retention might not be arranged for without risk. As already mentioned unless to find earth for the banks, it will not be necessary to lower the present bed below 6 feet from the revised water surface.

(1) The proposed conversion of the canal into a still water navigation will not prevent its use as a duct for the supply of irrigation water to the west side channel and its branches either temporarily or permanently. When there is no water wanted for irrigation the surface may be held up to a dead level, but at any rate until the demand for water under the W. S. channel becomes such as to make it desirable to introduce the revised arrangements for its supply, it will be economical to convey water for that irrigation by the canal and the existing lock weirs which are to be retained will with slight alterations enable water to be passed down in sufficient quantities for probably a good many years to come.

Canal may still be used for irrigation

Virantic lock alterations

(2) It is questionable whether it will be practicable to scarf the heel posts of the gates effectually. At any rate the arrangement shown

in the drawing would not do.

(3) Before the working drawings are prepared the designs of some of the more successful locks recently constructed in the Godavery delta may with advantage be studied. The following details appear to require further consideration at any

Tadamole new lock
Plan No 14 of B.

a- the side walls of the chamber are too slight: the depth of water above the springing of the invert will be 16 feet and the mean thickness is 4.7½ whereas 5⅓ feet is as little as is safe.

b- the thickness 3 and 2½ feet of the side walls of the side culverts is too small. On the other hand the thickness of the wall above the lower culverts can be reduced materially by giving a more abrupt batter to the back of this wall from about 2 feet above the crown of the arch.

c- the invert to be of value must have a greater versed rise than

Circular No 33
Drawing No 3 - vide also Circular No 33/1

1/20: the springing line might be placed 1 foot higher which would make the versed rise 1/10π. Inverts are not now generally found requisite.

d- Wooden sill bars should be provided for the gates.

e- The gates of the lower culverts should be worked by double purchase rack and pinion gear.

f- Lock gates have in the Godavery been of late made much lighter than formerly and without any diminution of efficiency - drawings can be obtained from the Rajahmundry workshops.

Tadamole lock site plan.

(4) The lower wing returns of the new lock will be about 108 feet above the upper wing returns of the old lock: it will therefore be practicable if the new lock cannot be completed during the closure of the canal for one season to arrange for making the old lock available

for all boats which commonly use the canals of this Delta and their convenience should be seen to.

(5) It has been found in the Godavery delta that the minimum prescribed headway of 11 feet is of inconvenient and as the cost of altering this bridge will be extremely small it will be better to raise the roadway 2 feet instead of only 1 foot as proposed. Including approaches 400 Rupees may be taken to be required.

Chintagumtapalem bridge

33 The following is a classified abstract of the estimates for the Masulipatam Canal.

Abstract Estimate classified.

Position mile	Position chains	Particulars	Sub heads	Mainhead Main Canals & branches Rupees	Totals of Subheads Rupees
0	0				
3 to 5	40	Widening Canal	L. Earthworks	122,580	
12 to 13½		——do——	——do——	52,080	174,660
12	16	Improving Canal	Irrigation works	12,000	
49	13	Altering Viranki lock	——do——	890	
24	6	Kodumuru lock (new)	——do——	25,330	
36	50	Altering Kukkumaru lock	——do——	240	
42	73	Raising Chintagumtapalem bridge	——do——	400	
46	16				38,860
					213,520
		Establishment 25 per cent			53,380
		Tools & Plant 8	——do——		17,080
					263,980

Probable returns on outlay

34. It is almost impracticable to estimate the returns on the outlay proposed on this canal for the following reasons.

1st This canal will supply the Bank Canal entirely as also the west side channel irrigation.

2ndly it will supply in part the Pullerw, the other source of supply of which is Ryves Canal. The general items of cost might be distributed were it known what the present water carrying capacity of the several canals is with any precision, but they are in the first place irregular and secondly the distribution is so incomplete that the water supply now afforded is by no means in direct proportion to the acreage. There will be it is expected 68,320 acres of additional irrigation under the Masulipatam Canal apart from the Bank Canal and the west side channel, but even if the cost of

widening due to the water to be carried for that canal and distributary were to be calculated and deducted, the revenue on the increased area could not be compared with the outlay on the production, because most of the water will be turned into the Pulleru, and so many canals and distributaries as and the estimates for these in part 400 but not wholly must be taken into account. It will be better therefore to postpone consideration of the returns from the Masulipatam Canal until the estimates for the 3rd and 5th subsections have been reviewed but in order that conclusions may then be arrived at the estimate for the Masulipatam Canal may be divided between it and the Bank Canal and the Masulipatam Canal as follows.

Position		Chains
miles		
0	C	
3	40	W
12	13½	
12	16	Im
49	13	All
24	6	
36	50	Ke
42	73	All
46	16	Ra
		bri
		Es
		J

Distribution of Estimate to several Canals supplied.

(1) Cost of Canal to 3½ miles. Rupees 122,580

Divisible between

Bank Canal 60,000 acres.

Masulipatam Canal

including Pullerw. 68,326 do (increase)

West side Channel 21,162 do (-do-)

149,488

Shares Bank Canal $\frac{60}{150} = \frac{20}{50}$ Rupees 49,032

* including Pullerw. " Masulipatam Canal $\frac{69}{150} = \frac{23}{50}$ " 56,387

" West side Channel $\frac{21}{150} = \frac{7}{50}$ " 17,161

Cost of Canal from 3½ miles to end of 1st reach Rupees 52,080

Divisible between

Masulipatam Canal 68,326 acres

West side Channel 21,162

89,488

Shares Masulipatam Canal $\frac{69}{90} = \frac{23}{30}$ Rupees 39,928

West side channel $\frac{21}{90} = \frac{7}{30}$ " 12,152

Cost of Canal below 1st reach Rupees 38,860.

This is a navigation charge but the navigation receipts from any particular canal are not determinable the licences being issued for the navigation of the whole of the canals of the Delta. It will be necessary therefore to consider it as a debit to the Masulipatam Canal

in connection with the 3, 4 and 5 subsections. It follows then that the proposed outlay on the Masulipatam Canal amounting for

Works to _____ Rupees 2,13,520

is distributable to

p. 1st Subsection Bank Canal — Rupees — 49,032

in 3,4&5 — do — Masulipatam — do — " — 1,35,175

al 1st Subsection West side channel — " — 29,313.

35. The review of the estimates for this channel will complete the notice of the irrigation of the 1st subsection. Its head will be as at present just above the Kunkipad lock at the end of the first reach of the Masulipatam Canal.

West side channel of Masulipatam Canal

(1) The area commanded is 96.92 square miles of which 76 square miles are reported to be Zemindary.

Area commanded

(2) The present area of irrigation (1873-74) is acres 6,836 and the ultimate area provided for in the estimates is acres 28,000 or 289 acres to the square mile.

Present & prospective extent of irrigation

36 At Campbell gives in para 20

Estimated velocities of currents for the Godavery

Position		Cusecs
miles		
0	0	
3	40	
12	132	
12	16	
19	13	
24	6	
36	50	
42	73	
46	16	

Appendix No 2 of his report on the 1st subsection a sketch of the present sources of irrigation and shows that they are very defective and he notices also the want of drainage, but there is no room for doubting the capability of the Masulipatam Canal and of the partially completed side channel to supply a far larger acreage than that for which water has hitherto been demanded. From para 21 of the same report it will be seen that in 1866, an estimate amounting to Rupees 49,860 for the construction of this side channel was sanctioned and that the work was stopped in 1871 and a revised estimate called for; that the whole of the excavation as far as Ankamarru, 43rd mile, was done in "a part of way", but that silting and the growth of weeds have almost obliterated parts of the channel; that the original estimate did not allow for any branch channels and provided only Rupees 1,200 for sluices,

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that 3 vents of the lock weir at Kunkipad were converted in 1869 into a head sluice for the channel and that some materials were collected for some minor masonry works the expenditure on these two last items having been apparently provided for from the sanction for earth work. It further appears that originally 42,000 acres were expected to be irrigated under this channel but that the village accounts showed only 12,000 acres with a possible addition of 4,000 more or together 16,000 acres; it is to be noticed however that the whole area of this tract of country was then supposed to be only 65 Rykare miles, and probably a larger number of villages are interested in the project as now drawn up. Dr Campbell's report is silent as to the data on which he has assumed that there is a probability of 28,000 acres being irrigated. There is for instance no statement like that given for the Diri irrigation, and

For particulars of expenditure see Appendix No 2. J.

vide also Notes of Inspection paras 23 & 24 in Bnl. 10th March 1871 No 722

Appendix No 2 E

in the case of Zemindary lands such information is even more necessary than for Government villages.

Particulars of Channel Earthworks.

37 The intended arrangements of the channel when completed have had to be adapted to the work already done under the sanction of 1866. The following are the principal details as shown or deduced from the longitudinal section.

Positions From Miles	Chains	To Miles	Chains	Reaches	Fall per mile Inches	Bottom width Feet	Depth of Water Feet	Discharge Cubic Feet a second	Mean Velocity Feet a Second	Remarks.
0	0	2	23½	1st Reach	7	25	6	420	2.06	Drop 3 feet.
2	23½	9	77⅓	2.d do	10	20	6	420 416	2.41	Drop 2 feet
9	77	13	4	3.d do	7	25	5½	416 364	2.13	Regulating bridge
13	4	24	34	4th do	7	25 18	5	312 209	1.80	Drop 3.78 feet.
24	34	30	34	5th do	7	15. 4½	3	87		
30	34	34	24½	do	8	4½ 8	3	57		Escape into drain

See remark on 01/101 Sheet No 4

The 4th reach is noted as having been already excavated. It would have been better had the channel been made of less width with a greater

bed fall and then no drop at the lower end would have been required. The actual discharge of the channel as excavated would if no alteration of arrangements were made in many parts greatly exceed the quantity required and with that quantity admitted to the reach the depth will manifestly be less than 5 feet supposed. What is necessary therefore is.

1st That a depth approximating to that required for the proper discharge should be fixed

2nd That this depth and not that shown on the longitudinal section should be taken into account in arranging for the supply of the branch channels.

3rd That the waterway should be restricted to the proper cross section.

With attention to such details the channel notwithstanding the irregularities of construction which it exhibits may

be made fairly effective.

Arrangements in connection with limited acreage.

38 During the probably long time which will elapse before anything like the contemplated ultimate area will be irrigated it will be necessary to provide for the effective irrigation of smaller areas without sending an excessive supply down the channel.

Width to be restricted to what is necessary

(1) Where the channel is now of less width than the full section, no widening should be carried out until required.

Masonry Works.

(2) The drops or falls, the bridges &c must be built of the dimensions suited to the full section of the channel, but the crests of the former should be contracted with brickwork built on the permanent crests so as to reduce the waterway and maintain the desired water surface level above. Enlargements can then be made from time to time without

difficulty and at a nominal expense.

Water levels in Machilipatam Canal & in W. S. Channel.

39. In order to see how far the Machilipatam Canal can for the present be made to supply the irrigation under the west side channel and to provide for its extension at each mouth the demand becomes much increased it will be useful to compare the water levels at a few points. First there are the two principal branches of the side channel

	Water levels in W.S. channel	Machilipatam Canal	
Medur branch channel	30.60	33.00	4000 acres
Bhimadi — do	26.00	21.00	6000 do

The Medur channel can be therefore effectively supplied from the Machilipatam Canal in the 22nd mile, but the Bhimanadi channel if supplied from that canal must be so supplied through the side channel from a point about the Nanki lock which is at the beginning of the 25th mile, or about 1000 yards above the proposed head of the Bhimanadi channel.

Similarly the Chinna Mutiv branch needs a water level of 16.70 at its head and the canal water level is 21.00 so there is plenty of command.

Such being the case the reality of the demand for water can be tested before any considerable expenditure is incurred in adapting the side channel for a large acreage.

Madawaj Works W.S. channel

Head sluice

40 The proposed masonry works are

(1) At Campbell shows that the present sluice of 9 vents of $2\frac{3}{4}$ by $2\frac{3}{4}$ feet is inadequate, and he proposes to adapt an additional part of the old lock weir to the supply of the side channel at a cost of 3580 Rupees. All however that seems to be necessary is to make this

points of the present sluice 5 feet high instead of 2¾ feet. A comparatively small sum will suffice for this alteration, but it is difficult to make out from the drawing what the present sluice is like. Probably 1,500 Rupees will do all that is needed.

(2) The design of this work is not suited to a discharge of 420 cubic feet a second with a depth of 6 feet of water. The drop should be of masonry and the level and length of creek should be adapted to the maintenance of the water surface in the 1st reach at the proper level. The cost of a suitable fall will probably be 1,200 Rupees.

Rough stone drop at end of 1st reach

(3) The waterway of the bridge is 120 square feet against 174 square feet in the channel. With a full supply in the channel there would be a head of 1¾ inches and erosion of the banks below would probably follow. Looking however to the improbability of the full discharge being required the design may be accepted; otherwise a span of 24 feet instead of 20 feet would have been necessary. A slight addition to the weight on the lower part of the arch will be desirable.

Vallon Road Bridge
In ch.
6.12

Drop at bridge end of 2nd reach
In ch.
9.77

(4) The waterway is too great viz 775 cubic feet a second against 342 cubic feet required. These works should not demand special regulation with a normal discharge of the channel. Either the creek should be raised or its length shortened. The latter is the cheaper arrangement but would involve a high velocity below. The front wings are short allowing slopes of barely 1 to 1 which must be reverted to be stable. The rear wing curves should be rather flat and should be struck from a centre on the outer line of the rear retaining wall.

be (5) The wings are conciderably Bridge Vezanki
the longer - 10 or 12 feet than is necessary m. ch.
g and it will be more economical 12. 0
ap to slope the roadway from 6
wi feet on either side of the centre
en of the bridge. The estimate may
g be reduced to Rupees 3,000.

g (6) The design is that of Plan Regulating bridge
as No 14 and requires material modi- m. ch.
wi fication as that bridge has been 13. 4
f designed for a different width
th of channel.

(7) The design provides only Bridge Pamunuwa
th 84 feet of waterway against 182½ 18. 30
s feet in the channels and this
reduction is too great. 2 spans
s of 15 feet each would do and
s would probably not cost more
or but a trifle more than the
b estimate as the masonry taken
out of the abutments would suffice
h nearly for the piers and the roadway
p would be 18 inches lower. The wings
a should not be made ——— longer
a than is needful for 1½ to 1 slopes with

Bridges Plans Nos 16 & 18
m. ch m. chs m. chs.
21.31, 24.34 & 20.74

Branch channels 41 The branch channels from the west side channel will be numerous. They are as follow;-

Vallavi channel
m. chs
5. 65

(1) Acreage 1200 - length 1 mile - Earthworks Rupees 360. Apparently the subsidiary arrangements for supplying water to the fields will exceed in extent the secondary distributary itself, the land to be watered being it would seem a strip about 3½ miles long between the Kanikalamadagn drain and the west side channel. It is doubtful whether the ryots will be prepared to make the long field channels which would be required and it will be advisable therefore to provide Rupees 500 for minor distribution channels.

Medwa Channel
m. ch
9. 40

(2) From the cross sections

say 2½ feet added.

(6) Somewhat similar remarks apply to these bridges.

it would seem that at the heavy cutting shown in the longitudinal section in the first mile and a quarter there is an old channel of dimensions in excess of those required. The length is 12 m. 20 ch. The bed level at head 24.6 and at tail 5.5 and the bedfall throughout is shown as 7 inches a mile and the mean velocity 1.43 feet a second in the upper part and 1.26 at the lower end. Considerable saving in earthworks and probably in masonry also will result from increasing the bedfall sufficiently to obtain a velocity of 2 feet a second and by placing the bed at a level which will make the cutting about provide the banking. The depth of water is to be 3 feet and if the tops of the banks be made 18 inches above water level instead of 3 feet as shown on the sections a further saving will be effected.

† Appendix 2-G

51

Meerwy works

The banks should be placed so as to confine the waterway to the proper section.

(2a) Such remarks as are necessary have been noted on the plans. The modifications needed will not affect materially the cost of the works.

Kistnapuram branch channel.

(2.b.) The banks should be placed so as to afford the proper waterway only. There is no need to make them 3 feet above W.L. 1 foot or 1½ feet at most will suffice.

Gudapad branch channel.

(2.c) The depth of cutting shown on longitudinal section indicates that it would be better to place the head somewhat lower down on Medur channel. For position and height of banks see (2.b).

Vemallamada branch channel

(2.d) The bedfall might be somewhat increased with advantage from ¼ miles. For position and height of banks see (2.b).

Bhimanadi Channel 9m. 10.2ch

(3) This channel directly and by

it wou... its branches is to irrigate 6225 cutting acres. The bed level at head is to section be at 20.5 and at tail 4.53 the quarter length being 15. 30 m. ch. The bed fall of dimshown in the section is 7 inches requires a mile throughout and the mean The bed velocities are 1.43 to 1.26 feet a second. at tail The cost of earthworks may be out is much reduced by and revising the bedfall so as to second obtain a velocity of about at the 2 feet a second.

2ndly reducing height of banks in ear... from 3 feet above W.L to 2 feet maso... in the first 8 miles and to 1½ increa... feet below that to ple... 3rdly by placing the banks close to a rec... the channel. bed... These alterations will also reduce make... the cost of masonry works and the b... of land. is to ... of th... abou... 3 fee... a fur...

(3.a.) The necessary remarks have been noted on the plans.

Masonry bridges

Agakodu branch channel

(3.b) The ground levels noted on the section of this channel and on that of the Bhimanadi channel differ materially. There appears to be no reason for dropping the bed at the head and the bed fall should be about 2 feet a mile which will give a velocity of 2 feet a second. No drop at 1 mile will then be required.

Kasar north branch channel

(3.c) Ground levels differ. A bed fall of 2 feet a mile should be substituted for 7 inches; the bed at head should correspond with that of the channel of supply, and the banks should be altered as noted in (2.b) above.

Kasar south branch channel.

(3.d.) The bed fall is very small and at any rate the drop of 18 inches should be omitted and the bed fall increased by 6 inches a mile; but seeing that water level in the Enampudi drain will be lia-

ble to be considerably above that in the channel no further lowering of the bed would perhaps be convenient, though in the lower part of 2nd and beginning of 3d mile it would be better somewhat lower. The design for the tail escape is that given on Plan D! No 23 and it will be necessary to add a swing shutter to exclude drain water.

(3.e) Similar remarks to those in (3.d) apply to this distributary. *Mallampalli branch Channel.*

(3.f) The bed fall of this channel, 7 inches a mile cannot be conveniently increased. The position and height of banks should be revised as noted in (2.b.) except that the banks in the lower part should be horizontal and 3 feet above W.L at end which corresponds very closely with W.L in Enampudi drain into which the channel tails. *Cocanada branch Channel.*

32

Gundakuduru branch channel.

9/1-7

Lankapalli branch channel.

(3.g.) The drain water is higher than channel water at the tail but so slightly as to be unimportant. The remarks on banks of (3.f.) apply.

(3.h.) Acreage 250. Earthworks Rs 565
Land — " - 170

on both a reduction will be feasible. 1st by selecting an offtake somewhat higher up the Bhimanadi channel and running the branch in 2 feet cutting, with banks 18 inches* above W.L and 2 feet wide at top. The quantity of earthwork will then be about 3430 cubic yards against 9,610 cubic yards in the estimate. 2ndly the land provided for in the estimate is 8.5 acres or 17 yards in width on the average: the channel should be about 9 feet, and the banks 6½ feet wide each or 22 feet altogether, add 2 or 3 feet for side cutting for making up banks and the total width would be 25 feet, so that 33 feet at most would be ample as an estimate

† ⅛ of a mile would seem suitable.

* this gives a thickness of 6½ feet of bank at W.L

provision, and 100 Rupees instead of 170 will be sufficient. 12 feet in width will be rendered unnecessary by the omission of berms. Rupees 350 instead of 735 should suffice for this channel, but to this about Rupees 75 will need to be added for regulating the heads of field channels so the entry may be 425 Rupees.

(4) The omission of berms and the reduction of the height and width of banks are points requiring attention. The length of the channel is 57⅛ miles: bed level at head 20.5 and bed and ground level at tail 12.09 and 12.06 and may be lowered to 11.00. Then the fall will be 9.5 feet which will give an average of 1.61 feet a mile, and this may be distributed so as to make the fall 3 feet in the upper miles about 1⅓ feet a mile and drops will be needed.

Pedasanagilla Channel m. 14. 61 ch.

Vuruttur Channel m. 16. ch. 65

Chinna Mutturi Channel m. 19. ch. 15

Nebhanpudi Channel m. 20. ch. 15

Nemmaluru Channel m. 23. ch. 35

Ramanapettah Channel m. 26. ch. 15

Polaveram Channel m. 26. ch. 5

Akumarru Channel m. 31. ch. 25

Rudvaram Channel m. 32. ch. 15

Gundupalem Channel m. 33. ch. 15

Battapanumaru Channel m. 12. ch. 55.

(5) It is not necessary to notice for each of these channels the modifications needed. The foregoing remarks will have indicated sufficiently clearly what alterations are desirable or necessary and in all some material saving can be secured. It is not at all apparent why generally a bed fall of 7 inches a mile has been adopted seeing that frequently this small slope would render drops necessary as well as place the bed on an inconveniently high level from an economical point of view and this has been done even where there is an existing channel with a better fall than that proposed. The reduction of the estimates may be taken as about one fifth, it will probably be more.

Masonry Works

42 On a sufficient number of the plans of the masonry works notes have been made to indicate the scope of the modifications requir

It should also be noted that the estimate for the subsidiary channels and branches is enclosed.

Position miles	chains	Particulars	Sub heads	Main heads: Distributaries: Original	Distributaries: Revised	Distributaries: Total of Subheads & Channels	Arrangs & Protective Works: Original	Arrangs & Protective Works: Revised	Arrangs & Protective Works: Total of Subheads & Drains	Remarks.
		Kotair North branch Channel	B. Land	150	100	100				
		Head Sluice	C. Works	575	400					
		Drop at 1 mile	do	395	—					
		Tail Escape	do	520	520	920				
		Channel	L Earthworks	800	640	640				
		Kosur South branch Channel	B. Land	710	300	300				
		Head sluice	C. Works	520	520					
		Drop at 1 mile	do	485	=					
		Tail Escape	do	575	525	1045				
		Channel	L Earthworks	2570	2000	2000				
		Mallampalli branch Channel	B. Land	710	400	400				
		Head Sluice	C. Works	505	505					
		Drop at 1.40	do	465	—					
		Tail Escape	do	460	470	975				
		Channel	L Earthworks	3360	2700	2700				
		Pussadam branch Channel	B. Land	670	400	400				
		Head Sluice	C. Works	540	540					
		Tail escape	do	600	600	1140				
		Channel	L Earthworks	3060	2460	2460				

Unified abstract of Estimate for the Kukkaidu with its branches to end

Projection		Particulars	Subhead	Main Heads: Distributaries: Original	Revised	Totals of Subheads & Channels	Drainage & Protective Works: Original	Revised	Totals of Drains	Remarks
Miles	Chains									
5.	65	Vallur Channel	B. Land	150	150	150				
		Head sluice	C. Works	365	365					
		Tail escape	do	550	550	915				
		Channel	L Earthworks	210	210					
		Minor channels	do	—	500	710				1,240 acres
		Total Vallur Channel		1,275		1,775				
9.	40	Medur Channel	B. Land	1,700	1500	1,500				
		Head sluice	C. Works	575	580					
		Drop (No 25) 2nd mile	do	460	460					
		drop (No 26)	do	495	—					
		Bridge (No 27)	do	1,570	1,570					
		Drop (No 29)	do	450						
		do (No 30)	do	465	1000					Two drops with an increased bedfall will probably suffice instead of 5.
		do (No 32)	do	445						
		do (No 34)	do	430						
		Tail escape (No 35)	do	640	640	4250				
		Channel	L Earthworks	11,490	9190	9190				
		Thirtnapuram branch Channel	B. Land	330	200	200				
		Head sluice	C. Works	450	450					
		Tail escape	do	370	370	820				
		Channel	L Earthworks	1500	1200	1200				
		Kundapad branch Channel	B. Land	570	250	250				
		Head sluice	C. Works	495	495					
		Tail escape	do	390	390	885				
		Channel	L Earthworks	1,850	1500	1,500				
		Vemallamada branch Channel	B Land	420	210	210				
		Head sluice	C. Works	530	530					
		Tail escape	do	550	550	1080				
		Channel	L Earthworks	1870	1600	1,500				4,000 acres.
		Total Medur Channel		28045		22585				
10.	20	Rhimanadi Channel	B. Land	2960	2600	2,600				
		Head sluice	C. Works	1120	1120					
		Drop at 2 miles	do	570	—					
		Bridge 5th mile	do	1,950	1,700					
		Drop 6th do	do	595	—					
		do at 8 miles	do	570	—					
		Tail escape	do	530	530	3350				
		Channel	L Earthworks	13,870	11000	11,000				
		Ajakodu branch Channel	B. Land	—	—					
		Head sluice	C. Works	520	400					
		Drop at 1 mile	do	380	—					
		Tail escape	do	650	650	1050				
		Channel	L Earthworks	4,220	1000	1,000				

Position Miles	chains	Particulars	Subheads	Main heads: Distributaries: Original	Distributaries: Revised	Distributaries: Totals of Subheads & Channels	Drainage & Protective Works: Original	Drainage & Protective Works: Revised	Drainage & Protective Works: Totals of Subheads & Drains	Remarks
		Kotur North branch Channel	B. Land	150	100	100				
		Head Sluice	C. Works	575	400					
		Drop at 1 mile	do	395	—					
		Tail Escape	do	520	520	920				
		Channel	L Earthworks	800	640	640				
		Kotur South branch Channel	B. Land	710	300	300				
		Head Sluice	C. Works	520	520					
		Drop at 1 mile	do	485	—					
		Tail Escape	do	575	525	1045				
		Channel	L Earthworks	2570	2,000	2,000				
		Mallampalli branch Channel	B. Land	710	400	400				
		Head Sluice	C. Works	505	505					
		Drop at 1.40	do	465	—					
		Tail Escape	do	460	470	975				
		Channel	L Earthworks	3360	2700	2,700				
		Pneadam branch Channel	B. Land	670	402	400				
		Head Sluice	C. Works	520	520					
		Tail Escape	do	600	600	1140				
		Channel	L Earthworks	3060	2460	2460				

Position Miles	chains	Particulars	Subheads	Main heads: Distributaries: Original	Distributaries: Revised	Distributaries: Totals of Subheads & Channels	Drainage & Protective Works: Original	Drainage & Protective Works: Revised	Drainage & Protective Works: Totals of Drains	Remarks
			B Land	9050	9000	9000				
0	0	Head Sluice	C. Works	3580	1,500	--				
2	26	Drop - Bodlapad	do	330	1,200					
6	12	Bridge - Nallur Road	do	2410	2,410					
9	77	do & drop	do	2800	2,800					The mileage of these bridges given in the book of earthwork estimates is incorrect.
12	6	Bridge - Virankti	do	3,535	3,000					
13	4	do - Regulating	do	2,320	3,000					
18	30	do - Samuvrm	do	2,410	2,450					
21	31	do - Tugbaveram	do	2,400	2,400					
24	34	do - Kedumole	do	2045	2,045					
24	77	do - Tarakatur	do	1,620	1,620					
34	25	Tail Escape	do	505	505	23170				
		Channel	L. Earthworks	65040	65040	65040				
		10 Cattle crossings	A. Miscellaneous	3770	3770					
		Bench mark stones	do	173	246	4136				28,300 acres.
		Total head side channel		102,265		101346				

		Gendakudiveru branch Channel	B. Land	570	350	350				
		Head Sluice	C. Works	450	450					
		Tail Escape	do	420	420	870				
		Channel	L Earthworks	3280	2,630	2,630				
		Sankapalli branch Channel	B. Land	170	100	100				
		Head Sluice	C. Works	470	470					
		Tail Escape	do	450	450	920				
		Channel	L Earthworks	505	220	220				
		Total Bhimanadi Channel		48806		37070				6000 acres included in sluice for Bhimanadi Channel
12	55	Bathupanamaru Channel	B Land							
		Head Sluice								

Position Miles	chains	Particulars	Subheads	Main heads: Distributaries Original	Distributaries Revised	Distributaries Totals of subheads & channels	Drainage & Protective Works Original	Drainage & Protective Works Revised	Drainage & Protective Works Totals of drains	Remarks
1	2			3	4	5	6	7	8	
0	0	Head Sluice	B Land	9050	9000	9,000				
2	26	Drop - Bodlapad	C. Works	3580	1,500					
6	12	Bridge - Nallur Road	— do —	330	1,200					
9	77	— do + drop	— do —	2410	2,410					
12	6	Bridge - Viranki	— do —	2800	2,800					
13	4	— do - Regulating	— do —	3,535	3,000					The mileage of these bridges given in the book of earthwork estimates is incorrect.
18	30	— do — Samavaram	— do —	2320	3,000					
21	31	— do - Tagbaveram	— do —	2410	2,450					
24	34	— do - Kedumole	— do —	2400	2,400					
24	74	— do - Tarakatur	— do —	2045	2,045					
34	25	Tail escape	— do —	1800	1,800					
		Channel	L. Earthworks	565	565					
		10 Cattle crossings	C. Miscellaneous	65,040	65040	23170				
		Bench mark stones	— do —	3,790	3,790	65,040				
				173	346	4136				25,000 acres.
		Total West side channel		102,268		101,346				
		Gendakudurru branch Channel	B. Land	570	350	350				
		Head Sluice	C. Works	450	450					
		Tail escape	— do —	420	420	870				
		Channel	L Earthworks	3280	2,630	2,630				
		Sankapalli branch Channel	B. Land	170	100	100				
		Head Sluice	C. Works	470	470					
		Tail escape	— do —	450	450	920				
		Channel	L Earthworks	565	220	220				
		Total Bhimanadi Channel		48806		37070				6,000 acres included in sluice for Bhimanadi Channel
12	55	Battupanamaru Channel	B. Land							
		Head sluice	C. Works	—	—					
		Drop at 1 mile	— do —	410	—					
		— do — at 3 miles	— do —	365	—					
		— do — at 4 miles	— do —	405	—					
		Tail escape	— do —	370	370	370				
		Channel	L Earthworks	3860	3,000	3,000				
		Total Battupanamaru Channel		5410		3370				
14	61	Pedaganagullu Channel	B. Land	260	250	250				2,000 acres.
		Head Sluice	C. Works	475	450					
		Drop at 1 mile	— do —	340	—					
		Tail escape	— do —	330	330	780				
		Channel	L Earthworks	1195	900	900				
		Total Pedaganagullu Channel		2600		1930				850 acres.

Position		Particulars	Subheads	Main heads: Distributaries — Original	Distributaries — Revised	Distributaries — Total of Subheads	Drainage & Protective Works — Original	Drainage & Protective Works — Revised	Drainage & Protective Works — Total of Subheads	Remarks
miles	chains									
15.65		Wyraturr channel	B. Land	345	230	230				
		Head sluice	C. Works	425	450					
		Drop at 1 mile	do	360	—					
		Tail escape	do	625	500	950				
		Channel	L Earthworks	1795	1430	1430				
		Total Wyraturr channel		3550		2610				
19.15		Chinna Mattur channel	B. Land	770	450	460				
		Head sluice	C. Works	550	500					
		Drop at 1 mile	do	365	—					
		2.30	do	375	—					
		Tail escape	do	625	500	1050				
		Channel	L Earthworks	3500	2500	2500				
		Total Chinna Mattur channel		6295		4010				
20.5		Nokkampudi channel	B. Land	520	535	535				
		Head sluice	C. Works	545	450					
		Drop at 1 mile	do	360	—					
		3 do	do	350	—					
		Tail escape	do	490	500	990				
		Channel	L Earthworks	3020	2750	2750				2500 acres
				5625		3890				
26.15		Ramanapettah channel	B. Land	780	500	500				
		Head sluice	C. Works	375	—					
		Drop at 3.30	do	360	—					
		Tail escape	do	600	600	975				
		Channel	L Earthworks	4246	3050	3050				
		Total Ramanapetta channel		6361		4625				1500 acres
28.5		Polaveram channel	B. Land	380	250	250				
		Head sluice	C. Works	355	355	355				
		Channel	L Earthworks	2200	1500	1500				
		Total Polaveram channel		2935		2105				1,600 acres
31.25		Akumarru channel	B. Land	280	150	150				
		Head sluice	C. Works	460	350	350				
		Channel	L Earthworks	1900	1000	1000				
		Total Akumarru channel		2640		1500				900 acres
32.15		Andraram channel	B. Land	280	150	150				
		Head sluice	C. Works	485	300					
		Tail escape	do	490	490	790				
		Channel	L Earthworks	2030	1060	1060				
				3285		2000				1000 acres.

Position Miles	Chains	Particulars	Subheads	Main heads: Distributaries — Original	Distributaries — Revised	Distributaries — Totals of Subheads & Channels	Drainage & Protection Works — Original	Drainage & Protection Works — Revised	Drainage & Protection Works — Totals of Subheads & Drains	Remarks.
33.	15	Gundupalem channel	B. Land	260	120	120				
		Head Sluice	C. Works	435	430					
		Tail Re. cape	do	435	435	865				
		Channel	L. Earthworks	1280	1000	1000				
				2,27,800		1,94,786				
		Nirankti Drain	B. Land				360	360	360	
1.	0	Bridge	C. Works				2,480	1,500	1,500	
		Drain	L. Earthworks				1,610	1,610	1,610	
		Total Nirankti Drain					4,450		3,470	
		Inampudi Drain	B. Land				7,020	5,820	5,820	
3.	54	Bridge Ilur road	C. Works				7,890	6,500		
5.	10	Inlet. Chinnamuttevi	do				1,560			
6.	40	do Nekkanpudi	do				1,480			
7.	70	do Nematur (L.B.)	do				1,600			
		do Kasur (R.B.)	do				1,600			
10.	0	do Mallampalli	do				1,650	11,500		
11.	30	do Samanapattah	do				1,670			
13.	0	do Inamadaka	do				1,710			
13.	20	do Agrakodu	do				1,636	—	18,000	
		Drain	L. Earthworks				1,81,030	1,81,030	1,81,030	
		5 Cattle crossings	O. Miscellaneous				1,940	1,940	1,940	
		Total Inampudi drain					2,10,785		2,06,790	
		Total Works		2,27,800		1,94,786	2,15,235		2,10,260	
		Establishment at 25 per cent				48,694			52,565	
		do Survey				3,000			3,000	
		Tools and Plant 8 per cent				15,580			16,825	
						2,62,060			2,82,650	

44. The total of the estimates for the west side channel and its distributaries as submitted by the District Engineer, is, it will be seen Rupees 2,27,800 and the estimates as revised amount to 1,94,736. It is probable that further reduction would be found practicable when working out the several channels in detail according to the modifications which have been suggested but probably the actual cost would not fall below 1,75,000 Rupees. From Appendix No. 2. it appears that close upon 60,000 Rupees have already been spent on original works of these channels. Consequently supposing the 28,000 acres to be irrigated ultimately the cost of distribution per acre would be 8.4 Rupees which is certainly a high rate, for the cost of the arrangements proposed has to be compared with that, usually not exceeding 4 Rupees an acre on the average, of distribution by off-takes from a canal without a parallel channel, seeing that the Masulipatam Canal has already been constructed and would be capable of conveying water, without the side channel, for all or nearly all the irrigation. The proposal to adopt side channels in preference to carrying the bulk of the irrigation water in the navigation canals was made some years ago in consequence of the heavy silting resulting from the conveyance of large bodies of water at low velocities in the canals and in this particular case it would seem that the side channel will be advantageous if thereby the cost of annual maintenance can be reduced by some 7,500 Rupees annually. Whether or no this would be the case it would probably be difficult to

Cost of distribution.

*Extra cost, Works, 1 lakh
other charges, ½ do
1½ lakhs
5 per cent 7,500 Rupees.

produce satisfactory data to
demonstrate; but it may be noticed
that the side channel will cost at
least 60 Rupees a mile to maintain,
and its length will be 28½ miles
from its head to where it ceases
to be a side channel, so that
the total saving required on
the Canal to make the side channel
arrangement profitable would be
7,500 + 1710 = 9,210 Rupees and this
is equivalent to about 300 Rupees
a mile on that part of the
Masulipatam Canal between Kunkipad and Kukkamarru locks, and
it is doubtful whether such a saving
will be secured. It may be said
that as a line of navigation the
Masulipatam Canal will be much
improved by making it a still
water canal below Kunkipad, but it
may be noticed that there is nothing
to prevent a moderate surface
fall and velocity being maintained

in the canal during the season
of irrigation and a still water
navigation being arranged for at
other times. Consequently considerations
of economy may properly govern
the arrangements. At any rate there is
no immediate necessity for carrying
out any large part of these estimates
because the demand for water has
not yet arisen and it is recommended
therefore that for the present the Canal
should be utilized to convey water
for irrigation, only so much water
as may from time to time be needed
for that purpose being passed into
the 2nd reach or that below the
Kunkipad lock. A few sluices may
have to be built in the Canal which
would not otherwise be required,
but with a little judicious clubbing
several of the minor channels can be
supplied, through the side channels
as it exists, from one off take.
On the whole it is believed that

an outlay of 30,000 Rupees at most will provide for all the requirements of distribution for a long time to come.

Drainage Works

Virankii drain

45. Only 2 drains have been estimated for the Virankii and Inampudi. The former is a short drain 1.36 in length intended to carry off the drainage of about 2 square miles of country which need to fall into a part of the Bhimanadi channel and which has been left without a proper outfall owing to the Masulipatam canal having cut off a loop of the Bhimanadi. It will run parallel to the canal. Its cost is entirely chargeable to the delta system. The roadway of the bridge in connection with the road crossing at the Virankii lock may apparently be lowered several feet which with the resulting shortening of the wings will reduce materially the cost

of this item.

Inampudi drain

46. The head of this drain is at the Masulipatam Canal at a recently constructed aqueduct which passes the drainage of 31 square miles of country lying to the north of the canal. The depth of water throughout the drain will be 6 feet. The bed level at head is to be at 6.5 corresponding with the floor of the aqueduct, that at the junction with the Kanakadamadugu drainage 0.91 so the total fall is 7.41 and the length is 14.66 giving a fall of 6 inches a mile throughout. The following are the principal particulars.

Position m. ch	Bed width	Discharge	area drained.	Inches of drainage.
Head	63	922	31	1.10
2.30	68	989	35	1.05
5.0	79	1,130	42	0.99
5.10	85	1,216	48	0.95
6.40	95	1,348	55	0.91
7.70	106	1,436	61	0.88
10.0	114	1,595	71	0.83
11.30	120	1,679	77	0.81
12.60	124	1,730	81	0.80
13.20	140	1,957	96	0.76
14.66	140	1,957	97	0.75

It has already been noticed in reviewing the arrangements of other main drains, the actual requirements of the country can be ascertained only by making the drain of comparatively small dimensions say one third of that estimated for in the first instance, and then enlarging it as experience may show to be necessary. It will be unnecessary certainly to provide 20 feet berms in the upper 10 or 12 miles where the water level will be below ground, and it is improbable that the extra width which they will afford will be wanted in the lower 2 or 3 miles. The omission will save 1,200 Rupees on land Compensation.

(1) Thur road Bridge. The height of the roadway may be reduced about 2½ feet. The gradients of the approaches may commence at 6 feet from the centre line

Masonry Works

Incidence of cost.

+ C. ft. a second 420

side arches which will lower the ends of the wings another 2 feet, and shorten them 9 feet.

(2) The quantity of surplus irrigation water to be disposed of may be assumed to be one fourth of the total supply of the West side channel or 105 cubic feet a second and this will be tolerably equally distributed throughout the drain. Consequently supposing the drain to be ultimately made of the full dimensions the cost of conveying away the surplus water artificially brought into this tract of country will be about $\frac{1}{19}$ of the whole cost. Apparently therefore not more than $\frac{1}{12}$th of the cost at most should be charged to the Delta system, and seeing that the country is all Zemindary it would seem to be impracticable to charge the remaining eleven-twelfths to Ordinary Agricultural for Government have

probably no direct revenue interest in the improvement of this Zemindary. It is indeed more than doubtful whether improved drainage would tend directly to develop a demand for water for irrigation. It would do so in the case of low lying lands which are now unfit for cultivation at all, and which when drained would still be unfit for dry cultivation, but on the other hand much land would be fitted by good drainage for bearing dry crops and for such land probably no water would be taken.

(3) On the whole it would seem to be advisable that no general drainage scheme should be sanctioned, but that within the limits of the scheme which has been planned any special work, which can be demonstrated to be necessary

Sanction of drainage scheme not recommended.

and to be likely to yield some direct return, should be submitted to Government for orders.

Ellore Canal

47. The estimates for this Canal provide for improvements which after much discussion as to the best way of removing the many defects of its original construction have been considered to be the best which at a reasonable cost can be devised. There at present 2 great defects. One the nominal bed and surface fall due to the level of the Tammidem aqueduct in the 38½ mile and of other masonry works near this end. The upper floor of the aqueduct is at 36.58, the bed of the canal at its head being at 37.50. There is therefore a fall of less than 1 foot in rather more than 37 miles. Moreover the upper sill of the Ellore Lock at 40 miles is at 31.95 or 4.63 feet lower than canal bed nearly 3

miles higher up. In order to provide a sufficient depth of water to pass boats over the aqueduct the water level at the lock has had to be kept up and thereby many inconveniences, including grave interference with the discharge of the East branch of the Tammilern, have resulted. The other great defect is the altogether inadequate provision for passing upland drainage across the canal. This has led to numerous breaches the cost of repairing which has not been very great, the greatest expenditure on repairs in any one year having been £235 to be Rupees, but on the average of 17 years Rupees 763 only yearly. On the other hand the resulting inconvenience by the stoppage of navigation has been very considerable and can the trade with Canada is on the increase so that it is very necessary

Appendix D.54 vide appendix F to Lt Campbells D.369.

Inspection notes paras 13 to 20. Dr. G. 29th Septr 1874, Dr. 2732

to prevent such accidents for the future. The subject was gone into at the end of 1873 and the present estimates have been based upon the arrangements then ascertained to be necessary.

General arrangements.

48 The canal as revised will have a depth of 8 feet and a bed and surface fall of 0.08 feet per mile from the head to the 11th mile, thence to the 20th mile the bed will be horizontal and the surface fall will be 0.228 feet a mile, the depth being thus diminished to 6 feet; from this point to the end at the Ellore Lock the depth will be 6 feet and the bed and surface fall 0.228 a mile. There will necessarily be some practical adjustment of water level and surface fall to equalize the discharges which, as will be seen from Appendix B to the Report, as calculated vary considerably.

Appendix D.54

The water surface is to be 60 feet in width as a minimum in the interests of the navigation, with however some diminution at old masonry works, which are serviceable and which it has not therefore been considered necessary to reconstruct. The details will be found in the general longitudinal section and in the detailed longitudinal and cross sections, Plan E.1., sheets Nos. 1 to 10 and 1 to 8 respectively. The deepening is inconsiderable down to the 30th mile and the maximum cutting required is about 3½ feet in the 39th mile. The upper 35 miles of the canal are for the most part wider than is necessary: the sections are very irregular, and adjustment and the restriction of the water to its proper width instead of allowing it to spread over the sometimes extensive berms on either side are two alterations needed in the lower few miles the lowering of the canal bed materially involves more earthwork. As regards distribution it is proposed to treat separately each part of the ground into which the area is divided by the cross drainages.

ent and in. 49 The area of land commanded by the canal is 140 ed area irrigation. square miles, and the intended area of irrigation for which water will be provided is 31,000 acres or 221½ acres to the square mile. The greater part of the land is Zemindary and there will therefore be much uncertainty as to when and to what extent a demand for water will arise. The present ndix Nr. 5A t Appendix C extent of irrigation is stated to be in the Kistna District acres 4,561 assessment Rupees 1819

" Godavery " " 13631
" 18192

leaving only 12,808 acres as the additional area to be irrigated.

As regards the irrigation in the Godavery District the latest information on record is contained in P.W.D. No 3,219 of the 13th November 1874 and it is there shown that for 1872-73 the

area was ——— acres 13,114

Water tax —"— ——— Rupees 34,228

or at the rate of 2.61 Rupees an acre, while for the 2 years 1871-72 and 1872-73 the average area was 12,445 acres, the water tax Rupees 34,115 and the rate 2.74 Rupees an acre. It has not been practicable to check the area given as the present extent of irrigation in the District under this Canal. The particulars given in the statements printed in the Proceedings as per margin are

No 2844. 7.th Oct. 1874

Year	Taluq	Description	Extent acres	Unit Rent Rupees	Water tax Rupees	Total Rupees	Water tax per acre
1871-72	Gudivada	Zemindary & Inam lands charged as irrigated ——	147	65	78	147	0.53
	Nuzvid Div.n	—do— —do—	5,798	334	17,502	17,836	3.02
	"	—do actually irrigated free of water tax and unit rent	1,753	-	-	-	-
			7,698	389	17,580	17,969	
1872-73	Gudivada	Zemindary & Inam lands charged as irrigated ——	147	55	103	158	0.70
	Nuzvid Div.n	—do— —do—	1,054	28	2,699	2,727	2.56
		—do— actually irrigated free of water tax and unit rent	882	-	-	-	-
			2,083	83	2,802	2,885	

There was no Government land under irrigation in the Kistna District under this Canal and there is no information on record as to the variations in area and rate of water tax in the 2 years to which the statements appertain.

The following are the particulars for the irrigation in the Godavery District under this Canal.

Year	Taluq	Description	Extent acres	Assessment Rupees	Water tax	Total Rupees	Water tax per acre Rupees
1872-73	Ellore	Government land charged as irrigated with wet crops —	9579	9030	33,415	42,445	3.51
		—do-do—2d crops—	27	—	—	—	
		—do-do-with dry crops	2	2½	¾	5½	1.50
		Zemindary Enam lands charged as irrigated with wet crops ———	206	15	004		3.90
		—do—do-with dry crops	2		5		
		—do—do—free 1st crop—	3340	—			1.97 area 2.30 water tax Rs 4.8.5
		—do-do— 2d —"—	28				
			13114	9045	34,227	42,451	

50 The estimates have been submitted not only without a classified abstract but without any general abstract. The subjoined abstract has been prepared from the estimates for individual works and it must be noticed that the works for spassing cross drainage across the Canal have, under the instructions given in P.W.D. 10th July 1875, No. 1968, ... been shown under the main head (4) Drainage and Protective works. This seems to be a very arbitrary

Abstract of Estimate

Govt of India Circular No 38 P.W. Genl D F 2nd centuno.

arrangement as such works are an integral portion of the Canal, and their omission in the first instance should, it is thought, not cause them to be placed under a different main head. Moreover it is doubtful whether the instructions are intended to apply to such circumstances as those of the Ellore Canal. The cross drainage is natural drainage from the uplands and not artificial drainage and as placing the cost of dealing with it under mainhead (4) would give an erroneous idea of the outlay on the drainage proper of the delta an alternative abstract has been prepared placing all the cross drainage works and outfall channels under mainhead (2). No explanation has been given of the reasons for including in the 2nd subsection drainage estimates the cost of embanking the south side of the Bandamair in the 3d subsection. This is a

Know all men by these presents, that we, [illegible] of the County of [illegible] and State of [illegible] are held and firmly bound unto the Commonwealth of Pennsylvania in the sum of [illegible] Dollars, lawful money of the United States, to be paid to the said Commonwealth, or its certain Attorney, its Successors or Assigns; for which payment well and truly to be made we bind ourselves, our Heirs, Executors and Administrators, jointly and severally, firmly by these presents. Sealed with our Seals and dated this [illegible] day of [illegible] in the year of our Lord one thousand eight hundred and [illegible].

The Condition of the above Obligation is such, that whereas the above bounden [illegible] hath been duly appointed [illegible] of the Township of [illegible] in the County of [illegible] for the year ensuing the date hereof, and hath taken upon himself the execution of the said Office, and is now about to enter upon the duties thereof. Now if the said [illegible] shall well and truly execute the said Office, and shall account for all such sum or sums of money as shall come into his hands belonging to the said Township, and shall pay and deliver the same to such person or persons as shall be appointed to receive the same, then the above Obligation to be void, else to remain in full force and virtue.

Sealed and delivered in the presence of [illegible]

Section	Description	Sub Head	Main head: Main Canal & Branches	Main head: Distributaries & Minor Works	Main head: Drainage & Irrigation Revised	Remarks
Miles Chains						
29.00	Kerikeri outlet	C. Works		19060	19060	
" "	do drainage	B. Land		470	470	
		E Earthworks		200	200	
28 "	Kamelenu drain	B. Land		880	880	
		E Earthworks		3200	3200	
31 .	Punnakallu drain	B Land		20	20	
		E Earthworks		200	200	
33.20	Peddapalli outlet	C Works		6720	2765	
		B. Land		480	480	
33.20	do drain	E Earthwork		6780	6780	
35.77	Wertlu outlet	C Work		21840	4920	
		B. Land		240	240	
	do drain	E Earthworks		3000	3000	
37.77	West Pennumelenu outlet	C Works		6600	2520	
38.10	do Aqueduct	C Works		19200	18200	
		B. Land		320	320	
	do drain	E Earthworks		4080	2500	No particulars furnished.
		B Land		160	160	
39.5	Jettipudi drain	E Earthworks		300	300	
		C Works				
39.60	East Pennumelenu outland additional outlet	C Works		17230	17230	
		E Earthworks		2160	2160	
	do drain	D. Miscellaneous		1645	1645	
	Minor drains			1020	1020	
	Minor improvements to old masonry works	do				
	Sewerage Estimates	Total				

I Works — Total	57,395	67,775	46,915	1,19,000 1,16,960
II Establishment 25 per cent on I	14,349		11,729	29,240
do Survey.			1,000	1,000
III Tools & Plant 5 per cent on I	4,590		3753	9,357
	76,334		63,397	1,56,557

Position			Main heads						Remarks.
			Main Canals & Branches		Distributaries		Drainage and Protective Works		
Miles Chains	Description	Sub heads	Original	Revised	Original	Revised	Original	Revised	
0.0 to 40.0	Improving Canal	1. Earthworks	29,640	29,640	4				Alternative abstract.
	do	2. Navigation Works	26,870	26,870					
7.16	Buckemair aqueduct Improvements	3. River & Hill Torrent Works	880	1,880					
10.21	Kasarapalli aqueduct	do	31,690	28,000					
20.54	Ampapuram outlet	do	1,235	1,235					
" "	do inlet	do	1,280	1,280					
22.20	Viravalli outlet	do	380	380					
" 50	Nellivagu do	do	255	255					
27.10	Perikeed do	do	19,060	6,720					
32.63	Kalapuram Bridge Tow path	2. Navigation Works	430	430					
33.20	Seddapad outlet	3. River & Hill Torrent Works	8,770	2,765					
35.77	Wuttur outlet	do	21,840	4,900					
37.7	West Tummilem do	do	8,180	2,520					
" 10	do Aqueduct alterations	do	19,080	13,000					
38.55	Ellore Bridge Tow path	2. Navigation Works	455	455					
39.60	East Tummilem outlet & additional outlet	3. River & Hill Torrent Works	17,230	17,230					

Position Miles	Chains	Description	Sub heads	Main heads: Main canals and Branches Original	Main canals and Branches Revised	Distributaries Original	Distributaries Revised	Drainage and Protective Works Original	Drainage and Protective Works Revised	Remarks.
11.	70	Kasarapalli Channel	B. land				200			
			C. Works				350			300 acres at 4 Rupees an acre.
			L. Earthworks				650			
							600			
14.	50	Butumalli channel	B. land				750			900 — do — do —
			C. Works				2,250			
			L. Earthworks							
17.	26	Panikamad Channel	B. land				900			
			C. Works				1,000			1353 — do — do —
			L. Earthworks				3,500			
20.	20	Cheruvada — do —	B. land				500			770 — do — do —
			C. Works				650			
			L. Earthworks			50,000	1,930			
21.	47	Suttayanta — do —	B. land				670			
			C. Works				650			1000 — do — do —
			L. Earthworks				2,480			
							550			
26.	2	Kakulapad do —	B. land				650			800 — do — do —
			C. Works				2000			
			L. Earthworks							
							800			
27.	40	Gogunta — do —	B. land				1000			1200 — do — do —
			C. Works				3000			
			L. Earthworks							
36.	20	Muparru Channel	B. land			1370	1370			
		Head Sluice	C. Works			850	1000			
		1.20 Fall	do			400	755			
		2.20 do	do			390	735			5430 acres
		20 do	do			420	755			
		Tail escape	do			455	860			
		Channel	L. Earthworks			4320	4320			
37.	10	Madapalli channel	B land			1410	1410			
		Head sluice	C. Works			420	500			* no plan furnished
		2.5 Fall	do			430	810			
		3.40 do	do			700	1320			
		4.35 do	do			400	755			
		5.15 do	do			420	800			
		Tail escape	do			490	925			
		Channel	L. Earthworks			5320	5320			
9.	0	Nakalam Drain	B. land					120	120	
			L. Earthworks					670	670	
10.	21	Kadrapalli Drain	L. Earthworks					300	300	
16.		Dritapalli do	B. land					300	300	
			L. Earthworks					400	400	
17.		Atkur — do —	B. land					80	80	
			L. Earthworks					490	490	
19.		Patipad — do —	B. land					50	50	
			L. Earthworks					150	150	
20.	54	Ampapuram do —	B. land					710	710	
			L. Earthworks					1800	1800	

Position			Main heads				Remarks
Position			Main Canals and Branches	Distributaries	Drainage and Protective Works		
Miles Chains	Description	Subheads	Original Revised	Original Revised	Original	Revised	
	Viravalli Drain	B. Land			50	50	✓
		L. Earthworks			350	350	✓
22.50	Nalligaon — do	L. Earthworks			830	830	✓
23.	Narsanapalem — do	B. Land			300	300	✓
		L. Earthworks			1,875	1,875	✓
24.	Kanamole — do	B. Land			225	225	✓
		L. Earthworks			1465	1465	✓
27.00	Serikut — do	B. Land			170	170	✓
		L. Earthworks			300	300	✓
28	Ramelem — do	B. Land			280	280	✓
		L. Earthworks			60	60	✓
31	Punnakollu — do	B. Land			40	40	✓
		L. Earthworks			20	20	✓
33.20	Seddipad — do	B. Land			1450	1450	
		L. Earthworks			6,780	6,780	
35.77	Kuthur — do	B. Land			70	70	
		L. Earthworks			500	500	
37.10	West Tummileru — do	B. Land			300	300	
		L. Earthworks			14,830	2,500	no particulars
39.5	Jolipudi — do	B. Land			100	100	
		L. Earthworks			200	200	
	East Tummileru drain	L. Earthworks			2,160	2,165	✓
	Minor drains — do	Miscellaneous			1,845	1,845	✓
	Minor improvements to old masonry works — do —				10,120	10,120	✓
	Surveys and Estimates & Preliminary Expenses						
	I Works - Total		187,275	137,560	67,775	46,915	49120 26795
	II Establishment 25 per cent on I			34390		11,735	9175
	- do Survey					1,000	1,000
	III Tools & Plant 8 per cent on I			11,000		3,750	2948
				182,950		63,400	49939

51. The figures above given afford no data for an estimate of returns from extension of cultivation and it would be unprofitable to attempt any such calculation in detail. The only material increase of water supply, which will be available for extended irrigation, will be the water which is now taken off by the old head of Ryves Canal on the 9th mile, which Canal has now a separate head at the lower end of the main Canal in course of construction and nearly completed, together with a share of the more ample supply which the main canal will carry now that it has been enlarged. Except as regards new works of distribution, which will not be carried out until the demand for water for particular areas arises, and indeed not until a demand is made for a fair proportion of the area under each distributary, the whole of the proposed expenditure may be deemed to be

Returns from proposed expenditure.

necessary for rendering the canal fairly efficient to meet the requirements of its circumstances, and of existing irrigation and navigation. If the area of irrigation be extended to the area contemplated and for which water will be available and if the water rate be 3 Rupees an acre on the average; and apparently even supposing that a considerable proportion of the area be dry crops irrigated; this rate would seem not to be excessive, there will be a gross return of about 38,000 Rupees. The expenditure on maintenance of the canal will certainly not be greater than in the past, and will probably be much less when the contemplated improvements have been carried out, and there are therefore grounds for supposing that ultimately a return of about 11 per cent will be obtained from the further proposed outlay on this canal, after allowing for the maintenance of the additional dis-

Budget provision for Repairs in 1876-77 Rs. 13,950
Supposed future " 17,500
Difference additional 3550

tributaries, drains &c

Provision for Distributaries

52 In Lt Campbell's report para 8 it is shown that Rupees 50,000 have been allowed in his estimates for 7 distributaries which are to water 6,323 acres and for which detailed estimates have not been prepared. This allowance of 8 Rupees an acre appears to be very unnecessarily high and as no reason for it has been given, as no instance of such a rate being necessary is on record, and as the average rates for the two channels which have been estimated for are 2½ Rupees and 2¾ Rupees respectively it is believed that 4 Rupees an acre, which have been entered in the above abstract in each case, and divided arbitrarily under the 3 subheads shown, will suffice. The entry for Surveys and Estimates under A Preliminary Expenses is a share, in proportion to the additional acreage to be irrigated, of the total outlay up to date with an addition

revised Estimate Column

vide memo of distribution of Preliminary Expenses Appendix &c

for probable future outlay. No entry had been made under Class VI. As regards (23) Capitalization of abatement of land revenue the amount, if any, will be nominal, the land to be acquired being nearly all private property (24) It is not possible to say whether there will be any, and if so what, payments in England (25) The leave and Pension allowances are ¼ of Class II. Establishments. The Canal being already in operation there will be no simple interest chargeable to Capital under Class VII.

Details of masonry works &c

53 The following remarks on the designs of the masonry works &c should be attended to in carrying out the estimates: When the alterations considered necessary will make no material difference in the amount of the estimates for individual works the amount has been left as in the original estimate otherwise an approximate revised amount has been allowed.

54 The design of this work is inappropriate, the roadway being below M.W.L in the Canal, which will be 2 feet above ordinary full supply level owing to the admission of upland drainage. The roadway of the sluice should be on the level of the top of canal banks. The line of the shutter and its groove should be advanced 1 foot. The bed of the distributary is to be 4 feet below Canal bed level and the water should be dropped at the front wall. All the foundations of the body wall and of the walls and flooring in rear of that should be laid on an all over bed of concrete and the flooring should be laid thereupon with cyclopean stone for a length of 9 feet and 2 feet thick. The alterations have been sketched on the plan and will add about Rupees 150 to the Estimate, making the total Rupees 1000.

Distributaries. Mukerian head Sluices. Plans 5 of E⅓

Falls or Rapids Plans Nos 9 & 10 of E⅓

55 Rapids are objectionable because the water passing down them acquires a high velocity and would necessitate extensive protective works below. The design is defective also in having no wing returns at either end. It is very desirable that shutters should be used at each falls which should as a rule and under ordinary conditions of supply be self regulating. Vertical falls should be substituted, and the length and level of their crests should be so adjusted as to maintain normal water level above them with a full supply in the channel, and any depth for water level considered requisite as a minimum with, say, a half supply, if there be any minor distribution channels taking off in the reach above. Shutter grooves may be provided for occasional use, but in that case the head walls must be at such a height above water as to leave 1 foot margin if the shutters

be accidentally left in when there is a full supply going down channel. A revised design has been prepared in this office for the fall at 1/4 miles on the Muparun channel and this may be taken as the general form of work for adoption on this and the Madapalli channel. The approximate amounts required for all the falls on the two channels have been entered above viz the column "revised estimate."

56 Certain points in the arrangement of this channel have been noted viz the plan E 5 as needing attention. The channel as designed is of slightly less section than is necessary for the discharge of the 81.45 cubic feet a second required, but as a very slight increase of depth will remedy this should the water be found insufficient no alteration of dimensions will be necessary. Some saving in earthworks may be effected by raising the bed level throughout.

Muparun Channel

Madapalli Channel

57 The alignment of this channel is defective; first as regards the details, supposing the general direction of the upper part to be right, and secondly it would seem that this upper part has been placed too far south. Probably a much less quantity of earthwork would be required for the first reach were the general alignment placed south of the line shown. The remarks noted on Plan E 5 Sheet No 1 should receive attention.

Cross Drainage Works.

Pudumadur Agency dist

58 The alterations to this work are small though not unimportant. They provide for a slight adjustment of the height of the side walls and the raising of the rings to 3 feet above maximum water level, which may at times be 2 feet above ordinary full supply level in the Canal. Iron railings are essential the tow path being but 4 feet wide. They will cost about Rupees 1,000, thereby raising the estimate from

Rupees 880 to Rupees 1.880.

59. Some modifications of the design are desirable and they have been shown on the plan. This work also will require rein railings on both sides. It is believed that this aqueduct can be built for much less than the estimate, the rates being very ample. The alterations in quantities have been taken into account in the entry in revised column of abstract.

Kasarapalle Aqueduct

*No 6 of $\frac{E}{1}$

60. The work provided for is the lengthening of the outlet from 50 to 190 feet. The cross section of the extension corresponds with that of the present outlet, and if the latter has been found suitable to the soil and circumstances this extension may be carried out as designed, otherwise the will modifications noted on the plan as desirable should be attended to. The estimate will it is thought cover the alterations if found necessary, the rate for rubble masonry (including facing & pointing) complete being nearly 6 Rupees.

Ampapuram outlet
Plan No 12 of $\frac{E}{5}$

Ampapuram Inlet
Plan No 13 of $\frac{E}{5}$

61. This work also provides for lengthening an existing inlet to 190 feet. The design corresponds with the old work, and probably a more satisfactory arrangement may be secured. In any case the wings should correspond with the earthworks as far as ordinary full supply level in the Canal and it is thought that a crest wall with 2½ feet of dry rubble apron 12 feet wide and 4 feet below the crest will be a cheaper and better arrangement. Most hydraulic works founded on alluvial soil are the better for being placed on a bed of concrete 2 feet wider than the walls built thereon. The crest wall if run into the centre of the bank stepped for the towpath and with revetments for the overlapping

ends of the bank, makes an efficient and cheap arrangement and an entirely new work of this pattern would probably cost less than the extension of the old inlet.

Design No 5 Circular 67.

62. The design for this outlet is inappropriate. A very inexpensive work will do very well ground level being only 1.37 feet below full supply level in the canal. The description of weir shown in Design No 5 Circular 67 should be adopted and it will cost but little more than one third of the estimate submitted. The superintending Engineer has noted on the plan the absence of any necessity for a drop of 9 feet as shown but he apparently contemplated wing walls of the same description as in the plan whereas a prolongation of the crest wall, which may be founded 4 or 4½ feet below ground

Perkaed outlet
Plan No 23 E/9

level, will suffice with substantial and well backed revetments for the slopes of the connection of the banks with the masonry.

Care must be taken that the surplus discharged from this outlet is not allowed to fall into any low level outfall channel except at a considerable distance from the canal. Apparently there is no risk of this occurring if the Jogmuta channel right bank be kept in order as it must be kept to prevent surplus running into that irrigation channel.

Seddapad outlet
Wattlwa —do—
West Jummilem do.

63. Similar remarks apply to these works for which the same general design was intended though the estimate for the Wattlwa outlet differs materially in cost per foot run viz

Perkaed outlet 960 feet Rs 19,060 per foot 20 nearly
Seddapad —do 395 " " 8,770 " " 22
Wattlwa —do 700 " " 21,840 " " 31
West Jummilem do 360 " " 8,180 " " 22

The proximity of the Wattlur outlet to an underground tunnel has probably induced Lt. Campbell to place the apron of the former on nearly the same level as the floor of the tunnel, but a training bank will prevent the weir surplus falling into the outfall from the tunnel and ground level here is somewhat higher than water surface in Canal so a very inexpensive work will answer the purpose. In the revised estimate the entries made are

Seddapad outlet	395 × 7 =	Rupees 2,765
Wattlur —— do —	700 × 7 = —"—	4,900
West Immiliem do —	360 × 7 = —"—	2,520

+ 29.85
+ 28.62

Immiliem 64. It has been considered plan desirable to revise the arrangements for for the conversion of this aqueduct but into a set of sluices, and to place ing the sills of the latter at the floor as in level instead of as was originally tion intended at 3 feet thereabove. Also to be found limit the height of the sluices to that

Immiliem Aqueduct Plan 1/3 1/4 E 1/4

required to secure the necessary discharge. The estimate for the design prepared by Lt. Campbell amounts to Rupees 1,080 and it is thought that the required alterations can be carried out for a much smaller sum, and in a way which will probably be more effective. The revised arrangements have been shown on the plan and it is hoped that there will be no difficulty in preparing working drawings and carrying them out. All the aqueduct except the parts shown as required in connection with the sluices will be demolished and a set of 24 sluices 6 feet wide and 5¼ feet high will be substituted the sills of the sluices being placed on the floor of the aqueduct viz at 27.58. The shutters when fully raised will then be just flush with water surface in canal. The revised estimate, after deducting value of materials

of aqueduct which, if not to any great extent required on these alterations, can be utilized at the outlets close by, amounts to Rupees 13,000 and an approximate abstract has been given on the plan.

West Tummilem Drain

65 The estimate contains the following entries for this work

Land — Rupees 300
Earthworks — " — 4,830

There is no specification or estimate of the work to be done.

This drain is really the west branch of a river. The canal works will not increase the discharge down it and wherever there is a freek and the sluices noticed in the preceding para are opened the water will pass through them by the artificial cut in which the aqueduct was built into the natural bed of the river. Some small improvements may be necessary

and for these Rupees 2,800 have been entered in the revised estimate column, but no heavy outlay is, it is considered, needed.

East Tummilem Escape
Plan 2136 of $\frac{E}{75}$

66 The existing work is a weir with self acting (intended) shutters 200 feet in length. The crest is 2½ feet below revised water surface in canal. It is intended to bridge this weir and furnish the bays with shutters worked by screws and to extend it so as to allow of 17 vents of 6 feet with the sills at canal bed level. A few remarks for guidance in carrying out the alterations have been noted on the plan. This is the last of the cross drainage works.

data for cross drainage works.

67 The arrangements have been designed throughout so as to afford the waterway determined to be necessary or desirable when the subject was examined into at the end of 1873 — vide Inspection Notes paras 13 to 20 in

P.W.S. Nº 2732 of the 29th September 1874. The conciderations affecting the disposal of cross drainage after it has passed the Canal will be found noticed in the correspondence as per margin.

68. When the works of the Kristna Delta come to be carried out the rates for the several descriptions of work should not exceed those at which similar work can be done in the Western Delta of the Godavery under similar circumstances. The Superintending Engineer to this end will do well to take measures to inform himself as to what the latter rates are and as to the variations in rates caused by distance over which materials have to be carried. The Bezwada stone is a more easily worked sand stone than is the Dowlaishwaram sand stone, and it is quarried under

† From Kistna Nº 106 17 Decr. 1875

To do Nº 1 1st January 1876

Vide appendix Nº

Rates for masonry Works.

more favourable circumstances. The cost of getting the stone in each locality should be first attended to, and then all subsequent charges for the finished masonry &c. The following are the rates at works in the two Deltas on the same canal viz the Ellore.

The mileages are from Bezwada in the one case & from Vijeshwaram in the other or from the respective heads of main canals.

		Kistna outlet 360 feet 37 mile		Godavery outlet 150 feet 43 mile.
Concrete per 100 C.ft.	Rs.	15.97	—	10.00
Rubble masonry	do	17.82	—	16.00
Cut stone	do	44.44	—	50.00
Dressing face work 100 sq.ft.	"	12.50	—	10.00
Rough stone revetment and apron 100 c.ft.	"	9.26	—	8.00

The rates for concrete, Rough stone in apron and revetments and face dressing in the Kistna need enquiry. The other rates appear to indicate that a considerable reduction is feasible. In such extensive works as are provided for in the Kistna Delta Completion Estimates rates are of very great importance and

the experience gained in the neighbouring delta where a high class of work at any rate on the locks and other large masonry works has been carried out should be utilized fully. The cost of the 150 feet anicut on the Godavery Ellore Canal appears to have been Rs 1074 against Rupees 1050 the estimated amount.

69 The importance of making an early commencement with the improvement of this Subsection of the Eastern Delta renders it desirable to review the scheme before taking up the estimates for the 3rd Subsection in order that, if possible, something may be done in 1877-78. One principal reason for losing no time is that Ryves Canal which through the Pullem will supply a large part of the water for the Kykalur

Kykalur Subsection.

Subsection has been nearly completed and unless the means of utilizing this water be provided much of the benefit to be derived from that canal will not be secured. This part of the delta is at present in a very unfavourable condition. The lands are generally not fit for dry cultivation, and the water supply is very inadequate and somewhat precarious. The drainage too is greatly in need of improvement, for which however the lie of the ground offers considerable facilities although as regards its natural definition by alternate ridges and hollows, though the slight fall available will make effective drainage more costly than elsewhere.

General arrangements.

70 The 3 principal canals of irrigation will be the

1. Sobrax Kodur Canal . . . 20,000 acres
2. Chevur Kodur Channel . . 14,000 do.
3. Lower Pullem Channel . . 12,000 do.

11. The Polavaram canal to the north and the Bandamalli canal to the south will be navigable both will join the Upteru, the former near Vikrampad and the latter near Vinjayanidu, the tail locks being about 14 miles apart. The Upteru is a good navigable river with which 3 lines of navigation in the Western delta of the Godavery are connected and this subsection will therefore be placed in complete connection with the whole system of the Godavery delta canals. Navigable Canals

12. The ryots of this subsection are very anxious for the improvement of the means of irrigation and communication. They have for a long time back seen the results of the far more advanced state of the irrigation in the Godavery delta where what were but a few years ago swamps like those of Kykalur are now fertile fields on which excellent crops are to be seen from the Kykalur side of the Upteru, and two years ago petitioned that an agreement might be built on that river to convey Godavery water across to their lands, so that they might share in the benefits which their neighbours to the east-ing while so much of their own land was lying uncultivated. Desire of the people for improvements.

Area of Sub. Section.

13. The area of the subsection is 201 square miles and the proposed extent of irrigation will there be nearly 229 acres to the square mile commanded. There is no room for doubting that water for the full area for which water can be supplied will be in demand, and probably a still larger area would be taken up for irrigation were it not that a very considerable extent of the

low lying & swampy lands might be reserved to afford adequate outfall for the drainage. At present there is very little cultivation and what there is is chiefly rice.

Appendix No 6 Mr Campbell's report No 100.

73. Owing to the circumstances that the existing channels of this subsection irrigate land in other subsections it is not easy to show accurately what the present area of irrigation in the 4th subsection is but Mr Campbell considers that it may be taken to be as follows.

Land now irrigated

	Present	Proposed	Difference
Sobrazkodu } do old }	6,735	20,000	13,265
Chevvakodu	—	14,000	14,000
Lower Pullern	5,260	12,000	6,740
Bamtimalli Canal			
	11,995	46,000	34,005

The Bamtimalli canal will cease to irrigate, its level being unsuitable, and it will be used as a line of navigation for the

This is as the intention of the estimates as prepared by Mr. Campbell, but some modification is now intended

northern part of the 4th and northern part of the 5th subsections.

Proportion of irrigation under Sevchal Channels to area commanded

74. The following particulars show the proportion between the intended area of irrigation and the total area commanded by each principal channel.

	Area Commanded Square miles	Acreage	Per Square mile
Sobrazkodu	74	20,000	270
Chevvakodu	67	14,000	209
Lower Pullern	60	12,000	200

Sobrazkodu Canal.

75. The estimates provide for improving and adjusting the level of the existing canal, for extending it to the Upullern, for making it navigable 2nd class throughout, and for the necessary distribution channels and works.

The head is situated on the left bank of the Pullern Canal at Miles chains 26 . 63 and the principal features of the canal will be as follow

length

Length ——— 26 miles 16½ chains.
Level of bed at head +11.12
do of do at tail +1.45
Bed & surface fall head to ^{m}ch 18.46 — 0.33 feet per mile
— do — do — 16.46 to tail 0.58 — do —
Depth of water ——— 5 feet

Alteration of off-take of Chevrokodu channel.

70. In para 14 of Lt Campbell's report on the 4th subdivision this alteration is referred to but no reason for it is given. The present offtake is at ^{m}ch 2.70 of the Labrakodu and it would seem to be unnecessary and not desirable to change the source of supply. The Polrakodu in these 2½ miles will including the Chevrokodu need to carry 670 cubic feet a second and the sections show that this can be done without at any rate more than a nominal addition to the cost of the arrangements there shown and intended to convey 300 cubic feet a second only. All that is necessary is to place the bed down to the Chevrokodu head sluice 2 feet lower than was proposed so as to carry a depth of 7 feet of water in this part. The bottom width of 36 feet intended will do very well and the side slopes can be 2 to 1, which will be more suitable to the present section of the channel, the bed of which is generally at low and in places lower than that of the revised arrangement. Immediately below the Chevrokodu head sluice the bed level may be raised by a wall or revetment corresponding to the intended cross section.

Appendix 2.6.A

S.4 Sheet 111 201

Flatter side slopes desirable

It may be noticed that flatter side slopes will generally be better suited to the circumstances and that the waterway should be confined to that decried.

Waterway to be limited

Arrangements for holding up water for navigation.

(2) These are referred to in para 9 of Lt Campbell's report. He explains that it will be cheaper

to raise the banks from the 8th mile to the 19th than to build an intermediate lock and apparently his proposal is to substitute a surface fall of 1 inch a mile for 4 inches a mile. However the supply of water may turn out short, but it is not 5 miles ahead what is intended. A fall of 1 inch a mile would fill the full depth at the head make the water surface at the 19th mile back and the bank at the lock is to be at 14.57 15.92 1.35

Margin, which is small

From the lock plans it would appear that maximum water levels and above the locks is to be 13.5 and 13.0 can I know this has been determined but more not been mentioned. Before anything is done in the to the in this direction is done a definite to shown understanding should be come to as to what the intended arrangements are to be, and it should be shown that an additional lock would cost materially more than the higher embankments for which Rupees 10,790 are entered. It is to be noticed that were a lock built at 11m 55ch the separate lattice bridge there estimated to cost 5,900 Rupees would be superseded and these two items would certainly go far towards building a lock with the small drop required.

Preferable arrangements. (3) Again the acreage below the 14th mile is only 6000, and the discharge required 90 cubic feet a second. To obtain the 1¼ inches a mile will suffice. The cutting below 18m 46ch is deeper than is desirable and altogether it would seem that the better arrangement would be to place the lock intended to be built in the 19th mile at 11m 55ch, to give it a drop of 18 inches, which will entail

very little cutting and not more than will suffice to properly section the old channel and form tow paths 1 foot or 15 inches above water level, to make the section of the canal from 5½ miles 25 feet bottom width with 2 to 1 side slopes, to give a fall of 4 inches a mile down to 14 miles where the Kyshlaw channel takes off, and below that a fall of 1¼ inches a mile only.

The water surface in the Dolraz-Kodur canal at 14 miles will then be 9.96
and that in the Kyshlaw channel — 9.91
The bed level at lower end will be — 3.69
ground — do — do — bem — 5.14
a difference which will be immaterial. The irrigation under the former will be 6000 and under the latter 7000 acres and the regulator at the head of the Kyshlaw channel may be of a very simple description as

ordinarily no regulation will be required

With these arrangements the surface fall to m. ch. 11.55 will be ——— 3.90 feet
and if the depth of water at the head of the canal be fixed at 3½ feet as a minimum, the water at the lock may have to be held up 3.90 − (5 − 3½) ——— 2.40 feet
It will be necessary to make the banks 18 inches higher than the maximum water level or 3.90 feet above ordinary supply level = 8.90 feet about lock upper sill but it may be noticed that the water will really never be held up so high for navigation will come to an end for want of water in the Pullers if there be not a sufficient supply to produce a surface fall of an inch to an inch and a half a mile. In the second reach the ordinary surface

full with the 2.03 feet and it to secure a minimum of 3½ feet on the 12½ mile track between Vizianagram and the Kurpam Ghat. The water surface at the Kurpam Ghat should not be raised to 0.53 feet above which can be drawn without any detriment from the natural arrangements where the fall of a canal is greater than the rise in the river. When it is better to consider to make a new lower reach where the river and the canal is greater

The following is a statement of the Estimate of the Executive Engineer Chicacole Division

Position Miles Chains | Particulars | Sub heads | Main heads: Main Canals & Branches Original | Main heads: Main Canals & Branches Revised | Distributaries Original | Distributaries Revised | Avenue walks & Protective works Original | Avenue walks & Protective works Revised | Remarks

	Compensation	B. Land	3785	3785					
	Improving head sluice	A Regulators	795	795					
	Head Lock	I. Navigation Works	17,875	17,875					
7.0	Bridge Madinapalli	G. Bridges	—	—					under construction
" "	Outlet	H Escapes	2735						
11.60	Bridge Lingala	G. Bridges	5900						
18.47	Outlet into Chinna Kommaleru	H Escapes	2965						
" "	Lock	I. Navigation Works	21,775	67,325					
" "	do River	do	2935						
26.17	Lock Tidal	do	27,265						
" "	do River	do	3750						
	Rest Houses (3)	K Buildings	3900	3900					
	Canal	L Earthworks	31,660	42,450					
	do raising banks to hold up water for navigation	I. Navigation Works	10,790						
	Cattle Ramps (14)	O Miscellaneous	5270	5270					

Position Miles Chains	Particulars — heads	Sub heads	Main heads: Main Canals & Branches — Original	Main heads: Main Canals & Branches — Revised	Main heads: Distributaries — Original	Main heads: Distributaries — Revised	Main heads: Drainage & Protective Works — Original	Main heads: Drainage & Protective Works — Revised	Remarks
	Embanking Upulam (2)	B. land					150		
	do	E Earthwork					2,710		
	Minor Sluices (25)	C. Works			5,000	5,000			
	Chanels (10)	E Earthworks			5,000	5,000			
2.70	Chevur Kodu Chanel	B. land			9,500	7,500			
	Head Sluice	C. Works			b/ 100	500			b/ in Canal estimate
	do	do			b/ 1,670	—			b/ in Chevur Kodu Estimate, both required.
	Bridge, Argole	do			2,925				
	do	do			2,705				
	Regulator	do			1,355				
	Bridge Tamarakallu	do			2,510				
	do Kaldindi	do			2,695	70,000			
	do & drop-do & Upulam	do			3,535				
	Regulator	do			580				
	Tail Escape	do			575				
	Chanels	E Earthworks			5,585				
	Cattle Ramps (17)	D. Miscellaneous			6,930				
	Embanking Upulam	E Earthworks					795		
	Kaldindi branch Chanel	B land			590				
	Head Sluice	C. Works			760				
	Drop 1st mile	do			675	6,145			
	Bridge 2d mile	do			1370				
	Tail Escape	do			410				
	Chanel	E Earthworks			2340				(2000) acres Rupees 6145
	Kondangi branch Chanel	B. land			610				
	Head Sluice	C. Works			1420	5,800			
	Tail Escape	do			425				
	Chanel	E Earthworks			3345				(4000) acres Rupees 5,800
	Muttagonta branch Chanel	B. land			635				
	Head Sluice	C. Works			1495				
	Tail Escape	do			485	4255			
	Chanel	E Earthworks			1640				(2000) acres Rupees 4255
	Minor Sluices (10)	C. Works			4,000	4,000			
	Chanels (10)	E Earthworks			5,000	5,000			
4.40	Akkam Chanel								
	Head Sluice	C. Works			150	150			
	Tail Escape	do			375	375			
4.63	Giratta Chanel								
	Head Sluice	C. Works			40	40			
5.20	Chizurukota Chanel	B. land			1310	1,000			
	Head Sluice	C. Works			250	260			
	Bridge 6th mile	do			1570	1400			
	Bridge 7th do	do			1420	—			
	Tail Escape	do			550	550			(400) acres
	Chanel	E Earthworks			8035	6000			

Position			Main heads						
miles chains	Particulars	Left heads	Main Canals & Branches		Distributaries		Drainage & Irrigation Works		Remarks
			Original	Revised	Original	Revised	Original	Revised	
14.0	Kistalur Channel	B. Land			1272				
	Head Sluice	C. Works			400				
	Outlet 6 miles	do			1100		13,647		
	Bridge Unmetalled road	do			1080				
	Tail Escape	do			1345				
	Channel	Earthworks			6450				
16.77	Sarvepalem Channel	B. Land							6000 acres
	Head Sluice	C. Works			580		5075		
	Tail Escape	do			580				
	Channel	Earthworks			3915				
17.54	Sitanapalli Channel	B. Land							
	Head Sluice	C. Works			580		4,375		
	Tail Escape	do			445				
	Channel	Earthworks			3350				
18.44	Ramaveram Channel	B. Land							
	Head Sluice	C. Works			465		6,950		
	Tail Escape	do			685				
	Channel	Earthworks			5810				
			141,400	141,400	170,822	153012	3,655		34,000 acres
Establishment 25 per cent				35,350		38,253	915		
do Surveys about ½ do				710		765	—		
Tools & Plant 8 per cent				11,310		12,240	—		
						204270	4570		

50

Head Sluice. The Engineer-in-Chief may sanction the Head Sluice with a discharging capacity not exceeding 20 per cent in excess of the estimate, but the Chief Engineer's sanction must be obtained before the Head Sluice is constructed with a greater discharging capacity than 20 per cent in excess of the estimate.

Canals and Branches. The Engineer-in-Chief may sanction alterations in the direction and slopes of the Canals and Branches; but the Chief Engineer's sanction must be obtained before any alteration is made which will affect the discharging capacity of the Canal, and the Engineer-in-Chief may sanction such modification of the alignment as he considers desirable. The Chief Engineer's sanction must be obtained before any alteration is made in the alignment or slopes of the Canals and Branches which will affect the discharging capacity of the Canal.

Sidesluices. (1) The Engineer-in-Chief may sanction the construction of sidesluices to the lower level of the Canals and Branches, with the exception of those which appear to the Superintending Engineer to be unnecessary, and may sanction such modifications in the position and number of the sidesluices as he considers desirable. The Chief Engineer's sanction must be obtained before any sidesluices are constructed which are not shown in the Project Estimate, or before any sidesluices are removed which are shown in the Project Estimate, or before any modification is made in the position of any sidesluice shown in the Project Estimate, if the discharging capacity of the sidesluice is affected thereby. The Chief Engineer may also sanction the construction of sidesluices to

is placed not less than 3 feet below
ordinary low water of springs.

Rest houses.

(2) All the rest houses have been placed under this head. Three are proposed to be built at Kamtalla, Kykaluv and Kalidindi; but as not one of these places is on a navigable canal, the propriety of their selection is more than doubtful. It is advisable to place rest houses in the neighbourhood of considerable distribution offtakes or where much work is to be done and in this view a proper place for one rest house would be about 3 miles from the head of the Polavaram Kodur Canal. A good site for a second would be on the same canal, some 15 miles lower down near Rachapatnam and perhaps the best place for the third would be as near the end of the Ramachandrapuram Canal as ground on a suitable level can be found.

Cattle ramps.

(3) The gradients should not be flatter than is necessary; 1 in 6 is a very easy gradient for cattle. The width should be ample, herds of cattle cannot be driven along a narrow way unless between strong fences.

Upstream right embankment.

(4) The specification report for the upper 6½ miles is in parts difficult to be understood; but the general arrangement is a bank 4½ feet wide at top with 2 to 1 slopes and a level 2½ to 3 feet above M.F.L. The lower part of the embankment will be formed by adjusting the level of the left bank of the Chevur Kodur channel.

Distributaries

79. The first and principal distribution channel is the Chevur Kodur.

Chevur Kodur Channel.

(1) Lt. Campbell proposed to give this channel a new head at the Pullerm, but for the reasons given in para 76 it is considered better

Main Heads

to retain the old head. The levels of the canal of supply and of the channel at the offtake are as follow.

Polvarakodu canal	Bed	10.19
	Water	15.19
Chevur Kodu Channel	Bed	7.81
	Water	11.81

The sill of the present head sluice is at 8.64. There are 4 vents 2 feet by 3 feet.

Taking the ordinary working head of water at 3 feet the area of vents required will be 210 divided by 9 or 23⅓ square feet, and the present vents are therefore large enough, but were it desirable to increase them this could apparently be easily done, and as it will be necessary to raise the sill of the vents to 10.19 and to provide for dropping the water to the bed, 7.81, of the channel an item of Rupees 500 has been entered for the alterations which may be required.

210 c.ft. a second the discharge required 9 feet a second velocity through vents.

The omission of a new head will save

+40 acres

about 6000 Rupees in earthwork and at least 200 Rupees in land, for the greater part of the new head would pass through wet cultivation for which the average rate of 20 Rupees an acre would not suffice.

Had a new head been necessary, it must be noticed that the alignment of the junction of the new and old channels would have much needed improvement.

General arrangements.

(1.a) Omitting the new head the length of the channel will be 27.50 m ch

Level at head	7.81
" at tail	− 0.61
Fall available	8.42
or per mile	0.304

On the longitudinal section the bed fall is 3 inches a mile, and there is a drop of 1½ feet in the 2½ mile (old) which is not an advantage as the fall available is already so small as to give a velocity of less than 1 foot a second. At ¼ mile of

the new for 3 miles of the old mileage it was intended to reduce the depth of water from 4 to 3 feet. It will of course not be necessary to make any change of depth now near this point, but it is a question whether as long as the channel has to carry water for a large acreage it is desirable to reduce the depth below 4 feet.

(b) It is further very doubtful whether the old head of this channel is not too high up the Sabraz Kodu canal. It will be seen that there is very little irrigation under the channel in the first 10 or 12 miles; that the ground levels in the upper miles are not very favourable; that the Chevur Kodu will run very close to the Dakern channel at about 9 miles from the old offtake; that at this point the bed level of the former will be about 5.56 and that of the Sabraz Kodu at the head of the

Further considerations as to position of head.

Depth of water

Dakern channel will be 9.66 and that the length from the Dakern head to a junction with the Chevur Kodu would be about 7 miles of which 6 will be occupied by the Dakern channel in any case. This channel being an existing distributary to which but trifling additions are contemplated no sections of it have been given, but it would appear from its circumstances that it will probably be a better and cheaper line by which to convey water for the irrigation below the 9th mile (revised) of the Chevur Kodu channel. In that case the old offtake of this channel would be used only for the small amount of irrigation in the upper 7 or 8 miles.

(c) Except in the last 3 miles there is nothing in the level of the ground to prevent a depth of 4 feet of water being carried economically and a drop 3 miles from the end can be

given for a discharge of say 200 cubic feet a second the areas of waterway required with 3 and 4 feet of water respectively would be about 200 and 225 and the bottom widths 44 and 70 feet respectively. If, therefore, the depth be made 4 feet there will be a reduction of cost of land, earthworks and masonry works. Rupees 70,000 have been allowed in the revised estimate column for the works below the head sluice and this sum will probably more than suffice.

(1.d.) The estimates for these have been left as submitted, but the amounts are generally too high for tertiary distribution and there is certainly room for reduction. This is especially the case with the Kaldindi branch channel in which a saving may be secured by increasing the bed fall considerably by omitting the drop and lowering the bed slightly at the tail so as to obtain a fall of 16 inches a mile which with a depth of only 2 feet of water will give none too high a velocity.

Khigwantola Channel.

(2) This is the next distributary of the canal on which any considerable expenditure is proposed. Its length will be 10 miles and 73 chains and it has been arranged to run with a velocity of only 1.18 feet a second. As there is a greater fall available than the 4 inches a mile allowed, the velocity should be increased considerably which will reduce the cost of all descriptions of work. The bed of the canal at the offtake is at 9.42, that of the channel at 6.19, the bed of the channel at the tail end is at 3.10. At least 9 inches a mile fall can be obtained by starting at 9.42 and the lower part of the channel will be all

Branch channels

the latter for being lowered. The reduction of depth as the acreage decreases may be conveniently arranged for by a reduction of bed fall keeping the surface fall about the same throughout.

(3) The first 5 to 6 miles are in rock and require very little in the way of improvement. As regards the extention the longitudinal section shows that the line selected gives heavier cutting than is desirable and this is especially the case in the 11, 12 and 13th miles. If practicable the line should be run on ground not so high. The head sluices of this channel will with the altered arrangements of the Polvarkodu canal require more water may than was intended by Lt. Campbell. It has 3 vents of 4 feet span and its sill is 0.61 feet below the proper level it can be re- arranged with two vents of 7½ or 8

Kykaluv Channel

feet each and 5.11 feet high which will make the sluice of ample capacity. The only other masonry works are a bridge in the 5th mile and outlet in the 6th mile and a tail escape, and flood water in the Upstream being but slightly above water level in the channel no special arrangements at the latter will be needed. No channels for distribution are shown on the plans in connection with the Kykaluv channel: they will be very short and necessarily some what numerous. It is not quite clear how they are to be provided for but it may be intended to construct them from the limpets for minor channels and sluices Polvarkodu canal.

Lower Pallem Channel.

80 This channel is to irrigate 12000 acres. Its head is close to that of the Polvarkodu and Bantu- malli canals at the end of the

Pullem canal. Its length will be 18½ miles. The following are the principal particulars, as shown in the sections

Level of bed — at head = 9.50
at tail = 2.25
Total fall 11.75

Width of bed — at head = 28.0
— tail = 3.0

From the lower part of the 5th mile it is proposed to be continued down to 7/8 miles as a side channel to the Ramtumalli canal, the estimate for the improvement of which latter forms a part of those of the 5th section

It will be seen that the fall available is only 0.635 feet a mile although for the tail end of the channel it is intended to be at a very low level. The depth of 1 foot is proposed at the 8 miles and one of 1½ feet at 4½ miles and some rock excavation is necessary perhaps if the Jadicherla

Kodur, in old course with a section very much greater than is required, be adopted, as intended by Lt Kimpshell for this distributary. It is doubtful however whether this plan is a good one, for it will necessarily be a long time before a proper regime would be established by the silting up of the section in excess of the proper waterway and a better arrangement would seem to be to make the Ramtumalli canal carry the irrigation water for the lower Pullem along rate as far as the 5th mile. This canal will have to be 25 feet wide at bed and will have a depth of 5 feet. Consequently to carry 225 cubic feet a second a velocity of 1.38 feet a second will be required, which will be moderate and suitable to a navigable canal. The expenditure proposed in the Jadicherla Kodur part of the

† Lower Pullem 180
Other irrigation 45

channil is about 4000 Rupees
and this would probably more
than suffice for all that would
be necessary to secure the efficiency
of the alternative arrangement. It
may be advisable to use the
canal as far as the 7½ miles where
the lower Pullem diverges finally
from the canal. The bed level of
the lower Pullem channel at 5 miles
is shown as

That of the Buntumalli canal
above the first lock at 6½ miles is — 7.00
the fall necessary for a discharge
of 180 cubic feet a second would
be 3.37 inches a mile and the
canal being generally of greater
than the normal section 3 inches
a mile will suffice. The bed level
at the 1st lock will then lie — 6.13
which will do very well and give
more than all the command required.
Again at the 7⅜ mile of the Buntumalli
Canal the bed level is shown to lie — 8.84
and water — do — 7.84

4.50

while those of the channel are bed — 3.06
water — 6.06.

It is clear therefore that it would
be quite practicable to do without
the first 7½ miles of the lower Pullem
as a separate channel and there
can be no doubt of the propriety
of using the first reach of the
Buntumalli Canal in supersession
of the first 5 miles of the lower
Pullem channel.

Abstract of Estimate.

(1) The following is a
classified abstract of the estimate
for the lower Pullem channel
and the revised estimate in
column will indicate the alteration
required

Position — Left — Main heads

Position	Particulars	Left heads	Main heads Distributaries Original	Revised	Remarks.
5	Compensation	B. land	2845	2000	This channel will be a distributary
	Head sluice	C. Works	680	1000	of the Buntumalli Canal.
	Drop at 3 miles	—do—	610	—	
	" at 4½ do	—do—	620	—	
	Bridge Argale road	—do—	2075	1500	
	Regulator 17½ mile	—do—	570	—	
	Tail escape	—do—	420	420	
	Channel	Earthworks	15340	12700	
	Cattle ramps (9)	Miscellaneous	2435	1800	
	Tadecherla Kadur branch channel	B. land	—	—	
	Head sluice	C. Works	645	645	
	Tail escape	—do—	390	390	(3000) acres.
	Haldindi Kadur branch Channel	B. land	615	460	
	Head sluice	C. Works	905	905	
	Regulating Bridge 9½ mile	—do—	950	950	
	Tail escape	—do—	465	465	
	Channel	Earthworks	2135	2135	(3000) acres
	Sedda Tummida branch Channel	B. land	1480	1100	
	Head sluice	C. Works	710	710	
	Bridge Argale road	—do—	1585	1500	
	Tail escape	—do—	465	485	
	Channel	Earthworks	6130	6130	(2000) acres.
	15 Minor sluices	C. Works	5250	5250	
	15 —do— Channels	Earthworks	7500	7600	
			55655	48660	12,000 acres.
	Establishment 25 per cent			12165	
	—do— Survey			500	
	Tools & Plant 8 per cent			3895	
				65220	

A few remarks on the alterations made will be convenient.

(2) One fourth has been deducted for berms between the channels and their banks being unnecessary. Land

(3) As a new work will have to be built on the Buntumalli ~~Canal~~, this item has been increased. L.J. Channel head sluice

(3.a) The bed width of channel being only 6 feet the smaller sum will be quite sufficient if splay wings be adopted and if the span be made equal to the mean width of the channel. Bridge Acqueduct road

(3.b) This may be dispensed with, the required discharge and the desired depth being obtained by adjusting the bed and surface falls of the channel. Regulator if any.

(3.c) The reduction is due to the upper 4½ miles of the channel not being required with an offtake from the Buntumalli canal. Earthworks

(4) Other reductions will probably be desirable but as sections of some of the channels and plans of the masonry works have not been furnished the details could not be examined. The rate, Rupees 5, per acre for the Pedda Tammidi branch channel is high and should be reduced if possible. Other reductions

Incidence of cost of bridges.

(5) In some cases provision has been made in the estimates for proposed roads. It will perhaps suffice to note that the cost of bridges will be debitable under the rules in force and the entry of items for them in these estimates will not warrant the debit of the expenditure upon them thereto except under those rules.

Drainages 4th Subsection

81 The principal drains of the subsection, commencing from the north, will be as follows:—

	Square miles of area drained.	Discharge in Cft. a second.	Drainage in 24 Hours in Inches.
Sullava main drain.	18.36	642	1.30
Damidi — do —	2.41	165	2.55
Pedatommelem do —	4.25	1108	1.00
Pedalanka — do —	107.31	2098	0.73

and the drains provided for the artificial relief of 169 out of the 201 square miles of country forming this subsection. The data on which they have been designed are the same as those adopted for other parts of the delta, and as elsewhere the dimensions of the drains should in the first instance be confined to such as may be sufficient to carry off about one third of the discharge calculated. Moreover Dr Campbell in the concluding part of his report on this subsection recommends that in the swamps the drainages should not be confined to a regular cross section, but should be allowed to spread, a narrow drain being cut through them and the spoil banks being placed sufficiently far apart to allow of ample waterway. Elsewhere and especially where the ground

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rises near the upstream the drains would be cut to such dimensions within the full size estimated for as experience may show to be necessary. Dr Campbell has calculated that the saving which will be effected by this arrangement will amount to 12½ lakhs of Rupees.

The details have not apparently been worked out for the sections and whatever is done in this direction must to be effective be adapted to the circumstances. To allow the water to spread in the swamps will at any rate for a considerable time to come occasion no inconvenience, and there can be no objection to the omission to form embankments through swamps where the cutting required to allow the water to run off is insufficient to form them, and where the omission will not cause the submergence of land

at a distance. In such cases the spoil banks if there be any cutting should be placed in the proper alignment should be made of such height as the soil will allow, and should be of the full dimensions of the base of the section. they will then confine the water within the drain except when it rises to a considerable level.

First requirements.

82. A great deal of drainage finds its way into the vicinity of the Upiterr and is then blocked by the comparatively high level of the river margin. The first thing to be done will be therefore to cut junk the tail ends of all the drains through this low ridge and this will at once afford much relief to the country and will moreover make it comparatively easy to ascertain the drainage works to be next taken up, and the extent to which it should in the first instance be carried out. The right embankment of the river will with the outfall sluices greatly reduce the quantity of water to be got rid of, and probably a comparatively small outlay judiciously made will reduce the extent of swamp so materially as to alter altogether the circumstances of this part of the Delta, and do all that is at present required.

Abstract of estimates.

83. The following is an abstract of the drainage estimates as submitted.

Position miles	chains	Particulars	Lnb heads	Main head Drainage & Protective Works Original	Main head Drainage & Protective Works Revised	Totals of Drains
		Pullava main drain	B. Land	5650	4500	
2	40	Bridge 3? mile	C. Works	3750	1500	
11	15	Outlet sluice at End	do	3185	3185	
		Drain	L Earthworks	66700	40000	49185
		Vedurava drain	B. Land	975	500	
		Culvert	C. Works	860	—	
		drain	L Earthworks	3690	3690	4190
		Arriava drain	B. Land	1335	620	
		Culvert	C. Works	825	—	
		drain	L Earthworks	6245	6245	6865
		Total Pullava main drain & affluents		93215	60240	60240
		Damidi drain	B. Land	2290	1500	
7	35	Outlet sluice at End	C. Works	2125	2125	
		drain	L Earthworks	15555	6000	
		Total Damidi drain		19970	9625	9625
		Seddakommelern main drain	B. Land	15280	10000	
0	60	Bridge	C. Works	4790	790	
5	40	do	do	9580	1040	
7	75	do	do	8940	1090	
		Outlet sluice	do	5140	5140	
		drain	L Earthworks	205000	83520	
				248730	101580	101580
		Chinnakommelern drain	B. Land	3760	2500	
		Bridge	C. Works	2570	815	
		do	do	4030	940	
		drain	L Earthworks	21815	21223	
				32175	23478	23478
		Total Seddakommelern & affluents		280905	125058	125058

Position miles	chains	Particulars	Lnb heads	Main head Drainage & Protective Works Original	Main head Drainage & Protective Works Revised	Totals of Drains
		Seddalanka drain	B. Land	15200	12000	
		drain	L Earthworks	415960	221260	
				431160	233260	233260
0	0	Singaraipalem drain	B. Land	2475	2000	
0	71	Road dam	C. Works	370	500	
4	4	Bridge	do	4400	1000	
7	33	do	do	6570	1200	
		drain	L Earthworks	30480	12400	
				44295	17100	17100
0	70	Utankuv drain	B. Land	1675	1700	
		drain	L Earthworks	8700	6220	
				10375	7920	7920
2	30	Kondanji drain	B. Land	1520	1250	
			L Earthworks	9235	4930	
				10755	6180	6180
5	20	Mattagunta drain	B. Land	1800	1600	
		drain (L.B)	L Earthworks	13180	6690	
				14980	8490	8490

Position	Particulars	Lib. heads	Main head Drainage & Protective Works		Totals of Drains
			Original	Revised	
5.20	Sedda Tumidi				
	drain ____	B. land	1,950	1,700	
	drain (R.B.) ____	Earthworks	12,060	8,540	
			14,010	10,240	10,240
6.30	Ammalapalli				
	drain	B. land	2,455	2,000	
	Bridge, Arcot road	C. Works	4,715	—	
	drain ____	Earthworks	21,060	9,530	
			28,230	11,530	11,530
	Total of Sedda Tanka drain & affluents		53,805		29,720
	Totals of drains 4" sub section		94,895		48,9643
	Establishment at 25 per cent				12,2417
	do Survey				5,000
	Tools & Plants 8 per cent				39,200
					6,56,260

84 The length is 11 m. 15 ch. It will start from the Salvankodu canal near Vinjarampadu. The level of the beds of the drain at the head is shown as 1.97 and as 3.5 at the tail ends so that the total fall available is 5.47 feet. Of this however 3.74 feet

Sullava drain.

are allotted to the first mile and the bed and surface fall thence to the end are only 0.9 feet a mile. This arrangement has entailed a much heavier estimate than is at all necessary. The upper end of the drain will it would seem require only canal surplus, and this can be carried partly in a narrow drain whence the earth for the banks will be taken, and partly above ground. The fall available should be totally equally distributed and may be taken as 1 inch in a mile through out, a much more effective fall than the 2 inches shown in the section. At the lower end of the drain where the discharge is suspended to the bed effect a second the bottom width will be and of the slopes of the spoil banks be placed not 70 feet instead of 104 feet, a part where will be plenty of space available and the drain there may be cut to a width of 30 feet in the first instance. The most important work will be the cutting through the 21 degrees in the 9, 10 & 11 miles & spread as instead of a dredger at 2½ miles will meet the requirements of the traffic.

Vidurava drain

(8) As this is to occupy swamp land entirely it is not clear why any compensation

compensation should be provided for. The drain as stands at ground level and a culvert at the head cannot be a necessity.

Estimates

(24) There are two estimates for the Pullavaram drain, one for Rs 50,220 and the other 66,706. The smaller estimate refers to the more economical arrangement suggested by Lieut Campbell & provides for a cut 20 feet wide only except at the lower end: the actual cost will with the modification of slope be less as the lower end will be 70 ft instead of 104 feet wide. The sum of Rs 50,000 entered in the received estimate column is intended to provide for such enlargements as are likely to be required.

Dumidi drain

85 The two estimates for the amount for the complete arrangement is Rupees 19,970
Modified do 14,875
This drain is intended to carry off the drainage generally only 2·41 square miles of country and the estimated cost as out of all proportion to the area to be benefited. The drain is due to an erroneous impression as to the discharge. The head fall is reasonably good

Peddakommedevu main drain

viz. 0·62 feet a mile, but it has been assumed that as the water will have little or no depth at the head & a depth of 4 feet at the tail the surface fall will be nearly 0·082 feet a mile. The bed of the drain will however be much below the surface of the country and there is nothing to prevent the surface fall approximating to the bed fall as the discharge increases. Consequently at the lower end the full section would be about 100 square feet instead of the 216 square feet designed. and a fully efficient drain may be provided at much less cost than the reduced estimate for even at the widest part the bottom width will be only 17 feet A drain 3 feet wide at bed level at the head and 7 feet at the tail can be cut for about 6000 Rupees, and to begin with, a width of 3 feet at the upper end with 1 foot added for each mile may be cut. The ultimate cost may be about 9625 Rupees, the first outlay will be about 7000 Rupees and even with this reduction the cost is heavy for the 1543 acres drained.

86 In this case the estimates are Rs 248,730 and Rs 96,825 respectively

a very important difference, but the greater part of the drain would with the reduced estimate bear no relation whatever to the area drained. The ground bed level at head is 3'91, the proposed bed level at the tail 3'50 and the length is 16.35 C. The bed fall available would therefore be 7'41 feet or on the average 0'45 feet a mile. The required discharge at the lower end is 1109 C.feet a second, the intended depth of water 4 feet. In the longitudinal section a fall of only 0'17 feet a mile is shewn and this greatly adds to the dimensions of the drain and to the amount of the estimate. Bearing in mind that the swamp is on a lower level than the surrounding country and that the ground level shewn in the longitudinal section is therefore one above which flood water may rise occasionally and temporarily without inconvenience, the proper arrangement will be to distribute the fall equally and to make the spoil banks about 6 feet above bed level as a minimum. Then if these banks be placed at a suitable distance apart (if where the cutting

is shallow it be confined to the width necessary for the formation of the banks, a drain will be obtained which if not perfect will probably do all that is necessary and this at a comparatively small expense. The revised levels of this main drain will be about as follow, and it will be assumed that the water level at the outfall of the Chunda Kommeitera will govern that of the drain above, which may perhaps rise thereabove but not more than will be provided for by the margin allowed in the embankments

Miles	Chains	Levels Bed Normal	Bed Actual	Ground	Water	Bank	Width at Bed	Earthwork Square Yards last Mile	Earthwork Cubic Yards in Mile	Width between Banks	Remarks
	1	2	3	4	5	6	7	8	9	10	11
0	0	3.91	1.35	3.91	4.11	6.11	14	4.11		20	
1	0	3.46	1.15	2.93	4.11	6.11	25	7.32	20,049	30	
2	0	3.01	0.96	0.93	4.11	6.11	—	16.53	20,996	240	
3	0	2.56	0.75	1.06	4.11	6.11	40	15.82	28,489	50	
4	0	2.11	0.55	1.05	4.11	6.11	50	15.68	27,896	60	
5	0	1.66	0.35	1.08	4.11	6.11	60	15.72	27,866	70	
6	0	1.21	0.15	1.27	4.11	6.11	70	14.72	26,787	80	
7	0	0.76	0.05	1.07	4.11	6.11	75	15.77	26,828	85	
8	0	0.31	0.25	1.22	4.11	6.11	80	14.98	27,069	90	
8	55	0.11	0.34	1.16	4.11	6.11	92	15.29	11658	96	
9	0	-0.34	0.14	1.37	3.86		150	25.00	28246	160	
10	0	-0.89	0.59	1.68	3.66		160	26.00	38,397		
11	0	-1.04	1.04	0.63	3.21		165	40.36	62,462		
12	0	-1.49	1.49	0.88	2.96		170	30.62	66,352		
13	0	-1.94	1.94	0.80	2.31		175	44.77	86,293		
14	0	-2.39	2.39	0.81	1.86		180	53.23	97,874		
15	0	-2.84	2.84	0.60	1.41		180	57.60	106,178		
16	0	-3.29	3.29	1.46	0.96		185	61.92	131,506		
16	35	-3.49	3.49	2.06	0.51		185	87.57	77755		
								114.08			

N.B. The width of cut in column 7 is down to actual bed level, column 3

The pits in column 11 are intended to be cut below actual bed level within the drain

The outside pits in do. are intended to be cut outside the drain banks

The earthworks above the Chinna Kommiléru junction will then be Cubic Yards - - - - - 207,545 at 1 Anna 12,972
and thence to end - 711,062 at ½ do. : 66,662

Hundreds - 3,986

Rupees 83,520

The above through taken only from a few depths will be a sufficiently near approximation as the ground is tolerably even - The amount 83,520 Rupees is more than Lt Campbell's reduced estimate, but it provides for all the requirements, and it may be found that a smaller drain will do

Practically the hydraulic mean and the actual depths may be taken to be equal at the lower end of the main drain and the velocity will be about 1½ feet a second - Consequently the area of drain at the tail end will be 740 feet, the mean width 185 feet, and the bottom width 173 feet instead of 265 feet as shewn on the section

The Chinna Kommiléru effluent enters at 8·35 chains and the discharge there required is 925 cft a second. The bottom width will be 116 feet against the 216 feet of the section

925
Chinna Kommiléru 552
375

The discharge immediately above M.C. 8·35 appears to be 375 cft a second - the velocity may be taken at 1¼ ft a second and the area of waterway required 300 sft, 67 feet would then be the bottom width of the drain instead of 210 ft, but to find soil for the banks a greater width than 67 feet has been allowed. The drain may be cut at first to about half the full dimensions in the lower 8 miles. In the upper part the excavation is only just enough for the banks

Chinna Kommiléru

Of course with reduced bed fall for the main drain the level of the bed of the latter at the junction with this effluent will be 0·11 instead of -2·16. The level of the bed at the head is shewn as 7·08 and the length is 9 miles 68 chains. Consequently the fall available is 6·97 feet or 0·708 ft a mile

The upper part of this drain appears to be what has hitherto been known as the Lingala drain which has been

been partly carried out. In the upper 4 miles where the drain runs alongside the Poltraghatta canal; it is not an advantage to have berms and banks on both sides. Lastly the water may be allowed to rise in the upper miles until it reaches the full depth of 4 ft intended at the lower end of the bank be made 6 feet above bed level. The arrangements of this drain will then be approximately as follow

Miles	Chains	Levels: Bed	Ground	Water	Bank	Earthwork: Square yards per mile	Cubic yards in mile	Width between Banks.	Remarks
a	0	7.08	7.08	11.05	15.08	10.66			
	0						17829		Right bank only
m 1	0	6.38	9.20	10.38	12.38	9.60			
	0						13868		Bottom width 25 ft
2	0	5.67	7.31	9.67	11.67	6.16			
	0						26787		do 30
3	0	4.96	9.84	8.96	10.96	24.27			
	0						38508		do 35
4	0	4.25	7.95	8.25	10.25	19.49			
	0						41541		do 40
5	0	3.55	9.16	7.55	9.55	35.67			
	0						52800		do 46
6	0	2.83	6.88	6.83	8.83	24.34			
	0						44458		do 52
7	0	2.13	1.39	6.13	8.13	26.18			
	0						38678	to	do double bank 58
8	0	1.42	1.06	5.42	7.42	18.00			
	0						29216	to	do 61
9	0	0.72	0.87	4.72	6.72	15.20			
	0						19508	to	do 64
9	0	0.11	1.16	4.11	6.11	10.87			
							323393		Bottom width 67

and the cost of earthworks Rs 21223

which is but little less than the Estimate. At first the cutting may be confined to half the bed width noted wherever this width will provide enough soil for the embankments

Masonry works

(2) The estimates provide for 9 bridges 3 for the main and 2 for the affluents It has first to be noticed that none of these bridges are for proposed roads, and their cost would therefore appear not to be chargeable to these estimates but to the roads. However the incidence of charge would be determined at the time when they may be undertaken, under the rules. These drains will except for a few days at a time have very little water in them and pavements or road dams will it is considered meet the requirements of the traffic

Peddalunka main drain & Singaraipalem drain

87. What is called in the estimate the Singaraipalem affluent is really the upper part of the main drain and determines the bed levels. They must therefore be considered together

	m	c
The length of the Singaraipalem drain is	9.	33
do do Peddalunka do.	10	
The level of the head of the affluent		
is that of the ground or	3.	60
do of rail of d.	2.	88
	6.	48

The head of tail of Peddakunka drain = 4'50. 6.48 1.62

The fall therefore is not equally distributed
The discharges at the several points are
as follows; for the effluent no discharges
in the several miles have been noted.
The crown sections where that there is an
old drain for a little more than 5 miles

		Discharge required
q.33		1896 cft a second
10.23	Utukur drain joins	1174
11.63	Kondangi do do	1446
14.53	Mattaguntu & Pedda Venkedu drains join	1840
15.63	Kunudalapalli do do	1997
19.33	out fall	

It will be desirable to reduce the fall
the upper part of the drain and increase
that of the lower part. This will reduce
a fair depth of cutting decrease the width of
necessary cutting in the lower half and make a
considerable material difference in the cost of the
slopes. upper part of the drain be likely to be
found on a somewhat too high level
of the cheap remedy will be the cutting
drain of a cunette say of 6 feet bottom width
and about a yard deep to carry off
and the last of the drainage and such a
to be cut and of any necessary width will
be the best way also of providing dead
be a for the banks where the cutting to ascertain
to the bed level may prove unnecessary

12 Ra. C

The average fall available for the q.33
is 0'417 and there appears to be nothing to
prevent its adoption throughout. The
following modifications will result and
it will be assumed
1st that water level at the head will not
exceed that at q.33 by more than about
a foot and that the bank for this part
of the drain which will leave a margin
of 2 feet at the lower end may be horizontal
2nd that the velocity at and immediately
above q.33 will be about 1.35 feet a second
3rd that the velocity below q.33 will be
about 1.45 feet a second
4th that the width of the drain in the upper
9 miles should increase tolerably regularly
from the head to that present

Position Miles	Chains	Bed levels Reduction	Revised Normal	Revised Actual	Ground levels	Water levels	Bank levels	Square yards at miles	Cubic yards in miles	Mean width of drain	Quantities and Rates	Remarks
												The actual levels of Column 4 will be those of the cunette
0	0	3.60	3.60	2.10	3.60	4.68	5.68	3.77		15		
1	0	2.97	3.19	1.85	3.25	4.67		4.78	7524	25		
2	0	2.23	2.77	1.60	3.62	4.46		3.72	7480	40		
3	0	1.55	2.36	1.35	3.46	4.35		7.33	9724	60		
4	0	0.86	1.93	1.10	2.58	4.24		7.63	43165	76		
5	0	0.17	1.52	.085	2.83	4.13		13.10	18242	90		
6	0	0.52	1.10	0.60	1.29	4.02		12.47	22502	105	78637 c. yards	4715
7	0	1.21	0.68	0.35	0.92	3.91		14.30	23558	120		
8	0	1.89	0.27	0.10	0.75	3.80		15.18	25942	140		
9	0	2.57	0.15	0.15	0.72	3.69		15.34	26858	160		
9	33	2.88	0.32	—	0.26	3.63	5.68	17.87	12065	166	88413 c. yards Sundries	6907 572 7485 / 12400

	10	23	2.98	0.68	–	0.36	2.32	5.32	23.11	31555	200		12400
	11	63	3.23	1.31	–	0.45	2.69	4.69	48.89	96040	250		
	13	0	3.44	1.82	–	1.07	2.18	4.18	66.95	123600	260		
	14	53	3.71	2.57	–	0.04	1.49	3.49	87.82	224442	320	476637 cu yds	44685
	15	63	3.89	2.98	–	0.34	1.02	3.02	125.42	210118	340		
	17	0	4.10	3.49	–	0.38	0.51	2.51	146.20	288606	340		
	18	0	4.26	3.90	–	0.56	0.10	2.10	173.44	281223	350		
	19	33	4.50	4.50	–	1.25	0.50	1.50	230.00	501476	360	1281283 cu yards	160185
												Sundries	2014870
													16390
													221260

By these modifications the cost of the main drain will be, if it should require to be carried out to the full dimensions, Rs 250360 instead of Rs 475,455. It should be remembered that as swamp land is not valuable land as 1 yard of lift is equal to 10 yards of lead, the banks should not be made too high. As this drain will have an open outfall into the Uppatera the banks in the lower part must be as high as the proper embankment as a minimum.

The top widths of all banks of drains are calculated for a top width of 4 feet and 2 to 1 slopes.

and (1) Road drains at 8 Rupees the foot Masonry works to have been substituted for bridges

(2) The level of this drain at its Ulukiwa drain head is to be 2.11 by the revised arrangement the bed at tail will be 0.68.

Fall 2.79 Its length will be 4 miles

5 chains. Fall per mile 0.687.

The water level may be assumed to be 8 feet higher at the head than at the lower end when the main drain is full or at — 4.32

The discharge required is at the lower end Cft a second 595

The velocity at this end, may be taken to be 1.45 feet a second and the mean width must be 103 feet

Position		Bed levels			Ground levels	Water levels	Bank levels	Square yards at miles	Cubic yards in miles	Mean width of drain	Quantities and Rates	
Miles	Chains	On Section	Revised Normal	Revised Actual								
0	0	2.11	2.11	0.02	2.11	4.32	5.32	748		32		
1	0	0.85	1.42	0.15	2.52	4.07		13.55	15286	45		
2	0	0.40	0.74	0.32	0.86	3.82		12.31	23,021	65		
3	0	7.65	0.04	0.49	0.21	3.57		16.15	25485	85		
4	5	2.95	0.68	0.68	0.32	3.32	5.32	15.56	27896	103	94628 Cubic Yards Sundries	5918 302 6220

Kondaruge drain

(3) The level of this drain at its head is to be 1.34
" do tail 1.31.
Fall 2.65

Its length will be 3 miles 55 chains Fall per mile 0.72ft
The water level may be assumed to be 0.67ft higher at the head than at the junction with the main drain when the latter is full or at 3.36
The discharge required is at the lower end, 572 cft a second. The velocity may be taken at the lower end as 1.45 ft and the mean width then will be 99 feet

Position		Bed levels			Ground levels	Water levels	Bank levels	Square yards at miles	Cubic yards in miles	Mean width of drain	Quantities and Rates	
Miles	Chains	On Section	Revised Normal	Revised Actual								
0	0	1.34	1.34	1.31	1.34	3.36	4.69	7.97	17002	27		
1	0	0.10	0.62		0.54	3.18		11.34	21648	46		
2	0	1.14	0.10		0.14	3.00		13.25	22141	65		
3	0	2.85	0.82		0.42	2.82		11.90	14314	85	75105 Cubic Yards Sundries	4694 236 4930
3	55	2.23	1.31	1.31	0.45	2.69	4.69	11.76		99		

(4)

(4) The level of this drain at its head is to be — 1.18
do tail — 2.51
Fall 3.69

Mattaguntu drain

The length will be M.C 5.20. Falls per mile — 0.70
The discharge required at the end is Cft a second 408
The velocity will be assumed to be 1.40 feet a second and the mean width at tail will be 70 feet

Position		Bed levels			Ground levels	Water levels	Bank levels	Square yards at mile	Cubic yards in mile	Mean width of drain	Quantities and Rates
		On Section	Reduced Normal	Reduced Actual							
Miles	Chains										
0	0	1.18	1.18	0.82	1.18	2.80	3.80	538		24	
1	0	0.25	0.48	1.14	1.11	2.55	3.55	850	13214	30	
2	0	0.60	0.22	1.46	1.25	2.40	3.89	10.58	47988	35	
3	0	1.61	0.93	1.78	0.133	2.15		9.38	17565	40	
4	0	2.64	1.68	2.11	0.45	1.90		14.22	28768	50	
5	0	3.47	2.33	2.43	0.20	1.65		17.53	27949	60	
5	20	3.71	2.51	2.57	0.04	1.49	3.49	19.21	8065	70	22455 cubic yards 4461 Earthwork 324 6890

(5) The level of the drain at the head is to be 1.18
do tail 2.51
Fall 3.69

Pedda Tumidi drain

The length will be M.C 5.60. Falls per mile — 0.64
The discharge required at lower end is Cft a second 438
The velocity will be assumed to be 1.40 feet a second, and the mean width of the drain will be 87 feet.

Position		Bed levels			Ground levels	Water levels	Bank levels	Square yards at mile	Cubic yards in mile	Mean width of drain	Quantities and Rates
		On Section	Reduced Normal	Reduced Actual							
Miles	Chains										
0	0	1.18	1.18	0.82	1.18	2.93	3.93	5.81			
1	0	0.33	0.64	1.11	0.20	2.68	3.68	8.48	12584	26	
2	0	0.52	0.10	1.40	0.89	2.48	3.49	12.42	18392	30	
3	0	1.37	0.74	1.71	0.68	2.18		11.44	20997	35	
4	0	2.22	1.38	2.00	0.95	1.93		12.71	24261	50	
5	0	3.07	2.02	2.29	0.85	1.68		19.02	27931	65	
5	60	3.71	2.87	2.87	0.04	1.49	3.49	23.88	23314	80	129479 cubic yards 3093 Earthwork 467 3560

(6) The bed level at the head of the section at Amudalapalli drain is 0.00
The level at tail is to be 2.98
Fall 2.98

The

16 E

M.C
The length is 5.45. Falls per mile available — 0.536
The discharge required at end is Cft a second 489.
The velocity has been assumed to be 1.40 feet a second and the width of drain will be 87 feet.
The water surface at the upper end of the drain will be taken to be 1.39 feet above that in the main drain

Position		Bed levels			Ground levels	Water levels	Bank levels	Sq Yards at Mile	C Yards in Mile	Mean width of drain	Quantities of trades
		On Section	Reduced Normal	Reduced Actual							
Miles	Chains										
0	0	0.00	0.00	—	4.77	2.41	3.41	3.18		6	The cutting is for main drain only
								7.74	12619	20	
1	0	0.70	-0.53	-1.98	0.02	2.16	3.16	7.17		30	
2	0	1.40	-1.07	-2.20	-0.25	1.91	3.02	8.66	13959	40	
3	0	2.10	-1.60	-2.42	0.34	1.66		16.33	24120	50	
4	0	2.80	-2.14	-2.64	0.10	1.41		19.79	30906	65	
5	0	3.50	-2.68	-2.86	0.05	1.16		24.25	38735	75	
									27888	87	46227 cubic yards 1712 Earthwork 4277 435 9530
5	45	3.89	-2.98	-2.98	1.34	1.02	3.02	32.09			

Total cost of drainage of 4th subsection.

The total cost of drainage as this arranged will be Rupees 489,643. the area drained being 128640 Acres, of which 46,000 Acres are expected to be irrigated. It is clear that the whole cost, whatever that may be, of drainage should not be charged to irrigation. It is not so easy to say what share of the outlay ought to be so charged and in most subsections of the delta would the share probably be the same if the circumstances be taken into account. In the case of the 4th subsection, irrigation is undertended beyond the disposal of surplus water conveyed by the canals, because a good deal of the land which it is intended to irrigate must be more

or

(4) or less completely drained to admit of its successful cultivation. On the whole probably a not unfair division of the cost would be obtained by charging about $\frac{5}{8}$ to Irrigation and $\frac{3}{8}$ to Ordinary Agricultural

Probable returns

89. The proposed outlay on the Irrigation works of this subsection without any addition for the cost of drainage would, it is expected, yield per cent ... 7%, and the returns including five eighths of the outlay on drainage improving that ultimately to cost as much as the estimates would be ... per cent 7.91

In this calculation it has been assumed that the land assessment as well as the water rate on irrigated lands rendered fit for cultivation will be credited to the Delta system, and it has further been assumed that one half of the additional area to be irrigated will be effected.

(1) There is no reason to doubt that the extra cost of maintenance will be more than covered by increase of current revenue. The canals and channels are to some extent already in operation and irrigation will in this subdivision spread as rapidly as the means may be afforded. Nothing therefore

+ the land assessment and water rate together have been taken to average 5.84

P. Maintenance

Items of Class VII

only 7 Oct 74 no 2844

(2)(23) Capitalization of abatement of land revenue. Lieut Campbell (Para 43) makes the loss of Revenue on lands taken up, Rs 3197 but by the modifications recommended in this Note the area will be considerably diminished and may be taken to be

250 Acres wet at 6 Rupees	1500.
500 do dry at 2 "	1000
Annual assessment	2500
Capitalized	62,500

and as the rates of assessment are much higher than those deducible from the Registers furnished by the Board of Revenue, and than those adopted in calculating returns from proposed outlay, it is considered that the capitalized abatement of land revenue will be very fully provided for, if assumed to be Rupees 50,000.

Exchange

(3)(24) This item will affect, if at all, only Tools and Plant, and the provision under this main head will suffice to cover exchange losses on the English materials which may be required.

Leave & Pension Allowances

(4)(25) These have been taken as one fourth the cost of establishment other than Surveys.

Class VII. Simple Interest

(5) There will be no interest on the

(4 The outlay on Irrigation works to be charged to Capital as Revenue will be secured directly the improvements are undertaken. It will however be necessary to allow for interest on drainage works expenditure, though it is considered that here also improvements will be rapidly followed by additional revenue. The drainage works will take some 10 years to make fairly complete. About half the work will be done in 5 years and by that time the ultimate requirements may probably be determinable

90. It has not been practicable to review at the present time the estimates which have been submitted by the Superintending Engineer for the 3rd Subdivision. Their amount will be about as follows, subject to such modifications as may be found necessary:-

Estimates for 3rd & 4th Subdivisions

Works			
Irrigation	173,550		
Navigation	129,680		
Drainage	342060	645,290	
Establishment		165,010	
Tools and Plant		52,000	862,300
Other charges			172600
		Total Rupees	1034,900

The net increase of Revenue is expected to be about 90,000 Rupees or per cent 8·70

The

The 3rd subdivision Estimates have also been received as soon as time will allow. The report of Lieut Campbell thereon (last paragraph) shews that the requirements are

Works Navigation	10,950	
Irrigation	265,245	
Drainage	622,980	899,175
to which would have to be added		
Establishment		230,225
Tools and Plant	72000	1202,000
and other charges would be about		248000
	Total Rupees	1450,000

Probably important modifications, especially of the drainage estimates, will be found

Supp Engrs No 30

The area of the subdivision is 277 Square miles
" " " expected area of irrigation 63,000 Acres
" " " present area of do 49,977 do
" " " additional do 23,023 do.

The most likely place for outlay of more than 10 lakhs, chargeable to the delta system, on this tract of country will be irrequisite or will be recommended for sanction

At the present moment, however, no information of value on this point can be given. The Superintending Engineer's letter shews that there is much need

for the improvements contemplated and the practical development of the Ryots' channels is specially noticeable

The

91

The subjoined Abstract will shew the estimates now submitted for the consideration of Government, the general scope of the proposals. In this Abstract the totals of the Estimates as revised have been entered and the percentages consequently are, with the addition of the entire cost of drainage and protective works, less considerable than is likely to be the case—

Condensed general Abstract

Nos of Sub Sections	Canals	Estimates Class I Works	Class II Establishment	Class III Tools & Plant	Class VI	Class VIII Simple Interest	Total	Area commanded Acres	Present Irrigation Acres	Additional Irrigation Acres	Total Irrigation Acres	Irrigation per square mile commanded Acres	Gross Revenue on Area in Column 11 Rupees	Additional Working Expenses Rupees	Net Revenue on Total Column 8	Per centage on Column 9	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	Bank Canal.																
	M. C & B.	8,05,445	2,04,365	64,400					—	60,000	60,000	242	188,000	63,795	124,205		
	Distributaries	106,217	27,553	14,900				45771									
	Drainage & Protective works	145,960	36,490	11,660													
	River embankment	50,000	12,500	4,000													
	Total—	11,87,622	296,908	94,960	214,227	185000	19,36,737										
	Masulipatam Canal							68771									
	M. C & B																
	Distributaries	213,520	53,380	17,080	13,353	—	297,330	28600									
	West Side Channel	194786	51694	15580	23000	25000	3,10,060		31,174	68,326	99,500	324	294,978	42,704	162,274		
	Drainage & Protective works	210,260	55665	16,825	23000	—	305,650										
2	Ellore Canal.	405,046	107,259	32405	46000	25000	615710										
	M. C & B.	137580							6838	21,162	28000	301	63,486	13,226	50,260	16.21	
	Distributaries	26,925	47,125	14757	14000	—	260,357	19600									
	Drainage & Protective works	56795	10,195	2940	3890	—	53820								50,260	8.16	
	Total—	221270	57,320	17,697	17,890	—	314377										
4	Cobrakodu Canal								18192	12,808	31,000	224	38000	3550	34,450	13.23	
	M C & B																
	Distributaries	141,400	36,060	11,310													
	Drainage & Protective works	153,012	39,018	12,240	102,000	57,000									34,450	10.96	
		3658	915	—													
		298067	75993	23,550	102000	57,000	556,610										
	Lower Pulleru Channel	48660	12665	3895	3170	4000	72390	12800	11995	34005	46000	229	102,015	25505	76,510	12.21	
	Drainage & Protective works	486643	127,417	39,200	81860	181,500	9,19,620	128644	11995	34005	46000	229	127,576	30,576	97,000	6.27	
		836370	216075	66,645	185030	242500	1546,620										

(4)

The preparation of a statement shewing the value of each canal as a remunerative work would be a somewhat difficult matter as it would involve a distribution of past expenditure, the proper incidence of which among the Delta Canals is not readily ascertainable. The most reliable estimate of the probable results of completing the Delta works is deducible from the effects of past expenditure & from the revenue of the present incomplete works what that revenue is and what its progress has been, is to be seen in the Appendix Abstract of Financial results [illegible] and it is noticeable that the percentage, up to the latest year, has remained good - 12 & 15 per cent, notwithstanding that there has been a good deal of expenditure in the last 7 or 8 years, on works which [illegible] delver, and without the further works included in these estimates, can have but a very small influence on the extension of irrigation in the Delta. There is no reason whatever to doubt the value of the irrigation canals and channels and of their being worth completing. As regards the drainage works, the best has been done that the data available would allow, to shew what the requirements of the tract

(5)

of country forming the Delta are, and the probable cost of meeting them; and it is believed that if there has been error it is on the side of a too ample, rather than of a too limited, provision for the disposal of flood water from rainfall. The drainage can and should be carried out tentatively in the first instance, and on a comparatively small scale. This is necessary in order to secure immediate relief to the country. Afterwards enlargement can go forward as the circumstances may shew to be necessary. The ultimate dimensions of these drains will be fixed from recorded rainfall and the corresponding discharges.

Incidence of cost of drainage

92. The Delta system can afford very well to bear a very full share of the cost of a fairly complete system of drainage, but an endeavour has been made to indicate in the case of each subdivision of the Delta what that share should be. It seems to be clear that to throw the whole cost of drainage works on the irrigation of the Delta would not be just, and it is believed that to do so would

(4)

...ual to...ctually ...ponsible for in long...time to come, improvements which it needs no demonstration to shew must be much required in a country, much of which is but little above mean sea level, and the soil of which, nevertheless, is for the most part rich and well adapted to cultivation.

93. ..... The completion of the delta works will occupy a great many years. The extension of operations so far as it has been submitted to Government in this Note, and in that on a portion of the estimates for the Western delta, will for within sufficiently close limits, the way in which the system of irrigation and navigable canals, of distributaries and of drains, should be carried out and the cost of their completion. Lieutt Mc Neill Campbell has bestowed great pains upon the preparation of the several parts of the scheme, and the undersigned is of opinion that the results are highly creditable to him. It is hoped that his labors will meet with the full approval of Government, and that sanction will be accorded

General remarks

P.M. Cy 19 Dec/76 No 3572

to

to the early commencement of those portions of the improvements which are most required, and which will lead to an immediate extension of irrigation and increase of revenue, leaving such other parts, e.g. the Masulipatam Canal, west side channel the distributaries under the Bank canals to be taken up at a future time, when such a demand for water, as would warrant the expenditure on these works being incurred, may have arisen. There is so much immediately remunerative work to be done, or so much work as in the case of the Ellore canal improvements which is necessary to the security of existing canals, and to the development of the trade of the country, that all parts of the scheme of doubtful utility may well be left alone for the present. It will be seen that the Superintending Engineer in the concluding paragraph of his letter No 31 of the 9th June/76, states the cost of the whole of the improvements of the Eastern section of the delta as follows:

Estimates submitted. Works	£47.12.667.
Tools & Plant 8 per cent	377.008
Loss of assessment on lands taken up	100.000
Repairs of works in progress	100.000
	5289.675

The

The returns here calculated to be ...

Water tax at 4 Rupees an acre Rs 519,232 : Acres 129,808

or 9.8 per cent on the expenditure.

This calculation, were the estimates as submitted by him to be accepted, would need some considerable modifications, and to begin with, it would be necessary to add to the expenditure side of the account, nearly 12 lakhs for establishment charges, and this would be necessary under the works orders at present in force, even were the existing establishment of the delta equal to carrying out of the extensive works contemplated, and this is certainly not the case. This alteration alone would reduce the anticipated returns to 8 per cent and would be further reduced by the proportion of the 5th & 6th subscriptions, noted in para 90 as the basis for a rough calculation, as when the revised Works estimates, as more completely particulars of the cutting required to be taken into account will be seen. The general results would be as follows

	Tallay Rs
Bank canal	19,86,737
Masulipatam	2,97,330
West side channel	6,16,740
Ellore canal	3,15,510
Polroy Kodu do	15,70,390
Lower Pallern Channels	
3rd Subscription	10,00,000
5th do	10,34,900
Total	68,21,607

and on this sum Rupees 519,232 would give a return of 7.61 per cent. It may, it is considered, safely be assumed that not more than about 60 lakhs will be spent and charged to the delta system, and that the net returns will not be less than 8 per cent. The net revenue stated by Major Haddock may not in the form given be capable of being accepted, as it implies an average gross revenue of about 4 5/8 Rupees an acre, but if, as he mentions, the Revenue officers have informed him that Rupees 6 an acre will be obtainable from irrigated waste lands, that average may very well be reached as it would require that 40,065 acres out of the total of 129808 acres should pay the higher rate, or that a smaller number of acres should be so assessed the balance being made up by

reduction

Reduction of premium

Fort St George
6th November 1876

Colonel Ryves. Lt Colonel R.E.
Chief Engineer for Irrigation

To

The Secretary to Government
Public Works Department

ED 19-10-66 L 3342
" 10-3-71 - 722
- 29-9-74 - 2732
" 7-10-74 - 2844
- 13-11-74 - 3299
- 19-12-74 - 3572
- 10-7-75 - 1968.
" 17-2-76 - 2134.
- 28-7-76 - 1923.

P.W.D.
15 DEC 76
Frodk. Q.100

The Chief Engineer for Irrig.

To the Secretary to Govt
P. W. D.

Dated 6 Nov. 1876.
Despd. 16 Dec. 1876.

Encls. 1 & 1)

No. 294-W.

Kistna-Eastern Delta—
Note on the Completion
Estimates for the—.

× 1 Sketch map
& Appendices.

No. 55)

Cir 16-12-76. [illegible]

Kistna. Eastern Delta.

Note on Completion Estimates by the Chief Engineer for Irrigation.

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1 From Suptg. Engineer Kistna dt. 100 4th November 1874
Completion Report on the Eastern Delta of Kistna. with its appendices

2. Report on 1st Subsection

3. Correspondence regarding Masulipatam and Bank Canals.
To Suptg. Engr. dt. 226 - 24th Feb/75.
From L. McNeil Campbell dt. 3 - 1st April/75
To Suptg. Engr. dt. 706 - 30th June/75

4 Report on Masulipatam Canal from Reyes Channel head sluice to Tidal Locks dt. 65. 7 September 1875. with accompaniments from A to E.

5 From Suptg. Engr. Kistna dt. 29 - 3d June 1876 with 1 appendix A

6 From Suptg. Engr. Kistna dt. 79 - 6 Octr. 1874 with appendices from A to J.

FORMER CASES.

R No. 3 2 4 5 of 1876.

I. R. 494 B/76

Receipt No.

Dated

LATER CASES.

R No. 59 & Q of 1877.
R " 424 J "/77
R " 547 W/77
R " 850 J/77
J 32 K/82
12147 W 9-11-84

Sent to Government with No. 20

9.3.85 R 34 K/85

Printed with G. O. No. 45 dated

REMINDERS RECEIVED.

No. 1, dated
" 2, " 187 .
" 3, " "
" 4 " "
" 5, " "
" "

KEEP-WITHS.

Receip

From Govt Bombay

3528
22nd Decr. 1876.

ject:— Completion Estimate
rem Delta, Kistna

Record

ENCLOSURES.

to
"
"
"

ers and Proceedings in file.

Date.	No.	Date.

Memorandum 134 A

Observations in explanation of the concluding part of the draft order under Kistna Eastern Delta Completion Estimates may be desired

The Chief Engr. for I. in communication with the Examiner of P.W.A. with a view to the settlement of the correct principles of accounting for Irrigation works and probably before long the discussion will result in definite proposals for orders

The Construction of this Office is that if interest on charges against Irrigation works where all withdrawals from the treasury, it is necessary, in order to the ascertainment of the true financial position of such works, that either

1st. net revenue receipts in excess of interest charges on capital sunk should be taken in reduction of capital, or

2nd. that such surplus receipts credit interest should be allowed of

Fo

Thus Ch. No. 1923
25 July 1876

The same result would follow in
either case 134B

Submitting the approximate abstract
of financial results of the Nistna to
be fairly correct, the real results
would appear to be upto end 1874-75

Net revenue minus of interest charges	Rs. 42,19,553
Interest on surplus receipts from 1860-61 at 4½ per cent	11,20,362
	53,39,915
Capital outlay 4493902	44,93,902
Balance credit of the system Rs.	8,46,013
~~Interest charge 2646665~~	~~7,40,507~~
~~Balance to debit of the system~~	~~15,00,652~~

The interest charges are a little over
2 lakhs a year since the net increase
of revenue almost 5 lakhs, so that
a balance of 3 lakhs of rupees and
~~3 lakhs are due to be annually for~~
are available for completing the system
~~charging interest above debit of Com-~~
~~pleting the works now in hand~~
~~Rupees~~ Rupees 4½ lakhs as the
yearly expenditure there will without
any increase of revenue in the 10

The expenditure shown here includes all the Capital outlay and all the interest charges and leaves a balance of £2½ Lakhs of Rupees and nearly ½ Lakhs of surplus annual revenue to work with

The future expenditure will probably not exceed 1½ Lakhs yearly, and leaves a balance to credit of the capital which will increase by leaps and bounds and which can be financed the necessary reasonable loans will be sanctioned in the draft order

Hy. 11/12/26

11

Memorandum.

A few words in explanation of the concluding part of the draft order on the Kistna Eastern Delta completion estimates may be desired.

The Chief Engineer for Irrigation has been in communication with the Examiner of P.W.A. ~~with a view to the settlement~~ as to the interest charges ~~to be ascertained~~ on capital outlay, while no interest is charged ~~on the capital principle of accounting~~ for Irrigation works and probably before long ~~the discussions will proceed~~ on supplies received. ~~in definite proposals for orders.~~

The contention of this office is that if interest is charged against Irrigation Works upon all withdrawals from the treasury, it is necessary, in order to the ascertainment of the true financial position of such works, that either

1st net revenue receipts in excess of interest charges on Capital sunk should be taken in reduction of Capital, or

2nd that on such surplus receipts credit

by Vice note

12

interest should be allowed.
The same result would follow in either case.

Supposing the approximate abstract of financial results of the Kistna to be fairly correct, the real results would appear to be up to end of 1874-75

Bm.G. Rs. 1923
28th July 1876.

Net revenue in excess of interest charges. Rupees 42,19,553

Interest on surplus receipts from 1860-61 at 4½ per cent. — " — 11,20,362

53,39,915

Capital outlay — " — 44,93,902

Balance to credit of the system Rs 8,46,013

The system then has paid off all the Capital outlay and all the interest charges and has a balance of 8½ lakhs of surplus annual revenue to work with.

The future expenditure will probably not exceed 4½ lakhs yearly, and so the balance to credit of the system will increase year by year, and when the works are finished

the result will be even more favourable than as stated in the draft order.

Lee. 12/12

Ex. 1 (a)

B

35.77	Wutlur outlet	F. River & Hill Torrent works	21,840	4,900			
37.7	West Tummilern do	—— do ——	8180	2,520			
10	do Aqueduct alterations	—— do ——	19,080	13,000			
38.55	Ellore Bridge Towpath	Navigation work	465	465			
39.60	East Tummilern outlet and additional outlet	F. River & Hill Torrent works	17230	17230			

I Works - Total -			1,87,275	1,37,500	67,775	46,915	49,120	37,795
II Establishment 25 per cent on I							
III Tools & Plant 8 per cent on I							

134.6

Position			Main heads					
Miles Chains	Description	Sub heads	Main Canals and Branches		Distributaries		Drainage and Protective Works		Remarks.
			Original	Revised	Original	Revised	Original	Revised	
11.70	Kasarapalli channel	B. Land				200			300 acres at 6 Rupees an acre.
		C. Works				350			
		I. Earthworks				650			
14.50	Butanalli Channel	B. Land				600			900 acres at do
		C. Works				750			
		I. Earthworks				2,250			
17.26	Panukanad Channel	B. Land				900			1353 — do — do
		C. Works				1,000			
		I. Earthworks				3,500			
20.20	Cherivada — do —	B. Land				500			770 — do — do
		C. Works			50000	650			
		I. Earthworks				1,930			
21.47	Puttagunta — do —	B. Land				670			1,000 — do — do
		C. Works				850			
		I. Earthworks				2480			
26.2	Kakulapad — do —	B. Land				550			800 — do — do
		C. Works				650			
		I. Earthworks				2000			
27.40	Gogunta — do —	B. Land				800			1200 — do — do
		C. Works				1,000			
		I. Earthworks				3,000			
					50,000	25,280			

D4A

	Description	Subheads	Main heads: Main Canals and Branches Original	Main heads: Main Canals and Branches Revised	Main heads: Distributaries Original	Main heads: Distributaries Revised	Main heads: Drainage and Protective Works Original	Main heads: Drainage and Protective Works Revised	Remarks
	Position				50,000	25,280			
	Miles chains								
	Channel	B. Land			1,370	1,370			
	Sluice	C. Works			850	1000			
36.20	Mupparru Head	do			400	765			5,430 acres
	1.20 Fall	do			390	735			
	2.20 do	do			400	755			
	3.20 do	do			455	860			
	Tail Escape	L. Earthworks			4,320	4,320			
	Channel	B. Land			1,410	1,410			
	Channel	C. Works			420	500			*no plan furnished
37.10	Madapalle Head	do			430	810			
	2.5 Fall	do			700	1,320			
	3.40 do	do			400	755			
	4.35 do	do			420	800			
	5.15 do	do			490	925			
	Tail Escape	L. Earthworks			5320	5320			
	Channel	B. Land					120	120	
	Nakalam Drain	L. Earthworks					670	670	
9.	Kasanapalli Drain	L. Earthworks					300	300	
10.21	do	B. Land					400	400	
	do	L. Earthworks					80	80	
11.	Kanaur do	B. Land							
		L. Earthworks					490	490	
19	Potipad do	B. Land					50	50	
		L. Earthworks					150	150	
		B. Land					710	710	
20.54	Simhapuram do	L. Earthworks					1,800	1800	
		B. Land					50	50	
	Viravalli do	L. Earthworks					350	350	
22.50	Nalligaram do	L. Earthworks					830	830	
26	Narsanapalem do	B. Land					300	300	
		L. Earthworks					1,875	1,875	
24	Canomole do	B. Land					225	225	
		L. Earthworks					1465	1,465	
27.00	Perikeet do	B. Land					170	170	
		L. Earthworks					300	300	
28	Ramelem do	B. Land					180	180	
		L. Earthworks					60	60	
31	Pennukollu do	B. Land					40	40	
		L. Earthworks					20	20	
33.20	Peddapad do	B. Land					1480	1480	
		L. Earthworks					6,780	6780	
35.77	Wutlur do	B. Land					70	70	
		L. Earthworks					300	300	
37.10	West Tummilem do	B. Land					300	300	
		L. Earthworks					14830	2500	no particulars
					67,775	46,915	34,595	23,265	

35.77 Wutlur outlet — F. River & Hill Forest Works 21,840 4,900

Position

Miles	Chains	Description	Sub-heads	Main heads: Main Canals and Branches — Original Service	Main heads: Distributaries — Original Service	Main heads: Drainage and Protective Works — Original Service	Remarks
				67,775	46,915	34,595	23,265
39	5	Jolipudi drain	B. Lands			100	100
			L. Earthworks			300	300
		East Tummilem do	L. Earthworks			2,160	2,165
		Minor drains	L. Miscellaneous			1,845	1,845
		Minor improvements to old existing works	do			10120	10,120
0	0	Improving Canal	L. Earthworks	29,640	29,640		
40	0	do	L. Navigation Works	26,870	26,870		
7	16	Undermain Aqueduct Improvements	F. River & Hill Forest Works	880	1,880		
10	21	Kasarapalli aqueduct	do	31,690	28,000		
20	54	Anupapuram outlet	do	1,235	1,235		
"	"	do inlet	do	1,280	1,280		
22	20	Viravalli outlet	do	380	380		
"	50	Nellivagu do	do	255	255		
27	10	Perikad do	do	19,060	6,720		
32	63	Kalapuram Bridge towpath	Navigation Works	430	430		
33	20	Peddapad outlet	F. River & Hill Forest Works	8,770	2,766		

Kistna. Eastern Delta
Consolidation Estimate,
Wutlur Section. No. 1.

This outlet is duplicate for
inlet and will be dropped
when Estimate comes to be
finally Consolidated.

Signed [illegible]
Lieut. R.E.

S.O. 434 - 12 Feb 1910 is
referred to in Para 6 (1)
of the Note Book
Capt. R.E.

Signed [illegible] Lieut. 11/5/10
Executive Engineer

Note on Kistna Delta
Completion estimates
Sheets 50 to 70
16 appendices.

Kistna. Eastern Delta.

Note on Completion Estimates by the Chief Engineer for Irrigation.

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Note on Kistna Eastern Delta Estimates.

Selects nos 26 to 49. Irrigation Colonization.

Pub. Wks Dept
G.O. No 3528 W.
22nd Dec 1876

E. I. Form No. 22.

135

No 3528 Public Works Department.

PROCEEDINGS of the MADRAS GOVERNMENT.

Under date the 22 Dec/76

Read the following:—

Note by the Chf. Engr. for Irrign. E.K.E. No 194 dt 6-Nov/76.

The Chief Engineer for Irrigation has in the foregoing Note laid before Government the general scheme for the completion of the works of the Kistna Eastern Delta, and has submitted for sanction estimates for a large part of the proposed arrangements.

2. This section of the delta lies on the left bank of the Kistna, and is bounded by the river

rivers on the one side,
and by the Eldora Canal,
the Clair Lake, the
Upintern and the sea
on the other side.
The total area is 1160 square miles
" area at present irrigated is 137723 acres
" area proposed to be do - 2700
For convenience of in-
vestigation it was found
desirable to divide this
track of country into
5 subsections, and the
estimates of all have
been prepared, but it
has not been found
practicable to examine
in detail more than three
of the 5 of the subsections
viz the 1st 2nd and 4th
in time for entry in
the Budget of 1877-78.
The proportion of intended
area of irrigation to total

area varies from 163 acres
to the square mile in the
5th subsection to 255 acres
to the square mile in
the 1st subsection.
3. Into the all im-
portant question of
water supply the Note
has entered at length, and
the general conclusion
arrived at is that, while
the present temporary
arrangements for raising
the crest of the anicut
annually on the subsidence
of the freshes, will suf-
fice until a considerable
extension of the irrigated
area has been effected,
it will within a few years
be necessary either to
place the masonry crest
something less than 3
feet higher, or to provide

shutters capable of being raised and lowered at pleasure. Before the time for this alteration arrives the data for determining the exact arrangements required will be ample, and there will be no difficulty in carrying them out, but the details will need to be very carefully considered. The Chief Engineer for Irrigation thinks that when the irrigation in the Eastern Delta has extended from 138,000 to 200,000 acres and that in the Western Delta from 75,000 to 150,000 acres, the raising of the water level above the amount for the better supply of the main canals will have to

to be provided for, and it will be desirable to be prepared at any time to carry out the necessary arrangements, which could be completed as far as would be requisite in one season. There appears to be no reason to doubt the feasibility of providing with a raised water level for the supply of the entire proposed area in all but very exceptional seasons. Such a season is now being experienced, and it may be noticed that, with the present very imperfect arrangements, the Superintending Engineer anticipates that from ¾ to ⅞ of the area under irrigation will be adequately supplied

4 The estimates include provision for the complete drainage of the country on a scale which has been designed to allow of all rainfall drainage being disposed of within a maximum period of 6 days. The data for deciding on the requisite capacity of drains for the relief of given areas are confessedly imperfect, and consequently it is proposed to cut them at first to from $\frac{1}{3}$ to $\frac{1}{2}$ of the designed dimensions, and thus to ascertain experimentally what is necessary for the efficient drainage of each particular locality. Another important point which has to be determined is

the proper incidence of the cost of drainage works. It has been shown that the quantity of surplus irrigation water to be disposed of is small compared with the discharge due to rainfall, and on the other hand the irrigated area interested in the improvement of the drainage is only about 36 per cent of the gross area. It will therefore not be proper to charge to the Delta system the whole cost of the drainage works, but at the present moment the Government are not in a position to arrive at a conclusion as to the proper distribution of the charge. The subject has for some

time past been engaging attention, and it is thought that the best plan will be

1st to consider these drainage estimates as an approximate indication of the amount which may ultimately have to be spent for the improvement of the agricultural condition of this tract of country,

2ndly to assume that about one third of the amount of these estimates will require to be laid out concurrently with the extension of irrigation in order, first to provide for the removal of the more prominent existing obstructions to effective drainage, and 2ndly to prevent all risk of deteriora-

-tion

tion of the condition of the country from the introduction by the canals of an increased supply of water,

3rdly to take sanction for this one third of these estimates as a lump sum provision for drainage, all proposals for expenditure being subsequently submitted for the specific sanction of the Government, so that improvements which may be shown to be necessary may from time to time be approved for execution,

4thly to charge to the Delta system the cost of this partial drainage on the assumption that at least so much will be necessary either in

the interests of the irrigated area, or to prevent increase of the inconvenience arising from defective drainage. By judicious arrangements it is anticipated that a good deal of subsidiary drainage will be secured without extra, or at a nominal, expence by forming catch drains alongside distributaries when outside cutting is required to make up the channel banks to proper section. This arrangement has been provided for in laying out the distribution and should be carefully borne in mind during the execution of the works.

5. The estimates of the 1st Section of the Eastern Delta contemplate

the irrigation of altogether 88,000 acres as follows:—

Under Bank Canal above Divi acres 15,000
— do —— in Divi —"— 45,000
—do— the West side channel of the Machlipatam Canal —"— 28,000

The Bank Canal will be an entirely new work and it will traverse Zemindary lands until it crosses the Puligadda branch of the Kistna and enters Divi. The experience of the past having shown it to be improbable that for any large proportion of these Zemindaries water will be demanded, it was intended that a supply should be provided for only 100 acres to the square mile or 8,300 acres, but the project having been worked

G.O. Nr. 434 of the 17th February 1876.

out before this decision was come to, a revision has not been made on this account. It is also to be noticed that the formula used for calculating the discharge of the canal as designed is believed by the Chief Engineer to give a higher than the probable discharge, and that consequently there is not likely to be too much water: in other respects some material alterations have been made by the Chief Engineer for Irrigation, and as submitted for sanction the estimates stand as follow:—

Classes	Main Canals and Branches	Distributaries	Drainage & Protective Works	Inner Embankments	
I Works	805,445	186,217	145,360	50,000	1187,622
II Establishment	204,365	51,553	38,470	12,500	306,908
III Tools & Plant	64,400	14,900	11,650	4,000	94,950
	1074,210	252,670	196,130	66,500	1589,410

The Chief Engineer for Irrigation in para 24 of his note gives reasons for recommending that the work required in excess of the spoil from the Bank Canal, to complete the river flood bank should not be charged to the Delta system. That system has already been debited with the cost of the existing embankment which has proved on more than one occasion in recent years inadequate, and it may readily be admitted that the Irrigation works are not the only works in property interested in the efficiency of these protective works. The Delta system may therefore be deemed to have already

contributed its full share to their cost, and the estimate of 50,000 Rupees for further improvements will therefore be sanctioned under Ordinary Agricultural.

6. The estimates for the Bank Canal and its subsidiary works will then stand as follows:-

Works.	Main Canals & Branches	Rupees 8,05,445
	Distributaries	" 1,86,217
	Drainage & Protective works one third of estimate	" 48,653
		10,40,315
Establishment		2,70,085
Tools and Plant		83,190
		13,93,590
To which may be added (para 26 of note)		
Huts	10,000	
Unforeseen outlay	20,000	30,000
Total direct charges		Rs. 14,23,590

The Chief Engineer for Irrigation has shown that the returns may be estimated in several ways, and that

Note para 26.

taking the least favourable the net revenue may be expected to amount to Rupees 1,18,605 or 8.32 per cent on the direct charges. With indirect charges added Lt-Colonel Mullins' figures indicate that the returns are likely to prove satisfactory even on the proposed outlay on this canal by itself, and his conclusions are supported by the results of past expenditure on the Delta works generally.

7. As regards details of the canal arrangements the note on the estimates has entered so fully into the subject of modifications which should be attended to in carrying out the works, that important as are many of the matters

referred to, it is unnecessary to notice them in this order further than to direct the careful attention of the Superintending Engineer to them.

8. The Masulipatam Canal will, by its West side channel, provide for the irrigation of that part of the 1st subsection of the Eastern Delta lying to the East of the Kanakalamadeiqu drain. After due consideration the Chief Engineer for Irrigation has decided to supply the West side channel from the end of the first reach of the Masulipatam Canal rather than through the Bank Canal which has its head at 3½ miles, and the estimates provide for this arrangement. The area commanded

commanded by the canal is 399.35 square miles or say 256,000 acres, of which 96.92 square miles or 62,029 acres are commanded by the West side channel. The area of irrigation in 1873-74 was ——— Acres 38,012 of which the area of irrigation under the West side channel was 6,838

The proposed ultimate areas are

Canal ——— 1,27,500
West side channel — 26,000

The greater part of the irrigation supplied by the Canal will be under the Pullern, the particulars being as follow.—

	Present	Intended	Increase
Masulipatam Canal —	3,000	6,000	3,000
Pullern ———	28,174	93,500	65,326
West side channel —	6,838	28,000	21,162
	38,012	1,27,500	89,488

The improvements to the Masulipatam Canal con-

templated provide for its enlargement down to 3½ miles for the supply of the Bank Canal, and thence to the end of the 1st reach for the supply (in part) of the Pullery and of the west side channel. This reach terminates at the Kunkipad lock, and thence to the Tidal lock at the lower end it is proposed to arrange for still water navigation and it was intended not to carry any water for irrigation in this part, but Lt. Colonel Mullins conceives that while it is desirable to secure still water at times, it is not necessary at any rate for the present to give up the use of the Canal as an irrigation duct, and

pending a demand for a greatly increased supply of water for the tract of country all Leminday commanded by the west side channel, there appears to lie no good or sufficient reason for incurring any considerable expenditure on the introduction of the more complete arrangements which the side channel will ultimately, if necessary secure.

The estimate for the Mandapatam Canal amounts to Rupees 2,83,980, as follows:-

Works -	Earthworks	1,74,660	
	Navigation Works	38,860	2,13,520
Establishment			53,380
Tools and Plant			17,080
		Total Rupees	2,83,980.

Of the above Rupees 122,580 are for widening the first

3½ miles of the canal and Rupees 52,080 for widening the rest of the 1st reach down to 12⅙ miles. A new lock at Nedumole, 36⅝ miles, is the principal item of the navigation works, and before this is undertaken it is intended to see whether by a much smaller expenditure the old lock cannot be made safe and efficient.

With regard to the direct returns to be anticipated from the above estimated outlay the Chief Engineer for Irrigation shows that it is difficult to indicate what the results will be apart from those from the several canals supplied from this source, but in para 34 (1) he notes the charges of distribution and these are for works

Bank Canal ——— Rupees 49,032
Machilipatam Canal (and Pullery) ... 96,315
do West side channel ... 29,313

There will then remain Rupees 38,860 to be considered in connection with the navigation receipts which are obtained from licences issued not for the navigation of particular canals, but of those of the Delta generally.

9 The Machilipatam West side channel commands with the exception of a few acres Zemindary lands only. The present area of irrigation is acres 6,836 and the proposed ultimate area 28,000

acres. It would be practicable with but a small outlay on distributaries to provide water for a much larger area than that at present watered were there a demand for water. The side channel has been partly constructed on an estimate of Rupees 49,860 sanctioned in 1860, but this estimate was a very incomplete one and the work done has varied considerably from that provided for. The proper treatment of the channel and its branches has been noticed by the Chief Engineer for Irrigation, and as the circumstances appear to support his opinion that for some time to come all the water needed may be conveyed by the Masulipatam Canal and distributed through the side channel as it is, with only some minor improvements and minor distributaries, for which he thinks a sum of Rupees 30,000 will probably suffice, it will be desirable that the arrangements should be re considered especially with reference to the assumed advantages of the side channel system, and the economy of maintenance supposed to attend it; and revised proposals submitted at a future time. This will not prevent such works as may from time to time be found necessary

to meet demands for water being carried out, and for these estimates may be separately submitted for sanction when necessary. The estimates, as in part revised by the Chief Engineer are as follows:-

	Works.	Establishment.	Tools & Plant.	Total
Distributaries -	1,94,786	51,694	15,580	2,62060
Drainage and Protective Works	2,10,260	55,565	16,825	2,82,650

With regard to drainage works, the land being Zemindary, Government could in no case be prepared to incur a larger outlay than would be necessary to secure the efficient cultivation of irrigated lands paying a water rate, or for which a water rate would be paid, and then also the financial bearing of the proposals would

would have to be very clearly demonstrated.

10 The 2nd subsection is connected with only one, the Ellore, Canal and of the estimates the Chief Engineer for Irrigation says they "provide for improvements which after much discussion as to the best way of removing the many defects of its original construction have been considered to be the best which at a reasonable cost can be devised". One great defect is the smallness of the bed and surface fall, the former being less than 1 foot in 3 miles. Again the upper sill of the Ellore lock at 40 miles is 4.63 feet lower than the Canal

bed nearly 3 miles higher up. The other great defect is the inadequate means of passing drainage across the canal. The remedy of these defects has been duly provided for in the estimates.

The area of land commanded by the canal is 140 square miles and the intended area of irrigation is 31,000 acres or 221½ acres to the square mile. The present area of irrigation is reported to be

in Kistna District— acres 4,561
" Godavery—do— " 13,631
Total— 18,192

leaving only 12,808 acres as additional area. In the Kistna District all the land irrigated is Zemindary and there is

little Government land commanded. As most of the additional area is in the Kistna; it is doubtful what increased demand for water will arise and when. The estimates as revised are, according to the alternative abstract, which ~~apparently~~ apparently adopts the more reasonable classification

	Works	Establishment	Tools & Plant	Totals
Main Canals & Branches	1,37,560	34,390	11,000	1,82,950
Distributaries	46,915	12,735	3,750	63,400
Drainage & Protective Works	36,795	10,195	2,940	49,930
	2,21,270	57,320	17,690	2,96,280

and on the total of Rupees 2,96,280 a water rate of 3 Rupees only on 12,808 acres would, after allowing for increased maintenance charges, yield a return of 11 per cent.

The improvements proposed however are shown, independently of the prospect of a direct return, to be necessary for rendering the canal fairly efficient to meet the requirements of its circumstances and of existing irrigation and navigation. Part of the expenditure will therefore be chargeable to the returns already derived from the Delta system, and it can hardly be doubted that in due course a sufficient return will result from the improvements.

The Note contains full information regarding the revisions of details which have been made by the Chief Engineer for Irrigation

11 The estimates of the

the 4th or Kyrtalur sub-section have been reviewed out of the regular order owing to much importance being attached to the early commencement of the improvements, 1st to utilize the water supply which will almost immediately be available from Lyves Canal through the Sullerw and 2ndly to ameliorate the condition of the tract of country concerned in which the lands are generally unfit for dry cultivation, the water supply is at present very inadequate, and the drainage greatly in need of improvement. The people are represented to be much anxious for improved means of irrigation and com-

munication, which the canals will afford.

The area of the subsection is 201 square miles, and the proposed extent of irrigation will be 229 acres to the square mile commanded. It is anticipated that all the land which is or can be rendered fit for irrigation and can be supplied, will be taken up as fast as the Canal and drainage improvements will admit

The canals and channels of the subsection will be

	areas acres Present	Proposed	Difference
Polavarkodu —	6,735	20,000	13,265
Cheruvukodu —	—	14,000	14,000
Lower Pullem Bintumalli Canal }	5,260	12,000	6,740
	11,995	46,000	34,005

considerable modifications have been made by the Chief Engineer for Irrigation in the details of the arrangements proposed by Lt. W.R. Campbell. They will not it is anticipated affect the cost of the Polavarkodu canal materially, and consequently the amount of the original estimates for this canal under drawhead (2) has been retained. The canal with its distributaries and the embanking of the Upiteru is estimated to cost as follows:-

	Works	Establishment	Tools & Plant	Total
Polavarkodu Canal	141,400	36,060	11,310	188,770
Distributaries —	153,012	39,018	12,240	204,270
Drainage & Protective Works	3655	915	—	4,570
	298,067	75,993	23,550	397,610

The Cheruvukodu instead

of having a separate head at the Pullerm is intended to be supplied from the Iobrazkodu Canal; the reasons for this alteration are stated in para 76 of the note, and the best position for the offtake should be further considered in connection with the remarks in para 79 (1.6)

12. Lt. Campbell proposed to make the Bentumalli Canal a still water navigation throughout, and to supply the lower Pullerm irrigation through the Vadicherlakodu. This arrangement has not been approved by the Chief Engineer for Irrigation, who points out that the first reach of 5 miles of the Bentumalli Canal should be used to convey water for the lower

Lower Pullerm channel and that it is feasible, and possibly may be desirable, to carry irrigation water in the Canal for $2\frac{3}{8}$ miles of the 2nd reach. The revision of the estimate provides for making the channel a distributary of the Bentumalli canal, and the cost will be as follows.

Lower Pullerm Channel- Works	48.660
Establishment	12,665
Tools & Plant	3895

The remarks in para 80 (5) on the incidence of the cost of bridges for proposed roads should be attended to at the proper time, and the rules duly carried out.

13. The estimates of the drains of the 4th subdivision amounted

under works to the very
large sum of Rupees 9,47,895,
and attention having been
given by Dr. Campbell
to the subject of the re-
duction of the cost of these
works, he suggested a
modified arrangement
by which an arbitrary
and fixed width was
to be allowed to all
the drains where these
run through swamps.
This plan having the
demerit of not propor-
ing the capacity of the
drains to the area drained,
the Chief Engineer for Irrigation
has gone into the subject
in detail and has worked
out arrangements under
which the proportions between
capacity and drainage
area have been maintained,
and the estimated cost

reduced to Rupees
4,89,643. This too is rather
an approximate estimate
of possible ultimate re-
quirements, and it will
be observed (vide para 82)
that a very material altera-
tion in the condition of
this tract of country is
anticipated from the
opening out of only the
tail ends of the drains
through the ridge separating
the swamps and low ground
from the Upstern; and
thereafter, this great
obstacle to all drainage
having been removed,
the requirements of the
country will be readily
ascertainable and, as
elsewhere, comparatively
small drains will in
the first instance be cut,

the obstructions presented by ridges and high ground being first removed.

The drainage estimates as revised are as follow.

Pullava main drain & affluents	– Rupees	60,240
Damidi drain	"	9,625
Pedda kommelem drain & affluents	"	1,25,058
Pedda Lanka drain & affluents	"	2,94,720
Total Works		4,69,643
Establishment		1,27,417
Tools and Plant		59,200
		6,56,260

The Chief Engineer for Irrigation (Note para 85) considers that about five-eighths of the cost of the drainage may fairly be deemed chargeable to the Delta system, and for the purpose of obtaining a rough approximation of the probable

results of the improvements contemplated this distribution will be accepted. The estimates for the Anicut will then be

Subrazkodu Canal	Rupees	3,97,610
Lower Sullem Channel	"	65,220
Drainage $\frac{5 \times 6,57,260}{8}$	"	4,07,040
Total of Anicut		8,69,870

The additional area of irrigation will be 34,005 acres and an average water rate of Rupees 3 will not be too much to assume.

The gross return will then be 1,02,015

Maintenance 10 annas an acre. 21253		
Revenue Collections 9 per cent – 9182		30,435
Net return		71,580

which will be equivalent to 8.23 per cent on the outlay. This calculation

takes no account of the dry accessment of lands reclaimed by the drainage works or of that of waste land the cultivation of which will be rendered feasible by the supply of water, and it gives therefore a view by no means favourable of the probable results of the improvements. In the first instance it will be best to take sanction for one-third of the whole amount of the drainage estimates, and all expenditure against this reduced amount will be chargeable to the Delta system. The way in which a commencement is to be made has been sufficiently indicated, and generally drains of one fourth of the capacity which ultimately may be needed should in

the first instance be provided throughout the subsection.

The Government of India will therefore be asked to sanction the following estimates

	Works.	Establishment	Tools & Plant	Total
Polavarkodu Canal	2,98,067	75,993	23,550	3,97,610
Bentumalli Canal Lower Pullem Channel	48,660	12,665	3,895	65,220
Drainage	1,63,215	40,805	13,070	2,17,090
Total	5,09,942	1,29,463	40,515	6,79,920

14. As already noticed the estimates for the 3rd and 5th subsections have been received by the Chief Engineer for Irrigation but have not yet been reviewed. As submitted (vide para 90) they would including all charges be as follows.

3rd

3rd subsection — Rupees 1,45,000
5th — do — :- 10,34,900

and it is thought that it is not likely that an outlay of, 10 lakhs on the 3d subsection, chargeable to the Delta system, will be found requisite.

15. ... In para 91 of the state is given a general abstract of the proposed outlay and of the charges other than direct, ales of the irrigation and revenue particulars for all the canals for which Estimates have been submitted. The results are generally satisfactory and this though a low rate has been assumed, and no credit has been taken for land assessment. It may be anticipated therefore

Rupees 3 an acre.

S.M.G. N. 1923 of the 28th July 1876.

therefore that the actual results will be more favorable and in support of this view the actual results of past expenditure may properly be brought forward. The history of the Kistna Delta works is briefly this as shown by the approximate financial statement up to the end of 1874-75. The works were commenced in 1852-53, the total capital outlay amounted to the above date to Rs 44,93,902 the direct income had risen from nothing to, for that year — 8,90,595 the total income up to end of that year had been — 92,16,261 and the net revenue do — do — 66,66,215

also

also the difference between the net revenue and the charge for interest to _____ Rupees 42,19,533

If these figures be verified by the special investigations on which Mr Wilson is now employed it would follow that nearly all the capital outlay of the past has been recouped. It would appear also that, but for this statement continuing to charge interest on capital outlay which had been refunded his revenue receipts in excess of interest, not only would all capital have been refunded, but there would have been a considerable balance to the credit of the works. It may be

98
96
93 X

be further noticed that the net increase of revenue derived from the Delta works will more than suffice to provide all the money required for their completion, and ultimately there will be a complete system of irrigation and navigation which will have cost the State nothing, and will become an addition, after meeting all charges, of about 9 or 10 lakhs annually to the resources of the country. Such are the conclusions to which the figures point, and they are not likely in any case to be so modified as to make the Delta works other than highly valuable.

Wy. 11/12/76 T.C

Comm

Col Hutchinson Harvey

His Grace the Governor in Council desires to place on record his appreciation of the great care and ability with which these important papers have been submitted to the Government by the Chief Engineer for Irrigation and he requests that Col Mullins will convey to Lieut Gn. Cambell the approval of the Government for the manner in which he has performed the difficult and important work entrusted to him

Mk

H.L. No 3525 dt 22/12/77

Copy of the above forwarded to the Government of India.

P 554-554a
535
Corrib-12-76

S.E. Kistna & Godavery
Collectors do
C.E. for Irrig
Ex. E. W. A.
Reading Dept.

Desp 6-2-77

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31-1-36 [illegible]

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Cobl. of 1870, Indrs.

PUBLIC WORKS.

To

Dated

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G. O., 22nd Decr 1875, No. 352
352

Nos. 573 [illegible]

Eastern Delta, Rivers

Passing under review the [illegible]
by the Chief Engineer for
Irrigation submitting the
general scheme for the com-
-pletion of the works in —
and favorably noticing
manner in which Colon
Mullins and Lieutenan
Campbell have dealt with
the project.

Forwarding copy of letter
passed on above by the Chief
for Irrigation submitting
general scheme for the com
-tion of the works in the Eas
Delta of Rivers.