

Madras Recov. Office.

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24-8-1864 (Pres.)

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*Proceedings of the Madras Government, Public Works Department,
24th August 1864.*

No. 506. Read the following letter from the Consulting Engineer, Irrigation and Canal Company :—

Report on the Sunkasala Ancient and Head Works, and on the }
1st to 8th Sections of the Main Canal, &c., &c, inspected } (Here enter 2nd July 1864; No. 40.)
between the 30th May and 30th June 1864.

No. 507. ORDER THEREON, 24th August 1864, No. 2,438.

1. The Governor in Council has perused the foregoing report on the state of the Irrigation and Canal Company's works with much interest. It is a clear and able document, and will be communicated to the Company's Agent, with a request that the suggestions made by Captain Mullins may be adopted.

2. The Agent's attention will be specially drawn to the suggestions in paragraphs 4, 5, 7, 9, 10, 13, 15, 26, 27 (revetments to interior slope of canal and on exterior of bank), 35 (Kadragh aqueduct), 51 (Ullur aqueduct), 63, 65, 68, 78, 84, 90 (revetments), 91, 100, 101, 104, 105 (irrigation sluices, ferries and width of channel), 106, 119, 125, and 148 to 153; and to the omission in many instances to provide rear aprons to calingulahs. Supplemental Estimates should be submitted, if necessary, to supply this omission.

3. The Agent will also be requested to cause the investigation proposed in paragraph 90, in connection with the discharge of irrigation water into the Caulee, to be made, reporting the result to Government through the Consulting Engineer.

4. The report shows that the number of crossings to be provided for the accommodation of the villagers will not be sufficient, and concurring in the views on this subject expressed by the Consulting Engineer in paragraphs 148 and 149, the Governor in Council directs the adoption of the suggestion that the Range Officers of the Department Public Works should, in communication with Divisional Officers of the Company, prepare a scheme of village roads, adapting the arrangements to the masonry works in progress, or about to be built, and settling what further provision will be necessary.

5. The Superintending Engineers of the 2nd and 3rd Divisions will be furnished with copies of the foregoing report, in view to their issuing the requisite orders to the Range Officers concerned.

6. The report will also be communicated, through the Revenue Department, to the Collectors of Kurnool, Cuddapah and Nellore.

(True Extract.)

(Signed) J. H. M. SHAW STEWART, Major, R. E.,

Deputy Secretary to Government.

To the Consulting Engineer, Irrigation and Canal Company.
„ Agent for do. do.
„ Superintending Engineer, 2nd Division.
„ Do. 3rd Division.
„ Revenue Department.

Exd. S. T. Augustin.

Proceedings of the Madras Government, Public Works Department,

No. . Read the following letter from Captain J. MULLINS, R. E., Consulting Engineer for Irrigation and Canal Company, to Colonel C. A. ORR, R. E., Secretary to Government, Department of Public Works, dated Madras, 2nd July 1864, No. 40 :—

SIR,

1. In their Order as per margin, Government desired that the banks in the first section of the Canal, should be ascertained to be in a safe state before the admission of water was permitted, and also that the provision of cross-

ings should be properly carried out, in order that the inhabitants of the villages near the Canal might be enabled to reach their fields without difficulty. I therefore proceeded to Kurnool, which I reached on the 29th May, and I have taken advantage of the opportunity to make a complete inspection of the Company's works, and I have the honor to report the result of my inspection, which will afford Government information regarding the progress made upon the works, since my predecessor's last general inspection,* and also regarding their present state and prospects.

* Vide letter No. 33 of the 6th July 1863; and Proceedings of Government, No. 2,055, 25th July 1863.

2. The special points referred to in the orders above quoted, will be reported on in their proper place, and I will now begin with the Anicut and head works at Sunkésala.

Sunkésala Anicut.

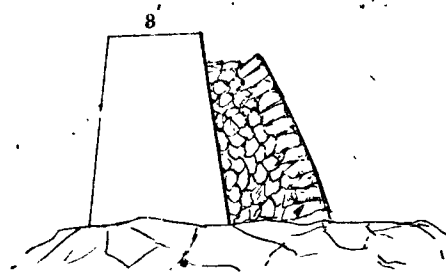
3. Both branches have been completed to their full height, no gaps remain, and that which formerly existed at the north end of the north branch has been closed by altering the line of the extreme end of the Anicut, in the direction of a more favourable ledge of rock, and raising across the deep channel a wing-wall of rubble masonry, which is connected with a mass of rock on the river bank, which rock forms a favourable termination, and will effectually prevent damage by the river turning the end of the work, should the northern embankment at any time give way. The wing is founded on a mass of rough stone.

4. Regarding the Anicut itself and the way in which it has been built, much need not be said here. General Ludlow, in paragraph 4 of his letter, alluded to the way in which the crown had been finished, and it has already been found necessary to repair parts, and it is clear that a crown composed of small irregular rubble stone is ill-fitted for such a position. All the rubble

stone work of the Anicut must be pronounced inferior, and its cost has been very high.† This part of the subject will be reported on fully when the Chief Engineer's report and the Supplemental Estimate, referred to in the Order as per margin,‡ are received and re-sub-

mitted, but even had the original rate, Rupees 3 per cubic yard, not been exceeded, a very superior class of work should have been obtained,§ and it cannot, in my opinion, be deemed at all a substantial or satisfactory weir

for the supply of the large and important Canal, at the head of which it stands. Some parts have already shown signs of weakness. In the north branch, at places, the rocky bed on which the Anicut was built, appears to be less hard than was anticipated, and at one place a sort of rubble retaining wall 6 feet from the rear of the Anicut at foot, and filled in with concrete had been commenced recently, with a view to keep the over-fall clear of the foot of the wall and cover the damaged rock; but the fresh had stopped this work, and I think its continuance would have been a waste of money; for in the first place its section was so slight, that there was little chance of its standing, and in the next place the formation of the rocks admits of



† According to the Supplemental Estimate the average cost is Rupees 4-3-0 per cubic yard, or deducting the excess of 5,000 cubic yards in the quantity therein shown, Rupees 5 per cubic yard.

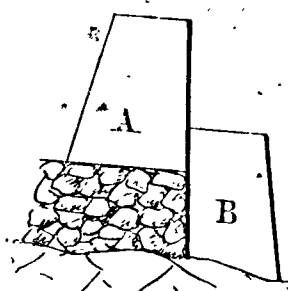
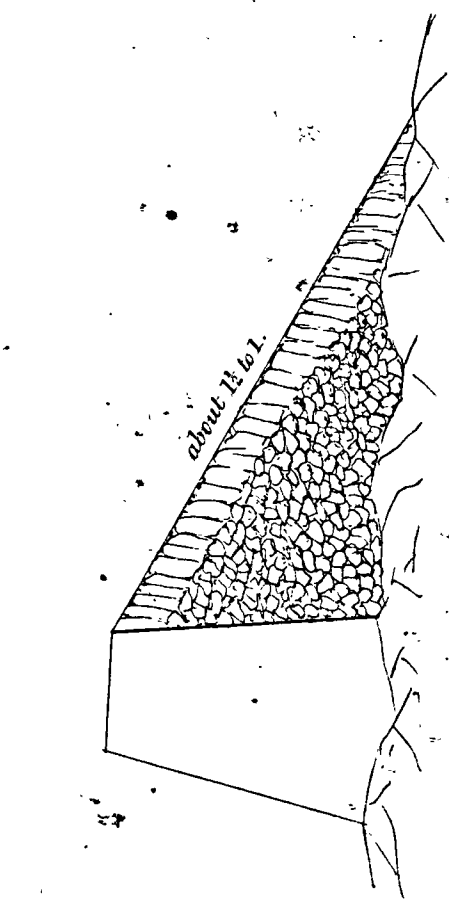
‡ No. 1,236, 29th April 1864.

§ See the cost of the very superior work noticed in paragraph 35, viz., Rupees 2½.

short retaining walls of small height being built a few yards below the work, and there are close at hand great boulders of rock which, if packed as an apron between the Anicut, and such retaining walls, or the contiguous masses of rock, would form a secure apron. It must be added also that it is very doubtful whether, in all cases, the wall forming the Anicut was founded directly upon the solid rock. Near the south end of the additional work above described, I observed what appeared to me to be a stratum of gravel under the base of the wall, and between it and the rock. This may be a mere patch, extending to but a small distance under the wall, but, if not, it would tend greatly to endanger the stability of the work. The water was running a few inches deep over the Anicut, so that a more accurate examination could not be made.

5. In paragraph 3 of General Ludlow's Report, it is mentioned that a gap in the south branch had been stopped by throwing in a mass of rough stone, and that upon this the body of the Anicut had been built. To relieve this part of the work from the effects of the over-fall, a wall was then being raised upon the crest of the work. The result probably would have been as anticipated, had the body wall immediately beyond been as stable as was supposed; but the actual effect was to cause a breach in the Anicut just beyond the termination of the raised portion. The damage has been made good, and to secure both the breached length and the original gap, the arrangement sketched in the margin has been made. This addition consists of a mass of rough stone, covered in with long packed stones, which are grouted with concrete, and the surfaces rendered tolerably smooth with plastering rubbed hard. Its stability is, in my opinion, very doubtful. Plaster does not usually stand with water passing over it at high velocities. The water would, were the plaster removed, soon pick out the concrete, and the displacement of a few of the packed stones would lead to the rapid destruction of the whole of this mass. As a temporary arrangement, it may answer the purpose of preventing a breach; but it cannot be relied on, and as a breach in the Anicut would be a most serious matter, when considerable tracts of land come to be converted from dry into wet cultivation, some more reliable plan of remedying the defects of the present body of the Anicut at this part, requires to be adopted. Probably it would be found economical in the end to make a puddled wall above the breach and gap, and to remove and re-build the body on the solid rock, or the body might be left, the lower part alone puddled, so as to stop the water coming through the rough stone, and then the second body built in rear to about a yard above the level of the present footing of the solid masonry. In the marginal sketch A represents the present body, founded on rough stone, and B would be the additional wall in rear.

Referred to also in paragraphs 11 and 12 of General Ludlow's letter of the 18th August 1868.
Proceedings of Government, No. 2,668, 15th September 1868.



6. Except under the new wing at the north end of the north branch, I observed no considerable leakage. That wing is built on rough stone, and a large mass of similar material is being thrown into the deep hollow in the rocks, immediately in rear of it. It is not unlikely that, as the bed of the river above the wall silts up, this leakage will be almost, if not entirely, stopped. There is a small vent in the wing near its southern end for the purpose of preventing stagnation in the water below, there being a village on the north bank of the river, which might otherwise suffer from the absence of fresh water.

Wing-walls of Anicut and their level.

7. It is estimated that the extraordinary fresh of 1851-52 would reach to 8 feet above the crest of the Anicut, and, according to present orders, their height is to be 9 feet above crest. This margin appears to me to be very much too small for safety, and it would be so even could it be considered certain that no higher fresh could occur, for the waves would wash over the walls and endanger the embankments at their junction with them. It will be advisable to construct upon the tops of these walls at least an additional wall 2 feet high, and of the same width. The cost will be very small, and I have asked the Executive Engineer to make an Estimate for it, and the additional security afforded by the small increase of masonry will be great.

Embankments, north end.

8. These, as originally constructed, went westwards from the north wing, and crossed a drainage channel, which would have required a culvert; an opening has been left to enable this drainage to reach the river. It is now intended to carry the embankment northwards in a direct line to the high ground about 300 yards distant. In order to do so, a small strip of land will have to be purchased, but from the present boundary of the Company's land to the opposite side of the cultivated land, is but a few feet, and beyond that there is waste stony land, so that the cost both of bank and land will be very small indeed. The proprietor asked a rent of Rupees 60 for a year's occupation, which at one time the Company's Officers thought of giving, in order to save time, pending the regular transfer of the ground; but, as only in extreme freshes, will the river rise and flow over the land, and as no injury to the works would be likely to occur, that idea has been given up, and the land will be applied for in the regular manner. This modified line of bank will be a great improvement upon the line originally selected, it avoids the difficulty of the drainage; it will be far less liable to injury from freshes, and its construction will be far less expensive than the completion of the existing embankment.

Embankment between the two branches of the Anicut.

9. In paragraph 7 of his letter General Ludlow speaks of the earth-work as being completed, but since last year considerable modifications have been made. The level of this cross bank has been for the most part raised to 15 feet above crest of Anicut, and the greater part of the earth-work of this addition has been thrown up. The up-stream slope was partially pitched with rubble stone last year, but the greater part of it will require re-packing, and, at the junction with the north wing of the south branch, either much additional stone must be given, or the wing return must be continued some distance further along the face of the embankment. As there is a rock foundation, perhaps the latter arrangement would be the better of the two.

Anicut Under-sluices.

10. These with the exception of the coping and roadway have been completed, and a few days will suffice to finish those works. At the time of my inspection nine out of the twelve vents were open, the water being 3 or 4 inches above the crown of the Anicut. They are fitted with revolving shutters, and considerable skill has been evinced in guarding against the evils attendant upon this method of regulating the discharge; but a good deal remains to be done before they can be considered really efficient. They are free from vibration when open, and this is a great point. They are not, however, at present capable of being opened and closed with less

than about 20 men, 10 to each capstan bar, and even then the difficulty is considerable, and the operation is not altogether free from danger. The capstan heads are somewhat less in diameter than is convenient, and while the workmanship of them is good, the mode of construction is faulty, for the pressure of the capstan bars is received on the bolts connecting the upper and lower plates, and these bolts, which are square, become displaced, and destroy the bars. It will probably be found the best plan to place a small crabwinch south of the sluices, and to work the bars by its means, when two men will be able to open and shut the sluices, and there will be no fear of the men falling over into the river, and being carried through the sluices by the breaking of a bar (as happened when I was present to the land bar). Iron eyes fixed in the masonry and a snatch block with a rope would be the means of transmitting the power of the winch. It may be conceded that the application of revolving shutters to Anicut under-sluices is in a fair way of being practically and successfully solved; but looking to the prime cost,* three times that of pole shutters, to the greater difficulty of executing repairs, and to the, perhaps impossibility of providing any alternative arrangement during the continuance of the freshes, in the event of a shutter of this description becoming unmanageable, it is very doubtful whether

* Original Estimate shows shutters
Raising gear Rs.
768
600

Supplemental Estimates gives 1,368
10,304

The first is too little, and probably 12 vents at 250—3,000
Rupees, would have been the cost of pole shutters with
iron work completed.

One of the present shutters will not remain open owing probably to some slight defect either in the shutter itself or in its setting up. This could of course be obviated by leaving a bar in the capstan, and lashing it, but it shows that great nicety is requisite, and when such is the case, so powerful an agent as water, with the velocity due to a great head, must be likely to cause such derangements as, without occasioning damage perhaps, would render a shutter useless.

11. From the Supplemental Estimate which, seeing that the work is nearly completed, may be taken as an approximation to actual cost, it would appear that the rubble stone in chunam has cost about Rupees 10-9-0 per cubic yard. It is much better work than that of the Anicut wall, but the rate is at least three times as high as it should have been. The cut stone work similarly has cost on the average Rupees 44 per cubic yard. That now being done, I am informed by the Resident Engineer, Mr. Harley, is costing Rupees 26 per cubic yard, but I was unable to make up this rate from the data. The chunam costs 2½ Rupees per candy* of 12 parabs or three

* Probably of 5 Parabs though stated to be 12.

Annas a parah, a very cheap rate. The stone, a laminated lime stone, comes from Kulguntlah on the north side of the river, and distant 12 miles. The carriage together with the cost at the quarries is one Rupee for each stone, and the average size of 195 stones, measured for the purpose when I was there, was 1½ cubic feet. One mason is paid 8 Annas for trimming and setting two stones. The cost of the stone and its carriage, therefore, amount to per cubic yard, Rupees 15-6-10, the dressing and setting Rupees 3-13-8, or together Rupees 19-4-6, exclusive of chunam and sundry labour, so that 20½ Rupees would appear to be the outside price, with the above data. This, however, would be much too high for the distance being 12 miles, the carriage, even allowing four cart loads to the cubic yard, and three Annas per load† per mile, or double

† Equivalent to 7½ Annas per ton per mile.

the ordinary rates, would amount to 9 Rupees a cubic yard. The quarrying, if the stone be near the surface, would perhaps be under 8 Annas, as laminated stone is easily detached; but at any rate 1 Rupee per cubic yard, which added to 9 Rupees for carriage, would make 10 Rupees per cubic yard at the work, would seem to be very ample, and I think that, if the material could not be obtained on contract at this, in my opinion, outside rate, special arrangements, under the management of the Executive Engineer, were called for. It is one of the very important duties of an Executive Engineer to ascertain what the cost of his work should be, and if any of his materials cannot be obtained on contract, at a moderate increase on the price which the current rates for the labour of able-bodied men, for carts, &c., show to be fair and sufficient, such materials ought to be procured by other means.

Main Canal Head Sluice.

12. This work has been completed with the exception of the screw gearing for working 10 out of the 13 vents. The large centre vent, however, which was to have had a sort of folding shutter, has been closed, and as it will certainly not be wanted for a long time to come, there will be ample opportunity for considering how it is to be regulated. The masonry work of the sluice appears to be good. The ordinary or rubble stone work has, according to the Supplemental Estimate, cost on the average Rupees 4-11-0 per cubic yard; but as the original estimate showed 400 cubic yards as the quantity, and the Supplemental Estimate gives 2,790 cubic yards, it will be necessary to wait for the explanations which were applied for by the late Consulting Engineer, before offering any opinion on the subject of this discrepancy, or speculating on the difference between the cost* of the rubble stone work here and at the under-sluices. Mr. Wilks, the officer deputed to measure the works and examine the accounts, has completed his investigation, so far as the Anicut and head works are concerned, so that ere long the Chief Engineer's report may be expected.

	Per Cubic Yard.
	Rs. A. P.
* Under Sluices	10 9 0
Head Sluice	4 14 0

The Head Sluice Shutters.

13. These have been fitted in their places, and their workmanship is, so far as I could judge, excellent; as however the bearings on either side are cut-stone, it may be doubted whether the screws will be capable of lifting and lowering them, and probably it will be found necessary to introduce three runners, or small iron wheels, at the back on each side, and perhaps also to insert an iron tram for the wheels to run upon. The cost of this alteration would not be great. One shutter was raised and lowered about half an inch or so, when I was there, but as its iron work was not completely fixed, and as moreover it would have been very inconvenient had the shutter been lifted, and had its lowering* proved impracticable, no further experimental working was attempted.

Rear Apron of Head Sluice.

14. This, last year, consisted of packed rubble of no great size, and only about a foot in depth. It was almost entirely destroyed, and since then it has been re-placed by a masonry apron of rubble stone in chunam one yard thick. The presence of water and mud upon it prevented my seeing it, and these particulars were obtained from the Resident Engineer.

Revetments to Channel banks immediately in rear of the Head Sluice.

15. These, last year, consisted of a very light rough stone pitching at a steep slope, and they were of course washed down. In such a situation either a massive revetment or a rubble masonry wall is indispensable for a distance of at least 40 or 50 yards. There is any quantity of suitable stone within a few hundred yards, so that it is advisable that the re-construction, for which preparations have already been made, by scarping the bank at a slope of two to one, should be carried out in an efficient manner.

Main Canal.

16. In the first mile the work remaining to be done consists of a moderate amount of rock clearing from the bed of the channel, and the levelling of the embankment at parts. The berm between the embankment and the Canal is generally too narrow, and in the absence of a counterslope to keep the drainage of the bank and berm from running into the Canal, the side slopes of the latter will be guttered, and a good deal of soil will be washed down into the Canal.

17. In the second mile the temporary bridge for Contalpaud has been commenced. It will, like all the small bridges, for the immediate convenience of the villagers, consist of two vents of 12 feet each, the piers being about 4½ feet high, with a platform roadway 10 feet 4 inches between the hand rails. For the first section of 17½ miles the superstructures are in an advanced state, some of them being under preparation at Kurnool, and the remainder at the sites of the bridges. In this mile the excavation of the Canal is complete, with the exception of a small amount of rock cutting.

18. *In the 3rd mile* the temporary bridge for Dudigála is nearly finished.

Just below the bridge a considerable quantity of hard rock has to be cleared out.

The banks in this mile require raising in several places, and revetting at the inlet calingulah and culvert.

19. *4th, 5th and 6th miles.*—In the 4th mile the first of the tanks resulting from the single bank arrangement occurs. It is but a small one, the revetment of the slope has been commenced, and is about a yard above the level of the sole of the Canal. A revetment is in progress also all along up to the first calingulah in the 6th mile.

Yeddarúr Tank breach.

In this mile is the Yeddarúr Tank, which breached last year. The embankment here has been completed to the full original section, and the widening is in progress with interior revetment; the base of the embankment, as now arranged, is sufficient, and if the work be carefully completed, the earth-work well consolidated behind the revetment, and the water admitted gradually, so as to season the bank, there will, I think, be no risk of another accident. A few days will suffice to complete the earth-work and revetment to 5 feet above sole of Canal. The Overseer's attention to the necessity of pushing on this part of the work was particularly called by the Executive Engineer, and when that is done, the bank will be safe from danger from any water likely to come into the basin from any ordinary fall of rain.

The Yeddarúr temporary bridge is to be commenced immediately at the east end of the first calingulah. Another temporary bridge, which has not as yet been commenced, is to be placed immediately to the east of the third irrigating sluice.

20. *7th, 8th, and 9th miles.*—A great deal of revetment has been done up to the end of the single bank in the 9th mile. The embankments also have been much strengthened, and, except at some few places for short lengths, the additional work of this description remaining to be done is inconsiderable. The rear stone apron of Calingulah No. 2, in the eighth mile, has not yet been completed.

The Singáram temporary bridge in the 9th mile has not yet been commenced. There is at present a pavement across the channel. In the 8th and 9th miles the sub-soil is by no means bad, but the bank is not so good as should, under such circumstances, have been the case. The coolies very naturally take the light clay or silt surface soil, but the rate paid, 2½ Annas a cubic yard, is quite sufficient to pay for the best soil, and at any rate all the interior of the bank should have been constructed with it. The soil of the cutting below the site of the Singáram temporary bridge, and up to the culvert in this mile, is very bad indeed.

The culvert is one of those which failed, and is that referred to as No. 10, in paragraph 18 of the late Consulting Engineer's report. A rubble masonry revetment is under construction on the north side of the canal above and below the culvert, and a stone pavement has been laid down on either side of the crown. The double bank terminates a few yards below this work. The embankments up to this point require but little additional earth-work.

21. *10th, 11th, 12th and 13th miles.*—Calingulah No. 3, in the 10th mile is on rock, and is complete. The masonry work of Calingulah No. 4 in the 11th mile is complete. About one-third only of the width of the rubble apron in rear has been laid.

Up to this the embankment is nearly complete, and the revetment in progress, and thence, up to Calingulah No. 5, in the same mile, the earth-works are nearly finished, but the revetment has not been commenced. The masonry work of Calingulah No. 5 is complete, also the slope rubble apron, but the horizontal apron has not been commenced.

At the upper end of this calingulah is the site selected for a temporary bridge for Nidajúd. Where the canal spreads out into a tank to the east of the above calingulah, both the earth-work and the revetment are making good progress. A second temporary bridge for Nidajúd is to be built at the west end of Calingulah No. 6.

The embankments in the 12th and 13th miles are approaching completion, and, at the great bank in the 13th mile, a good deal of the revetment has been completed; the revetment is also in progress immediately east of the Calingulah No. 7, in the same mile.

22. The calingulahs of this part of the Canal have been arranged with their crests on the level of the surface of the Canal water when full (8 feet deep), but as, at any rate for the current year, it would be unsafe to allow the Canal to fill to this extent, the Executive Engineer has given orders for the crests of two of the calingulahs to be lowered. This will not be necessary between the 13th mile and the Hindry Aqueduct, because, in addition to several small sluices, Calingulah No. 9 has a set of powerful under-sluices, which will discharge the land drainage without allowing too much water in the Canal.

23. *14th mile.*—Calingulah No. 8 in this mile is just opposite the village of Mungalpau, for which a temporary bridge near that work is to be built. A mass of stone opposite this calingulah is being got out.

Between this calingulah and the Mámdialpau tank below it, the soil of the embankment is good, and I do not think a revetment is necessary. Nos. 15 and 16 irrigating sluices in this mile require some rubble revetment in rear, to protect the foot of rear slope of embankment.

24. *15th mile.*—The earth-work of the Mámdialpau tank is nearly finished, and the revetment is 3 feet above Canal bed, and if the backing were well tamped, it would be very substantial. The crossing for the village of Mámdialpau is to be a platform bridge, which has not yet been commenced.

25. *16th mile.*—A ferry boat has to be provided for the village of Mússamasid in this mile. Down to the Calingulah No. 9, the revetment of the slope has been completed for the most part to 5 feet above Canal.

17th mile.—Calingulah No. 9, 300 yards in length with its under-sluices, has been completed. The shutters are also in the vents, but they are not quite complete, and I observed that many of the nuts, &c., had been stolen, so that, in future, rivets will have to be substituted or the threads of the screws destroyed. From this work to the end of the mile, the Canal is in cutting.

26. *18th mile.*—The bridge that was commenced for the Bellary road stands, with its piers, abutments and wings, completed to the level of the springing. The road is now carried by a diversion under the first arch of the Hindry Aqueduct, and the arrangement appears fully to answer the purpose, so that the bridge will not be required. It may as well, however, stand as it is, at all events for the present, as it is just possible some use for it may be found, and it would be a pity to spend more money in pulling down what has cost a good deal. The embankments above the aqueduct are nearly complete, but not quite so. They are heavy and the soil is bad. Since General Ludlow (paragraph 28) inspected this part, much has been done. First the inner slopes were revetted with dry stone, but this being thought insecure, a rubble masonry revetment is being built outside, and over, the old revetment, and this probably will, and certainly would, be sufficient, supposing the earth-work in rear to be settled, but whether this is the case is doubtful, and should it alter materially these expensive stone works will be liable to damage.

Summary of 1st Section, Hindry Division, 0 to 17 Miles.
First.—Excavation and embankments.

27. Patches of rock remain to be removed at many places along the line. The quantity is not large, but the rock is hard. Except below the site of the temporary bridge in the 3rd mile, the rocks occupy but a portion of the width of the Canal, and will not interfere with the supply of such quantities of water as will be required for some time to come, but there the bed generally is obstructed for some distance, and the effect is that of a low dam. Here and there small mounds of earth have been left uncleared; a few days would suffice for their removal.

At the Yeddarúr tank the entire completion of the earth-work of the embankment will occupy probably the better part of two months. Elsewhere no large amount of additional earth is required, but much remains to be done in the way of dressing the slopes, levelling the top, making

Second.—Revetments to interior slope of Canal.

good settlements; &c. A large amount of work has been done. At a few places, but generally where not so much required, they have not been commenced; elsewhere the stone facings are at least 3 feet above the Canal bed, and in many parts they are 5 feet above that level. It is intended to complete them as early as possible to the latter height all along, and then to proceed with another yard and so on, and this is the best arrangement that could be made. The revetments are generally of good section, and the material is very well adapted to the purpose. In two respects, however, the way of carrying out this work, is very defective. All along the line, two or three short lengths alone excepted, there is very good soil obtainable at a moderate depth, if not on the surface, and this should have been used as a backing to the revetment; and in the next place the stones have been packed on unconsolidated earth, a very serious error, and one likely to increase greatly the ultimate cost and to give much trouble in carrying out repairs. Had the earth-work of the bank in rear been well tamped, a matter of no difficulty as in most cases the slopes have recently been increased, and had half a yard or two feet of the best soil been laid as a dressing to the slope, and backing to the revetment, then well consolidated, and the stones packed against it, the extra expense would have been but very small, and the failure of any part of the work would have been out of the question, while for many years no expenditure on repairs would have been needed. I pointed out to the Executive Engineer the great importance of taking these precautions to ensure stability, and he has given orders accordingly, so that it may be hoped that the remainder of the work will be executed in a thoroughly satisfactory manner.

Third.—Revetment on exterior of bank.

A small quantity of this revetment had just been done at the upper part of the Canal to protect the earth-work from the river current in high freshes. It has been very badly done, and ought to be done over again, and moreover instead of following the irregularities of the earth-work, which is simply in the rough state in which it was thrown over, the latter ought to be dressed and put into line before the stone work is added.

Fourth.—Rates for Revetments.

These are at present far from satisfactory. Sufficient care has not been taken to ascertain what the fair rates would be, and a good deal of money has in consequence already been spent unnecessarily. For instance, 14 Annas per cubic yard, were being allowed the contractor for the very indifferent exterior revetment noticed just above, and, even supposing it to be of any use, it could be done for 4 or 5 Annas. At other places some of the work was being done for 14 Annas and some for 10 Annas, and in all cases this is very much above a fair average, though of course less so in the tanks, where the revetment will be of considerable height. The stone is very abundant, is generally within two or three hundred yards of the embankment, and is very easily packed. The rates appear to have been fixed by a predecessor of the present Executive Engineer, and that Officer admits that they are far too high, and he has ordered their reduction. Probably 6 or 7 Annas would be a fair average rate for the whole section.

* Vide paragraphs 38 and 39 below.

Fifth.—Masonry Works.

All the Calingulahs, culverts, and irrigating sluices have been completed, so far as the masonry work is concerned. The rear aprons of some of the calingulahs are incomplete, and it is doubtful whether the rubble aprons will, where the height of the over-fall is great, be found sufficiently substantial. The self-acting shutters of those culverts which are on a low level were noticed by General Ludlow as not efficient. The one I examined particularly was not well arranged, and I think it will prove useless to exclude river water. The shutter when closed hangs perpendicularly, and it is intended to attach a counterpoise to check vibration. Such sluices are not at all difficult works to plan, and it is to be regretted that a more efficient arrangement was not adopted.

The irrigating sluices have all been completed. Those in the embankment require a little dry stone revetment in rear. The rest are in the calingulahs, and will answer very well.

Hindry Aqueduct.

28. No part of the flooring of this work is quite finished, but otherwise two-thirds of the width are completed, for the whole length, and one arch, the northern or upper one, under which the diverted Bellary road runs, is finished to the full width. The parapets or side walls of the Canal are completed only for a short length at the wings. The heavy rains of the last day or two* have leaked in many places through the arches, and particularly at the junctions of the thirds in which they were built. The Executive Engineer informed me that he proposed recommending that the flooring of the Aqueduct over the Bellary road arch should be asphalted, at an estimated cost of Rupees 800, and this appears to be a very necessary arrangement, because, if ordinary rain finds its way through the masonry, the leakage, with eight feet of water in the Canal, would be great enough to render the road almost useless. Somewhat may perhaps be done, in completing the flooring, to stop the leakage, but I am afraid the improvement can at best be but partial. To asphalt the whole interior of the duct would probably cost Rupees 15,000, and at present I cannot say whether it would be advisable to incur so great an expense. It will be easy, however, to try what the leakage amounts to, the first time water is admitted after the left parapet is raised, and upon the result must depend the settlement of the question. The stone of which the work is built will not suffer, but it would not do to allow the mortar to be gradually washed out. The work is a handsome and substantial one, and it is to be regretted that precautions were not taken to make it water-tight. To make it absolutely so under the pressure of 8 feet of water might have been difficult, but as ordinary half brick masonry can be made to hold two or three feet of water without leaking, the percolation of rain water at a pressure due to, at most, three or four inches must be considered as evidence that sufficient care was not taken.

*Main Canal below Hindry Aqueduct.
2nd Section, 18 to 32 miles.*

29. 18th mile.—Between the Aqueduct and the Kullár road, rubble stone masonry walls have been substituted for dry stone revetments, these are in an advanced state, and it is expected they will be completed by the end of June. If, in filling in the earth in rear, care be taken to consolidate it thoroughly, this part of the Canal, the insecure state of which at the time of General Ludlow's inspection was specially noticed, will be quite free from risk of damage, and as the soil is very bad, and there was not room without greatly encroaching on the Canal to re-form the slopes at a stable angle, I think those walls, though necessarily costly, will have met the difficulty in the best manner. From the Kullár road the interior slopes will be revetted with dry stone. This work has been commenced in some parts, but most of it remains to be put in hand. The excavations are nearly completed, and the embankments are in a forward state.

Gooty road bridge.

30. 19th mile.—This bridge is one of three arches of 30 feet span. It is built of slate rubble, with cut limestone dressings. The work is very good. The east parapet and the coping of the west parapet are alone incomplete.

The cut stone work has cost 14 Rupees a cubic yard.

The slate " " " 2½ " "

These rates are exclusive of petty superintendence, but they contrast very favourably with those at Sunkésala.

Main Canal.

The double bank ends a little below the bridge. The excavations above bridge are complete with the exception of two patches of rock. The embankments in this mile are for the most part in a forward state, and the soil is generally very good.

The revetment between the bridge and Sluice No. 23 is in progress. It would have been sufficient had the stone facing commenced below the sluice as a ridge confines the Canal, and the soil is good enough to stand in a position where there will be no waves or wash.

Above Calingulah No. 10 the revetment has been completed for a considerable distance. Between Calingulahs Nos. 10 and 11, the revetment has not been commenced, and is not required, the soil being very good, and the bank not exposed. The embankments have been nearly completed.

Cubic contents 1,20,000 cubic yards.

31. 20th mile.—The chief feature in this mile is a cutting 800 yards in length, by an average of five yards in depth, through a ridge. The rate allowed in the estimate was one Rupee for three cubic yards. The cutting has, for $\frac{1}{3}$ rd of the intended width, advanced sufficiently to admit of an opinion being formed of the cost of excavation, and there is so much easy work, that, after carefully examining it, I came to the conclusion that the original rate was but little, if at all, under the mark, and that a skilful contractor could have done the work for the money. The work was given on contract to a Mussulman gentleman, who has made a mess of it, simply I think because he was quite unacquainted with any work of the kind, and he has made use of subordinates equally unskilful, added to which he has seldom been to see how matters were getting on. Looking, however, to the absence of trained contractors in this part of the country, and to the fact that this contractor has been of much assistance on other parts of the line, it is intended to raise the rate to 8 Annas. Beyond this it would not be right to go, and as the Executive Engineer is quite prepared to cancel the contract should the contractor desire it, and as he declined to do so, I presume that he thinks he can work at a profit at this rate. Below the cutting no revetment is required above the irrigating sluice. I have proposed to the Chief Engineer that the additional bridge for Zorapore should be built at the deepest part of the cutting. The Collector approves of this selection, and as it is the most economical site, both as regards the bridge and also the connecting road which will thus run along the water shed I have no doubt of the Chief Engineer's concurrence.

Probable date of completion of embankments up to this point.

32. The Executive Engineer considers that all the embankments from Sankésalah to the cutting in the 20th mile, will be fully completed, the upper parts of the revetments excepted, by the 31st August. The cutting* should be finished to nearly half width by that time, and that will suffice for present wants.

* In the 20th mile.

Main Canal.

33. 21st mile.—Up to the under-tunnel at 20—570 the greater part of the earth-work has been finished, and the revetment is making good progress from the commencement of the mile. The under-tunnel is now 240 feet long, its original length having been 190 feet. It is said to leak considerably, but perhaps the new plastering over crown will improve this. Just below the under-tunnel the Canal embankment crosses a valley where a moderate tank will be formed. The revetment of the deepest part of the bank has been commenced, and from 20—1,100 the revetment is finished. The bank is of full height, but some strengthening is required, and the cutting through a narrow stony ridge remains to be completed.

34. 22nd mile.—Up to the Calingulah No. 12 embankment complete, and revetted, but three or four small ridges remain to be cut through.

The calingulah is on rocky ground, the east end however is not secure at present, and Mr. Smith has given orders for a training wall to prevent the surplus water running diagonally across the wing, which it would now do, and then perhaps the wing and some of the embankment would be carried away.

Below the calingulah much additional earth-work is required to the embankments, and the revetment is incomplete.

In this mile there will be a tank of considerable depth (20 feet at the deeper part). The interior slope is revetted not very strongly, and at too steep a slope. It was done last year, so that it has had some seasoning.

35. 23rd mile.—This mile commences with a wall instead of an embankment, as the sub-soil of rock comes to within a few inches of the surface, and earth was not, therefore, procurable in sufficient quantities. The wall is of rubble stone in chunam, 4 feet thick at the top, or rather the water level, and its average thickness is about one-third its height. The length is 600 yards. The towing path is 2 feet above water level, and under it there are openings for surplus water. The workmanship is very good, and the cost was $2\frac{1}{2}$ Rupees a cubic yard. This is a solid wall, and from an inspection of the section at the unfinished part at the end of the under-sluices, I think it will probably be water-tight. The sluices are eight vents of 4 feet.

Kadragh Aqueduct.

Originally designed with three arches of 9 feet each, and piers 5 feet high, in fact as a culvert to carry banks over it. Then it was proposed to raise the piers to 15 feet, and so convert it into an aqueduct. Lastly, upon observations of a flood at the one arch bridge over the Gardidimadugú road, a little south of the Canal, three arches of 25 feet were given. The arches have been completed, and the wing-walls are in progress. I was informed that the eastern pier was founded at 10, 11, 12 and even 14 feet, the soil being found to be extremely bad, and that the foundations of the western pier are $2\frac{1}{2}$ feet deep only, the soil being said to be similar. The western arch is to be a roadway, and its flooring is 2 feet higher than that of the other arches, and it would seem that $4\frac{1}{2}$ feet, the intended depth of the west pier foundations, were taken from this elevated, instead of from the lower floor. However, before the superstructure is built, and further expense incurred, it should be ascertained whether the foundations are as stated, and if so, whether the soil is hard and firm. If not safe, under-pinning or piling or some equivalent arrangement must be resorted to. The work is estimated to cost 30,000 Rupees, and this would be a large sum to pay for an aqueduct unequal to its position. This estimate, however, I learn, does not include the whole expense, for in the estimate submitted by the Executive Engineer, an item Rupees 7,282-8-0, the value of 2,913 cubic yards of masonry rendered useless by the change in design was included, but this was struck out, probably owing to some misapprehension, by the Chief Engineer. The centre arch is somewhat out of shape, apparently from an imperfect centring, or from the distortion of the centring from unequal building on the two sides.

The embankments above this aqueduct will be very high, and they are not as yet nearly finished. The revetments are hardly commenced.

Main Canal.

36. 23rd mile.—In the portion of this mile to the east of the aqueduct the south bank is nearly finished, and the north bank is about two-thirds done. Revetment not commenced.

37. 24th mile.—Up to the first spur, where the south embankment terminates, the bank works have made similar progress to those in the latter part of the preceding mile. The south bank is terminated by a wall in lieu of earth-work. It now averages the level of the bed of the Canal, and is at this level $7\frac{1}{2}$ feet thick exclusive of the buttresses. It has to be raised 9 feet or to one foot above water surface level. The wall was not absolutely necessary, as soil was procurable for the completion of the embankment.

From this up to the $\frac{1}{2}$ mile the north embankment (single) is about half done. The inner slope is to be shingled, and the rate is 4 Annas a cubic yard. Thence for 600 feet in length across a deep gully, a double wall, in place of an embankment, is being built. In the stream or nullah this wall will be 37 feet high; where 30 feet high its dimensions are: Canal wall $6\frac{1}{2}$ feet at base, $2\frac{1}{2}$ at top, out side batter 1 in 12. At $9\frac{1}{2}$ feet from the back of this wall is the outer wall 4 feet at base, $1\frac{1}{2}$ at top. There are to be three intermediate horizontal connecting walls, each 2 feet thick. The rear wall is furnished with weep holes, and the spaces between the walls are being filled in with dry rubble and sand. It will be seen that a leak through the front or Canal

wall involves a leak through the whole work. The cost of chunam not being very great, 8 Annas a Parah, and it might probably be had for about half* this; it would have been better, I think, to have built a solid wall, or to have filled in the spaces with concrete. There is to be a scouring sluice in the deep channel, but the plan for this has not yet been furnished. The wall is at present 25 feet below its full height. It is not clear why a wall was substituted for an embankment at this point, as plenty of soil was procurable. Up to the end of the half mile two-thirds of the earth-work done. Thence the bank is up to its full height, and pitching the inner slope with lumps of lime kunkur has been commenced, and is for some distance finished to 3 feet above water level. Up to next small valley, bank full height, but not full section. Thence to No. 13 Calingulah the earth-work is three-fourths done, and the revetment nearly half done.

No. 13 Calingulah.—Body wall completed to full height except at a gap where a sluice is to be put in. The piers to carry the towing path have been commenced at lower end; only a small part of this calingulah is in the 24th mile. It will require a substantial rear apron, length 450 feet.

38. 25th mile.—Earth-work very nearly finished, and the revetment also. The last 200 yards of the mile somewhat behind-hand; rate for revetment 6 and 8 Annas a cubic yard, soil good all along.

39. 26th mile.—Up to the first ravine the earth-work of the embankment is behind-hand, but the revetment is well advanced. This latter is on a steep slope, is well packed, and its cost is 4 Annas a cubic yard. The wall across the ravine is to be 400 feet long, and on the same section as that in the 24th mile. Cost of the wall about Rupees 2-2-0 per cubic yard. It is well built, and is at present 8 feet below level bed of Canal. The rubble and sand filling is here a mistake, I consider, for the chunam costs only Rupees 1-1-0 per Candy of 5 Parahs, and the extra cost of constructing a solid wall would therefore be very small, especially as much less sand would be used and that material has to be brought a long way.

A few yards further on there is another wall, which is at present 4 feet below full height. This, too, has a thin core of rubble and sand, and it would have been actually cheaper to build it solid. Thence across ridge the embankment is nearly finished, and revetment is not necessary, but the interior slope may be shingled at 6 cubic yards for the Rupee. Across the next valley another double wall is in progress, and is now 8 feet below bed of canal.

40. 27th mile.—First of all an embankment was planned and partly constructed; then a line rather higher up the slope was chosen, and a shallow cutting with a low wall parallel to it was proposed; next a very high wall across the ravine was to be substituted, and lastly, an embankment on the upper line is intended to be carried out, and this latter, including revetment, is estimated to cost 21,000 Rupees less than the walls. A tramway is to be laid down to bring the soil of the first embankment down to the ravine, and it is expected that the soil will thus be placed in position at 6 yards the Rupee, though the comparative estimate allows 4 Annas per cubic yard.

At the lower end of the 27th Mile the bank terminates at a low semi-detached hill, and the Canal is carried round it, a little cutting being required at the saddle only; up to the end of this mile no great amount of earth-work remains to be done, and the soil is generally too stony to make a very water-tight bank.

41. 28th mile.—At the beginning of this mile a small quantity of revetment was being done at 1 Rupee per cubic yard, this was an extravagant rate, and it has been stopped. Embankment nearly completed up to where a wall takes its place. This wall is altogether nearly $\frac{2}{3}$ ths of a mile in length. It is double, its dimensions (8 feet base to 18 feet height) are insufficient, and it is to be backed with a bank. Near the lower end the very thin casing walls, with cross walls at 90 feet intervals, and a filling of clay and gravel led to cracks; the wall is now

being backed with earth on both sides. A short break of between 200 and 300 yards occurs in the wall, and then it will be continued to the end of the mile. This part, 120 yards in length, has not been commenced.

42. 29th mile.—The wall, not yet commenced, is to be continued to the $\frac{1}{2}$ Mile, where it will end. Thence Canal cuts through a low saddle up to No. 14 Calingulah, 450 feet long. A good deal of earth-work remains to be done in that part. There is a gap in the Calingulah where under-sluices are to be built. A rubble stone rear apron will be necessary. From Calingulah up to the end of the mile the earth-work has been nearly completed. No revetment done.

43. 30th mile.—Most of the earth-work of the first $\frac{1}{2}$ of the mile done. From this point the line was originally taken on a very low level with very high banks; after 17,000 Rupees had been expended a line higher up the slope of the spur was chosen, and the Canal is being made in cutting, while the embankment is formed by a wall or masonry revetment with rubble backing and the soil from the cutting in rear. This is a very expensive arrangement, and moreover, the work is on a portion of the line which it is proposed to abandon ultimately for a deep cutting through the ridge, which would shorten the line 2 miles. The work along this part appeared to be very much above the level of the preceding mile, but the Sub-Assistant Engineer says that the levels have been repeatedly checked. The estimated cost of the cutting for $\frac{2}{3}$ ds of a mile is Rupees 35,000, and for the wall revetment 18,000 Rupees, or altogether 53,000 Rupees. The principal mistake made is in the position of the embankment works: The transverse slope of the ground is great, and the wall is placed so far from the edge of the cutting that its height is materially increased. Calculating roughly, a cutting averaging $1\frac{1}{2}$ yards in depth would have provided about enough soil for an embankment placed close to the edge of the cutting, and at the rate the work is now being done, the whole cost would have been between 20 and 25,000 Rupees.

31st mile.—Commences with a high wall, where a more economical cutting might have been made close by and on a better line. Beyond the wall up to the lower end of the Nellumpaud tank, the earth-work is very nearly finished. The revetment has not been commenced, but it has been given out on contract at Rupees 1-2-0 per cubic yard, where 5 or 6 Annas would have been sufficient, and stone is so plentiful, that pitching might have been executed at 1 Rupee per 6 cubic yards. At the lower end of this mile a little shingling has been done on the inner slope.

44. 32nd mile.—An irrigation sluice has been constructed at the beginning of this mile. Earth-work very nearly completed throughout. No revetment has been commenced, and it will be better to wait until after the rains. A second sluice is to be built where the foundations of the wing of a calingulah,* not now considered necessary, had been laid. The embankments are

* No. 15.

very high. The soil is generally not good, though the latter part of the mile is much better than that found higher up.

Cut stone work has been done here at Rupees 7-8-0 per cubic yard, but it is considered that this did not pay the contractor, and that 10 Rupees would be a fairer rate. This mile completes the second section of this division.

Alternative line below Calingulah in 29th mile.

45. Levels were taken for an alternative line from the Calingulah in the 29th mile, and this line would have struck the one adopted about the middle of the 32nd mile, and would have shortened the Canal to the extent of nearly two miles. It was thought, however, better in the first instance to carry out the supposed cheaper circuit, and to leave the straighter cut for execution at some future time. The real difficulties however of the line chosen were not duly estimated, and supposing the estimate, one lac of Rupees, for the shorter line to have been at all adequate, it is now clear that it could have been executed for less money than will have been expended by

the time the present unfavourable line is completed. It is much to be regretted therefore that fuller consideration was not given in the first instance to the difficulties and advantages of the alternative routes.

Summary of the 2nd Section, Hindry Division.

46. The country through which the greater part of this section of the Canal runs slip of comparatively level ground near the Toombuddra, and the Jugganath hills, which it skirts, throwout on this side a great number of low spurs divided by ravines of considerable depth, while the soil is either scanty or not well suited for embankments intended to retain water. By the arrangement adopted, the Canal is carried round the spurs and there is but little cutting, and the ravines are crossed either by very heavy embankments or by masonry walls. The cost of this part of the line has necessarily been great, and I think it is probable that a cheaper, straighter, and safer plan would have been to cut to a considerable depth through the spurs and to carry the spoil by trams to form the embankments across the ravines. Every cubic yard of cutting would have been made to do double duty, by a careful adjustment of the yield of the cuttings to the wants of the embankment. This plan was not examined in detail, and therefore the data for a comparison do not exist, but when the very heavy cost of the massive high walls is looked to, there appear to be weighty reasons for considering that cuttings would have proved more economical.

1st.—Excavation and Embankments.

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there will be no difficulty in so far completing them, as to enable the canal to carry one-half the maximum supply of 4,00,000 cubic yards. These are making good progress, and the work is being well done. They will throughout be completed to at least two yards above the level of the Canal bed in time for the irrigation of next season; but it will take the greater part of a second year to finish them entirely. The rates are in many parts of this section very reasonable, while in other parts they are certainly very extravagant. Where contracts have been entered into of course a reduction is not possible, and all that can be done is to require first rate work, elsewhere a great reduction will be made. Stone is abundant every where, and if the style of revetment or shingling be adopted to the material available, the requisite protection to the banks will be obtained for a sum by no means out of proportion to the advantage gained. Judging from the actual cost of good revetment in this and other sections of the division, an average rate of 6 Annas a cubic yard is likely to suffice for the work remaining to be done. The Executive Engineer is fully alive to the necessity of reducing the rates which were at first supposed to be necessary.

3rd.—Masonry works.

though there would be no difficulty in finishing it in eight or nine months, if necessary. A very little work will suffice to enable it to carry all the water which will be required for the next two or three years.

One bridge, that for the Gootty road, is all but finished, and will be opened for traffic this month. A second bridge for Zorapore, in the 20th mile, remains to be built. The masonry work of the calingulahs has, with few trifling exceptions, been finished; but all those works require substantial rear aprons, and this work is behind-hand, and in several cases no provision has been made in the Estimates for any such protection. It would seem that the effect of an over-fall of 6 to 8 feet has not been sufficiently considered, for, even where rubble stone has been packed in rear, I am afraid the first considerable discharge will show its inadequacy to withstand the force of the water. The irrigation sluices are behind-hand. It is towards the lower end of this section that the breadth of irrigable land first begins to be considerable, and there a good many sluices will be needed; the plans have not yet been issued to the Range Officers.

The walls in place of embankments are many of them still much below the level of the bed of the channel, and the quantity of work to be done is very large. They will within a year be completed to 5 or 6 feet above bed, but a much longer time will be necessary to finish them.

The Executive Engineer thinks that it will take fully two years to complete the work of all descriptions in this section of his division.

Main Canal, 3rd Section, 33 to 44 Miles.

48. 33rd mile.—The banks have just been raised 1½ ft above the 14 feet above bed before allowed. This additional height was not necessary, and it would appear that the Chief Engineer did not intend it to be done. At the beginning of this mile the bank takes a curve to double a stony spur, and a small tank will be formed. Revetment at Rupees 1-2-0 per cubic yard has been commenced, the material being obtainable at 250 to 300 yards distance, and the work being by no means good, it will be improved, but the contractor will probably insist upon continuing the work at this rate. Up to the culvert near Sultunpore the earth-work is finished, except dressing the slopes, and the revetment is well advanced. The culvert 13 feet span and 12½ head way is intended to provide a passage for the villagers. All except south wings and embankments to connect them with high ground finished. No flooring has been provided for; but one is necessary, and will be given. The masonry of the arch-work is not sufficiently well fitted to prevent leakage. It is proposed to cover the crown with concrete. Thence to Calingulah No. 16 (15) the earth-work nearly complete.

Calingulah complete, except a gap where no irrigation sluice is to be put in. The rear apron not commenced; a very substantial one will be required as the drop is 7 to 8 feet; no allowance for this apron in the Estimate. Earth-work nearly completed up to end of mile. Revetment of this part not commenced.

49. Nearly all the way along the last two miles the embankment has been placed too far north on ground far too low. The result is embankments 14 to 25 feet high, where 12 feet to 15 feet might have been arranged. At the close of the 33rd and beginning of 34th mile there is ground with a moderate transverse slope, and yet the bank is placed on ground 7 or 8 feet below the bed of the Canal. The intention was to obtain the full section of water-way without cutting,

A Minimum of 60 feet.

and also a certain breadth* of water, having a minimum depth of 8 feet, but the plan is open to objection as regards both economy and safety. The revetments alone are a very heavy item in such a bank, and the excavation for the banks answers but one purpose, whereas in cutting it does double duty.

50. 34th mile.—Immediately in rear of the embankment in the first ¼ of this mile, there are very deep pits, some of them as much as 5 yards deep, and had the alternative arrangement referred to in the preceding paragraph been adopted not one yard need have been taken from the outside of the bank. The work is costing 3 Annas 2½ Pice per cubic yard, which is cheap for the lead and height. Up to Calingulah No. 17 (16) earth-work nearly finished. The masonry work of calingulah complete. No rear apron allowed, but one is certainly necessary, there being an over-fall of several feet on to very moderately hard soil. Here the Canal enters a short cutting, and diverges from the line partially worked out originally, in order to avoid submerging* the

Vide Order of Govt. No. 898, dated 26th May 1864.

large extent of land below Ullūr. There is an awkward bend at the lower end of the cutting, which will have to be altered.

35th mile.—This is nearly 3 miles in length, as the new line is just 2 miles longer than the old. Up to the site of the Ullūr Aqueduct a commencement has been made nearly all along. At only a few places does bad (black cotton) soil occur, and except there the banks will require shingling only.

51. A large portion of the excavation for this work has been done, and one pier has been founded, the expenditure being about 1,100 Rs. The plan provides four arches of 25 feet, the

Ullūr Aqueduct.

Estimate is Rupees 22,010, and it is expected that the cost would be 28,000, as the rates are low. The nullah for which the work has been planned has been formed by a breach in the rocky ground, which formed part of the bund of an old tank, and the site of the aqueduct is within a few yards of the breach. As arranged the wings of the work on the up-stream (nullah) side were to be connected with the high ground on either side of the breach, and consequently the water spread of the canal would be shut out only from the few square yards of rocky ground on the two sides of the nullah itself.

The village of Ullūr is close at hand on high ground, and after carefully examining the locality and seeing the contour levels checked, I could not but conclude that the aqueduct would occasion an unnecessary outlay, and that a wall with under-slucices across the nullah and a bridge for the village road a little below the wall would be a preferable arrangement. This will, if sanctioned, save about 6,000 Rupees on the estimate, and double that in reality. One arch of the aqueduct was to be made into a roadway, but the level would be very inconvenient, and the bridge will be very much better. Formerly a sort of surplus channel from the tank ran through a corner of the village, it will be advisable to prevent the Canal water entering this, and a bank at a cost of a few Rupees will do this effectually; it would have been equally necessary with the aqueduct. I have addressed the Chief Engineer on the subject.

Main Canal.

52. *35th mile continued.*—From Ullūr up to the Calingulah No. 18 (17) at the commencement of the old 36th mile, the new embankment has hardly been commenced. The calingulah is two-thirds finished, it has superseded a similar work which was constructed a few yards distant, and in a direction at right angles to that now necessary. Masonry good. No rear apron allowed, but one is absolutely necessary.

53. *36th mile.*—Earth-work almost finished throughout, and nearly all the revetment done. First part of the mile soil bad (black cotton), after that much better (red, with laterite). The revetment has cost on the average $5\frac{1}{2}$ Annas per square yard, its height being 6 yards. Its thickness is great, and looking to economy unnecessarily so, it has been very well done. The embankment averages 14 feet in height.

54. *37th mile.*—Commences with a cutting averaging a little over 5 feet in depth, this is finished, except a little clearing and levelling. Below this, embankment finished except a little backing to top of revetment. A gap has been left for a sluice; revetment very good, cost $4\frac{1}{2}$ to 5 Annas per square yard. The material is a very fine limestone.

55. *38th mile.*—Up to the wall nearly all the earth thrown up, and the revetment generally completed up to water level. The wall is 3 feet 9 inches in width at base, and its height will be 11 feet; length about 420 yards. It is to be backed by a thin earth bank. The cost will be about 3,150 Rupees, besides earth-work. A revetment would have been about 630, and as earth is obtainable, and the wall has superseded an embankment, of which a large portion had been thrown up, the change was not an advantageous one. Thence for a few hundred yards to the lowest part of the valley $\frac{2}{3}$ of the earth-work have been thrown up in the rough. At the deep part a double wall of 510 feet in length with a base of 16 feet and an intended height of 24 feet has been commenced. All these high banks and expensive walls might have been avoided, by carrying the line higher up the slope to the south-west. An emptying sluice, which will do also for irrigation, is to be built in the wall. This mile will be terminated by an irrigation sluice just about to be commenced. Earth-work below the wall $\frac{1}{2}$ th done, soil of this mile bad (black cotton).

56. *39th mile.*—Up to calingulah the embankments are nearly finished, soil bad, revetment not commenced. Calingulah No. 19 (18) finished, except kerb on one side. Over-fall is 9 feet and no rear apron has been provided for; the foundations are 3 feet on detached rock, last part of mile, soil red with gravel. Near end of mile canal crosses low spur by a cutting (rate 6 Annas) containing a good deal of a very hard conglomerate rock (quartz and limestone) below this a double wall takes the place of an embankment. An under sluice of five vents is under construction.

57. *40th mile.*—Commences with a continuation of the wall, which altogether is 1,100 feet long. Beyond this a narrow deep valley is crossed by a high bank, then, over a low rocky ridge there will be a wall, and thence to within a few yards of the village of Malayāla there is a high embankment. All these works are behind-hand, though a large extent of work has been done, but the error of avoiding cutting and placing wall and embankment far below the level of the bed of canal has been repeated. A little revetment commenced, rate for bottom yard 6 Annas, which is much too high, I think. The village will be passed on the west side by a cutting through the ridge on which the houses are built; twelve feet will be the greatest depth, but the cut is a very short one. From the end of cutting, for a few yards to the end of the gravelly soil, the embankment will require a core of clay with a base of eight, and a height of three yards, to prevent leakage into the village. Below this there is an embankment seventeen to twenty feet high, of which three-fourths of the earth-work have been done, and the revetment has made great progress. It is most excellent work, but it is, on the average, four feet thick, and fourteen yards measured on the slope; rate 2 Annas for bottom yard, 6 Annas for the next yard, and 1 Rupee and 3 Annas for the top yard, which gives an average of eleven and three-quarter Annas, and a cost per yard run of ten and a quarter Rupees. It seems hard to condemn such excellent and beautiful work, which is extremely cheap indeed, compared with work elsewhere, but as revetments will in any case be a heavy burden to the undertaking, and as an excellent revetment of half the thickness could be done for half the price, it is necessary to point out the mistake. A scouring sluice of very elaborate design, and with its sill twenty feet below water surface level, has been commenced near the end of this mile, stone and work good, but I anticipate no advantage from such a work, and it will always be a cause of weakness. The sooner the tanks below the first twenty miles silt up to level of bed of canal the better. The sluice may be the indirect cause of a breach, but its effect on the silt generally will be nothing, and the area of its action will probably not exceed two or three hundred square yards.

58. *41st mile.*—The rate and style of revetment is the same as that noticed in the last mile, the stone is obtainable from the embankment pits. Soil generally bad, and the embankments are considerably higher on the average than those at the end of the 40th Mile. The heavy part of the earth-work has been completed.

59. *42nd mile.*—At the end of the preceding mile, and for some little distance in this mile, the general line has been diverted in order to make use of the bund of the Madigūla ruined tank. At the deep part it is intended to build a sluice on the same plan and on a similar level to that referred to in the latter part of paragraph 56 above. The arrangement was, I believe, approved by General Ludlow, and it is referred to in the last sentence of the 48th paragraph of his

Report as per margin,* but the capacity of the sluices designed is small, and the risk appears to me to more than counterbalance the possible advantages. The site is a few yards below the breach in the old bund. The earth-work has been nearly completed. The revetment is just commenced, and it should be very cheap, as slate shale is abundant close to the embankment.

The mile ends with Calingulah No. 20 (19) 420 feet long, which is complete, including a rear apron of carefully packed dry rubble. Whether this latter will be found sufficiently strong is, I think, doubtful, but it is very well done.

60. In the paragraph of General Ludlow's Report just alluded to, this observation is made:—"The course of the canal near the village of Malayāla appears very objectionable." I did not notice this remark until I looked for his opinion about the scouring sluice, but I entirely agree with him, and it may be well to explain what has been done, and what was the alternative arrangement. Immediately on leaving the cutting at Malayāla, the embankment is carried down on to ground 5 to 7 feet below the level of the canal bed, and it is carried nearly due east to a short distance west of Madigūla. At

* No. 33, 6th July 1863.
Proceedings of Government, No. 2,055, 25th July 1863.

Remarks on the line of embankments in the 41st and 42nd miles.

the lower end, at the calingulah above noticed, it crosses the next ridge by a moderate cutting: between these two points distant along the present bank line, rather more than 2 miles, the ridges spread out east and west at a gentle slope, while between them there is a very flat plain, extending nearly up to the village of Nundikotkoor. The present single bank is from its height, the nature of the soil, and the consequently great width of base rendered necessary, and from the great extent of revetment required, a very expensive work, and while at the two ends the breadth of land submerged will be small, in the middle the water though not deep will spread out for about $1\frac{1}{2}$ miles. By carrying the line more to the south from Malayála, the height of the banks might have been reduced at least 9 feet. Their present average is about 24 feet, and the sectional area 120 square yards. The reduced area of one bank on the higher level would have been about 55 square yards. In the low part in the middle this would, however, have been increased considerably, and perhaps the saving in height there would not have exceeded 3 or 4 feet. On the whole, therefore, the double-banked arrangement on the higher ground would probably have taken 10 to 20 per cent. more earth, and there would have been the necessity for a culvert of considerable dimensions.

On the other hand the calingulah might have been dispensed with, or its dimensions much curtailed. The two scouring sluices would not have been needed for any purpose, and the revetment might have been not only less in height, but of a much lighter description. Much valuable land would have been saved from submergence, and this part of the Canal would have been far safer.

The extra length of line would perhaps have been $\frac{1}{4}$ th of a mile.

The advantages, as regards water storage by the tank arrangement, are here almost nominal, and the extra cost, if any, of a regular Canal would have been so small, that, I think, it is much to be regretted, that the original arrangement was not revised. It is too late now to do any thing more than make the present embankment secure.

61. 43rd mile.—The cutting, which commenced a little above the calingulah, is continued for three or four hundred yards into this mile, a gap for an irrigating sluice has been left about the middle of the mile.

The earth-work of the embankment has been completed, slopes sufficient; soil at upper part of mile decomposed slate, and at the lower part lime and clay. The mile and the division end at the Nagatore tank bund, which has been cut into so far, as to render a breach into the Canal probable, and this is not wanted while gaps for sluices, &c., remain unclosed.

Summary of the 3rd Section, Hindry Division, or 3rd Section
Main Canal, 33 to 43 miles.
1st.—Embankments and Excavation.

completion will not be long. Near Ullúr also there is nothing to prevent their being finished within six months.

2nd.—Revetments to interior slopes:

These have made good progress on the whole; a large extent of this description of work remains to be done in the 33rd, 34th, and 35th (3 miles) miles, and also in the 41st, 42nd, and 43rd miles.

The revetments executed are in all respects very satisfactory, except in the matter of cost. As regards this, too, it is only right to repeat that all the work recently commenced, or contracted for, is cheap for the quantity and style of the work. The error, where there has been any, is in the provision of an unnecessarily substantial protection. In other sections of the Canal, the work done has often been paid for at far too high a rate, here the contractors have done good work for the money, and I have dwelt somewhat particularly upon the point, because, when estimates have been so greatly exceeded in all directions, it is absolutely necessary that all practicable economy should be exercised.

3rd.—Masonry works.

The calingulahs, the rear aprons excepted, are generally either completed or likely to be

so within a few months. It is necessary that the rear aprons, where not already provided for in the estimates, should be included in supplemental estimates, and carried out at an early date. The failure of these works would be a great misfortune, and the loss would be very great were the supply to be stopped pending restorations.

The walls in lieu of embankments are much behind-hand, and it will be well to push forward their construction as far as may be practicable.

There is only one culvert, which will be completed very shortly. The Ullúr aqueduct will probably be superseded by a wall and a bridge, these works will easily be completed before the next irrigation season.

The irrigation sluices are much behind-hand, and it is a pity that they were not built at an earlier date, because the gaps in the embankments will now be filled in after the earth-work on either side has settled, and where the soil is bad, those places will, at all events for one season, be weak points.

Tamping.

63. I have not seen one rammer on the works, from one end of the division to another.

In the case of the revetments the omission of tamping is one of much importance, as has been already noticed in a former part of this report. I hope this point will receive due attention for the future, and that care will be taken to select soil for the backing of the revetments, where this can be done without much extra expense.

Probable date of completion of the whole of the works up to the 43rd mile inclusive

64. The works of the first and third sections may very well be completed within a year, and two years will be required to finish

the second section, but by the 1st May 1865, the Canal throughout ought to be able to carry at least 5 feet of water.

65. 44th mile.—The bank along and immediately below the Nagatore tank, should be completed at once, as it is not safe in its present state. A gap for an irrigation sluice has been left here. Thence the embankment has been very nearly completed, including the extra $\frac{1}{4}$ th allowed for settlement, up to the end of the mile. Revetment not commenced, soil not very good, a decomposed slate for the most part.

66. 45th mile.—At the beginning of this mile, a culvert of 3 feet span has been completed. The double banked Canal commences just above this point.

Nagatore Bridge.

The masonry work of the bridge of three arches (centre arch 32 feet span, side arches

30 feet each) is complete, the approaches have hardly been commenced, and the embankments immediately above and below bridge are incomplete.

Two irrigation sluices have been completed.

An under-tunnel of 8 feet span has been finished.

It is on too low a level for a crossing.

Just below this the embankments are very soft, and it will be some time before they become properly consolidated.

67. 46th and 47th miles.—Cutting is for the most part behind-hand, and the right embankment is in parts hardly commenced. The soil improves in these miles. Two irrigation sluices have been completed in the 46th mile. The first calingulah in this division is in the 47th mile. The masonry work is finished: there is no rear apron though the over-fall is 6 feet. Stone good, workmanship not as good as on the similar works in the Hindry Division. There is an under-workmanship of five vents in the centre of this calingulah. About 600 yards below the calingulah, an under-tunnel of one yard span has its side walls finished, arch not commenced. The excavation up to this point is very incomplete. The left bank below the under-tunnel is much out of line,

this was unintentional. About 200 yards of revetment done at this part, rate 7 Annas per cubic yard, the courses are laid horizontally instead of at right angles to the slope, and this is the case throughout the division wherever work of this sort has been commenced.

68. 48th and 49th miles.—The double bank ends immediately below the under-tunnel just noticed, and a single bank is carried across a narrow valley. A small tank will be formed; the land submerged will be neither extensive nor valuable, but I doubt whether any considerable saving will be effected by the arrangement.

At the lower side of the valley excavations for a culvert of 8 feet have been completed; no masonry work commenced; from this point the double banks re-commence. For the first half mile below culvert the cutting and embanking are only just commenced; for the next half mile about half this work is finished. In the 49th mile excavations for a culvert of 8 feet span have been made; construction not commenced. Care will be necessary in letting down the drainage into the tunnel, as the soil is easily washed away, and both to prevent damage to the lands by the formation of gullies, and to the rear of the embankments by a channel, it will be expedient to build a semi-circular rubble masonry wall round the entrance. Up to the end of the mile the earth-works are more than half done.

69. 50th mile.—Up to the 3-foot culvert the earth-works are more than half done. Excavations ready for culvert; masonry not commenced. The soil in this part is very bad (black cotton). Thence, up to the end of the double banks, the earth-works are more than half finished; soil bad; cutting averages one yard in depth. Thence a single bank across the valley and up to the end of the mile a good deal of earthwork has to be done to complete. A small piece of slate stone revetment has been done, rate six Annas.

70. 51st mile.—The single bank is continued, and just below the drainage nullah a so-called sluice, consisting of two walls 10 feet apart at bottom, has been commenced. The space between these walls is to be filled in with earth, and I am informed that the object with which they have been built is to enable the tank to be breached with safety if necessary. The work will entail extra care in the earth-work, and even then there will be some additional risk of leakage at the junction of earth and masonry. For one-half of the single bank below the sluice a great deal more earth is required, beyond this the earth-work is nearly finished; and red soil supersedes the black cotton. The revetments are not commenced.

71. 52nd mile.—A small length of revetment has been commenced; it is well done, rate 6 Annas. The tank ends, and at re-commencement of double banks the excavations for a culvert are ready; masonry work not commenced. Thence up to the calingulah No. 2 which is on the same plan as No. 1 the soil is good, and the cutting, averaging 4 feet in depth, is rather more than half done. The calingulah, with the exception of the under-sluices of 5 vents and a part of the kerbing, which are under construction, is completed. The over-fall will be about 4 feet, and a rear apron is required; up to the end of the mile the cutting is nearly finished to half width.

72. 53rd mile.—Cutting diminishes in depth and is nearly completed to full width; soil for banks short, and the additional required is being brought by tram from the deeper cutting. The double banks terminate just below the village of Puggydial; and there a culvert of 6 feet span will provide for the drainage. Thence, to the end of the mile, a single bank part of which is on the bund of an old tank has been 3/4ths completed, and the revetment is just commenced; soil bad; embankment will average 28 feet in height.

73. 54th mile.—In this there is to be another sluice or wall-vent of the same dimensions and description as that in the 51st mile; one side has been commenced and is now 14 feet high; the full height being 32 feet; average height of bank in this mile 20 feet; 3/4ths of earth-work done up to the sluice and 3/4ths below that point. Revetment not commenced.

74. 55th to 57th mile.—In the upper part of the 55th mile the embankment is behind-hand, and a very large amount of earth-work is required to complete in the latter half of the mile;

earth-work nearly finished. Revetment not commenced; only the first few yards of the 56th mile will require revetting. The earth-work of this mile in an advanced state; calingulah No. 3 is 200 yards in length, and on the same plan as Nos. 1 and 2. The body will be about 7 feet in height above ground, and a substantial rear apron will be required, it is now a little short of the full height and the superstructure remains to be built; under-sluices not commenced; an irrigation sluice is to be built at the end of this mile. In the 59th mile the earth-work has been about 1/3rd done in the rough.

75. 58th mile. In the first half of this mile the earth-work is all but finished. A small piece of revetment has been commenced with brown slate quarried close by; but it has turned out indifferently, and it has broken up on exposure; so that a better material will be sought for for the rest of this work. There are a few gaps in the embankment; but most of the earth-work to end of mile is well advanced. A sluice or wall-vent has been ordered near the lower end of the mile; it is not yet commenced.

76. 59th mile.—For the first 32 chains the embankment is almost finished; at 34th chain the double embankments re-commence, and a culvert of 8 feet span is to be built; the excavations for which are ready but the construction not commenced. Below the culvert up to calingulah No. 4 the excavation and banks have not been commenced. Below the calingulah the earth-work is about 1/4th done. The calingulah excavations have been made; the masonry work has not been commenced.

77. 60th mile.—Up to the site of the Jupad Bridge about 1/4th of the earth-work done. Materials for the bridge under preparation. Construction not commenced. A short distance below bridge site a 6 feet culvert is to be built. It is not yet commenced. Earth-work at this part only just commenced, and for some distance ground has not been broken.

78. The earth-works present no difficulties; and the time of their completion is dependent;

Summary of the Nagatore Division, being the 4th Section of Main Canal.
1st Excavations and embankments.

upon the labor obtainable. They are in very many miles in a backward state; and much work remains to be done before any water can be passed down the canal. It is of importance

that the very heavy embankments in the 50th to 59th mile should be completed as soon as possible. The tanks are all open at present; as gaps filled in after the banks have been completed and settled are less stable than would be the case were the earth-work completed continuously; care will have to be taken to prevent accidents. Out of the 17 miles in this Division about one-half the canal is double banked. The canal has been well laid out in the double banked parts. Had a line for the single banked portion been laid out somewhat higher up the sloping ground about half the water spread would have been got rid of, and the length of the bank from 52 1/2 to 59 1/2 would not have been increased by more than about 1/6 of the present length. There would have been one rather deep cutting but great saving in embankments and revetment.

2nd Revetments to interior slopes.

The amount of work done, compared with that to be done, is so small that these must be considered as only just commenced. They will require to be pushed on very vigorously if it be desired that any thing like a fair supply should be sent down the canal next year. In the tanks on average about two yards in height have to be built to reach level of canal bed, and two yards above that to admit of one and half yards of water being passed down; and there being some eight miles of tank or single embankment the work up to that height alone will require over 50,000 cubic yards of stone; while, as the level of the water in the tanks is liable to be increased by land drainage, it would require an addition of 10 or 12,000 cubic yards to make these banks quite safe. The rates of the portions of work done are not very high and care should be taken that they be not allowed to become excessive; and also that where the water spread is not large and regular stone is not to be had close, at hand the less perfect protection of shingling be given on a somewhat flatter slope.

Tamping earth-work.

The use of rammers to consolidate the earth-work immediately in rear of revetments is equally necessary in this division. None have been used at present, and no more revetment should be put up without first ramming the earth. A backing of the best soil obtainable, such as lime-kunkur, gravel, or red soil, should be given where the soil of the embankments is black cotton, or otherwise inferior and easily soluble.

3rd Masonry works.

There will be two bridges for this division; one at Nagatore which is finished, the approaches excepted; and the other opposite Jupad, the construction of which has not yet been commenced. Of the four calingulahs, No. 1 is completed, except a rear apron; No. 2 finished, with the exception of the under-sluices and rear apron; No. 3 is about $\frac{3}{4}$ done; and the construction of No. 4 is not commenced. All these calingulahs require substantial rear aprons.

The number of culverts will be ten; and taking the sizes of those completed into consideration not more than $\frac{1}{4}$ th of the under drainage has been completed. The rate, Rupees 2-8-0, for the walls is reasonable, and the work is sufficiently good. None of the culverts in this part of the canal will make crossings which can be considered as providing for the wants of the villagers. The tunnels are dark and on a low level, and some, as No. 2 for instance; will always be wet. Those of 3 feet span are not intended to be used. In the Hindry Division, where the lower end of the flooring is generally on a level with the ground, the case was different. Of the ten Irrigation sluices provided for, five have been completed and the others have been commenced. The number allowed appears to be less than is desirable.

There are to be three wall sluices in Tank banks, these are all behind-hand, and I think it would be as well to dispense with them.

Depth of water and fall.

The full depth of water in this division will be 9 feet, and the fall of the bed of canal will average 4 inches per mile.

Bowen Division, 1st Section 61 to 72nd mile.

73. 61st mile.—The earth-works in this mile are behind-hand; the ground in many places has not been broken. An 8 feet culvert is under construction, and will be finished this month (June). It will make a very indifferent crossing, and should only be considered a subsidiary one. Soil bad.

74. 62nd mile.—Two 8 feet culverts have been finished, and an irrigation sluice just below. No 3 culvert has been completed also. Earth-work nearly completed, where there is a little cutting; elsewhere $\frac{1}{2}$ to $\frac{3}{4}$ done. Soil, brown cotton.

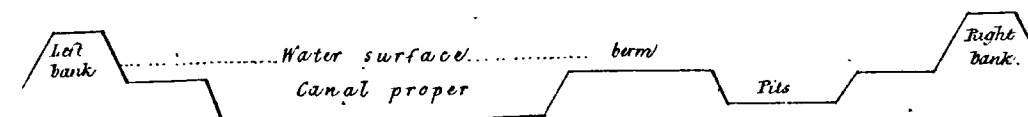
75. 63rd mile.—Up to site of Teragopila aqueduct one bank, the left one, is about $\frac{3}{4}$ done, the other not yet commenced. Aqueduct three arches of 25 feet not commenced. Below the nullah the left embankment is nearly finished, the right not commenced. Revetment not yet started. Stone to be had close by. Soil for greater part of this mile is bad.

76. 64th mile.—Left bank nearly finished; right bank just commenced up to the beginning of the former double banks and end of former tank. Soil in this mile good generally. An 8 feet culvert is under construction at the $\frac{1}{2}$ mile; rate for rubble masonry, Rupees 2-8-0, which is about 10 Annas too low; that for arch work Rupees 8 is, looking to the material, rubble, and to the style of work, at least double what is right. The stone is very unsuited to such work. Up to the end of the mile the earth-work is about $\frac{3}{4}$ done.

77. 65th mile.—In this mile a calingulah was partly built in connection with the Teragopila Tank, which has now been superseded by a double bank and an aqueduct. There is here a cutting which when completed will be 9 feet deep. The calingulah body has an under-sluice of 6 vents which will do for irrigation. No rear apron will be necessary for the calingulah; but one will be needed for the sluices with revetment for the out-fall channel for a few yards. About half the excavation has been finished above the calingulah, and below it to the end of the mile the canal is very nearly cleared out.

83. 66th mile.—The upper part completed to full depth, and only a little clearing to be done. There are some queer bends on the right margin of the canal—the result apparently of very precise calculations of the sectional area required and the ground being slightly undulating. The line consequently is thus , and the corners will require cutting off. Irrigation Sluice No. 2 is in this mile and has been completed. Culvert No. 5 of 8 feet span, has been completed. The arch stone of this tunnel is of the same description as that of No. 4 culvert. About one-half of the earth-work of this mile has been completed.

84. 67th mile.—An additional culvert at 66th mile and 30th chain is required, as there is a considerable drainage to be provided for. Up to this earth-work $\frac{3}{4}$ done. The cross section of the canal here is somewhat singular, and is of this form.



The position of the banks is such that the sectional area above ground-level added to that of the canal in cutting gives the required water-way. The cutting is placed near the left bank for convenience of towing; and to obtain sufficient soil for the right bank pits are dug in the broad berm between it and the canal. It would have been an improved arrangement had the banks been placed rather closer together, and the cutting of the canal proper increased sufficiently to provide the soil required; as thus the navigation would have been improved, and the excavations would have answered the double purpose. It is of small consequence where the cutting is shallow, but elsewhere when the water is low the width for navigation will be more restricted than was necessary. Earth-work of latter part of miles $\frac{3}{4}$ done. The excavation for an 8 feet culvert has just been commenced.

85. 68th mile.—Irrigation Sluice No. 3 is at the $\frac{1}{4}$ th mile, rubble masonry rough; a crack of no great importance in the face wall. The excavation and banks of the latter part of the mile require a good deal of levelling and sectioning; and at some places ground has not yet been broken. There is some laterite boulder of a hard description to be got out towards end of mile.

86. 69th mile.—Up to the 3 feet culvert in the middle of the mile the earth-work is incomplete all along; but the greater part of the work is done. The culvert was built two years ago, and looks sound, and is said to be water-tight; but as the banks have not been connected with it a full trial has not been made. Thence up to Sluice No. 4 (a small one) the greater part of the earth-work has been done, but no part is finished. Most of this work was done nearly two years ago. Just below sluice, the cutting through the ridge, on which (below the canal) Purnápaud is situated, commences. The greater part done.

87. 70th mile.—The canal runs south of the village; the greatest depth of the cutting is 9 feet. About the half mile, a set of scouring sluices, 6 vents of 3 feet, is $\frac{3}{4}$ done. Stone and work of piers, good. The rate for cut stone is Rupees 7-8-0. The wings are rough rubble in chunam, rate Rupees 2-8-0. No rear apron allowed but one will be absolutely necessary. At end of this mile a small irrigation sluice completed and earth-work finished.

88. 71st mile.—Up to culvert, excavation and earth-work nearly finished. In parts the same cross section of the canal as that mentioned in the 67th mile has been adopted. The culvert side walls are up to the level of springing; work stopped by water for the present. Up to the end of the mile the canal is in cutting all through, and the earth-work is finished, all but a little clearing and widening.

89. 72nd mile.—The Metacondal cut may be considered to commence in the previous mile, and it is continued throughout this mile. The greater part of the work has been completed

in a very satisfactory manner, and it was undoubtedly a work of some difficulty. At the deepest part is a bridge of 2 arches of 35 feet span, which has been finished and is open for traffic. The pier and abutment facings are of cut stone, as also the arch facing; the rest of the work is the rubble stone of the cutting, and it is not good enough to stand exposure without plastering, so that the superstructure and soffits of the arches are plastered. At the bridge and a few feet above and below a considerable mass of stone has to be cleared out, and the cut is some feet short of its full width throughout; 200 yards from the lower end of the mile, the calingulah to discharge the greater part of the water into the Caulee will be built, and below this point the width of the canal is reduced from 70 to 40 feet.

Works for discharging about 3,00,000 cubic yards per hour into the Caulee.

90. From the calingulah just referred to, and the working plan of which has not yet been drawn out, a channel about $1\frac{1}{2}$ miles in length 500 feet wide, and intended to run 2 feet deep will conduct nearly all the irrigation water into the Caulee—a tributary of the Kunder. The banks of this channel have just been commenced. The fall of the ground to the Caulee is 34 feet, and that of the river itself for the first mile is said to be about 24 feet. The surplus channel will join the Caulee about $\frac{1}{2}$ mile above the village of Banakacherla, which stands on the right bank. The land on the right bank of the river is about 7 feet above its bed, that on the left is low. The villagers informed me that after heavy falls of rain the Caulee, opposite Banakacherla where its width is about 70 feet, rises to 7 feet; that communication across it is then stopped for a few hours at a time; and that the lands on the left bank are flooded for a considerable distance. The drainage basin of the Caulee, above Banakacherla, Mr. H. Cotton told me, is about 5 square miles. Probably the water of the Caulee, when running 7 feet deep, amounts to nearly 8,00,000 cubic yards per hour, and this would be an extreme fresh I should imagine, as it would require a rain-fall of 9 inches in the 24 hours over the basin named; at any rate, however, the addition of 3,00,000 cubic yards of water brought from the Toombuddra and added to that in the Caulee will, whenever the latter has more than 4,00,000 or 5,00,000 cubic yards of its own water, occasion a fresh equivalent to the high freshes now sometimes experienced. At present such freshes last but a short time, and the lands inundated on the left bank soon drain off again; but it is clear that such inundations will last for a much longer period, and that some extent of land will be almost constantly submerged when the irrigation water is thrown in. Again the villagers of Banakacherla are, under existing circumstances, occasionally for a few hours prevented from crossing the river; but when the surplus water is thrown in it is probable that for days together the Caulee will not be fordable. No provision has as yet been made for embanking the river; nor has any land on the left bank been applied for; and I think an investigation should be made;

1st. To determine more accurately the present discharge of the Caulee, and the effect that an addition of 3,00,000 or even* 4,00,000 cubic yards per hour will have in raising the level of the flood waters.

2nd. To ascertain how far the flood waters will extend near Banakacherla, and what works will be necessary to confine the waters within reasonable limits.

3rd. To show at what point down the river the water-way becomes sufficient to remove all fear of injurious inundation and,

4th. To find out what villages if any, besides Banakacherla, will be more liable than they are at present to be isolated from the fields belonging to them, and to provide such means of crossing as each case may seem to require.

It would never do to find out, after the surplus works are in operation, that they could not be made use of without serious risk and injury to the lands and villages on the Caulee.

It may perhaps be urged that it is not intended to discharge water into the Caulee when this river is in fresh; but even were the Telegraph used without an hour's delay, and the Sunkésala Head Sluice entirely closed, the surplus works in the 72nd mile would continue to

discharge an almost undiminished quantity of water for several days, the Canal alone, without the tanks, holding enough to suffice for 36 hours, and therefore, apart from questions of navigation, which would be stopped by such a proceeding, it is clear that no sufficient regulation to do away with the necessity for the works I have indicated, could be exercised.

Summary of 2nd Section, Bowanassy Division, or 5th Section of the Main Canal, 61 to 72 miles.
1st.—Embankments and excavations

At the beginning of this section, the earth-works are behind-hand, the ground in some places had not been broken. In the

63rd and 64th miles where the banks near Terogopila will be very high, the left bank is nearly finished, and the right, which has only become necessary since the abandonment of the single banked arrangement with a tank, is only just commenced; beyond this newly arranged portion the earth-work is $\frac{3}{4}$ th done. For the rest of the section great progress has been made all along, and the greater part of some of the miles only needs finishing, while at other parts a considerable portion of the work is still incomplete. The whole of this section will now be double-banked. The soil in the first half of the section is much of it bad; lower down it improves greatly.

2nd.—Revetments.

No work of this description has been done, and the double banks render protection of this

sort generally unnecessary; near Terogopila however it will be found advisable to revet the high banks above and below the aqueduct, and for short lengths, elsewhere, the soil is bad, and not likely to stand unprotected. Compared however with the upper sections of the canal, but a very small outlay on this account will be required.

3rd.—Masonry works.

The greater part of the masonry of the calingulah in the 65th mile has been done. The

Terogopila tank having been abandoned, it will not now be required as a surplus work, but its under-sluiques will prove useful for irrigation. It is the only masonry work of the kind.

Four culverts of different sizes have been completed, two are nearly finished, two half finished, and for one the excavation has been made. An additional culvert is required at the 30th chain of the 67th mile. The one set of scouring sluices in the 70th mile is $\frac{2}{3}$ ds built, it will require the addition of a rear apron and some revetment to protect the rear of the canal banks.

There is one bridge in this section, that across the Canal at the Metacondal cut, and this has been fully completed. The aqueduct in the 63rd mile of three arches of 25 feet span, has not yet been commenced.

Probable time of completion of the works of the section.

The earth-works and revetments, as also the little that remains to be done to the minor

masonry works can, I think, easily be completed within six months; and if no time be lost after the rains, in laying the foundation of the aqueduct in the 63rd mile, this, the largest masonry work of the section, may be finished within the year.

The discharge Works.

These, including such supplementary works as may be found necessary, with reference to

the remarks contained in paragraph 89 above, should be completed within the year.

Main Canal, 2nd Section Bowanassy Division, or 6th Section of the Canal, 73rd to 91st miles.

91. 73rd mile.—The water through the Metacondal cut and up to the head works in

this mile, will have a maximum depth of 10 feet. Below the depth will be 5 feet. A scouring sluice is under construction, to aid in keeping the navigation channel clear, and to discharge the water not required for irrigation and navigation into the surplus channel leading to the Caulee.

These sluices have the wing-walls of rubble masonry, which are completed. The faces of the abutments and the piers will be of cut stone, and this part of the work is about half done. The sluice is founded on rock, but the rock is at some depth below the surface. No rear wings are provided for; but I think an apron is necessary, and that a substantial revetment at least, if no water wings be built, should be given, for the water will leave the sluice at a very high

velocity. A short distance below these sluices, a head sluice of four vents for the supply of the Canal, has been completed. The vents are of cut stone carefully built, the rest of the work, rubble masonry, plastered. This work also is without either front or rear aprons or water wings, and I do not see how the banks to be connected with it can possibly stand without a much better protection, than a simple revetment, which I understood to be the only work of this sort intended. The rock here is 3 feet below the level of the floor of the vents.

The regulating lock is within a few yards of the head sluice. It has been completed as far as was practicable, in the absence of the regulating valves. I saw a tracing of the valve, but it was not correctly drawn or at least the drawing was not clear either to the Executive Engineer or to myself, and therefore I will leave to a future time all comment on its probable efficiency. It is an iron cylindrical valve revolving on a spindle, and with openings 6 feet high by 3 feet wide on opposite sides, and when these openings are brought into a line with an opening in a wall to be built across the culvert, the water will pass through the valve. Originally there were to be 22 openings, each 18 feet wide from the culvert to the lock chamber. To save labour and expense in cut stone, these openings have been reduced to 11 of double the width. Probably this arrangement will work very well, if a little care be used in not admitting the water too fast at first. All the masonry of the lock, except the linings of the vents leading to the chamber, the quoins and the mitre sills are built of rubble stone from the Metacondal cutting. This stone is a slate which is too rough in form and too easily operated upon by water and air to stand without being plastered, so that the greater part of the work will be coated. This is unfortunate both as regards appearance and wear. The quoin stones have cost 50 Rupees a cubic yard, and the vent linings 15 Rupees.

The earth-works near these head works have hardly been commenced, and the Canal down to the end of the mile has for the most part yet to be formed.

The Canal as far as 79th mile will have a fall of 4 inches per mile, and a width at water surface of 60 feet.

92. *74th to 78th miles*.—The ground has been broken in some few places, but generally no earth-work has yet been commenced. In the 74th mile a culvert of 10 feet has been completed, and there is a similar one in the 75th mile. In both cases the headway under these culverts is too small to allow of their being used as crossings. In the latter mile, also, a bridge of 2 arches of 25 feet span is under construction, near the village of Metacondal, and the arches have been completed. The rubble stone is similar to that used in the head works. The country in these miles is favourable, the general direction of the Canal is westerly, the line makes long sweeping curves, and it has been carefully selected and laid out. At the lower end of the 78th

mile all the irrigation water will be taken off by a channel, which is to diverge from the right

bank. The Plans and Estimates for the irrigation works are approaching completion. I looked over them, and, with the exception of what is termed the ridge channel, they appeared to have been carefully and successfully planned. That channel however will run at a very heavy incline and will be cut in rock, and either the sides and bottom must be revetted at a heavy cost, or the fall must be reduced by masonry drops. The Executive Engineer is about ascertaining which will be the cheapest method. Several irrigation sluices in the left bank of the Canal in these miles will be required.

93. *78th mile*.—At the beginning of this mile, is the site of a treble lock, dropping the Canal 20 feet, and below this the Canal will be a still water navigation. The excavations for the lock are in progress, and they are, with the exception of the first few inches, in rock, composed of a hard blue limestone and slate. The stone will be used, and is well suited for all the work, except the gates, which will be of the dark blue limestone. Below this point up to the head sluice the ground has been cut. The upper part is in rock, which quickly, however, is superseded by the same soil. At the 1 mile a single lock, No. 3, is under construction, the stone being brought on a tramway from a quarry about half a mile distant. Just at the upper end of the

lock a considerable nullah crosses the line, and this will be spanned by a double 10 feet culvert in connection with the lock. This under bridge will form a tolerably good crossing at most times, but the waterway struck me as rather small, as the foundations however will be on rock, this does not so much matter. The foundations of the lock have been laid at 12 feet below floor, nothing was allowed for foundations in the estimate. The rates for rubble and cut stone could not be ascertained, as the work is being done by the Company's own agents. For a short distance below the lock the ground has not been broken, thence to the end of the mile the Canal is finished; soil black cotton.

94. *80th mile*.—For the first half of the mile, Canal completed, except a little clearing; in the latter half, bed of Canal is above ground level, the banks are $\frac{2}{3}$ rds finished; soil bad, black cotton, and some pitching will be needed.

95. *81st mile*.—At the 5th chain the double lock, No. 4, with a drop of 21½ feet, will be built; the excavation for the upper chamber is down to level, and at the 62nd chain there will be a similar lock with however a culvert or under bridge. Not much of the Canal work in this mile has been done.

96. *82nd and 83rd miles*.—At the 11th chain, a considerable drainage crosses, for which a double culvert of 8 feet span is required. Lock No. 6 of 11½ feet drop will be at the junction of the miles, and the excavation is ready; and at the 65th chain of the 83rd mile the double lock No. 7 of 20 feet drop with an under bridge, is in progress, the upper chamber being about 4 feet above floor level, and the bridge abutments complete. The stone is very good, and the work also. No foundations were allowed for in the Estimate, they are between 5 and 6 feet. The rate 2½ Rupees for the rubble masonry is expected to suffice. In the 82nd mile, about half the earth-works have been finished; below Lock No. 6 the Canal is complete for a few chains, and thence to Lock No. 7 very little has been done, after which greater progress has been made.

97. *84th mile*.—At about the half mile, the excavation for a culvert of two vents of 10 feet has been partly made. The greater part of both banking and cutting completed. Near the station of Valapanur the Canal runs through hard kunkur, and here the cutting is rather behind hand; the berms are very narrow.

The roofing of the permanent station building is being put up. The walls are of excellent stone, the roof will be thatched.

98. *85th mile*.—Up to the culvert at the 25th chain, excavations nearly completed, banks require sectioning and levelling; culvert side walls and half the arch completed, masonry and stone good. Thence to end of the mile Canal completed, and banks rough sectioned, berms narrow and much guttered. A good deal of silt in the Canal. The culvert will make a tolerably good crossing.

99. *86th mile*.—In the first half mile a great deal of water found its way into the Canal through the gaps left in the embankments, and brought much silt. Here a culvert of 8 feet span is under construction, and is likely to prove too small for the drainage; the side walls and a part of the arch have been built. The out fall channel must be cut out to level. The culvert will make a passable crossing. The excavations in this mile are very nearly complete. Near the lower end of this mile a quarry of good blue limestone has been opened in the bed of the Canal, and it is intended to lay a tramway down to the Caulee to furnish stone and lime for all the masonry works. A lime kiln has been built, and a charcoal oven is under construction, though whether it is economical to bring wood from a considerable distance to be made into a charcoal is rather doubtful.

100. *87th mile*.—To within 300 yards of lower end, excavations complete, and banks full height, but the high banks at the lower part are not safe at their present section, and it will be necessary to make the interior slopes 2 to 1, and to turn over the top soil in so doing; the soil is very bad, black cotton. Rest of mile ground not broken.

101. 88th mile.—At the 3rd chain there will be a double lock, No. 8, of 20 feet drop, with an under-bridge or culvert; excavation for this work commenced; Canal earth-works not commenced. Below this lock the line crosses a succession of low spurs and valleys, with considerable drainage; for these culverts Nos. 10 and 11 of 10 feet span only are allowed, and these, I think, will not be enough. Lock No. 9, a double one and similar to No. 8, but without a culvert, is to be built at the 34th chain, and not the end of the mile, as shown in the longitudinal section. It would be better, as is indeed proposed, to build it, or at any rate one-half of the drop, in connection with Lock No. 8, for the soil is not at all suited to the very high embankments now rendered necessary; and in fact I think the desire to economise masonry has led to Lock No. 8 being double, and to its being placed too low down, a single drop half a mile above would have been a safer arrangement, and not less convenient than the present position of these works.

102. 89th mile.—Portions of excavation and embankment done down to the 60th chain, the site of No. 10 lock, double, with 20 feet drop.

103. 90th mile.—A considerable part of the earth-work done. Lock No. 11, a double drop, will be at about the $\frac{1}{2}$ mile; soil bad all along, and embankments near the locks will be very high, and require much care.

104. 91st mile.—The Canal joins the Caulee in this mile. Lock No. 12, a single drop of 10 feet, bringing it down to the required level. A great deal of the earth-work has been done. The part below the lock approaches the river at too great an angle. It would be far better to curve it round, for with any current in the river, boats will find considerable difficulty in getting into and out of the Canal.

Summary of the 6th Section, miles 73 to 91.
1st.—Excavations and embankments.

than commenced, and the ground is unbroken for nearly half the length of the section.
2nd.—Revetments.

No work of this description has been done. It is intended to revet the banks above the head works in the 73rd mile with stone from the Metacondal cut, any quantity of which is available. There are many parts of the banks in the section, however, which will have to be revetted sooner or later, and this is the case especially in the last six miles where the soil is very bad, and the lower half of each length between the locks has high banks, which will assuredly suffer when water comes to be admitted. If the upper miles of the section be finished continuously, stone might be brought down at a very small expense by the Canal.

3rd.—Masonry works.

There is only one bridge allowed for this section. It is in the 75th mile, and will very soon be finished, as the arches are turned and the superstructure is in progress.

Of the 12 locks, Nos. 1, 3, and 7 are actually under construction; the first is completed as far as it can be, without the valves, which are expected shortly, the other two are about one-fourth done. Preparations are being made for the other locks, but it is probable that Nos. 8 and 9 will be somewhat modified, and I think a change is desirable with a view to reduce the height of the embankments, the soil being very bad. Locks Nos. 3, 5, 7, and 8 will have culverts or under-bridges attached, which will serve both for drainage and for crossings. The total lockage of the section will be 194½ feet.

Culverts.

Two have been completed in the 74th and 75th miles, they would have served as crossings had the headway been sufficient, but, as constructed, they are useless for this purpose; there is a bridge however in the latter mile. Another culvert has been partially built in the 85th mile. The other works of this description included in the estimate have not been commenced. Two or three additional culverts will probably be found necessary.

Irrigation sluices.

Works of this sort will only be needed up to the 78th mile, below which the Canal will not carry irrigation water.

There is a considerable area of land available, and it is of consequence that the sluices should be planned and constructed as early as possible. The irrigation details are generally much behind-hand, and even when water becomes available, I am afraid the means of distributing it will be wanting until a much later date than is advisable, added to which it must not be expected that the villagers will even ask for a supply, until the channels are laid out, and each man can see from exactly what point he will obtain the water for his fields. It is not like an extension of irrigation in an irrigated country. The people know little about the subject, and are rather disposed to doubt the advantages of irrigation, and therefore every care is requisite to give them timely notice, and to show them that the distribution arrangements will be ready.

The scouring sluice at the upper end of the section is about half finished; the head sluice near it has been completed as far as the estimate allows, but both these works require additions in the way of water wings and rear aprons.

Probable time of completion.

It will probably take the greater part of two years of hard work to complete this section. Labour does not appear to be very abundant, and the masonry works are very heavy, added to which it will, in my opinion, be the better plan to devote much of the available labour to the utilization of the 40,000 cubic yards of irrigation water which will be carried by the first 6 miles of the Canal, by getting the irrigation channels and sluices carried out.

Ferries.

Several ferries are to be provided for this section, and as the width of the Canal is but 60 feet, it will be necessary to provide recesses for the boats, and to place the embankments back, so as to allow proper slopes for the approaches. In some cases extra work will be caused by the omission to take this into consideration, when laying out the lines for excavation and embankment.

Present width of channel.

This is, as already remarked, 60 feet, a narrow allowance for a first class navigation, and I think it would have been better throughout to have placed the embankments further apart. This would have entailed no extra expense, and, where the Canal is in cutting, it would still have been easy to make the narrow cut in the first instance, and to have left broad berms for future enlargement. Some few culverts might either have been built short in the first instance, to be lengthened when required, or they might have been built longer originally. It is not too late to take this into consideration in some of the miles.

106. 92nd mile.—The still water navigation Canal will terminate at the right bank of the Caulee, and this section will, from an Anicut to be thrown across that river, take off 1,00,000 cubic yards of the water turned into it by the surplus works at the lower end of the 72nd mile. The Canal will have a water surface width of 70 feet, a maximum depth of water of 6 feet, and a fall of 6 inches per mile. The head works commenced, or to be built, are, first, the Jootoor Anicut across the Caulee; second, a head sluice; third, a navigation head with a regulating lock.

The right wing of the Anicut has been completed to full height; the left wing is in progress; the body of the dam will not be commenced until after the rains, it will be 10 feet high above the floor of the under-sluices, and its length between the wings will be 346 feet. In the original design no apron whatever was provided, but this addition was made by the late Consulting Engineer before submitting the estimates for sanction. This apron is shown as 18 inches thick, and, until the river bed is cleared, I cannot say whether the rock there will, with this protection, be strong enough to resist the overfall; but, judging from that on which the head sluice is founded, I am disposed to think a stronger work will be necessary. The under-sluices will be close to the left wing of the Anicut, and the head sluice is to be connected with that wing by a

wall 120 feet in length. The floor of the head sluice is on the same level as that of the under-sluices, and, with this considerable space between them, inconvenience is likely to be experienced from silting.

Just above the site of the Anicut, a nullah falls into the Caulee, and it is proposed to use this as the navigation head, but the lower part of it is very unsuitable for that purpose; as it is very winding, it would oblige the boats to approach to within an unsafe distance of the Anicut and under-sluices, and it would certainly silt up. A head much higher up would be preferable, and there is no advantage, even as regards economy, in bringing the head down so low. As some embankments are required on the left bank of the Caulee, I requested the Executive Engineer to place these banks so as not to interfere with a revised navigation head, should the Chief Engineer think a change desirable.

The excavation for the regulating head lock has been made; good hard soil has been found. The Bridge No. 1 for the nullah which, at a road crossing, will be unfordable when the

Anicut has been built, has been completed to the springing, and the arch would have been turned had not a fresh carried away the centring; it will be finished after the rains.

The Canal works in the latter half of the mile have made considerable progress; soil tolerably good.

107. 93rd mile.—Very little earth-work done; Bridge No. 2 for the Nundial road not commenced.

103. 94th mile.—First half, ground broken, nothing else done. It is doubtful whether the culverts provide sufficient waterway.

103. 95th mile.—Earth-works about half done; a large drainage crosses the line, and at the 54th chain a calingulah is to be built. The nullah is some feet below the bed of Canal, and its banks will require embanking for one to one and a quarter miles. The direction of the drainage, is to be improved, and the heavy banks across the old course will require to be revetted.

110. 96th mile.—Excavations nearly finished, and banks being made up from outside pits.

111. 97th mile.—In the first half mile excavation nearly finished; below this half the cutting, which will be from 4 to 4½ feet, has been completed. There will be a calingulah for a cross drainage at the half mile. Materials under preparation. There will be a considerable over-fall, as the nullah is about 10 feet below surface water of Canal. The plan provides a simple body wall, and therefore the estimate will necessarily be considerably exceeded, in providing a suitable apron, retaining walls, &c.

112. 98th mile.—Throughout, the excavations, which are 4 to 5 feet deep, are nearly finished.

113. 99th mile.—At the eighth chain excavation for a treble-culvert completed, and materials under preparation. Thence nearly up to the Byap Gudur tank, earth-work nearly done. The Canal is arranged to be carried through the tank, the water of the latter being passed under it by a culvert. The difference of level of the Canal and tank water is about 5 feet, the latter being the higher, so that no other arrangement was feasible on the present line. Nothing has been done inside the tank.

114. 100th mile.—This begins in the middle of the tank. From the tank bund to the ¾ mile, about half the earth-work done; the last ¼ mile is only commenced. A bed of limestone and slate occurs in the middle of this mile.

115. 101st mile.—There are four culverts to be built in this mile, and the excavations for two are in progress; in one case several feet of hard slate rock suitable for masonry have to be excavated. Coolies were at work with crowbars, blasting would be quicker and cheaper. Up to half a mile Canal cutting ¾th done, below that cutting complete, and embankments ¾th finished. Soil moderately good.

116. 102nd mile.—Excavation finished except levelling. Embankments about one yard below full height. Soil good, red.

117. 103rd mile.—Excavation nearly finished. The embankments, except at last part of mile, want a good deal of raising; excavations for a culvert, No. 20 in progress, and part of the stone for masonry is being obtained therefrom. Soil for last ¾ths of mile, bad.

118. 104th mile.—Very little done to the earth-works, and masonry works not commenced beyond preparatory excavations.

119. 105th mile.—Nearly all the earth-work in this mile has been finished. The aqueduct across the Nundial Tank supply channel has not been commenced; materials should be collected in good time for the foundations, for the period during which such work can be done is very limited, and if any portion of this be lost the completion will be delayed for an additional year. Soil bad.

120. 106th mile.—The cutting in this mile is rather deep, and at the ridge it is 7 feet. The earth-works are well advanced, and the deep cutting is down to full depth. Soil indifferent; masonry works not commenced.

121. 107th mile.—The Iyalur station buildings are in this mile, at the junction of the new Cuddapah and Kurnool road with that from Cumbum. Up to the bridge site on this road the earth-works have made good progress; below bridge one-half the cutting has been completed. The foundations of the bridge are partly laid.

122. 108th mile.—In the first half of this mile, half the cutting done; earth-work below this not commenced. The culvert of two vents of 10 feet, the excavations for which are in progress, will not make a good crossing. The village road from Chabole to Gungaram, a little below the ¾ mile, does not appear to be provided with any crossing.

123. 109th mile.—Half the full depth (4 feet) of cutting done for a few yards at commencement of mile, ground not broken beyond this.

124. 110th mile.—Ground not broken, about the ¼ mile culvert No. 7 is to be built, this will probably do for a crossing, and one is very much needed hereabouts. The sketch map of crossings shows this culvert as one of three vents near the end of the mile, but this does not agree with the arrangement pointed out by the Executive Engineer.

125. 111th, 112th and 113th miles.—Canal formation not commenced: In the former mile the Canal crosses the line of the old Cuddapah road, but no bridge is to be built there, the late District Engineer having considered the better site to be where several village roads meet to the west of Dipaguntla, and there excavations for a bridge are being made. The bandy-track at 50 chains, in the 113th mile, is, as stated in the section, but little used, but it is also a drainage, and as the ground slopes towards this point for a long distance, both north and south, this drainage will be much increased, and an 8 feet culvert will be required. Soil at lower part indifferent.

126. 114th mile.—Work not commenced. There are three village roads crossing this mile, two of which carry some bandy traffic. No provision has been made for this, unless the intended ferry in the next mile be supposed to be sufficient.

Summary of the 7th Section of the Canal, 92nd to 114th mile.

First.—Excavations and embankments.

Second.—Revetments.

Third.—Masonry works.

127. About three-eighths of the total quantity of the earth-works have been completed. The supply of labour is not very abundant.

but it will probably suffice to complete these works by the end of another year.

There is no provision in the Estimate for any work of this description. Some will be required

at the navigation head; for the banks immediately below the head sluice; for the banks near the two calingulahs; for the bank across the old course of the nullah in the 95th mile; probably for the banks through the Byap Gudur tank, and for the banks above and below the Nundial channel aqueduct. The soil throughout this section is much of it very bad, but the line has been well selected, and there are very few places where the embankments will be high.

The Anicut and head sluice and the foundations of the bridge at Iyalur are the only works actually commenced. Excavations and preparations for others are in progress. It is not improbable that extra masonry will be required for the Anicut.

wall 120 feet in length. The floor of the head sluice is on the same level as that of the under-slucies, and, with this considerable space between them, inconvenience is likely to be experienced from silting.

Just above the site of the Anicut, a nullah falls into the Caulee, and it is proposed to use this as the navigation head, but the lower part of it is very unsuitable for that purpose; as it is very winding, it would oblige the boats to approach to within an unsafe distance of the Anicut and under-slucies, and it would certainly silt up. A head much higher up would be preferable, and there is no advantage, even as regards economy, in bringing the head down so low. As some embankments are required on the left bank of the Caulee, I requested the Executive Engineer to place these banks so as not to interfere with a revised navigation head, should the Chief Engineer think a change desirable.

The excavation for the regulating head lock has been made; good hard soil has been found.

The Bridge No. 1 for the nullah which, at a road crossing, will be unfordable when the Anicut has been built, has been completed to the springing, and the arch would have been turned had not a fresh carried away the centring; it will be finished after the rains.

The Canal works in the latter half of the mile have made considerable progress; soil tolerably good.

107. 93rd mile.—Very little earth-work done; Bridge No. 2 for the Nundial road not commenced.

103. 94th mile.—First half, ground broken, nothing else done. It is doubtful whether the culverts provide sufficient waterway.

102. 95th mile.—Earth-works about half done; a large drainage crosses the line, and at the 5th chain a calingulah is to be built. The nullah is some feet below the bed of Canal, and its banks will require embanking for one to one and a quarter miles. The direction of the drainage is to be improved, and the heavy banks across the old course will require to be revetted.

110. 96th mile.—Excavations nearly finished, and banks being made up from outside pits.

111. 97th mile.—In the first half mile excavation nearly finished; below this half the cutting, which will be from 4 to 4½ feet, has been completed. There will be a calingulah for a cross drainage at the half mile. Materials under preparation. There will be a considerable over-fall, as the nullah is about 10 feet below surface water of Canal. The plan provides a simple body wall, and therefore the estimate will necessarily be considerably exceeded, in providing a suitable apron, retaining walls, &c.

112. 98th mile.—Throughout, the excavations, which are 4 to 5 feet deep, are nearly finished.

113. 99th mile.—At the eighth chain excavation for a treble-culvert completed, and materials under preparation. Thence nearly up to the Byap Gudur tank, earth-work nearly done. The Canal is arranged to be carried through the tank, the water of the latter being passed under it by a culvert. The difference of level of the Canal and tank water is about 5 feet, the latter being the higher, so that no other arrangement was feasible on the present line. Nothing has been done inside the tank.

114. 100th mile.—This begins in the middle of the tank. From the tank bund to the ½ mile, about half the earth-work done; the last ¼ mile is only commenced. A bed of limestone and slate occurs in the middle of this mile.

115. 101st mile.—There are four culverts to be built in this mile, and the excavations for two are in progress; in one case several feet of hard slate rock suitable for masonry have to be excavated. Coolies were at work with crowbars, blasting would be quicker and cheaper. Up to half a mile Canal cutting ½th done, below that cutting complete, and embankments ¾th finished. Soil moderately good.

116. 102nd mile.—Excavation finished except levelling. Embankments about one yard below full height. Soil good, red.

117. 103rd mile.—Excavation nearly finished. The embankments, except at last part of mile, want a good deal of raising; excavations for a culvert, No. 20 in progress, and part of the stone for masonry is being obtained therefrom. Soil for last ¾ths of mile, bad.

118. 104th mile.—Very little done to the earth-works, and masonry works not commenced beyond preparatory excavations.

119. 105th mile.—Nearly all the earth-work in this mile has been finished. The aqueduct across the Nundial Tank supply channel has not been commenced; materials should be collected in good time for the foundations, for the period during which such work can be done is very limited, and if any portion of this be lost the completion will be delayed for an additional year. Soil bad.

120. 106th mile.—The cutting in this mile is rather deep, and at the ridge it is 7 feet. The earth-works are well advanced, and the deep cutting is down to full depth. Soil indifferent; masonry works not commenced.

121. 107th mile.—The Iyalur station buildings are in this mile, at the junction of the new Cuddapah and Kurnool road with that from Cumbum. Up to the bridge site on this road the earth-works have made good progress; below bridge one-half the cutting has been completed. The foundations of the bridge are partly laid.

122. 108th mile.—In the first half of this mile, half the cutting done; earth-work below this not commenced. The culvert of two vents of 10 feet, the excavations for which are in progress, will not make a good crossing. The village road from Chabole to Gungaram, a little below the ½ mile, does not appear to be provided with any crossing.

123. 109th mile.—Half the full depth (4 feet) of cutting done for a few yards at commencement of mile, ground not broken beyond this.

124. 110th mile.—Ground not broken, about the ¼ mile culvert No. 7 is to be built, this will probably do for a crossing, and one is very much needed hereabouts. The sketch map of crossings shows this culvert as one of three vents near the end of the mile, but this does not agree with the arrangement pointed out by the Executive Engineer.

125. 111th, 112th and 113th miles.—Canal formation not commenced. In the former mile the Canal crosses the line of the old Cuddapah road, but no bridge is to be built there, the late District Engineer having considered the better site to be where several village roads meet to the west of Dipaguntla, and there excavations for a bridge are being made. The bandy-track at 50 chains, in the 113th mile, is, as stated in the section, but little used, but it is also a drainage, and as the ground slopes towards this point for a long distance, both north and south, this drainage will be much increased, and an 8 feet culvert will be required. Soil at lower part indifferent.

126. 114th mile.—Work not commenced. There are three village roads crossing this mile, two of which carry some bandy traffic. No provision has been made for this, unless the intended ferry in the next mile be supposed to be sufficient.

Summary of the 7th Section of the Canal, 92nd to 114th mile.

First.—Excavations and embankments.

Second.—Revetments.

Third.—Masonry works.

127. About three-eighths of the total quantity of the earth-works have been completed. The supply of labour is not very abundant.

but it will probably suffice to complete these works by the end of another year.

There is no provision in the Estimate for any work of this description. Some will be required at the navigation head; for the banks immediately below the head sluice; for the banks near the two calingulahs; for the bank across the old course of the nullah in the 95th mile; probably for the banks through the Byap Gudur tank, and for the banks above and below the Nundial channel aqueduct. The soil throughout this section is much of it very bad, but the line has been well selected, and there are very few places where the embankments will be high.

The Anicut and head sluice and the foundations of the bridge at Iyalur are the only works actually commenced. Excavations and preparations for others are in progress. It is not improbable that extra masonry will be required for the Anicut.

The first diagram and a list show the first eight of some descriptions.

of the machine parts for an overall of 10 feet are necessary, and probably nearly double the quantity of material involved will be required. The collector generally appeared to me to be keen & the power of adjustment for the draughts, several changes in dimensions and arrangements suggested & some made on the sketch plan in my office were prepared. An additional quantity of 2 tons again will certainly be required in the final state of the

Department of Justice

Looking to the backward state of the masonry works, and seeing that two of them at least, the culvert in the Sijap Gully road, and the Nandial aqueduct cannot be commenced for some months coming, I do not think that the whole of the works of this section can be finished within two years, and probably the time will be exceeded.

129. 11254 mts.—The cutting is almost entirely, and the embanking nearly finished.

From 1 to 2 but little
of the mile the

Lock No. 1 will be nearly completed. The Yaloor

[illegible]

191. 11th mile — Down to Lock No. 3 the earth-work is nearly finished. Lock construction progressing, parts of the walls are nearly 3 feet above floor. Stone work very good. The lower channel are 14 paces 7 for the face work, and 7 paces 3 for the rubble backing, and the 7 paces are 14 paces more than three feet deep. My own opinion is, from seeing what is doing in other countries, that this gate rate is more than sufficient, and that the rubble requires perhaps a very small amount on account of carriage. A small drainage cut in rear of the gate works to cut of water flushed all but bank dressing. A small drainage cut behind the

Earth work nearly finished. No work commenced.

10-11-68
10-11-68

10-11-68 — Earth work nearly finished.

122. 122.1 mile - Earth-work nearly finished.
123. 123.1 mile - Look No. 4 will be in this mile. No work commenced.

1121 1121 mile.—Foot of the mile, one-third of the distance.
1122 1122 mile.—Foot of the mile, one-third of the distance.
1123 1123 mile.—Foot of the mile, one-third of the distance.
1124 1124 mile.—Foot of the mile, one-third of the distance.

2nd Nov 3 at the 2nd China commencing. No work commenced.

100. Work done. - A little stone collected for Lock No. 6. No work commenced.

101. Work done. - Lock No. 7, with Calagulah and the Donapaud bridge will all be close up about the 30th inst. Earth works up to this commenced all along, and in parts are well advanced, and thence to the end of the mile, are making rapid progress. The Donapaud section looking at the best quarters of the division is nearly ready to receive the roof.

102. Work done. - Stone collected for Lock No. 8. No work done.

103. Work done. - Treatment about two-thirds done, as far as the commenced. At end of mile

127. 1911 work - Some stone collected for Lock No. 8. No work done.
128. 1911 work - Earth work in embankment about two-thirds done, as far as the
1 mile where Lock No. 8 will be, and which has not been commenced. At end of mile
a good dam proposed to Kinigapoum crosses, and carries a good deal of traffic which requires
a good crossing. That I think would have been a better position for both bridge and station.
and is close to the village of Thompson, whereas the station is close to nothing but the Canal.
The work on earth work all but finished.

139. 126th mile.—In the first half of the mile the earth-works are two-thirds finished, beyond that ground not broken.

The 17 feet drop Lock No. 10 is planned for the end of this mile, and the Executive Engineer proposes to add 10 feet of this to Lock No. 9, whereby some 80,000 cubic yards of earth-work would be saved, and very high banks in very bad soil avoided. Excavation for the lock has been commenced.

140. 127th and 128th miles.—Ground not broken in the former, and in the latter only for a length of a few yards. It is at the end of the latter mile that the balance of seven feet fall from Lock No. 10 is proposed to be placed. A culvert will, I think, be required in the 127th mile.

141. 129th, 130th and 131st miles.—Canal works not commenced. In the first mile a culvert, No. 9, is proposed to be considered as a crossing. It could only be used in dry weather, and should not be taken into account. About the middle of the 131st mile, the road from Chintagunta to Lingumdinny crosses, provision has to be made for this.

142. 132nd mile.—Lock No. 11 will be at the 14th chain, and the excavations are in progress. Excellent dark blue limestone obtained from the lock excavation. Below this Canal formation commenced here and there all along. Soil red and much better.

143. 133rd to 141st mile.—A little earth-work has been commenced in the 133rd mile, and in the 136th mile preparations are being made for Lock No. 12 of 13½ feet drop, while below this one-third of the earth-work has been done for 4 or 5 chains, beyond this no work has been done in the section.

144. Up to the 141st mile, from the beginning of this section, the Canal will run along the water shed; the longitudinal fall is considerable, but the ground is remarkably even in all directions, and the trouble in laying out irrigation channels will be very small, as also will be the labour of forming paddy fields.

145. From the beginning of the 142nd mile the ground falls rather rapidly towards the Kunder, to which river the Canal approaches, and considerable cross drainage, with ground cut into ravines, is met with. Opposite the village of Rajoly, on the right bank of the Kunder in the 144th mile, the bed of the river is a vast mass of blue limestone rock, and here it is intended to build an Anicut to take up another portion of the water to be turned into the Caulee in the 72nd mile. The site is a very favourable one, and the Anicut ought to cost but little. The channel from the river to the Canal has been lock spitted. It is not more than 300 to 350 yards in length. Below this to the end of the section the Canal will run very close to the Kunder, and will for the most part be cut on the face of a very steep incline, the ground here rising very rapidly from the river. It is at present full of little ravines.

146. The soil of this section from end to end, is, with the exception of a few trifling patches, the dark clay, called black cotton soil. The only variations are, from bad to very bad, and much of it is nothing but the worst sort of silt. At some parts the banks will be very high, and I must confess that I view the experiment of trying if loose banks, without any puddling, of such soil will stand, especially with slopes of $1\frac{1}{2}$ to 1, with considerable anxiety.

There is no doubt whatever about the slope altering itself, and additional work on this account having to be done, but it may be said that the banks themselves are an experiment, for tanks are differently circumstanced, being subjected to the alternate presence and absence of water, whereas perhaps if water be admitted very carefully at first, these Canal banks may puddle themselves, and prove perfectly water tight. If such prove to be the case it will be a matter of rejoicing for all, for the expense, should this soil prove unstable, of making an efficient Canal, would be enormous.

147. This section is the last portion of the Main Canal which has been sanctioned, and I will therefore hasten to conclude this already over-grown report by adding a few remarks on some points affecting the Canal generally.

Communications across the line of the Canal.
* No. 1,540, 27th May 1864.

118. This question has occupied the attention of Government a good deal and, in their Order as per margin,* the arrangements proposed for the first 112 miles of the Canal were generally approved. An inspection however of the Canal, the country and its circumstances, has convinced me that these arrangements are, or will be, very far from adequate. In the first 30 miles of the Canal, the ground on the right bank is either rocky and uncultivated, or, as in the part west of Kurnool, the villages are small and not cut off from their chief market by the Canal, and the only inconvenience they will suffer is in some cases a difficulty in reaching their fields, a difficulty be it remembered which, however annoying at first, will constantly diminish, for the cattle will doubtless soon take to swimming across the Canal, if a suitable take off and landing, with ramps over the banks, be provided, and this will cost very little. It may be also remarked that many of the culverts in the western sections are lofty, well drained, and at the lower end their floors are flush with the natural ground level. As the Canal however proceeds to the eastward, the country opens out, the traffic in various directions becoming large; the country is crossed by many village roads used by bandies, and forming very tolerable communications for many months in the year. With the best possible arrangements probably one-half of these roads will be closed, and it is necessary to consider briefly whether any thing like a fair amount of accommodation will be provided by the crossings proposed.

149. Below the 30th mile the Bridges are:—

1. (Probably) at Ullur in the 35th mile; this is under discussion.
2. Nagalore bridge 45th do.
3. Jupaud do. 60th do.
4. Metacondal cut do. 72nd do.
5. Metacondal do. 75th do.
6. Bridge over nullah flooded by Jootoor Anicut, and not over the Canal. 92nd do.
7. Nundial road bridge, 93rd do.
8. Cumbum and Cuddapah Road bridge, 107th mile. 112th do.
9. Dipaguntah do. 123rd do.
10. Donapaud station, 139th do.
11. Jungalpilly, 139th do.

There will therefore be 10 first class crossings in 116 miles. The second class crossings are the culverts or under-bridges in connection with the locks. These occur in the 6th section only, at the locks in the 79th, 81st, 83rd, and 88th miles. They will be very fair crossings, for though carts and cattle will have to descend into nullahs and get up again out of them, there will be room enough, and the approaches can, without much difficulty, be made easy.

The ferries may be considered as the third class crossings, they will be placed at the

M. Ch.	M. Ch.
31.79	95.78
38.78	99.9
41.8	102.47
52.70	115.?
58.18	119.?
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85.51	134.?
87.25	142.0

or 16 ferries for 116 miles.

The design for the boats shows that they are intended to be 25 feet in length and 8 feet wide. The ends are pointed, so that a staging or platform of corresponding shape will be necessary to allow of carts being placed on them without difficulty. As, moreover, carts cannot be put upon

them, except at the ends, and as below the 70th mile the Canal is comparatively narrow, while above that point the current is considerable, it will be necessary to provide recesses of a depth corresponding with the length of the boats, and the embankments should also be thrown back sufficiently far to admit of ramps of 1 in 12 for carts, and 1 in 6 where only foot-passengers or cattle are intended to cross. I would also recommend that a sloped landing should be made on each side of the Canal, alongside the ferry stations, to allow of cattle taking the water without difficulty, for I have no doubt the cattle will very soon learn to cross the Canal in this way, and when they do so, much of the loss of time in getting to and from the fields which would occur, even with the best managed ferry boat, will be avoided.

In the part of the Canal below the 30th mile, the culverts must be considered as the least efficient crossings, and many of those at present considered as likely to be useful for that purpose will, I believe, be of no use. They are generally on a very low level, and will be wet and muddy; the out-fall channels will in some cases be very long, their size both as regards breadth and height is too limited, for a bullock yoke is often six feet long, and sometimes more, and 8 feet culverts leave therefore but a small margin; and a cart laden with straw or cholum or indeed cotton, would not pass through at all, added to which they are long and dark, and will in many cases be very wet from leakage. The idea was suggested by the railway culverts, but the circumstances are entirely different, and no railway culvert, situated as are most of these, would be used as a crossing at all.

In connection with this subject it should also be remembered, that ere very long what is now a dry country will be irrigated; that between all the numerous villages on either side of the line, raised roads will then be an absolute necessity, that if the questions of communications be now taken up thoroughly, the greatest benefit to the traffic may be obtained at the least possible cost, but that, if neglected now, there will be no such opportunity again; and I would suggest, therefore, that the Range Officers of the Department of Public Works should, in communication with divisional Officers of the Company, prepare a scheme of village roads, adapting the arrangements so as to make the most of such of the masonry works, whether over or under bridges, now about to be built, as may be possible, and then settling what further provision will be necessary. The Collectors of the several Districts would then be able to understand what is proposed, and to ascertain whether the several villages would be enabled without unnecessary difficulty to carry on their agriculture and transport their produce. At present were the Government to require all the different means of crossing to be doubled, and were the Company's Officers to agree at once thereto, there would be no certainty that the communications would be available for the use of the people for whose benefit they were constructed. I am quite convinced that the arrangements proposed at present are inadequate, but I think that no proper opinion can be formed without maps showing all the villages within the intended areas of irrigation, and exhibiting the connections of the several villages with each other, and with the Canal and existing made roads. The schemes for roads which have been prepared in the several Districts under the orders of Government would form a basis; in Kurnool, there is no time for delay, and each section, commencing, I would suggest, with the 3rd, might be disposed of to a great extent separately and successively; in the Cuddapah and Nellore Districts there will be more leisure. Probably the villages within 2 or three miles of the Canal on either side would determine the arrangement and position of all the roads crossing the Canal, and the connection of these villages with those more remote, might be taken up after this first point had been determined.

Economy would result from comparison of rates.

150. While passing through the several divisions it has struck me that much good would result were the Chief Engineer to take measures for ascertaining the relative cost of work in the several sections of the Canal. I have remarked a great difference in rates for similar work not only in different divisions, but in the different sections of the same division and were the experience gained in one locality made available for works elsewhere very great benefit would be

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The design for the boats shows that they are intended to be 25 feet in length and 8 feet wide. The ends are pointed, so that a staging or platform of corresponding shape will be necessary to allow of carts being placed on them without difficulty. As, moreover, carts cannot be put upon

them, except at the ends, and as below the 70th mile the Canal is comparatively narrow, while above that point the current is considerable, it will be necessary to provide recesses of a depth corresponding with the length of the boats, and the embankments should also be thrown back sufficiently far to admit of ramps of 1 in 12 for carts, and 1 in 6 where only foot-passengers or cattle are intended to cross. I would also recommend that a sloped landing should be made on each side of the Canal, alongside the ferry stations, to allow of cattle taking the water without difficulty, for I have no doubt the cattle will very soon learn to cross the Canal in this way, and when they do so, much of the loss of time in getting to and from the fields which would occur, even with the best managed ferry boat, will be avoided.

In the part of the Canal below the 30th mile, the culverts must be considered as the least efficient crossings, and many of those at present considered as likely to be useful for that purpose will, I believe, be of no use. They are generally on a very low level, and will be wet and muddy; the out-fall channels will in some cases be very long, their size both as regards breadth and height is too limited, for a bullock yoke is often six feet long, and sometimes more, and 8 feet culverts leave therefore but a small margin; and a cart laden with straw or cholum or indeed cotton, would not pass through at all, added to which they are long and dark, and will in many cases be very wet from leakage. The idea was suggested by the railway culverts, but the circumstances are entirely different, and no railway culvert, situated as are most of these, would be used as a crossing at all.

In connection with this subject it should also be remembered, that ere very long what is now a dry country will be irrigated; that between all the numerous villages on either side of the line, raised roads will then be an absolute necessity, that if the questions of communications be now taken up thoroughly, the greatest benefit to the traffic may be obtained at the least possible cost, but that, if neglected now, there will be no such opportunity again; and I would suggest, therefore, that the Range Officers of the Department of Public Works should, in communication with divisional Officers of the Company, prepare a scheme of village roads, adapting the arrangements so as to make the most of such of the masonry works, whether over or under bridges, now about to be built, as may be possible, and then settling what further provision will be necessary. The Collectors of the several Districts would then be able to understand what is proposed, and to ascertain whether the several villages would be enabled without unnecessary difficulty to carry on their agriculture and transport their produce. At present were the Government to require all the different means of crossing to be doubled, and were the Company's Officers to agree at once thereto, there would be no certainty that the communications would be available for the use of the people for whose benefit they were constructed. I am quite convinced that the arrangements proposed at present are inadequate, but I think that no proper opinion can be formed without maps showing all the villages within the intended areas of irrigation, and exhibiting the connections of the several villages with each other, and with the Canal and existing made roads. The schemes for roads which have been prepared in the several Districts under the orders of Government would form a basis; in Kurnool, there is no time for delay, and each section, commencing, I would suggest, with the 3rd, might be disposed of to a great extent separately and successively; in the Cuddapah and Nellore Districts there will be more leisure. Probably the villages within 2 or three miles of the Canal on either side would determine the arrangement and position of all the roads crossing the Canal, and the connection of these villages with those more remote, might be taken up after this first point had been determined.

Economy would result from comparison of rates.

150. While passing through the several divisions it has struck me that much good would result were the Chief Engineer to take measures for ascertaining the relative cost of work in the several sections of the Canal. I have remarked a great difference in rates for similar work not only in different divisions, but in the different sections of the same division and were the experience gained in one locality made available for works elsewhere very great benefit would be

the consequence. In some parts of the Canal work of each description is being done both well and cheaply; in other parts, the exact reverse in the case, and what is required is to approximate the cost every where to that which is found sufficient, where the best management prevails.

Position of Station buildings.

151. It has been stated that these buildings, though in the first instance used for Office and store accommodation, are intended afterwards as traffic stations, and if so, they should be placed close to the Canal in such a position as will be most convenient for the traffic. This would be, I think, on the opposite side to the towing path, and just so far removed from the Canal as to allow of a loading basin being formed. In the Kundar division the buildings are tolerably near the Canal, but in the other divisions they are much too far away, and at Bowanasay they are half a mile distant. The goods have to be taken out of carts, weighed and loaded, and these operations require the station to be situated like a railway station.

Precautions required in making excavations.

152. It would be well were the Chief Engineer to impress upon all his Executive Officers the necessity for precautionary measures in making deep excavations. I have noticed cuttings for masonry works several yards deep with perpendicular sides and the spoil placed close to the edge of the cutting. Many slips occurred during the recent rains, and one accident occurred, though fortunately without serious results.

Necessity for carrying out Irrigation details without delay.

153. The expenditure up to the 30th April last on the Toombuddra project was about 42 lacs of Rupees, and as yet the returns have been nothing. The first 30 miles of the Canal were necessarily very expensive, and up to the end of the 3rd section or 43rd mile, the whole possible irrigable area is but 10,000 acres. Up to the Metacodal cut, however, this area becomes increased to 50,000 acres, and below that the extent of land is very large. The importance of getting land under irrigation is so great that I would bring this point prominently forward with a view to attention being given, during the current year, to the completion, as far as is necessary for irrigation purposes, of the first 78 miles of the Canal, and to the pushing forward the distribution works. The irrigation Canal ends at the end of the 78th mile, below that the Canal down to the Caulee, 91st mile, is one of navigation only. At present, beyond the construction of a few sluices nothing has been done towards getting ready for irrigation, and yet undoubtedly much has to be done before any area worth mentioning can be watered. If very great exertions be used, the main Canal may be opened to the end of the 78th mile by May 1865, and sufficient water for all the possible irrigation carried, but it will be useless to expect results from the utilization of the water if concurrently the distribution works be not advanced. In a letter* dated the 10th February last, the Chief Engineer appeared to think that water could be carried to the Kundar valley† by the present July, but he must have been quite unaware of the state of progress of the works on the main Canal, especially in the 2nd section, where in the 20th mile, within 2 miles of the central office, the backward state of the cutting presented an insuperable barrier, and where in June the walls‡ in several miles were still several feet below the level of the bed of the Canal; and similarly, with regard to irrigation, it is only by fully recognizing the work to be got through, and taking adequate steps to get such work done, that the anticipations of returns can be realized. I hope that it will be possible this time next year to report that much has been accomplished, and I have written strongly on this subject, because there is no chance of results anticipating the work, on which alone those results depend, and that work has not yet been commenced.

* No. 1,255, paragraph 2.

† i.e. to below the 72nd mile.

‡ In lieu of embankments.

Information not yet received regarding expenditure and cost of works as compared with estimated cost.

154. I have not yet received from any of the divisions the information asked for to enable me to report on this subject. A separate report therefore with the illustrative sketch Map required, will be submitted as soon as possible.

*Consulting Engineer's Office,
Irrigation Canal Company.*

2nd July 1864.

N^o 40 dated 19th 65

*From
Captain J. Mullins R.E.
and Engrs of the Company
To
The Secretary to Government
Department of Public Works.*

*2:3668 of 15 Sept 65.
Report in 2:1540 of 27
May 65 para 6.*

1. In the order as per margin Government decided that the ~~at the~~ banks in the first section of the canal, should be ascertained to be in a safe state before the admission of water was permitted, and also that the provisions of drainage should be properly carried out in order that the inhabitants of the villages near the canal might be enabled to reach their fields without difficulty. I therefore proceeded to Annamal, which I reached on the 29th May and have taken advantage of the opportunity to make a complete inspection of the Company's works, and have the honor to report the results of my inspection, which will afford Government information regarding the progress made upon the works, since my predecessor's last general inspection, and also regarding their present state and prospects.

*Letter to 2:35 of 16
July 65 & 2:1540 of 27
May 65.*

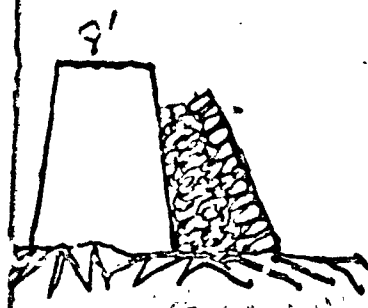
2. The special points referred to in the orders above mentioned, will be reported on in their proper place, and I will now begin with the Annamal and Head works at Annamal. Both branches have been completed to their full height, no gaps remain, and that which formerly existed at

Lonkasalaricut.

The north end of the north branch has been closed by altering the line of the extreme end of the ancient, in the direction of a more favorable ledge of rock, and raising across the deep channel a wing wall of rubble masonry, which is connected with a mass of rock on the river bank, which rock forms a favorable termination, and will effectually prevent damage by the river turning the end of the work, should the northern embankment at any time give way. - The wing is founded on a mass of rough stone.

Regarding the ancient itself and the way in which it has been built, much need must be said here. General Ludlow in para. 2 of his letter alludes to the way in which the crown had been finished, and it has already been found necessary to repair parts, and it is clear that a crown composed of small irregular rubble stone is ill-fitted for such a position. All the rubble stone work of the ancient must be pronounced inferior, and its cost has been very high. This part of the subject will be reported on fully when the Chief Engineer's report and the supplemental estimate, referred to in the order as per margin, are received and H. B. Westmiller, but even had the original rate, supers 3 per cubic yard, not been exceeded, a very superior class of work should have been obtained, and it cannot in my opinion be deemed shall a substantial or satisfactory view for the supply of the large and important canal at the head of which it is located. Some parts have already shown signs of weakness. In the north branch, at places, the rock, too on which the ancient was built appears to be less hard than was anticipated, and at one place

According to the supplemental estimate the average cost is Rs. 6-5-10 per C.Y. of masonry in the space of 5000 C.Y. in the quantity shown thereon Rs. 5-0-0 per C.Y. -
 1836-29 April 1837

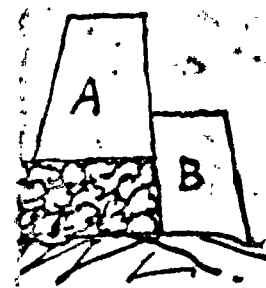


place a sort of rubble retaining wall 6 feet from the rear of the ancient at foot and filled in with concrete had been commenced recently, with a view to keep the overfall clear of the foot of the wall and cover the damaged rock, but the fresh had stopped this work, and I think its continuance would have been a waste of money, for in the first place its section was so slight that there was little chance of its standing, and in the next place the formation of the rocks admits of short retaining walls of small height being built a few yards below the work, and there are close at hand great boulders of rock which, if packed as an apron between the ancient and such retaining walls, or the contiguous masses of rock, would form a secure apron. - It must be added also that it is very doubtful whether, in all cases, the wall forming the ancient was founded directly upon the solid rock. - Near the south end of the additional work above described, I observed what appeared to me to be a stratum of gravel under the base of the wall, and between it and the rock. - This may be a mere patch, extending to but a small distance under the wall, but, if not, it would tend greatly to endanger the stability of the work. - The water was running a few inches deep over the ancient, so that a more accurate examination could not be made. -

In para. 3 of General Ludlow's Report it is mentioned that a gap in the south branch had been stopped by throwing in a mass of rough stone, and that upon this the body of the ancient had been built. To relieve this part of the work from the effects of the overfall, a wall was then being

being raised upon the crest of the work. - The result probably would have been as anticipated, had the body wall immediately beyond been as stable as was supposed, but the actual effect was because a breach in the ament just beyond the termination of the raised portion. - The damage has been made good and to secure both the breach length and the original gap the arrangement sketched in the margin has been made. - This addition consists of a mass of rough stone covered in with long packed stones, which are grouted with concrete, and the surfaces rendered tolerably smooth with plastering rubbed hard. Its stability is in my opinion very doubtful. Plaster does not usually stand with water passing over it at high velocities. The water would, were the plaster removed, soon pick out the concrete, and the displacement of a few of the packed stones would lead to the rapid decay of the whole of this mass. - As a temporary arrangement it may answer the purpose of preventing a breach, but it cannot be relied on, and as a breach in the Ament would be a most serious matter, when considerable tracts of land come to be converted from dry into wet cultivation, some more reliable plan of remedying the defects of the present body of the ament at this part requires to be adopted. - Probably it would be found economical in the end to make a puddled wall above the breach and gap, and to remove and rebuild the body on the solid rock; or the body might be left the lower part alone

Reference to the
1852 of the
of the 10th
to the 10th
Sept 1853



alone puddled so as to stop the water coming through the rough stone, and then the rough stone in rear might be removed and a second body built in rear about a yard above the level of the present footing of the solid masonry. - In the marginal sketch it represents the present body, founded on rough stone, and B would be the additional wall in rear. -

6. Except under the new wing at the north end of the north branch, I observed no considerable leakage. That wing is built on rough stone, and a large mass of similar material is being thrown in to the deep hollow in the rocks, immediately in rear of it. It is not unlikely that as the bed of the river above the wall rises up, this leakage will be almost if not entirely stopped. There is a small vent in the wing near its southern end for the purpose of preventing stagnation in the water below there being a village on the north bank of the river, which might otherwise suffer from the absence of fresh water.

This estimates that the extraordinary fresh of 1857/58 would reach to 8 feet above the crest of the Ament and, according to present orders, their height is to be 9 feet above crest. This margin appears to me to be very much too small for safety, and it would be so even could it be considered certain that no higher fresh could occur, for the waves would wash over the walls and endanger the Embankments at their junction with them. It will be advisable to construct upon the tops of these walls at least an additional wall 2 feet high, and of the same width. The cost will be very small and

King walls of ament
and their level. -

and I have asked the Executive Engineer to make an estimate for it, and the additional security afforded by the small increase of masonry will be great. Embankments North end.
2. These, originally constructed, went westward from the north wing and crossed a drainage channel which would have required a culvert if an opening has been left available for this drainage to reach the river. It is now intended to carry the embankment northwards in a direct line to the high ground about 300 yards distant. In order to do so, a small strip of land will have to be purchased, but from the present boundary of the Company's land to the opposite side of the cultivated land is but a few feet, and beyond that there is water along land, so that the width of bank and land will be very small indeed. The proprietor asked a rent of Rs 60 for a year's occupation, which at one time the Company's officers thought of giving, in order to save time, pending the regular transfer of the ground, but has only in return freshes will the river rise and flow over the land, and no injury to the works would be likely to result, that idea has been given up, and the land will be applied for in the regular manner. This modified line of bank will be a great improvement upon the line originally selected, - it avoids the difficulty of the drainage, it will be far less liable to injury from freshes, and its construction will be far less expensive than the completion of the existing embankment.

3. In para. 7 of his letter General Ludlow speaks of the earthworks as being completed, but since last year considerable modifications have been made between the two branches of the ancient under sluices.

been made. The level of the cross bank has been for the most part raised to 15 feet above crest of ancient, and the greater part of the earthwork of this addition has been thrown up. The up stream slope was partially pitched with rubble stone last year, but the greater part of it will require repitching, and at the junction of the bank with the north wing of the south branch, either much additional stone must be given, or the wingretains must be continued some distance further along the face of the embankment. As there is a rock foundation, perhaps the latter arrangement would be the better of the two.

4. These with the exception of the sloping and roadway have been completed, and a few days will suffice to finish these works. At the time of my inspection 9 out of the 12 vents were open, the water being 3 or 4 inches above the crown of the vents. They are fitted with revolving shutters, and considerable skill has been shown in guarding against the evils attendant upon this method of regulating the discharge, but good deal remains to be done before they can be considered really efficient. They are free from vibration when open, and this is a great point. They are not however at present capable of being opened and closed with less than about 20 men, 10 to each capstan bar, and even then the difficulty is considerable, and the operation is not altogether free from danger. The capstan heads are somewhat less in diameter than is convenient, and while the workmanship of them is good, the mode of construction

construction is faulty for the pressure of the cap. chamber is received on the bolts connecting the upper and lower plates, and these bolts, which are square, become displaced and destroy the bars. It will probably be found the best plan to place a small engine south of the sluices, and to work the bars by its means, when two men will be able to open and shut the sluices, and there will be no fear of the men falling over into the river, and being carried through the sluices by the breaking of a bar as happened when I was present. To the hand bar, or iron eyes fixed in the masonry and a snake block with a rope, would be the means of transmitting the power of the winch. It may be considered that the application of revolving shutters to ancient run-down sluices is in a fair way of being practically and successfully solved, but looking to the prime cost of ³ times that of pole shutters, to the greater difficulty of executing repairs, and to the perhaps impossibility of providing any alternative arrangement during the continuance of the freshes, in the event of a shutter of this description becoming unmanageable, it is very doubtful whether pole shutters would not have been preferable. One of the present shutters will not remain open, owing probably to some slight defect either in the shutter itself or in its setting up. This could of course be obviated by leaving a bar in the capstan and lashing it, but it seems that great nicety is requisite, and when such is

Original estimate shows shutters - 768
 raising gear - 600
 Supplemental estimate gives - 1368
 The first is too little, and probably
 1200 to 2500-3000 Rupees would have
 been the cost of pole shutters with iron
 work complete.

is the case, so powerful an agent as water, with the velocity due to a great head, must be likely to cause such derangements as, without occasioning damage, perhaps, would render a shutter useless. From the supplemental estimate which, seeing that the work is nearly completed, may be taken as an approximation to actual cost, it would appear that the rubble stone in chunam has cost about Rupees 10-9-0 per cubic yard. This is much better work than that of the ancient wall, but the rate is at least 3 times as high as it should have been. The cut stone work similarly has cost on the average Rupees 24 per cubic yard. That now being done, I am informed by the Resident Engineer, Mr. Stanley, is costing Rupees 26 per cubic yard, but I was unable to make up this rate from the data. The chunam costs 2 1/4 Rupees per candy of 12 parabs or 3 annas a parabh, a very cheap rate. The stone, a laminated limestone, comes from Keelgintah on the north side of the river, and distant 12 miles. The carriage together with the cost at the quarries, is one Rupee for each stone, and the average size of 190 stones, measured for the purpose when I was there, was 1 1/4 cubic feet. One mason is paid 8 annas for trimming and setting two stones. The cost of the stone and its carriage therefore amount to per cubic yard, Rupees 15-6-10, the dressing and setting Rupees 3-13-8, or together Rupees 19-4-6, exclusive of chunam and sundry labor, so that 20 1/2 Rupees would appear to be the outside price, with the above

x probably of 5 parabs though stated to be 12

above data. This however would be much too high
for the distance being 12 miles the carriage, &c. &c.
allowing 4 cart loads to the cubic yard, and 8 annas
per load per mile, or double the ordinary rates, would
amount to 9 Rupees a cubic yard. - The quarrying,
if the stone be near the surface, would perhaps be
under 8 annas, as laminated stone is easily detached,
but at any rate one rupee per cubic yard, which
added to 9 Rupees for carriage, would make 10 Ru-
pees per cubic yard at the work, would seem to
be very ample, and I think that, if the material
could not be obtained on contract at this, in
my opinion, outside rate, special arrangements,
under the management of the Executive Engineer,
were called for. This one of the very important
duties of an Executive Engineer to ascertain what
the cost of his work should be, and if any of his
materials cannot be obtained on contract, at
a moderate increase on the price which the cur-
rent rates for the labor of able bodied men, for
cartage &c. when to be fair and sufficient such
materials ought to be procured by other means. -
12. This work has been completed with the Main Canal
exception of the screw gearing for working 10 out Head Sluice. -
of the 13 vents. The large centre vent however
which was to have had a sort of folding shutter
has been altered, and as it will certainly not be
wanted for a long time to come, there will be no
ample opportunity for considering how it is to be
regulated. - The masonry work of the sluice ap-
pears

appears to be good. The ordinary or rubble stone work
has according to the supplemental estimate, cost on
the average Rupees 4-14 in per cubic yard, but as the
original estimate & the supplemental estimate gives 2790
cubic yards, it will be necessary to wait for the
explanations which were applied for by the late
Consulting Engineer, before offering any opinion on
the subject of this discrepancy, or speculating on
the difference between the cost of the rubble stone
work here and at the undervelined. - Mr. Withers the
officer deputed to measure the works, and examine
the accounts, has completed his investigation, so
far as the account and Head works are concerned,
is that ere long, the Chief Engineer's report may
be expected.

The Head Sluice 13. Shutter. - These have been fitted in their places, and
their workmanship is, as far as I could judge, ex-
cellent, as however the bearings on either side are cut
stone, it may be doubted whether the screws will
be capable of lifting and lowering them, and proba-
bly it will be found necessary to introduce screw
mills, or small iron wheels, at the back on each
side, and perhaps also to insert an iron beam for
the wheels to run upon. The cost of this alteration
would not be great. One shutter was raised and
lowered about half an inch or so, when I was
there, but as its ironwork was not completely
fixed, and as moreover it would have been very
inconvenient had the shutter been lifted, and had
it

The embankments in the 12 and 13 miles are approach-
ing completion, and at the great bank in the 15 mile,
a good deal of the revetment has been completed,
the revetment is also in progress immediately east
of the calingulah #7 in the same miles.

22. The calingulahs of this part of the canal
have been arranged with their crests on the level of
the surface of the canal water when full 8 feet
deep, but as a heavy rain for the current year, it would
be unsafe to allow the canal to fill to this extent,
the Executive Engineer has given orders for the crest of
two of the calingulahs to be lowered. This will make
the necessary between the 15 mile and the 16 mile
duct because, in addition to several small sluices,
calingulah #9 has a set of powerful undersluices,
which will discharge the tank drainage without al-
lowing too much water in the canal.

23. 14 mile. Calingulah #8 in this mile is just
opposite the village of Mungalspand, for which a temporary
bridge near that work is to be built. A series of three
opposite this calingulah is being got out.
Between this calingulah and the Mungalspand tank
below it, the soil of the embankment is good, and I do
not think a revetment is necessary. #15 and 16
irrigating sluices in this mile require some rubble
revetment in rear to protect the foot of rear slope
of embankment.

24. 15 mile. The eastward of the Mungalspand tank
nearly finished, and the revetment is 3 feet above
water, and if the backing were well tamped, it would

be very substantial. The crossing for the village of
Mungalspand is to be a plank bridge, which has not
yet been commenced.

25. 16 mile. A ferry boat has to be provided for the
village of Missamasid in this mile. Down to the
calingulah #9, the revetment of the slope has been
completed, for the most part, to 5 feet above canal.
17 mile. Calingulah #10, 300 yards in length with its
undersluices has been completed. The shutters are
also in the works, but they are not quite complete, and
I observed that many of the rivets had been stolen, so
that in future rivets will have to be distributed on the
threads of the screws destroyed. From this point to the
end of the mile, the canal is in cutting.

26. 18 mile. The bridge that was commenced for the
Bellary Road stands with its piers, abutments, & wings
completed to the level of the springing. The road is now
carried by a diaphragm under the arch of the abutment
& viaduct, and the arrangement appears fully to answer
the purpose so that the bridge will not be required.
It may as well however stand as this, at all events for
the present, as it is just possible some use for it
may be found, and it would be a pity to expend more
money in pulling down what has cost a good deal.
The embankments above the aqueduct are nearly com-
plete, but not quite so. They are heavy and the soil
is bad. Since General Suddow (para 38) inspected this
part much has been done. First the inner slopes
were revetted with dry stone but this being thought in-
sufficient, a rubble masonry revetment is being built
outside, and over the old revetment, and this probably
will

will, and certainly would, be sufficient in improving the
earthwork in rear to be settled, but whether this is the
case is doubtful, and should it alter materially these
expensive stone works will be liable to damage. —

Patches of rock remain to be removed at many
places along the line. The quantity is not large, but
the rock is hard except below the side of the temporary
ridge, in the 2nd mile, the rocks occupy but a portion
the width of the canal, and will not interfere with
a supply of such quantities of material as will be re-
quired for some time to come, but there the bed gene-
rally is obstructed for some distance, and the effect
is that of a low dam. Here and there small mounds
of earth have been left unleared, a few days would
suffice for their removal. —

At the Cedron Falls the entire completion of the
earthwork of the embankment will occupy probably
better part of two months. Elsewhere no large
amount of additional earth is required, but much
needs to be done in the way of dressing the slopes,
filling the top, making good settlements, &c. —
A large amount of work has been done. In a few places,
generally where not so much required, they have
been commenced; elsewhere, the stone drains are
at least 3 feet below the canal bed, and in many parts
are 5 feet above that level. — This is a great
defect, and as far as possible to the later high fall
long, and then to proceed with another yard and so on,
— this is the best arrangement that could be made.
The revetments are generally of good section, and the
material is very well adapted to the purpose. In two
respects however the way of carrying out this work, is —

Summary of 1st section
Bridgway Division. 06
17 miles
1st excavation. 11 m. —
Revetments. —

2nd Revetments to
interior slope of
Canal. —

very defective. — Still along the line, but in three short
long the alone excepted, there is very good soil obtainable
at a moderate depth, if not on the surface, and this
should have been used as a backing to the revetment,
and in the next place the stones have been packed on
unconsolidated earth, a very serious error, and one
likely to increase greatly the ultimate cost and to
give much trouble in carrying out repairs. — Had the
earthwork of the bank in rear been well tamped, a
matter of no difficulty as in most cases the slopes
have recently been increased, and had half a yard or
two feet of the best soil been laid as a dressing to the
slope and backing to the revetment, then well con-
solidated, and the stones packed against it, the extra
expense would have been but very small, and the failure
of any part of the work would have been out of the
question, while for many years no expenditure on
repairs would have been needed. — I pointed out to the
Executive Engineer the great importance of taking these
precautions to insure stability, and he has given
orders accordingly, so that it may be hoped that the re-
mainder of the work will be executed in a thoroughly
satisfactory manner. —

3rd Revetment on
exterior of bank. —

4th Rates for re-
vetments. —

A small quantity of this revetment had just been
done at the upper part of the canal to protect the
earthwork from the river current in high freshes. —
It has been very badly done, and ought to be done over
again, and moreover instead of following the irregulari-
ties of the earthwork, which is simply in the rough
sketch, in which it was thrown over, the latter ought
to be dressed and put into line before the stone work
is added. —

There are at present far from satisfactory. Sufficient
are

care has not been taken to ascertain what the fair
rates would be, and a good deal of money has in conse-
quence already been spent unnecessarily. - In instance
of 14 annas per cubit, were being allowed the con-
tractor for the very indifferent exterior rement
noticed just above, and then supposing it to be of any
use, it would be done for 4 or 5 annas. - At other places
some of the work was being done for 14 annas and
some for 10 annas, and in all cases this is very much
above a fair average, though of course less than the
banks, where the rement will be of considerable
height. The stone is very abundant, is generally
in two or three hundred years of the same kind,
it is very easily packed. The rates appear to have been
fixed by a predecessor of the present Executive Engineer,
and that officer admits that they are far too high, and
has ordered their reduction. Probably 6 or 7 annas would
be a fair average rate for the whole section. I obtained
practical evidence of the correctness of this opinion
in the 22 section of this division. -
All the culverts, culverts, and irrigating sluices have
been completed, so far as the masonry work is concerned.
The rear aprons of some of the culverts are incom-
plete, and it is doubtful whether the rubble aprons
will, where the height of the overfall is great, be found
sufficiently substantial. - The culverts which are
of three culverts which are on a low level were not
so by General Baidar as not sufficient. The one I examined
particularly was not well arranged, and of thin brick
and stone masonry, and a river water. The culverts
when stones change for brickwork, and it is intended
to be built a similar piece for the same purpose. The
culverts are not at all difficult in the topography, and it

to be regretted that a more efficient arrangement was
not adopted. -
The irrigating sluices have all been completed. Those in
the embankment require a little dry stone rement
in rear. The rest are in the calingulaks, and will an-
swer very well. -
Hindry aqueduct - 22. - To part of the flooring of this work is quite
finished, but otherwise two thirds of the width are
completed, for the whole length, and one arch, the north
or upper one, under which the diverted Bellary road
runs, is finished to the full width. The parapets or
side walls of the canal are completed only for a short
length at the wings. The heavy rains of the last day or two
have leaked in many places through the arches, and
particularly at the junctions of the thirds in which
they were built. The Executive Engineer informed me
that he proposes recommending that the flooring of the
aqueduct over the Bellary road arch should be asphalt-
ed, at an estimated cost of Rupees 800, and this appears
to be a very necessary arrangement, because, if ordinary
rain finds its way through the masonry, the leakage, with
8 feet of water in the canal, would be great enough to
render the road almost useless. Somewhat may per-
haps be done, in completing the flooring, to stop the
leakage, but I am afraid the improvement can at best
be but partial. To asphalt the whole interior of
the duct, would probably cost Rupees 15,000, and at
present I cannot say whether it would be advisable
to incur so great an expense. It will be easy however to
try what the leakage amounts to, the first time water
is admitted after the left parapet is raised, and upon the
result must depend the settlement of the question.
The stone of which the work is built will not suffer, but
it

29- 18th mile - Between the junction and the Little River Coal belt
road, rubble stone masonry walls have been on both sides. 2nd section 18.
road for dry stone construction. 32 miles.

50. 1/2 mile. The bridge is one of three arches of
30 feet span. It is built of slate rubble, with an lime
stone dressing at the arch is very good. The rock faces
incompleteness.

The red stone work has cost 14 Rupees a cubic yard
 and slate $\frac{23}{4}$

soil is generally very good. The reinforcement between the bridge and sluice No. 23 is in progress. It would have been sufficient had the stone facing commenced below the sluice, a ridge confines the canal, and the soil is good enough to stand in a position where there will be no waves or wash.

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seldom been better how matters were getting on. Looking
 however to the absence of trains on the line in this part
 of the country, and to the fact that this contractor has been
 of much assistance on other parts of the line, it is intended
 to raise the rate to 8 Annas. Beyond this it would not be
 right to go, and the Executive Engineer is quite prepared to
 cancel the contract should the contractor desire it, and as
 he declines to do so, I presume that he thinks he can work
 at a profit at this rate. Below the cutting no reclamation is
 required above the irrigating sluice. I have proposed to the
 Chief Engineer that the additional bridge for 700 ft. -
 should be built at the deepest part of the cutting. The Col.
 has approved of this selection, and as it is the most
 economical site, both as regards the bridge and also the
 connecting road which will then run along the watershed
 I have no doubt of the Chief Engineer's concurrence. -
 32. The Executive Engineer considers that all the embankments
 from Sonkhal to the cutting in the course, <sup>Probable date of com-
pletion of embankment
up to this point</sup>
 will be fully completed, the upper parts of the reclamation
 excepted, by the 31st August: the cutting should be fi- ^{in the 20 mile}
 nished to nearly half its depth by that time, and that
 it will suffice for present wants. -
 33. 21st mile. - Up to the under-tunnel at 20-500 the greater Main Canal
 part of the earthwork has been finished, and the reclamation
 is making good progress from the commencement of the
 mile. - The under-tunnel is now 340 feet long, its original
 length having been 190 feet. This said to be considerably
 but perhaps the new plastering over crown will improve
 this. Just below the tunnel the canal embankment
 is forming. - The ^{moderate bank} will be
 the deepest part of the bank. ^{20. 1100} The reclamation
 is required, and the cutting through a narrow strong
 ridge remains to be completed. -

34. 22nd mile. - Up to the culminated at 12, embankment
 complete, and renetted, but 3 or 4 small ridges remain to
 be cut through. -
 The culminated as on rocky ground the east end however is
 not secure at present, and Mr. Smith has given orders for
 a training wall to prevent the surplus water running
 diagonally across the wing, which it would mind, and then
 perhaps the wing and some of the embankment would
 be carried away. -
 Below the culminated much additional earthwork is re-
 quired to the embankments, and the renetment is incom-
 plete. -
 In this mile there will be a tank of considerable depth -
 (20 feet at the deeper part) the interior slope is renetted
 not very strongly, and at too steep a slope. It was done
 last year, so that it has had some seasoning. -
 35. 23rd mile. - This mile commences with a wall in-
 stead of an embankment, as the subsoil of rock comes to
 within a few inches of the surface, and earth was not
 therefore procurable in sufficient quantities. The wall
 is of rubble stone in chunam, 4 feet thick at the top,
 or rather the water level, and its average thickness is
 about 1/2 its height. The length is 600 yards. The
 towing path is 3 feet above water level, and under it
 there are openings for surplus water. The workman-
 ship is very good, and the cost was 2 1/2. Requires a cul-
 vert. - This is a solid wall and from an inspection of
 the section at the unfinished part, at the end of the
 under-slues, I think it will probably be rather high.
 The sluices are 8 vents of 4 feet. -
 Madralag aqueduct. Originally designed with 5 arches of 9 feet each, and piers
 8 feet high, in fact as a culvert to carry banks over it. -
 It was proposed to raise the piers to 15 feet, and so convert
 it into an aqueduct. Lastly upon observations of a flood

the one arch bridge over the Gaurimangra Road, a little south of the canal, 3 arches of 25 feet were given. The arches have been completed, and the wing walls are in progress. I was informed that the eastern pier was founded at 10.11.12 and driven 14 feet, the soil being found to be extremely bad, and that the foundations of the western pier are $2\frac{1}{2}$ feet deep only, the soil being said to be similar. The western arch is to be a roadway, and its flooring is 2 feet higher than that of the other arches, and it would seem that $\frac{1}{2}$ feet, the intended depth of the west pier foundations, was taken from this elevation, instead of from the lower floor. However before the superstructure is built, and further expense incurred, it should be ascertained whether the foundations are as stated, and if so, whether the soil is hard and firm. If not, safe, and requiring on piles or some equivalent arrangement must be resorted to. The work is estimated to cost 3,000 Rupees, and this would be a large sum to pay for an agreement unequal to its position. This estimate however, I think does not include the whole expense, for the estimate submitted by the Executive Engineer, and then Rupees 1,202-0-0, the value of 2913 cubic yards of masonry rendered useless by the change in design, was included, but this was struck out, probably owing to some misapprehension, by the Chief Engineer. The centre arch is somewhat out of shape, apparently from an imperfect centring, or from the distortion of the centring from unequal building on the two sides. The embankments above this agreement will be 10 feet high, and they are not yet nearly finished. The embankments are hardly commenced. - 236 - 250 miles. In the portion of this mile, in the east of the agreement the south bank is nearly finished

and the north bank is about $\frac{3}{4}$ done. Reinforcement commenced - 37. 24 miles. Up to the first spur, where the south embankment terminates, the bank works have made similar progress to those in the latter part of the preceding mile. The south bank is terminated by a wall in lieu of aithwork. It now averages the level of the bed of the canal, and is at this level $7\frac{1}{2}$ feet thick exclusive of the buttresses. It has to be raised 9 feet or to one foot above water surface level. The wall was not absolutely necessary, as soil was procurable for the completion of the embankment. From this up to the $\frac{1}{4}$ mile the north embankment (single) is about half done. The inner slope is to be singled, and the rate is 4 annas a cubic yard. Thence for 600 feet in length across a deep gully, a double wall, in place of an embankment, is being built. In the stream or nullah this wall will be 37 feet high, where 30 feet high its dimensions are; Canal wall $6\frac{1}{2}$ feet at base, $2\frac{1}{2}$ at top, outside batter 1 in 12. At $9\frac{1}{2}$ feet from the back of this wall is the outer wall, 4' at base, $1\frac{1}{2}$ at top. There are to be 3 intermediate horizontal connecting walls each 2 feet thick. The rear wall is furnished with weep holes and the spaces between the walls are being filled in with dry rubble and sand. It will be seen that a leak through the front or canal wall involves a leak through the whole work. The cost of the work not being very great, 8 annas a parakh, and it might probably be had for about half this, it would have been better I think to have built a solid wall, or to have filled in the spaces with concrete. There is to be a scouring sluice in the deep channel, but the plan for this has not yet been furnished. The wall is at present 25 feet below

the cost of that in the 26 mile -

113 in Canal

its full height. It is not clear why a wall was built at
this point, as plenty of soil was
procured. Up to the end of the half mile 38th of the
earthwork done. Thence the bank is up to its full height
and pitching the inner slope with lumps of lime stones
and has been commenced, and in some distance finished
up to 3 feet above water level. Up to next small valley, bank
up to full height, but not full section. Thence to 40th mile
than 40th the earthwork is ^{to be} done, and the revetment nearly
2 feet, half done. -
was to 40th mile. Body wall completed to full height
floor except a gap where a sluice is to be put in. The first
further to carry the towing path have been commenced at 40th mile
then the only small part of this canal is in the 25th mile
the soil will require a substantial near a pond, length 250 feet
on 30th - 25th mile. Earthwork very nearly finished, and the
revetment also. The last 200 yards of the mile were
and this behind have rate for revetment 6 annas as a rule
magnat 7 annas - soil good all along -
does not 39th - 26th mile. Up to the 1st ravine the earthwork of the
embankment is behind him, but the revetment is well on
4202 - 8 annas. This latter is on a steep slope, is well pitched
rendered its cost is 4 annas a cubic yard. The wall across the
but this ravine is to be 40 feet long, and in this same cut
approach that in the 24th mile. Cost of the wall a little 3 annas
is some 7 annas. This wall built and is at present 10 feet below
12 feet end of bed of canal. The rubble and sand filling is here
from some lake, decision, for the channel is only 10 feet
4. The embankment for sandy of a paraka, and the other end of some bank
high, and a solid wall would be very small, especially at
of revetments much less sand would be used, and the channel
36th - 25th mile brought along way -
of the 1st ravine there is

present 4 feet below full height. This too has a thin core
of rubble and sand, and it would have been actually cheaper
to build it this. Thence across ridge the embankment is
nearly finished, and revetment is not necessary, but the
interior slope may be shingled at 6 annas a yard for the super
across the next valley another double wall is in progress,
and is now 8 feet below bed of canal. -
40. 27th mile. First of all an embankment was planned,
and partly constructed. Then a line rather higher up
the slope was chosen, and a shallow cutting with a low
wall parallel to it was proposed. Next a very high wall
across the ravine was to be substituted, and lastly ~~the~~
~~intended~~ an embankment on the upper line is intended.
To be carried out, and this latter, including revetment, is
estimated to cost 21,000 Rupees less than the wall. The
tramway is to be laid down. Working the soil of the 1st em-
bankment down to the ravine, and it is expected that the
soil will thus be placed in position at 6 annas a yard, the super,
though the comparative estimate allows 4 annas per cubic
yard. -
At the lower end of the 27th mile the bank terminates at a
low eroded hill, and the canal is carried round it,
a little cutting being required at the saddle only. At the
end of this mile a great amount of earthwork remains
to be done, and the soil is generally too stony to make a very
water tight bank. -
41. 28th mile. At the beginning of this mile a small
quantity of revetment was being done at one rupee per cu-
bic yard, this was an extravagant rate, and it has been stop-
ped. Embankment nearly completed up to where a wall
takes its place. This wall is altogether nearly 1/2 of a
mile in length. Its double, its dimensions (8 feet base
to 10 feet height) are insufficient, and it is to be backed with
a bank. Near the lower end the very thin casing walls, with 3 annas

as walls at 90 feet intervals, and a filling of clay and gravel laid
to each side. The wall is now being backed with earth on both
sides. A short break of between 200 and 300 yards occurs
in the wall, and then it will be continued to the end of the mile.
The first 120 yards in length have not been commenced.

42. 29 miles. The wall not yet commenced, is to be continued
to the 1/4 mile, where it will end. Thence canal cuts through
a low saddle up to No. 14 Calingulak, 500 feet long. A considerable
amount of earthwork remains to be done in that part. There is a gap
in the Calingulak where embankments are to be built. At
rubble stone near a span will be necessary. From Calingulak
up to the end of the mile the earthwork has been nearly
completed. A revetment done.

43. 30 miles. Most of the earthwork of the first 1/4 of
the mile done. From this point the line was originally
taken on a very low level with very high banks, after
17,000 Rupees had been expended a line higher up the slope
of the spur was chosen, and the canal is being made in cut-
ting on hills. The embankment is formed by a wall or masonry
revetment with rubble backing and the soil from the cutting
is rear. This is a very expensive arrangement, and moreover
the work is on a portion of the line which it is proposed to
abandon ultimately for a deep cutting through the ridge,
which would shorten the line 2 miles. The work along this
part appeared to be very much above the level of the pre-
ceding mile, but the Sub Assistant Engineer says that
the levels have been repeatedly checked. The estimated
cost of the cutting for 1/4 of a mile is Rupees 55,000, and
for the wall revetment 18,000 Rupees, or altogether 73,000
Rupees. The principal mistake made is in the position
of the embankment works. The transverse slope of the
ground is great, and the wall is placed so far from the
edge of the cutting that its height is materially increased.
Calculating roughly a cutting averaging 1 1/2 yards in depth
would have provided enough soil from the hill to build

close to the edge of the cutting, and at the rate the work is now
being done, the whole cost would have been between 20 and
25 thousand Rupees.

31 mile. Commenced with a high wall, where a more
economical cutting might have been made closer to and
on a better line. Beyond the wall up to the end of the
Calingulak and to the earthwork is very nearly finished.
The revetment has not been commenced, but it has been
given under contract at Rupees 1.20 per cubic yard, where
5 or 6 annas would have been sufficient, and stone is so
plentiful, that pitching might have been executed at
one Rupee per six cubic yards. At the lower end of this
mile a little shingling has been done on the inner slope.

32 mile. An irrigation sluice has been constructed at
the beginning of this mile. Earthwork very nearly completed
throughout. No revetment has been commenced, and it will
be better to wait until after the rains. A second sluice
is to be built where the foundations of the wing of a Calin-
gulak, not now considered necessary, had been laid. The
embankments are very high. The soil is generally not
good, though the latter part of the mile is much better
than that found higher up.

No. 15.

Alternative line
below Calingulak in
29 miles

Cut stone work has been done here at Rupees 7.50 per
cubic yard, but it is considered that this did not pay the
contractor, and that 10 Rupees would be a fair rate. This
mile completes the 32 section of this division.

33. Levels were taken from an alternative line from the
Calingulak in the 29 mile, and this line would have struck
the one adopted about the middle of the 32 mile, and would
have shortened the canal to the extent of nearly two miles.
It was thought however better in the first instance to
carry out the supposed cheaper circuit, and to have the
straight cut for execution at some future time. The
real difficulties however of the line chosen, were not

only

only estimates, and supposing ~~that~~ the estimate one has
of expenses for the shorter line to have been a safe estimate,
it is now clear that it could have been executed for less
money than will have been expended by the time the
present unfavorable line is completed. This must be
regretted therefore that fuller consideration was not
given in the first instance to the difficulties and advan-
tages of the alternative routes.

The country through which the greater part of this
section of the canal runs undoubtedly is a very difficult
one. The lands along the line have been carried above the sur-
rounding of comparatively level ground near the town
of Chudda, and the Sagganath hills which it is to throw out
on this side a great number of low spurs divided by ravines
of considerable depth, while the soil is either sandy or
not well suited for embankments intended to retain water.
By the arrangement adopted, the canal is carried round
the spurs and there is but little cutting, and the ravines
are crossed either by very heavy embankments, or by masonry
walls. The cost of this part of the line has ne-
cessarily been great, and I think it is probable, that a
cheaper, straighter, and safer plan would have been to
cut to a considerable depth through the spurs and to
carry the spoil high enough to form the embankments across
the ravines. Every cubic yard of filling would have been
made to do double duty, by a careful adjustment of the
width of the cuttings to the wants of the embankments.
This plan was not examined in detail, and therefore
the data for a comparison do not exist, but when the
very heavy cost of the masonry high walls is looked at,
there appear to be weighty reasons for considering that
cuttings would have proved more economical.
I think it should be considered advisable to direct the
labor to other descriptions of work, it is probable that
these

Summary of the
section - Hind
Division -

June 18th. There will be completed within a year from this date, but taking
rates there will be no difficulty in so far completing them, as
to enable the canal to carry one half the maximum sup-
ply of 4,00,000 cubic yards. These are making good progress
and the work is being well done. They will throughout be
completed to at least two yards above the level of the canal
bed in time for the irrigation of next season, but it will
take the greater part of a second year to finish them
entirely. The rates are in many parts of this section very
reasonable, while in other parts they are certainly very
exorbitant. Where contracts have been entered into, of course
a reduction is not possible, and all that can be done is
to require first rate work, elsewhere a great reduction
will be made. Stone is abundant everywhere, and if the
style of revetment or shingling be adapted to the mate-
rial available, the requisite protection to the banks
will be obtained for a sum by no means out of propor-
tion to the advantage gained. Judging from the actual
cost of good revetment in this and other sections of the
division, an average rate of six annas a cubic yard is
likely to suffice for the work remaining to be done.
The Executive Engineer is fully alive to the necessity
of reducing the rates which were at first supposed
to be necessary.

3rd. Masonry work. The ordinary Aqueduct will probably not be comple-
ted much within two years, though there would be
no difficulty in finishing it in 8 or 9 months if ne-
cessary. A very little work will suffice to enable it
to carry all the water which will be required for the
next two or three years.
One bridge - that for the Gooty road, is all but finished
and will be opened for traffic this month. A second
bridge for Gooty, in the 30 mile, remains to be built.
The masonry work of the calingale has, with few excep-

at Gooty and
at Calingale

only a few things been finished, but all those yet to remain on the
channel rear apron, and this work is behind hand, and in
several cases no provision has been made in the estimate
for any such protection. It is to be seen that the effect
of an overfall of 6 to 8 feet has not been sufficiently
considered, for, even where rubble stone has been put
in rear of the apron the fish considerable size have
will when its machinery touches the force of the
water. The irrigation sluices are behind hand. It is found
that the lower end of this section that the breadth of navigable
channel begins to be considerable, and there a good many
sluices will be needed, the plans have not yet been
submitted to the Range Officers.
On the walls in place of embankments are many of them
of a still much below the level of the bed of the channel
not and the quantity of work to be done is very large. They
will within a year be completed to 5 or 6 feet above the
the sluice much longer time will be necessary to finish
are shown.
The Executive Engineer thinks that it will take fully
two years to complete the work of all descriptions in
this section of his division.
cut 40. 33rd mile. The banks have just been raised 14
feet above the 14 feet above the before allowed. This is
the height was not necessary, and it would appear that
the Chief Engineer did not intend it to be done. At
the beginning of this mile the bank takes a curve.
It is double a strong spur, and a small bank will be
the former. Embankment at 1.2. per acre yard has been
commenced, the material being obtainable at 50 to
30 yards distance, and the work being by means of
a good, it will be improved, but the contractor will pick
up the material upon embankment the work at this rate 44 days
to

Main Canal 34
Sections 33 to 43
miles

The cut near Sultanpur the earthwork is finished, except
dressing the slope, and the reinforcement is well advanced.
The cut is 15' 2 span and 12 1/2 headway is intended to pro-
vide a passage for the villagers all except South wing
and embankment to be constructed there with high ground
7 feet high. No flooring has been provided for, but one is neces-
sary and will be given. The masonry of the arc bank is not
sufficiently well fitted to prevent leakage. This proposes to
cover the crown with concrete. These localizing at 11.16
115/ the earthwork nearly completed.
Caligala is complete, except a gap where navigation
sluice is to be put in. The rear apron not commenced,
a very embankment but one will be required as the top is 7 1/2
feet. no allowance for this apron in the estimate.
Earthwork nearly completed of about 1/2 mile. Re-
ment of this part not commenced.
49. Nearly all the way along the last two miles the
embankment has been placed as far north as possible
far too low. The rear bank embankment 14 to 25 feet
high, where 12 to 15 might have been arranged. At the
close of the 33rd and beginning of 34 miles there is ground
with a moderate transverse slope, and yet the bank
is placed on ground 7 or 8 feet below the bed of the
canal. The intention was to obtain the full section
of water-way without cutting, and also a certain bridge
of water, having a minimum depth of 8 feet, but the
plan is open to objection as regards both economy
and safety. The reinforcements alone are a very heavy
item in such a bank, and the excavation for the bank
answers but one purpose, whereas in cutting it does
double duty.
50. 34th mile. Immediately in rear of the embankment
in the first 1/4 of this mile, there are very deep pits, some
of them as much as 5 yards deep and had the alternate
arrangement referred to in the preceding pages been adopted

one good road have been broken from the outside of
of the bank. The work is costing 3.25 per cubic yard, which
is cheap for the load and height. Up to a culminated 1817
16/earthwork nearly finished. The masonry work of
culminated complete. No rear apron allowed, but one is
certainly necessary, there being an overfall of several
feet containing moderately hard soil. Now the canal enters
bank, and diving from the line partially water
out originally, in order to avoid embanking the large extent
of land below Ullin. There is an ancient road at the
lower end of the cutting, which will have to be altered
50 miles. This is nearly 5 miles in length, as the main line
is just 2 miles longer than the old. Up to the side of the
Ullin Aqueduct a commencement has been made, mean-
while all along. At only a few places does the soil require
of soil, and except these the banks will require strengthening
only.

51. A large portion of the excavation for this work has
the been done and one pier has been founded, the expenditure
are being about 11000 Rupees. The plan provides 4 are, half
20 feet, the estimate is 22,000, and it is expected that the
each would be 20,000, as the rates are low. The mulla
ch, for which the work has been planned has been formed
by a breach in the rocky ground, which formed part
of the bund of an old tank, and the site of the aqueduct
is within a few yards of the breach. As arranged the
wings of the work on the up stream / mulla / side more
to be connected with the high ground on either side of the
breach and consequently the water spreads of the canal
it would be shut out only from the few square yards of
the rocky ground on the two sides of the mulla itself.
The village of Ullin is close at hand on high ground, and
after carefully examining the locality and seeing the con-
ditions of the aqueduct would occasion an unnecessary outlay, and
that a well with underlines across the mulla and

Main Canal.

a bridge for the village, was a little below the wall was
be a preferable arrangement. This will, if sometimes, con-
about 1000 Rupees on the estimate, and quite within
reality. One arch of the aqueduct was to be made into a
roadway, but this would be very inconvenient, and the
bridge will be very much better. Formerly a surplus chan-
nel from the tank, ran through a corner of the village, it will
be advisable to prevent the canal water taking this, and a
bank at a distance of 1000 Rupees will do this effectually.
It would have been equally necessary with the aqueduct
I have addressed the Chief Engineer on the subject.

52. 35 mile continues. From Ullin up to the culminated
1818/17 at the commencement of the old 36 mile, the new
embankment has hardly been commenced. -
The culminated is two thirds finished, it has superseded a
similar work which was constructed a few yards distant
and in a direction at right angles to that now necessary.
Masonry good. No rear apron allowed, but one is absolutely
necessary.

53. 36 mile. Earthwork almost finished through bank,
and nearly all the revetment done. Part of the mile
soil has black cotton, after that much better, with
laterite. The revetment has cost on the average 5 1/2 annas
per square yard, its height being 4 yards. Its thickness
is great, and looking reasonably unnecessary, it has
been very well done. The embankment averages 14 feet
in height.

54. 37 mile. Commences with a cutting averaging a little
over 5 feet in depth. This is finished, except a little
clearing and levelling. Below this, the bank is finished
except a little backing to top of revetment. A gap
has been left for a sluice. Revetment very good. Cost
4 1/2 to 5 annas per square yard. The material is a very
fine limestone.

55. 38 mile. Up to the wall nearly all the work is done.

and the embankment generally completed up to the level of the
of 15 ft. The wall is 18 ft. in width at base and its height will be 11 ft.
it is 12 ft. high at about 200 yards. This lake is bordered by a thin earth bank.
The embankment will be about 11 ft. high, besides the earth bank.
The embankment would have been about 11 ft. high, and as earth is ob-
tainable and the wall has superseded an embankment,
which a large portion had been thrown up, the embankment
was not an advantage. Hence for a few hundred
yards to the lower part of the valley 11 ft. of the earth
wall has been thrown up in the north. At the deep part
a double wall of 50 ft. in length with a base of 16 ft.
and an intended height of 26 ft. has been commenced.
All these high banks and expensive walls might have
been avoided, by carrying the line higher up the slope
to the south west. An empty line, which will be
a desirable irrigation, is to be built in the valley.
This mile will be terminated by an irrigation & line, just
about to be commenced. The embankment below the wall is
about 1/2 mile long, but to be continued.
155. 59 miles. At the village of the embankment is
nearly finished, soil has been removed, not commenced.
Caligula 11:19/10/10 finished, except the north side.
Overfall is 9 feet and no rear apron has been provided for
The foundations are 3 feet on detached rock. Last part
of mile, soil red with gravel. Near end of mile canal
crosses low spur by a cutting, pale banna containing
a good deal of a very hard conglomerate rock, quartz and
limestone. Below this a double wall takes the place of
an embankment. Its underpiece of 50 ft. is under construction.
50 miles. Commences with a continuation of the wall,
which altogether is 1100 feet long. Beyond this a narrow deep
valley is crossed by a high bank, then over a low rocky ridge,
there will be a wall, and thence to within a few yards of the
village of Malayala there is a high embankment. All these
works are behind hand, though a large extent of work has been
done, but the error of avoiding cutting and placing wall and embankment

29
embankment far below the level of the top of canal
has been repeated. A little embankment com-
menced, rate for bottom yard six annas,
which is more or less high, I think. The
village will be passed on the west side by a
cutting through the ridge on which the
houses are built, twelve feet will be the
greatest depth, but the cut is a very short
one. From the end of cutting, for a few yards
to the end of the gravelly soil, the embank-
ment will require a core of clay with a base
of eight, and a height of three yards, to prevent
leakage into the village. Below this there is
an embankment even to twenty feet
high, of which three fourths of the work
have been done, and the remainder has made
great progress. It is most excellent work,
but it is on the average, four feet thick, and
fourteen yards measured on the slope, rate
two annas for bottom yard, six annas for
the next yard, and one rupee and three annas
for the top yard, which gives an average of
eleven and three quarters annas, and a cost per
yard run of ten and a quarter Rupees. It
seems hard to condemn such excellent and
beautiful work, which is extremely cheap
indeed.

indeed, compare with work elsewhere, but as
renewments will in any case be a heavy burden
on the undertaking, and as an excellent reach-
ment of half the thickness could be done for
half the price, it is necessary to point out
the mistake.

A scouring sluice of very elaborate design,
and with its sill twenty feet below water
surface level, has been commenced near
the end of this mile. Stone and work good,
but I anticipate no advantage from such
a work, and it will always be a cause of
weakness. The sooner the tanks below the
first twenty miles with up to level of the
canal, the better. The sluice may be the in-
direct cause of a breach, but its effect on
the sill generally will be nothing, and the
area of its action will probably not exceed
two or three hundred square yards.

57. 41st mile. - The rate and style of re-embankment
is the same as that noticed in the last
mile, the stone is obtainable from the
embankment pits - soil generally bad,
and the embankments are considerably
higher.

higher on the average than those at the end of
the fortieth mile. - The heavy part of
the earthwork has been completed.

1853-6 July 1853.
Proc. of Govt. No. 2055-
25 July 1853.

58. 42nd mile. At the end of the preceding mile, and for some little
distance in this mile, the general line had been directed in order to
make use of the bank of the Madigutta river tank. At the same time
part it is intended to build a sluice on the same plan and on a ^{similar} plan to
that referred to in the latter part of para. 56 above. The arrangement
was, I believe, approved by General Ludlow, and it is referred to in the
last sentence of the 40th para of this Report, as far as origin, but the
capacity of the sluices designed is small, and the risk appears to be
more than counterbalanced by the possible advantages. The site is a fine
quadrilateral below the breach in the old tank. The earthwork has been nearly
completed. The re-embankment is just commenced, and it should be very
cheap, as slate shale is abundant close to the embankment.
The mile runs with culverts at 20/19/421 feet long, which
is complete, including a rear apron of carefully placed dry stone
work. Whether this latter will be found sufficiently strong, is, I
think, doubtful, but it is very well done.

Remarks on the line 59. In the para of General Ludlow's Report just alluded to, this
of embankments in observation is made; the cause of the canal near the village
the 41st and 42nd miles of Malayala appears very objectionable. - I did not notice
this remark until I looked for his opinion about the recon-
structing sluice, but I entirely agree with him, and it may be well
to explain what has been done, and what was the alternative
arrangement. Immediately on leaving the cutting at Madigutta
the embankment is carried down on sagrums 5 to 7 feet below
the level of the canal bed, and it is carried nearly due east
for a short distance west of Madigutta. At the lower end
at the culvert above noticed, it crosses the next ridge by
a moderate cutting: between these two points distant
along the present bank line, rather more than 2 miles, the
ridge spreads out east and west at a gentle slope, while be-
tween them there is a very flat plain, extending nearly up to
the village of Kunditottoor. The present single line is, in
its height, the nature of the soil, and the considerable width
width of these renders necessary, and from the great extent of

ment requires, a very expensive work, and while at the
 towards the breadth of land submerged will be small, in the
 middle the water though not deep will spread out for
 about 1 1/2 miles. By carrying the line, near to the south,
 from Malayala, the height of the bank might have been
 reduced at least 4 feet. Their present average is about
 14 feet, and the sectional area 100 square yards. The
 median area of one bank on the higher level, would have
 been about 50 square yards. In the lower part the width
 as this would have been increased considerably, and
 perhaps the rising in height then would not have exceeded
 3 or 4 feet. On the whole therefore the south bank is an
 arrangement on the higher ground would probably have
 been 10 to 20 per cent more earth, and then would have
 been the necessity for a culvert of considerable dimensions.
 On the other hand the culvert might have been dispensed
 with, or its dimensions much smaller. The two securing sluice
 would not have been needed for any purpose, and the remainder
 might have been made, less in height, but of a much lighter
 description. Much valuable land would have been saved from
 submergence, and part of the canal would have been far easier
 The extra length of line would perhaps have been 1/2 of a mile.
 The advantages, as regards water charge by the bank arrangement,
 there here almost nominal, and the extra cost, if any, of a
 canal would have been so small, that I think it is much to be
 regretted that the original arrangement was not revised. It
 is too late now to do anything more than make the present bank
 arrangement secure.
 37. to 43 1/2 miles - The cutting, which commenced a little above the
 at Malayala, is continued for 5 or 6 hundred yards into this mile. West
 is for an irrigating sluice has been left about the middle of the mile.
 The earthwork of the embankment has been completed,
 slopes sufficient, soil a topsoil part of mile. Some forest
 land, and at the lower part, lime and clay. The mile and
 the division and at the Nagbore bank land, which has been
 and into a canal, as to render a breach into the canal probably
 and this is not wanted while gaps for sluices &c. remain
 enclosed.

summary of the 37. 61. With the description of the situation here in the 37.
 section - History &c. mile, on the new line, near Mithun, nearly all the work has
 38 Section of Canal 33 to 43 miles. are in an advanced state, and the time required for them
 "Embankments and excavations - completion will not be long. Near Mithun also there is
 nothing to prevent their being finished in three months.
 39. Reclamation of slopes - These have made good progress on the whole. A large part
 of this description of work remains to be done in the 38, 39, 40,
 and 41 1/2 miles, and also in the 41, 42, and 43 miles.
 The reclamation works are in all respects very satisfactory,
 except in the matter of soil. As regards this, the only
 right to repeat that all the work recently accomplished is
 traced for, is a hint for the quantity and style of the work. The
 error, where there has been any, is in the provision of an amount
 necessary to sustain the protection, and the execution of the
 canal the work done has often been paid for at far too high
 a rate, here the contractors have done good work for the money,
 and I have dwelt somewhat particularly upon this point,
 because, when estimates have been so greatly exceeded in all
 directions, it is absolutely necessary that all practicable
 economy should be exercised.
 The culverts, the rear aprons, &c., are generally in the
 complete or likely to be complete within a year. It is much
 easy that the rear aprons, which are not a heavy provision for
 the estimates, will be included in a supplement. But the estimates
 and carried out at a daily rate. The failure of these works
 would be a great misfortune, and the loss would be very great.
 were the supply to be stopped pending the completion of the
 The walls in the irrigation canals are much to be desired,
 and it will be well to put forward their construction as
 far as may be practicable.
 There is only one culvert, which will be completed in a
 shortly. The Mithun agreement will probably be completed
 by a wall and a bridge - these works will really be completed
 before the next irrigation season.
 The irrigation sluices are much to be desired, and it is just
 that they were not built at an earlier date, because the
 in the embankments will now be better in position than
 on either side has settled, and when the soil is dry, the
 will at all times be for one season, or more points.

62. I have not even one rammer on the works, from
ends one end of the division to another. In the case of
middle the reinforcement the omission of tamping is one of
about some importance, as has been already noticed in a
from the former part of this report. I hope this point will
be given due attention for the future, and that care
will be taken to select soil for the backing of the
reinforcements, where this can be done without much
inconvenience.

63. The works of the first and third sections may
perhaps very well be completed within a year, and two years
will be required to finish the second section, but by
the 1st May 1865, the canal throughout ought to be
able to carry at least 5 feet of water.

64. 4 1/2 miles. The bank along, and immediately
with, or below, the Nagatone Bank, should be completed at once.
The right bank, should be completed at once.
The left bank, should be completed at once.
The right bank, should be completed at once.
The left bank, should be completed at once.

65. 4 1/2 miles. At the beginning of this mile, a cut
of 3 feet span has been completed. The double
banked canal commences just above this point.
The masonry work of the bridge of three arches has
been completed. The approaches have hardly been commenced, and the
embankments immediately above and below bridge
are incomplete.

66. 4 1/2 miles. The masonry work of the bridge of three arches has
been completed. The approaches have hardly been commenced, and the
embankments immediately above and below bridge
are incomplete. The masonry work of the bridge of three arches has
been completed. The approaches have hardly been commenced, and the
embankments immediately above and below bridge
are incomplete.

Probable date of
completion of the
whole of the works
up to the 4 1/2 mile
inclusive.

Nagatone Division
Main Canal
4 1/2 to 6 1/2 miles.

Nagatone Bridge

Just below this the embankments are very soft, and will
be some time before they become properly consolidated.
66. 4 1/2 and 4 7/8 miles. - Cutting is for the most part
behind hand, and the right embankment is in parts
hardly commenced. The soil improves in these miles.
Two irrigation sluices have been completed in the 4 1/2
mile. The 1st calingulab in this division, is in the 4 7/8
mile. The masonry work is finished: there is now
near a pier, though the overfall is 6 feet. Some good
workmanship is not as good as on the similar works
in the Hindry Division. There is an under sluice of
5 vents in the centre of this calingulab. About 600
yards below the calingulab an undertunnel of one yard
span has its side walls finished - arch not commenced.
The excavation up to this point is very incomplete.
The left bank below the undertunnel is much out of
line - this was unintentional. About 200 yards of
reinforcement done at this point, rate 7 annas per cubic
yard - the courses are laid horizontally instead of at
right angles to the slope, and this is the case through-
out the division, wherever work of this sort has been
commenced.

67. 4 1/2 and 4 7/8 miles. - The double bank ends imme-
diately below the undertunnel just noticed, and a
single bank is carried across a narrow valley. A
small bank will be formed: the land submerges will
be neither extensive nor valuable, but I doubt whether
any considerable saving will be effected by the
arrangement.

At the lower side of the valley, excavations for a cut
of 8 feet, have been completed: no masonry
work commenced - from this point the double bank
recommences. For the first half mile below culvert
the cutting and embanking are only just commenced.

For the next half mile about half this work is finished.
In the 49th mile, excavations for a culvert of 8 feet span
have been made, construction not commenced. Care will
be necessary in letting down the drainage into the tunnel,
as the soil is easily washed away, and both to prevent
damage to the lands by the formation of gullies, and to the
rear of the embankments by a channel, it will be espe-
cially to build a semi-circular rubble masonry wall
round the entrance. Up to the end of the mile, the earth-
works are more than half done.
68. 50th mile. Up to the 3 feet culvert the earthworks
are more than half done. Excavations ready for culvert,
the black cotton. Thence, up to the end of the double
banks, the earthworks are more than half done. The
soil has cutting averages one yard in depth. Thence a
single bank crosses the valley, and up to the end of the
mile, a good deal of earthwork has to be done to com-
plete. A small piece of lake stone revetment has
been done - rate six annas.
69. 51st mile. The single bank is continued, and just
below the drainage nullah, a scatted sluice, consisting
of two walls 10 feet apart at bottom, has been com-
menced. The space between these walls is to be
filled in with earth, and I am informed that the object
with which they have been built, is to enable the
bank to be breached with safety, if necessary. The
work will entail the care in the earthwork, and when
at the junction of earth and masonry. - For one half
of the single bank below the sluice, a great deal
more earth is required. Beyond this the earthwork
is nearly finished and red soil supercedes the black
cotton. The revetments are not commenced. The
70. 52nd mile. A small length of revetment has
been commenced, it is well done - rate six annas. The

bank ends, and at recommencement of double banks, the prepa-
rations for a culvert are ready - masonry work not commenced.
Thence up to the calingulah No. 2, which is on the same plan
as No. 1, the soil is good, and the cutting, averaging 4 feet in
depth, is rather more than half done. The calingulah, with
the exception of the underlines of 5 cents, and a part
of the keeling which are under construction, is complete.
The overfall will be about 4 feet, and a rear apron is re-
quired up to the end of the mile - the cutting is nearly
finished to half width.
71. 53rd mile. Cutting diminishes in depth, and is nearly
completed to full width. Soil for banks short, and
the additional required is being brought by train from the
deeper cutting. The double banks terminate just below
the village of Puzgudal, and there a culvert of 6 feet span will
provide for the drainage. Thence to the end of the mile, a
single bank, part of which is on the bank of an old tank, has
been 3/4th completed, and the revetment is just commenced.
soil has embankment will average 20 feet in height.
72. 54th mile. In this there is to be another sluice, or wall
vent of the same dimensions and description as that in
the 51st mile - one side has been commenced and is now 14
feet high, the full height being 32 feet. average height of
bank in this mile 20 feet. 3/4th of earthwork done up to the
sluice, and 3/4th below that point. Revetment not commenced.
73. 55th to 57th miles. In the upper part of the 55th mile the
embankment is behind hand, and a very large amount of
earthwork is required to complete, in the latter half of
the mile, earthwork nearly finished. Revetment not
commenced - only the first few yards of the 56th mile will
require revetting. The earthwork of this mile in an as-
named stake, Calingulah, No. 3, is 200 yards in length,
and on the same plan as Nos. 1 and 2. The body will be
about 7 feet in height above ground, and a rear apron
will be required, it is now a little short of the
full height, and the superstructure remains to be built.
underlines not commenced - an irrigation sluice is 1/2nd

built at the end of this mile. In the 59th mile the earth-
 work has been about 1/2 done in the rough.
 58th mile. In the first half of this mile the earthwork
 is all but finished. A small piece of revetment has been
 commenced with brown slate, quarried close by, but it
 has turned out indifferently, and it has broken up on ex-
 posure, so that a better material will be sought for for the
 rest of this work. There are a few gaps in the embank-
 ment, but most of the earthwork has been done, and is
 well advanced. A sluice or wall vent has been ordered
 near the lower end of the mile, it is not yet commenced.
 59th mile. In the first 32 chains the embankment
 is almost finished. At 34 chains the double embankment
 recommences, and a culvert of 8' span is to be built, the
 excavations for which are ready, but the construction
 not commenced. Below the culvert at Sacalingulak.
 Below the excavations and banks have not been commenced.
 The excavations for the earthwork is about 1/2 done.
 60th mile. The excavations have been made, the ma-
 sonry work has not been commenced.
 61th mile. Up to the site of the Inpad Bridge, about
 1/4 of the earthwork done. Materials for the bridge under pre-
 paration. Construction not commenced. A short distance
 below bridge site, a six feet culvert is to be built. This not
 yet commenced. Earthwork at this part only just commenced.
 62th mile. The earthwork at this part only just commenced.
 63th mile. The earthwork at this part only just commenced.
 64th mile. The earthwork at this part only just commenced.
 65th mile. The earthwork at this part only just commenced.
 66th mile. The earthwork at this part only just commenced.
 67th mile. The earthwork at this part only just commenced.
 68th mile. The earthwork at this part only just commenced.
 69th mile. The earthwork at this part only just commenced.
 70th mile. The earthwork at this part only just commenced.
 71th mile. The earthwork at this part only just commenced.
 72th mile. The earthwork at this part only just commenced.
 73th mile. The earthwork at this part only just commenced.
 74th mile. The earthwork at this part only just commenced.
 75th mile. The earthwork at this part only just commenced.
 76th mile. The earthwork at this part only just commenced.
 77th mile. The earthwork at this part only just commenced.
 78th mile. The earthwork at this part only just commenced.
 79th mile. The earthwork at this part only just commenced.
 80th mile. The earthwork at this part only just commenced.
 81th mile. The earthwork at this part only just commenced.
 82th mile. The earthwork at this part only just commenced.
 83th mile. The earthwork at this part only just commenced.
 84th mile. The earthwork at this part only just commenced.
 85th mile. The earthwork at this part only just commenced.
 86th mile. The earthwork at this part only just commenced.
 87th mile. The earthwork at this part only just commenced.
 88th mile. The earthwork at this part only just commenced.
 89th mile. The earthwork at this part only just commenced.
 90th mile. The earthwork at this part only just commenced.
 91th mile. The earthwork at this part only just commenced.
 92th mile. The earthwork at this part only just commenced.
 93th mile. The earthwork at this part only just commenced.
 94th mile. The earthwork at this part only just commenced.
 95th mile. The earthwork at this part only just commenced.
 96th mile. The earthwork at this part only just commenced.
 97th mile. The earthwork at this part only just commenced.
 98th mile. The earthwork at this part only just commenced.
 99th mile. The earthwork at this part only just commenced.
 100th mile. The earthwork at this part only just commenced.

Summary of the
 Nagatore Division
 being the 12 section of
 Main Canal.
 1st Excavations and
 embankments.

is double banties. The canal has been well laid out in the
 double banties parts. Had a line for the single bantied portion
 been laid out somewhat higher up the sloping ground, about
 half the water spread would have been got rid of, and the
 length of the bank from 52 1/4 to 59 1/4 would not have been
 increased by more than about 1/6 of the present length. There
 would have been one rather deep cutting, but great
 saving in embankments and revetment.

2nd Revetments to interior slopes. - The amount of work done, compared with that to be done,
 is so small, that these must be considered as just com-
 menced. They will require to be pushed on very vigorously,
 if it be desired that anything like a fair supply should
 be sent down the canal next year. In the banties, on the
 average, about 2 yards in height have to be built to raise
 level of canal bed, and 2 yards above that to admit of
 1 1/2 yards of water being passed down, and then, being
 some 8 miles of bank or single embankment, the work
 up to that height alone, will require over 50,000 cubic
 yards of stone, while, as the level of the water in the
 bank is liable to be increased by land drainage, it will
 require an addition of 10 or 12 thousand cubic yards, to
 make these banks quite safe. The rates of the portions
 of work done, are not very high, and care should be taken
 that they be not allowed to become excessive, and also that
 where the water spread is not large, and regular aban-
 don of shingling be given on a somewhat flatter slope.
 The use of rammers to consolidate the earthwork, im-
 mediately in rear of revetments is equally necessary
 in this division. Stone have been used at present, and
 no more revetment should be put up without first
 ramming the earth. A backing of the best sand obtain-
 able, such as lime runter, gravel, or red soil should be
 given where the soil of the embankments is black-
 cotton, or otherwise inferior and easily soluble.

3rd Masonry works. There will be two bridges for this division, one at Nagatore
 which is finished, the approaches & gables, and the other at
 opposite Inpad, the construction of which has not yet been

commenced. Of the 4 calingulaks, #1 is completed, except a rear apron and rear apron. #2 is finished, with the exception of the bend and sluices. #3 is about $\frac{2}{3}$ done, and the construction of #4 is not commenced. All these calingulaks require substantial rear aprons. The number of culverts will be 10, and taking the sizes of those completed into consideration, not more than $\frac{1}{4}$ of the under-drainage has been completed. The rate, Ruppes 2-2, for the walls is reasonable, and the work is sufficiently good. Stone of the culverts in this part of the canal will make crossings, which can be considered as providing for the wants of the villagers. The tunnels are dark and on a low level, and some, as at #2 for instance, will always be wet. Those of 3 feet span are not intended to be used. In the Hindry Division, where the lower end of the flooring is generally on a level with the ground, the case was different. Of the 10 irrigation sluices provided for, 5 have been completed, and the others have been commenced. The number allowed appears to be less than is desirable. There are 5 or 6 small sluices in Bank banks, these are all behind hand, and I think it would be as well to dispense with them. The full depth of water in this division will be 9 feet, and the fall of the bed of canal will average 4 inches per mile.

77. 61 mile. The earthworks in this mile are behind hand; the ground in many places has not been broken. An 8 feet culvert is under construction, and will be finished this month/June/ It will make a very indifferent crossing and should only be considered a subsidiary one. Soil bad.

78. 62 mile. 2-8 feet culverts have been finished, and an irrigation sluice just below. #3 culvert has been completed. Also. Earthwork nearly completed where there is a little cutting, elsewhere $\frac{1}{4}$ to $\frac{1}{2}$ done. Soil brown cotton.

79. 63rd mile. Up to the Seragopila Aqueduct one bank, the left one, is about $\frac{2}{3}$ done. The other not yet commenced. Aqueduct 3 arches of 25 feet, not commenced. Below the nullah, the left bank is nearly finished, the right not

Depth of water and fall.

Hindry Division
Section - 61 to 72 miles

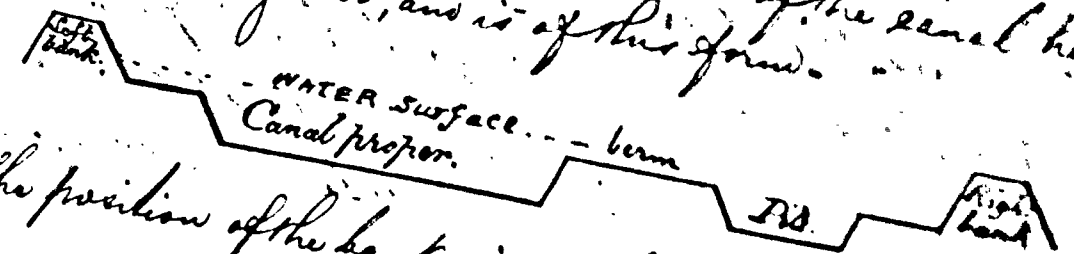
commenced. Revestment not yet started. Stone to be laid by. Soil for greater part of this mile is bad.

80. 64 mile. Left bank nearly finished, right bank just commenced. Up to the beginning of the former double banks and end of former tail soil in this mile good generally. An 8 feet culvert is under construction at the $\frac{1}{2}$ mile, rate for rubble masonry, Ruppes 2-2, which is about 10 annas too low; that for archwork, Ruppes 6, is, looking to the material - rubble - and to the style of work, at least double what is right. The stone is very unsuited to work. Up to the end of the mile the earthwork is about $\frac{1}{2}$ done.

81. 65 mile. In this mile a calingulak was partly built in connection with the Seragopila tank, which has now been superseded by a double bank and an aqueduct. There is here a cutting, which when completed will be 9 feet deep. The calingulak body has an under-sluice of 6 vents, which will do irrigation. No rear apron will be necessary for the calingulak. But one will be needed for the sluices, with revestment for the outfall channel for a few yards. About half the excavation has been finished along the calingulak, and below it to the end of the mile the canal is very nearly cleared out.

82. 66 mile. The upper part completed to full depth, and only a little clearing to be done. There are some queer lines on the right margin of the canal, the result apparently of very precise calculations of the sectional area required, and the ground being slightly undulating. The line consequently is thus  and the corners will require cutting off. Irrigation sluice #2 is in this mile, and has been completed. Culvert #5 of 8' span, has been completed. The arch stone of this tunnel is of the same description as that of #4, culvert. About one half of the earthwork of this mile has been completed.

83. 67 mile. An additional culvert at 66-50 is required, as there is a considerable drainage to be provided for. Up to this earthwork $\frac{1}{2}$ done. The cross section of the canal here is somewhat singular, and is of this form.



The position of the banks is such that the sectional area

commenced. Of the 4 calingulaks, #1 is completed, except a rear apron and rear apron. #2 is finished, with the exception of the bend and sluices. #3 is about $\frac{2}{3}$ done, and the construction of #4 is not commenced. All these calingulaks require substantial rear aprons. The number of culverts will be 10, and taking the sizes of those completed into consideration, not more than $\frac{1}{4}$ of the under-drainage has been completed. The rate, Rupees 2-2, for the walls is reasonable, and the work is sufficiently good. Stone of the culverts in this part of the canal will make crossings, which can be considered as providing for the wants of the villagers. The tunnels are dark and on a low level, and some, as at #2 for instance, will always be wet. Those of 3 feet span are not intended to be used. In the Hindry Division, where the lower end of the flooring is generally on a level with the ground, the case was different. Of the 10 irrigation sluices provided for, 5 have been completed, and the others have been commenced. The number allowed appears to be less than is desirable. There are 5 or 6 small sluices in Bank banks, these are all behind hand, and I think it would be as well to dispense with them. The full depth of water in this division will be 9 feet, and the fall of the bed of canal will average 4 inches per mile.

77. 61 mile. The earthworks in this mile are behind hand; the ground in many places has not been broken. An 8 feet culvert is under construction, and will be finished this month/June/ It will make a very indifferent crossing and should only be considered a subsidiary one. Soil bad.

78. 62 mile. 2-8 feet culverts have been finished, and an irrigation sluice just below. #3 culvert has been completed. Also. Earthwork nearly completed where there is a little cutting, elsewhere $\frac{1}{4}$ to $\frac{1}{2}$ done. Soil brown cotton.

79. 63rd mile. Up to the Seragopila Aqueduct one bank, the left one, is about $\frac{2}{3}$ done. The other not yet commenced. Below the Aqueduct 3 arches of 25 feet not commenced. Below the nullah, the left bank is nearly finished, the right not

Depth of water and fall.

Honamasey Division
Section - 61 to 72 miles

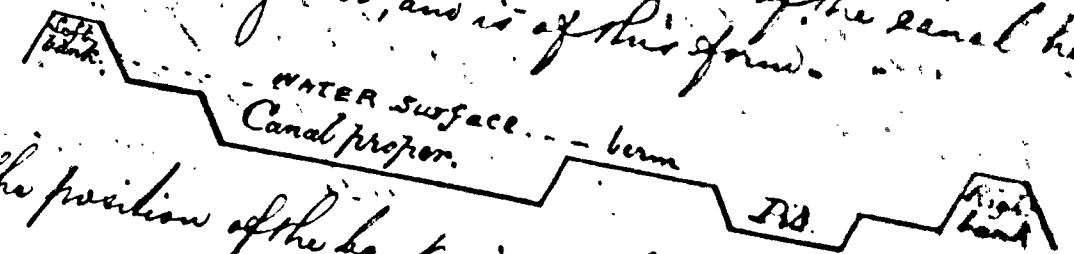
commenced. Revestment not yet started. Stone to be laid by. Soil for greater part of this mile is bad.

80. 64 mile. Left bank nearly finished, right bank just commenced. Up to the beginning of the former double banks and end of former tail soil in this mile good generally. An 8 feet culvert is under construction at the $\frac{1}{2}$ mile, rate for rubble masonry, Rupees 2-2, which is about 10 annas too low; that for archwork, Rupees 6, is, looking to the material - rubble - and to the style of work, at least double what is right. The stone is very unsuited to such work. Up to the end of the mile the earthwork is about $\frac{1}{2}$ done.

81. 65 mile. In this mile a calingulak was partly built in connection with the Seragopila tank, which has now been superseded by a double bank and an aqueduct. There is here a cutting, which when completed will be 9 feet deep. The calingulak body has an under-sluice of 6 vents, which will do for irrigation. No rear apron will be necessary for the calingulak. But one will be needed for the sluices, with revestment for the outfall channel for a few yards. About half the excavation has been finished along the calingulak, and below it to the end of the mile the canal is very nearly cleared out.

82. 66 mile. The upper part completed to full depth, and only a little clearing to be done. There are some queer lines on the right margin of the canal, the result apparently of very precise calculations of the sectional area required, and the ground being slightly undulating. The line consequently is thus  and the corners will require cutting off. Irrigation sluice #2 is in this mile, and has been completed. Culvert #5 of 8' span, has been completed. The arch stone of this tunnel is of the same description as that of #4, culvert. About one half of the earthwork of this mile has been completed.

83. 67 mile. An additional culvert at 66-50 is required, as there is a considerable drainage to be provided for. Up to this earthwork $\frac{1}{2}$ done. The cross section of the canal here is somewhat singular, and is of this form.



ground level, added to that of the canal in cutting, gives the re-
quired waterway. The cutting is placed near the left bank for
convenience of towing, and to obtain sufficient soil for the
right bank. Pits are dug in the lower bottom between the
canal. It would have been an improved arrangement had the
banks been placed rather closer together, and the cutting of
the canal proper increased sufficiently to provide the soil
required, as thus the navigation would have been improved,
and the excavations would have answered the double purpose
of this of small consequence where the cutting is shallow, but
elsewhere, when the water is low, the width for navigation is
rather restricted than was necessary. Earthwork of
this part of mile $\frac{1}{2}$ done. The excavation for an culvert
has just been commenced.

84. 68th mile. Irrigation sluice No 3 is at the $\frac{1}{2}$ mile, rubble
masonry rough, a crack of no great importance in the face
wall. The excavation and banks of the latter part of the mile
require a good deal of levelling and sectioning - and at some
places ground has not yet been broken. There is some
lake-like boulder of a hard description to be got out towards
end of mile.

85. 69th mile. Up to the 3rd culvert in the middle of the mile
the earthwork is incomplete all along, but the greater part
of the work is done. The culvert was built 2 years ago, and
looks sound, and is said to be water-tight, but, as the banks
have not been connected with it, a full trial has not been
made. Three up to sluice No 4, a small one, the greater
part of the earthwork has been done, but no part is finished.
Much of this work was done nearly 2 years ago. Just below
sluice the cutting through the ridge, on which the canal
Principal pond is situated, commences. The greater part done.

86. 70th mile. The canal runs south of the village, the greatest
depth of the cutting is 9 feet. About the half mile a set of
scouring sluices or vents of 3 feet - is $\frac{1}{2}$ completed. Above
and west of pits good. The rate for cut stone is 7.00. The
wings are rough rubble in human rate. Piers 7.00. The
rear apron attains, but one will be absolutely necessary. At
end of this mile a small irrigation sluice completed and earth
work finished.

87. 71st mile. Up

87. 71st mile. (Up to culvert excavation and earthwork nearly finished)
In parts the same cross section of the canal, as that mentioned
in the 67th mile, has been adopted. The culvert side walls are
up to the level of springing, work stopped by water for the pre-
sent. Up to the end of the mile the canal is in cutting all through,
and the earthwork is finished all but a little clearing and widening
88. 72nd mile. The Makcondal Cut may be considered to commence
in the previous mile, and it is continued throughout this mile. The
greater part of the work has been completed in a very satisfactory
manner, and it was undoubtedly a work of some difficulty. At the
deepest part is a bridge of 2 arches of 30 feet span, which has
been finished, and is open for traffic. The piers and abutment
facing are of cut stone, as also the arch facing, the rest of the
work is the rubble stone cutting, and it is not good enough to
stand exposure without plastering, so that the superstructure
and soffits of the arches are plastered. At the bridge, and a few
feet above and below, a considerable mass of stone has been
cleared out, and the cut is some 2 feet short of its full width
throughout - 200 yards from the lower end of the mile, the
calingulah hadicahar the greater part of the water into
the Canlee will be built, and below this point the width of
the canal is reduced from 70 to 50 feet.

Works for discharging
about 300000 cubic yards
per hour into the Canlee

89. From the calingulah just referred to and the working plan
of which has not yet been drawn out, a channel about $\frac{1}{2}$
miles in length, 500 feet wide, and intended to run 2 feet deep,
will conduct nearly all the irrigation water into the Canlee, a
tributary of the Sundar. The banks of this channel have just
been commenced. The fall of the ground to the Canlee is 3 1/2 feet,
and that of the river itself for the first mile, is said to be
about 2 1/2 feet. The surplus channel will join the Canlee
about 1/4 mile above the village of Kanatachhula, which
stands on the right bank. The land on the right bank of the
river, is about 7 feet above its bed, that on the left, is low. The
villagers inform me that after heavy falls of rain, the Canlee
opposite Kanatachhula, where its width is about 70 feet,
rises to 7 feet, that communication across it is then stopped
for a few hours at a time, and that the lands on the left bank
are flooded for a considerable distance. The drainage basin
of the Canlee above Kanatachhula, Mr. St. Catharine Salome, is
about

about 5 square miles. Probably the water of the Cauter, when running 7 feet deep, amounts to nearly 30,000 cubic yards per hour, and this would be an extreme fresh. I should imagine, as it would require a rain fall of 9 inches in the 24 hours over the basin named; at any rate, however, the addition of 30,000 cubic yards of water brought from the Coombudra, and added to that in the Cauter will, whenever the latter has more than 4,000 or 5,000 cubic yards of its own water, occasion a fresh equivalent to the high freshes now sometimes experienced. At present such freshes last but a short time, and the lands inundated on the left bank, soon drain off again but it is clear that such inundations will last for a much longer period, and that some extent of land will be almost constantly submerged, when the irrigation water is thrown in. Again the villages of Banatka, Churka, and existing circumstances, occasionally for a few hours prevented from crossing the river, but when the surplus water is thrown in, it is probable that for days together, the Cauter will not be fordable. No provision has as yet been made for embanking the river, nor has any land on the left bank been applied for, and I think an investigation should be made, to determine more accurately the present discharge of the Cauter, and the effect that an addition of 30,000 or even 40,000 cubic yards per hour will have in raising the level of the flood waters. For the evening sluices in the 73rd mile will come in to discharge all the rest of the canal water into the Cauter.

Q. To ascertain how far the flood waters will extend near Banatka Churka, and what works will be necessary to confine the waters within reasonable limits.

Ans. To show at what point down the river, the waterway becomes sufficient to remove all fear of injurious inundation. and to find out what villages, if any, besides Banatka Churka, will be more liable, than they are at present, to be isolated from the fields belonging to them, and to provide such means of crossing as each case may seem to require.

It would indeed do to find out, after the surplus works are in operation, that they could not be made use of, without serious risk and injury to the lands and villages on the Cauter. It may perhaps be urged that it is not intended to discharge water into the Cauter when this river is in fresh, but even more the telegraph need without an hour's delay, and the Banatka Head Sluice, which is closed, the surplus works in the 73rd mile, would continue to discharge an almost undiminished quantity of water for several days, the canal alone, without the tanks, holding enough

Summary of 2nd section
Romanesque Division or
section of the Main Canal -
61 1/2 miles -
1st Embankments and
works

to suffice for 36 hours, and therefore, a part from questions of navigation, which would be stopped by such a proceeding, it is clear that no sufficient regulation to do away with the necessity of the works I have indicated, could be exercised.

At the beginning of this section, the earthworks are behind hand, - the ground in some places, had not been broken. In the 63rd and 64th miles where the banks near Serajapile will be very high, the left bank is nearly finished, and the right, which has only become necessary since the abandonment of the single banked arrangement with a tank, is only just commenced; beyond this newly arranged portion, the earthwork is 1/4th done. For the rest of the section, great progress has been made all along, and the greater part of some of the miles only needs finishing, while at other parts, a considerable portion of the work is still incompletion. The whole of this section, will now be double banked. The soil in the first half of the section is much of it bad, lower down it improves greatly.

2nd Revetments. - No work of this description has been done, and the double banks render protection of this sort generally unnecessary, near Serajapile, however it will be found advisable to reach the high banks, above and below the aqueduct, and for short lengths elsewhere, the soil is bad, and not likely to stand unprotected. Compared however with the upper sections of the canal, but a very small outlay on this account will be required.

3rd Masonry works. - The greater part of the masonry of the calingulak in the 65th mile has been done. The Serajapile tank, having been abandoned, it will not now be required as a surplus work, but its under sluices will prove useful for irrigation. This is the only masonry work of the kind.

Four culverts of different sizes have been completed, two are nearly finished, two half finished, and for one the excavation has been made. An additional culvert is required at the 80th chain of the 67th mile. The one set of seaming sluices in the 70th mile is 1/3rd built, - it will require the addition of a rear apron and some revetment to protect the rear of the canal banks.

There is one bridge in this section, that crosses the canal at the Metacondal Ck, and this has been fully completed. The aqueduct in the 63rd mile of 3 arches of 25 feet span, has not yet been commenced.

Probably time of completion of the works of the section. - The earthworks and revetments, as also the little that remains to be done to the masonry works, can I think, easily be completed within six months, and if no time be lost after the rains, in laying the foundation of the aqueduct in the 63rd mile, the

this, the largest masonry work of the section, may be finished with-
in the year. These, including such supplementary works as may be found ne-
cessary, with reference to the remarks contained in para 89 & 90, should be completed within the year.
The water through the Macacondal Cut and up to Main Canal. The
head works in this mile, will have a maximum depth of 10 feet. Below, the depth will be 5 feet. A scouring sluice is under
construction, trans in keeping the navigation channel clear, and
to discharge the water not required for irrigation and navigation,
into the surplus channel leading to the Canal. These sluices have the wing walls of rubble masonry, which are
completed. The faces of the abutments and the piers will be of
cut stone, and this part of the work is about half done. The sluice
is founded on rock, but the rock is at some depth below the sur-
face. No rear wings are provided for, but I think an apron is ne-
cessary, and that a substantial revetment at least, if no water-
wings be built, should be given for the water will leave the sluice
at very high velocity. At short distance below these sluices, a head
sluice of 4 vents for the supply of the canal, has been completed.
The vents are of cut stone carefully built, the rest of the work,
rubble masonry, plastered. This work also is without either co-
front or rear apron or waterwings, and I do not see how the vents
could connect with it, can possibly stand, without a much re-
bitter protection, than a simple revetment, which I under-
stand to be the only work of this sort intended. The rock here
is 3 feet below the level of the floor of the vents. The regulating
locks, is within a few yards of the head sluice. It has been completed as far as was practicable, in the absence
of the regulating valves. I saw a tracing of the valve, but it was not
correctly drawn or at least the drawing was not clear either to
the Executive Engineer or to myself, and therefore I will leave that
to a future time, all comment on its probable efficiency. - This an
iron cylindrical valve revolving on a spindle, and with an opening
6 feet high by 3 feet wide on opposite sides, and when these openings
are brought into a line with an opening in a wall to be built across
the culvert, the water will pass through the valve. Originally there
were to be 22 openings, each 18' wide from the culvert to the lock
chamber. To save labor and expense in cut stone, these openings
have been reduced to 11 of double the width. Probably this arrange-
ment will work very well, if a little can be used in making
something the water to pass at first. All the masonry of the lock,
except

Irrigation channel
above 3 drop locks.

except the linings of the vents leading to the chamber, the Curins and
the miter sills are built of rubble stone from the Macacondal cut.
This stone is a slate which is too rough in form and too
easily operates upon by water and air, to stand without being plas-
tered, so that the greater part of the work will be plastered. This is
unfortunate both as regards appearance and wear. The Curin stones have cost 30 Rupees a cubic yard, and the vent
linings 15 Rupees. -
The earthworks near these head works have hardly been commen-
ced, and the canal down to the end of the mile, has for the most
part yet to be formed.
The canal as far as 79th mile will have a fall of 4 inches per mile,
and a width at water surface of 60 feet.
91. 74th to 78th miles. - The ground has been broken in some places,
but generally no earthwork has yet been commenced. In the 74th
mile, a culvert of 10 feet has been completed, and there is a
similar one in the 75th mile. In both cases the headway under
these culverts is too small to allow of their being used as cross-
ings. In the latter mile, also, a bridge of 2 arches of 25 feet span
is under construction, near the village of Macacondal, and the
arches have been completed. The rubble stone is similar to that
used in the head works. The country in these miles is favorable,
the general direction of the canal is westerly, the line makes long
sweeping curves, and it has been carefully selected and laid out.
At the lower end of the 78th mile, all the irrigation water will be
taken off by a channel, which is to diverge from the right bank.
The plans and estimates for the irrigation works are approach-
ing completion. I looked over them, and with the exception of
what is termed the ridge channel, they appeared to have been
carefully and successfully planned. That channel however will
run at a very heavy incline through black cotton soil, and either
the sides and bottom must be revetted with heavy earth or the fall
must be reduced by masonry drops. The Executive Engineer is
about ascertaining which will be the cheapest method. - Several
irrigation sluices in the left bank of the canal in these miles will
be required. -
92. 79th mile. - At the beginning of this mile, is the site of a rubble
lock, dropping the channel 30 feet, and below this the canal will
be a still water navigation. - The excavations for the lock are
in progress, and they are, with the exception of the first few inches
in rock, composed of alternating bands of lime stone and slate. The
stone will be used, and is well suited, for all the lock, except the miter
which

which will be of the dark blue limestone. Below this point up to the 4th mile, about 1/3 of the canal has been cut. The upper part is in rock, which quickly, however, is superseded by cotton soil. At the 3 1/2 mile a single lock, No. 3, is under construction, the stone being brought on a tramway from a quarry about 1/2 a mile distant. Just at the upper end of the lock a considerable nullah crosses the line, and this will be spanned by a double 10 feet culvert in connection with the lock. This under bridge will form a tolerably good crossing almost times, but the waterway is but one or rather small, as the foundations however will be on rock, this does not seem much matter. The foundations of the lock have been laid at 12 feet below floor, nothing was allowed for foundations in the estimate. The rates for rubble and cut stone could not be ascertained, as the work is being done by the Company's own agents. For a short distance below the lock the ground has not been broken, thence to the end of the mile the canal is finished - soil black cotton. -

93. 80th mile. - For the first half of the mile, canal completed, except a little clearing in the latter half, bed of canal is above ground level, the banks are 2 1/2 feet finished - soil has black cotton, and some pitching will be needed. -

94. 81st mile. - At the 5th chain the double lock, No. 4, with a drop of 21 1/2 feet, will be built, the excavation for the upper chamber is down to level, and at the 62nd chain there will be a similar lock with however a culvert or under bridge. Not much of the canal work in this mile has been done. -

95. 82nd & 83rd miles. - At the 11th chain, a considerable drainage crosses, for which a double culvert of 8 feet span is required. Lock No. 5, of 11 1/2 feet drop, will be at the junction of the nullah and the excavation is ready, and at the 65th chain of the 83rd mile the double lock No. 6 of 30 feet drop with an under bridge, is in progress, the upper chamber being about 4 feet above floor level, and the bridge about 10 feet above floor level. The stone is very good, and the work also. Foundations were allowed for in the estimate, they are between 5 and 6 feet. The rate 2 1/2 piers for the rubble masonry is expected to suffice. In the 82nd mile, about half the earthworks have been finished: below lock No. 6 the canal is complete for a few chains, and thence to lock No. 7 very little has been done, after which some greater progress has been made. -

96. 84th mile. - At about the half mile, the excavation for a culvert of 2 vents of 10 feet has been partly made. The greater part of both banking and cutting completed. Near the station of Tadapani, the canal runs through hard kimber, and here the cutting is rather behind hand; the banks are very narrow. The roofing of the permanent station building, is being put up. The walls are

are of excellent stone, the roof will be thatched. -
97. 85th mile. - Up to the culvert at the 25th chain, excavations nearly completed, banks require sectioning and levelling, culvert side walls and half the arch completed - masonry and stone good. Thence to end of the mile, canal completed and banks rough sectioned, berms narrow and much guttered. A good deal of silt in the canal. The culvert will make a tolerably good crossing. -

98. 86th mile. - In the first half mile a great deal of water found being into the canal through the gaps left in the rimbankments, and brought much silt. Here a culvert of 8 feet span is under construction, and is likely to prove too small for the drainage; the side walls and a part of the arch have been built. The outfall channel must be cut out to level. The culvert will make a passable crossing. The excavations in this mile are very nearly complete. Near the lower end of this mile a quarry of good blue limestone has been opened in the bed of the canal, and this intends to lay a tramway down to the Cutler to finish stone and line of small the masonry works. A line-timber has been built, and a charcoal oven is under construction, though whether it is economical to bring wood from a considerable distance to be made into a charcoal, is rather doubtful. -

99. 87th mile. - Within 30 yards of lower end, excavations complete, and banks full height, but the high banks at the lower part are not safe at their present section, and it will be necessary to make the interior slopes 2 to 1, and to turn over the top soil in so doing, the soil is very hard black cotton. - Bed of mile ground not broken. -

100. 88th mile. - At the 3rd chain there will be a double lock, No. 8, of 20 feet drop, with an under bridge or culvert; excavation for this work commenced - canal earthworks not commenced. Below this lock the line crosses a succession of low spurs and valleys, with considerable drainage, for these culverts No. 10 and 11 of 10 feet span only are allowed, and these, I think will not be enough. Lock No. 9, a double one and similar to No. 8, but without a culvert is to be built at the 34th chain, and not the end of the mile, as shown in the longitudinal section. - It would be better, as is indeed proposed to build it, or at any rate one half of the drop, in connection with lock No. 8, for the soil is not at all suited to the very high rimbankments now rendered necessary, and in fact I think the desire to economize masonry has led to lock No. 9 being double, and to its being placed too low down, a single drop half a mile above, would have been a safer arrangement, and not less convenient than the present position of these works. -

101. 89th mile. - Portions of excavation and rimbankment done down to the 60th chain, the site of No. 10 lock double with 20 feet drop.
102. 90th mile. - A considerable part of the earthwork done. Lock

No. 11 a double drop will be at about the $\frac{1}{4}$ mile - soil bad all along, and embankments near the locks will be very high, and require much care.

103. 91st mile. - The canal joins the Canler in this mile. Locks 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.

104. - In some of the miles a large part of the earthwork has been done, but generally the formation of the canal has been little more than commenced and the ground is unbroken for nearly half the length of the section. -

Work of this description has been done. This intended to reach 2nd Revestment. -

The banks above the head works in the 73rd mile with stone from the Metacoudal cut, any quantity of which is available. There are many parts of the banks in the section, however, which will have to be revetted sooner or later, and this is the case especially in the last six miles where the soil is very bad, and the lower half of each length between the locks has high banks, which will be seriously injured when water comes to be admitted. - If the upper miles of the section be finished continuously, stone might be brought down at a very small expense by the canal. -

There is only one bridge allowed for this section. This in the 75th mile, 3rd Masonry works. - and will very soon be finished, as the arches are turned, and the superstructure is in progress. -

Of the 12 locks Nos. 1, 3 and 7 are actually under construction; the first is completed as far as it can be, without the valves, which are expected shortly, the other two are about one fourth done. Repairs are being made for the other locks, but it is probable that Nos. 8 and 9 will be somewhat modified, and I think a change is desirable, with a view to reduce the height of the embankments, the soil being very bad. Locks Nos. 3, 5, 7, 8, will have culverts or under bridges attached, which will serve both for drainage and for crossings. The total lockage of the section will be 194 1/2 feet. Culverts. Two have been completed in the 74th and 75th miles, they would have served as crossings had the headway been sufficient, but as constructed, they are useless for this purpose. There is a bridge, however in the latter mile. Another culvert had been partially built in the 85th mile. The other works of this description included in the estimate, have not been commenced. - Two or three additional culverts will probably be found necessary. -

Irrigation sluices. - Works of this sort will only be needed up to the 78th mile, below which the canal will not carry irrigation water. - There

There is a considerable area of land available, and this offering is considerable. The sluices should be planned and constructed as early as possible. The irrigation details are generally much behind hand, and given when water becomes available, I am afraid the means of distributing it will be wanting, until a much later date than is advisable, added to which it must not be expected that the villagers will even ask for a supply, until the channels are laid out, and each man can see from exactly what point he will obtain the water for his fields. - This is not like an extension of irrigation in an irrigated country. The people know little about the subject, and are rather disposed to doubt the advantages of irrigation, and therefore every care is requisite to give them timely notice, and to show them that the distribution arrangements will be ready. -

The securing sluice at the upper end of the section is about half finished; the head sluice near it has been completed, as far as the estimate allows, but both these works require additions in the way of water wings and rear aprons. -

It will probably take the greater part of two years of hard work, to complete this section. - Labor does not appear to be very abundant, and the masonry works are very heavy, added to which it will, in my opinion, be the better plan, to devote much of the available labor to the utilization of the 40000 cubic yards of irrigation water, which will be carried by the first 6 miles of the canal, by getting the Irrigation Channels and sluices carried out. -

Several ferries are to be provided for this section, and as the width of the canal is but 60 feet, it will be necessary to provide recesses for the boats, and to place the embankments back, so as to allow proper slopes for the approaches. In some cases extra work will be caused by this omission to take this into consideration, when laying out the lines for excavation and embankment. -

This is, as already remarked, 60 feet, a narrow allowance for a first class navigation, and I think it would have been better throughout, to have placed the embankments further apart. - This would have entailed no extra expense, and, when the canal is in cutting, it would still have been easy to make the narrow cut in the first instance, and to have left broad berms for future enlargement. - Some few culverts might either have been built shorter in the first instance, to be lengthened when required, or they might have been built longer originally. It is not too late to take this into consideration in some of the miles. -

Section 7 of the canal 105. 92nd mile. - The still water navigation canal will terminate at the right bank of the Canler, and this section will, from an ancient hole thrown across that river, take off 100,000 cubic yards of the water turned into it by the surplus works at the lower end.

of the 92nd mile. The canal will have a water surface width of 70 feet, a maximum depth of water of 6 feet, and a fall of 6 inches per mile. The head works commenced, or to be built, are, 1st the lock or Amient across the Canoe, 2nd a head sluice, 3rd a navigation head with a regulating lock.

The right wing of the amient has been completed to full height, the left wing being in progress; the body of the dam will not be commenced until after the rains, it will be 10 feet high above the floor of the under sluices, and the length between the wings will be 346 feet. In the original design no apron whatever was provided, but this addition was made by the late Consulting Engineer before submitting the estimates for sanction. This apron is shown as 18 inches thick, and until the river bed is cleared, I cannot say whether the rock there will, with this protection, be strong enough to resist the overfall, but judging from that on which the head sluice is founded, I am disposed to think a stronger work will be necessary. The under sluices will be close to the left wing of the amient, and the head sluice is to be connected with that wing by a wall 120 feet in length. The floor of the head sluice is on the same level as that of the under sluices, and, with this considerable space between them, inconvenience is likely to be experienced from silting.

Just above the site of the amient, a nullah falls into the Canoe, and it is proposed to raise this as the navigation head, but the lower part of it is very unsuitable for that purpose, as it is very winding, it would oblige the boats to approach within an unsafe distance of the amient and under sluices, and it would certainly silt up. A head much higher up would be preferable, and there is no advantage, even as regards economy, in bringing the head down so low. As some embankments are required on the left bank of the Canoe, I requested the Executive Engineer to place these banks as far as not to interfere with a revised navigation head, should the Chief Engineer think a change desirable.

The excavation for the Regulating headlock has been made, good hard soil has been found. The Bridge for the nullah, which, at a road crossing, will be unfordable when the amient has been built, has been completed to the springing, and the arch would have been turned, had not a fresh sand stormy the cutting; it will be finished after the rains.

The canal in the latter half of the mile, has made considerable progress, soil tolerably good.

106. 93rd mile. - Very little earthwork done; bridge for the canal not commenced.

107. 94th mile. -

107. 94th mile. - First half ground broken, nothing else done. No doubt whether the culverts provide sufficient waterway.

108. 95th mile. - Earthworks about half done. A large drainage crosses the line, and at the 5th chain a culingulah is to be built. The nullah is some feet below the bed of canal, and its banks will require embanking for one to one and a quarter miles. The direction of the drainage is to be improved, and the heavy banks across the old course will require to be reworked.

109. 96th mile. - Excavations nearly finished, and banks being made up from outside pits.

110. 97th mile. - In the first half mile, excavation nearly finished, below this half the cutting, which will be from 4 to 4 1/2 feet, has been completed. There will be a culingulah for a cross drainage at the half mile. Materials under preparation. There will be a considerable overfall, as the nullah is about 10 feet below surface water of canal. The plan provides a simple body wall, and therefore the estimate will necessarily be considerably exceeded, in providing a suitable apron, retaining walls &c.

111. 98th mile. - Throughout, the excavations, which are 4 to 5 feet deep, are nearly finished.

112. 99th mile. - At the 8th chain excavation for a treble culvert completed, and materials under preparation. - Thence nearly up to the Byap Sadur Sanki, earthwork nearly done. The canal is arranged to be carried through the bank, the water of the latter being passed over it by a culvert. The difference of level of the canal and bank water is about 5 feet, the latter being the higher, so that no other arrangement was possible on the present line. Nothing has been done inside the bank.

113. 100th mile. - This begins in the middle of the bank. From the bank bend to the 3/4 mile, about half the earthwork done; the last 1/4 mile is only commenced. A bed of limestone and slate occurs in the middle of this mile.

114. 101st mile. - There are 4 culverts to be built in this mile, and the excavations for two are in progress; in one case several feet of hard slate rock suitable for masonry have to be excavated. Cories were at work with crowbars, blasting would be quicker and cheaper. Up to half mile canal cutting 1/2 done, below that cutting complete, and embankments 3/4 finished. Soil moderately good.

115. 102nd mile. - Excavation finished except levelling. Embankments about one yard below full height. Soil good - red.

116. 103rd mile. - Excavation nearly finished. The embankments, except last part of mile, want a good deal of raising. Excavations for a culvert, 1 1/2 to 20 in progress, and part of the stone for the masonry is being obtained therefrom. Soil for last 3/4 of mile, bad.

117. 104th mile. - Very little done to the earthworks, and masonry works not commenced beyond preparatory excavations.

118. 105th mile. - Nearly

118. 105th mile. - Nearly all the earthworks in this mile has been finished. The aqueduct across the Mundial Tank supply channel, has not been commenced. Materials should be collected in good time for the foundations, for the period during which such work can be done is very limited, and if any portion of this be lost, the completion will be delayed for an additional year. - Soil bad.

119. 106th mile. - The cutting in this mile is rather deep, and at the ridge it is 7 feet. The earthworks are well advanced, and the deep cutting is down to full depth. - Soil indifferent. Masonry works not commenced.

120. 107th mile. - The sugar station buildings are in this mile, at the junction of the new Cuddapah and Hurmoor Road with that from Cumbar. Up to the bridge site on this road, the earthworks have made good progress, below bridge one half the cutting has been completed. The foundations of the bridge are partly laid.

121. 108th mile. - In the first half of this mile, half the cutting done, earthwork below this not commenced. The culvert of 2 vents of 18 feet, the excavations for which are in progress, will not make a good crossing. The village road from Chabot to Gungiram a little below the $\frac{1}{4}$ mile, does not appear to be provided with any crossing.

122. 109th mile. - Half the full depth $\frac{1}{4}$ of cutting done for a few yards at commencement of mile - ground not broken beyond this.

123. 110th mile. - Ground not broken. - About the $\frac{1}{4}$ mile, culvert No. 7 is to be built, this will probably do for a crossing, and one is very much needed hereabouts. The sketch map of crossings shows this culvert as one of 3 vents near the end of the mile, but this does not agree with the arrangement pointed out by the Executive Engineer.

124. 111th to 112th & 113th miles. - Canal formation not commenced. In the former mile the canal crosses the line of the old Cuddapah road, but no bridge is to be built there, the Lake District Engineer having considered, either side to be where several village roads meet to the west of Dipajimla, and there excavations for a bridge are being made. The handy track at 50 chains, in the 113th mile, is, as stated in the section, but little used, but it is also a drainage, and as the ground slopes towards this point for a long distance, both in north and south, this drainage will be much increased and an 8' culvert will be required. Soil at lower part indifferent.

125. 114th mile. - Work not commenced. There are 3 village roads crossing this mile, 2 of which carry some heavy traffic. No provision has been made for this, unless the intended ferry in the next mile be supposed to be sufficient.

126. About 107th to 114th mile error

Summary of the 7th section of the canal. 92nd to 114th miles. 1st Excavations and 2nd Bankments.

126. About $\frac{1}{8}$ of the total quantity of the earthworks have been completed. The supply of labor is not very abundant, but it will probably suffice to complete these works by the end of another year. There is no provision in the estimate for any work of this description. Some will be required at the navigation head, for the banks immediately below the head sluice, for the banks near the 2nd Calingulaha, for the bank across the old course of the nullah in the 95th mile, probably for the banks through the Ryap Kundur tank, and for the banks above and below the Mundial channel aqueduct. The soil throughout this section is much of it very bad, but the line has been well selected, and there are very few places where the bankments will be high.

3rd Masonry works.

The ancient and head sluice, and the foundations of the bridge at Ryapur, are the only works actually commenced. Excavations and preparations for others are in progress. It is not improbable that extra masonry will be required for the ancient. The head sluice will need a lower flooring and waterways of some description.

The five Calingulahas have, as designed, little to do with the sides where they are to be built, additions to provide for an overfall of 10 feet are necessary, and probably nearly double the quantity of masonry allowed will be required. The culverts generally appear to be some to be likely to prove of sufficient size for the drainage. Several changes in dimensions and arrangement appear to have been made, since the sketch plans in my office were prepared. An additional culvert of 8' span will certainly be required in the 113th mile.

Probable date of completion.

Looking to the backward state of the masonry works, and seeing that two of them at least, the culvert in the Ryap Kundur tank, and the Mundial Aqueduct cannot be commenced for six months become finished under 2 years and probably this time will be exceeded. I don't think that the whole of the works of this section can be nearly finished. The cutting is almost entirely, and the embanking nearly finished. It is met with at middle of mile, and line has been near the end.

7th section of the Main Canal. 115th to 116th miles forming the Mundial tank.

127. 115th mile. - The cutting is almost entirely, and the embanking nearly finished. It is met with at middle of mile, and line has been near the end.

128. 116th mile. - First quarter excavation done to half depth. From $\frac{1}{4}$ to $\frac{1}{2}$ mile, but little done. The 2nd half of mile earthwork, well advanced. At about $\frac{3}{4}$ of the mile, the Stotapas and Sillala Road crosses. No provision has been made for this. Soil, $\frac{1}{2}$ ft., will be near the commencement of this mile.

129. 117th mile. - First half of the mile, earthworks nearly completed. Last $\frac{1}{2}$ will be just below the $\frac{1}{2}$ mile. Latter part of mile, earthwork not commenced. The Caloor station building has been completed. Here the Caloor and Stotapas road crosses, it carries much heavy traffic, and requires a serviceable crossing of some kind. 130. 118th mile. - Down to Stotapas, the earthwork is nearly finished.

Lock construction in progress, parts of the walls are nearly 5 feet above floor - Stone work very good. The rates allowed are 10 paces for the face work, and 10 paces for the rubble backing, and the Executive Engineer considers these insufficient. My own opinion is, from seeing what is doing in other sections, that the higher rate is more than sufficient, and that the rubble requires perhaps a very small addition, on account of carriage.

Earthwork's tail end of mile finished, all but bank dressing. A small drainage cut in rear of bank will be required lower down to drain the pools which would otherwise form behind the bank in this mile.

131. 119th mile. - Earthwork nearly finished.

132. 120th mile. - Lock A. 4 will be in this mile. No work commenced for 1/4 of the mile, B. of the earthwork done. Excavation for lock A. 5 at the 3/4 chain commenced. Stone being collected; this length 3 miles from Honak and Dinny, the rates will be affected by car.

133. 121st mile. - For 1/4 of the mile, B. of the earthwork done. Excavation for lock A. 5 at the 3/4 chain commenced. Stone being collected; this length 3 miles from Honak and Dinny, the rates will be affected by car.

134. 122nd mile. - A little stone collected for Lock A. 6. No work commenced.

135. 123rd mile. - Lock A. 7 with calingulah and the Donapans Bridge will all be close together at about the 2/3 chain. Earthwork up to this point continues all along, and in parts are well advanced, and thence to the end of the mile are making rapid progress. - The Donapans station building at the Head Quarters of the Division, is nearly ready to receive the roof. Walls are of stone in mud.

136. 124th mile. - Some stone collected for Lock A. 8. No work done.

137. 125th mile. - Earthwork in Donapans about 3/4 done, as far as the 5/8 mile, where Lock A. 9 will be, and which has not been commenced. At end of mile, road from Donapans to Honapursam crosses the canal carries a good deal of traffic, which requires a proper crossing. This I think would have been a better position for both bridge and station, as it is close to the village of Donapans, whereas the station is close to nothing but the canal. Below lock A. 8, earthwork all but finished.

138. 126th mile. - In the first half of the mile the earthwork is 3/4 done, beyond that ground not broken.

139. 127th mile. - The 17 feet drop lock A. 10 is planned for the end of this mile, and the Executive Engineer proposes to add 10 feet of this to lock A. 9, whereby the banks in very bad soil avoided. - The action for the lock has been commenced.

140. 128th mile. - Ground not broken in the former, and in the latter only for a length of a few yards. It is at the end of the latter mile that the balance of 17 feet fall from lock A. 10 is proposed to be placed. A cut near will, I think, be required in the 127th mile.

141. 129th mile. - Canal works not commenced. In the first mile a culvert A. 9 is proposed to be considered as a crossing. It would only be used in dry weather, and should not be taken into account. About the middle

of the 131st mile, the road from Chintagunta to Lingundim crosses - provision has to be made for this. - 142. 132nd mile. - Lock A. 11 will be at the 1/4 chain and the preparations are in progress. Excellent dark blue limestone obtained for the lock excavation. Below this canal formation continues here and there all along. Soil red and much better. 143. 133rd mile. - A little earthwork has been commenced in the 133rd mile, and in the 136th mile preparations are being made for lock A. 12 of 15 feet drop, while below this 13th of the earthwork has been done for 2000 chains. Beyond this no work has been done in the section. - 144. - Up to the 141st mile from the beginning of this section the canal will run along the water shed, the longitudinal fall is considerable, but the ground is remarkably even in all directions, and the trouble in laying out irrigation canals will be very small, as also will be the labor of forming good gills. From the beginning of the 142nd mile, the ground falls rather rapidly towards the Hindar, to which river the canal approaches, and considerable cross drainage, with ground cut into ravines, is met with. - Opposite the village of Rajoli, on the right bank of the Hindar in the 144th mile, the bed of the river is a vast mass of blue limestone rock, and here it is intended to build an ancient. It takes up another portion of the water to be turned into the Canal in the 145th mile. - The site is a very favorable one, and the ancient ought to cost but little. The channel from the river to the canal has been kept open. This not more than 300 to 350 yards in length. Below this to the end of the section, the canal will run very close to the Hindar, and will for the most part be on the face of a very steep incline, the ground here rising very rapidly from the river. It is at present full of little ravines. - 145. The soil of this section from river banks, is, with the exception of a few bright patches, the dark clay called black cotton soil. The only variations are, from bad sandy soil, and much of it is nothing but the worst sort of silt. At some parts the banks will be very high, and I much confess that I view the experiment of trying if loose banks without any puddling, of such soil, will stand, especially with slopes of 1 to 1, with considerable anxiety. - There is no doubt whatever about the slope altering itself, and additional work on this account having to be done, but it may be said that the banks themselves are an experiment, for banks are differently circumstanced, being subjected to the alternative presence and absence of water, whereas perhaps if water be admitted very carefully at first, these canal banks may puddle themselves, and prove perfectly watertight. If such prove to be the case it will be a matter of rejoicing for all, for the expense, should this soil prove unstable, of making and repairing canals would be enormous. - 146. This section is the last portion of the Main Canal which has been sanctioned, and I will therefore hasten to conclude this already over

End of the section.

ground

Lock construction in progress, parts of the walls are nearly 5 feet above floor - Stone work very good. The rates allowed are 10 paces for the face work, and 10 paces for the rubble backing, and the Executive Engineer considers these insufficient. My own opinion is, from seeing what is doing in other sections, that the higher rate is more than sufficient, and that the rubble requires perhaps a very small addition, on account of carriage.

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133. 121st mile. - For 1/4 of the mile, B. of the earthwork done. Excavation for lock A. 5 at the 3/4 chain commenced. Stone being collected; this length 3 miles from Honak and Dinny, the rates will be affected by car.

134. 122nd mile. - A little stone collected for Lock A. 6. No work commenced.

135. 123rd mile. - Lock A. 7 with calingulab and the Donapans Bridge will all be close together at about the 2/3 chain. Earthwork up to this continues all along, and in parts are well advanced, and thence to the end of the mile are making rapid progress. - The Donapans station is building at the Head Quarters of the Division, is nearly ready to receive the roof. Walls are of stone in mud.

136. 124th mile. - Some stone collected for Lock A. 8. No work done.

137. 125th mile. - Earthwork in Donapans about 3/4 done, as far as the 5/8 mile, where Lock A. 9 will be, and which has not been commenced. At end of mile, road from Donapans to Honapursam crosses and carries a good deal of traffic, which requires a proper crossing. This I think would have been a better position for both bridge and station, and is close to the village of Donapans, whereas the station is close to nothing but the canal. Below lock site, earthwork all but finished.

138. 126th mile. - In the first half of the mile the earthwork is 3/4 finished, beyond that ground not broken.

139. 127th mile. - The 17 feet drop lock A. 10 is planned for the end of this mile, and the Executive Engineer proposes to add 10 feet of this to lock A. 9, whereby the banks in very bad soil avoided. - The action for the lock has been commenced.

140. 128th mile. - Ground not broken in the former, and in the latter only for a length of a few yards. It is at the end of the latter mile that the balance of 17 feet fall from lock A. 10 is proposed to be placed. A cut near will, I think, be required in the 127th mile.

141. 129th mile. - Canal works not commenced. In the first mile a culvert A. 9 is proposed to be considered as a crossing. It would only be used in dry weather, and should not be taken into account. About the middle

of the 131st mile, the road from Chintagunta to Lingundim crosses - provision has to be made for this. - 142. 132nd mile. - Lock A. 11 will be at the 1/4 chain and the preparations are in progress. Excellent dark blue limestone obtained for the lock excavation. Below this canal formation continues here and there all along. Soil red and much better. 143. 133rd mile. - A little earthwork has been commenced in the 133rd mile, and in the 136th mile preparations are being made for lock A. 12 of 15 feet drop, while below this 13th of the earthwork has been done for 2000 chains. Beyond this no work has been done in the section. - 144. 134th mile. - Up to the 141st mile from the beginning of this section the canal will run along the water shed, the longitudinal fall is considerable, but the ground is remarkably even in all directions, and the trouble in laying out irrigation canals will be very small, as also will be the labor of forming good gills. From the beginning of the 142nd mile, the ground falls rather rapidly towards the Hindar, to which river the canal approaches, and considerable cross drainage, with ground cut into ravines, is met with. - Opposite the village of Rajoli, on the right bank of the Hindar in the 144th mile, the bed of the river is a vast mass of blue limestone rock, and here it is intended to build an ancient. It takes up another portion of the water to be turned into the Canal in the 145th mile. - The site is a very favorable one, and the ancient ought to cost but little. The channel from the river to the canal has been kept open. This not more than 300 to 350 yards in length. Below this to the end of the section, the canal will run very close to the Hindar, and will for the most part be on the face of a very steep incline, the ground here rising very rapidly from the river. It is at present full of little ravines. - 145. The soil of this section from river to end, is, with the exception of a few bright patches, the dark clay called black cotton soil. The only variations are, from bad to very bad, and much of it is nothing but the worst sort of silt. At some parts the banks will be very high, and I much confess that I view the experiment of trying if loose banks without any puddling, of such soil, will stand, especially with slopes of 1 to 1, with considerable anxiety. - There is no doubt whatever about the slope altering itself, and additional work on this account having to be done, but it may be said that the banks themselves are an experiment, for banks are differently circumstanced, being subjected to the alternative presence and absence of water, whereas perhaps if water be admitted very carefully at first, these canal banks may puddle themselves, and prove perfectly watertight. If such prove to be the case it will be a matter of rejoicing for all, for the expense, should this soil prove unstable, of making and repairing canals would be enormous. - 146. This section is the last portion of the Main Canal which has been sanctioned, and I will therefore hasten to conclude this already over

End of the section.

ground

overgrown report, by adding a few remarks on some points affecting the canal generally. -

147. This question has occupied the attention of Government a good deal, and, in their order as per margin, the arrangements proposed for the first 112 miles of the canal, more generally approved. An inspection however of the canal, the country and its circumstances, has convinced me, that these arrangements are, or will be, very far from adequate. - In the first 30 miles of the canal, the ground on the right bank is either rocky and uncultivated, or, as in the part west of Harwood, the villages are small and not cut off from their chief market by the canal, and the only inconvenience they will suffer, is in some cases a difficulty in reaching their fields, a difficulty which is remembered, which, however annoying at first, will constantly diminish for the cattle will doubtless soon take to swimming across the canal, if a suitable take off and landing, with ramps over the banks, be provided, and this will cost very little. It may be also remarked that many of the culverts in the western sections are high, with drains, and at the lower end their floors are flush with the natural ground level. - As the canal however proceeds to the eastward, the country opens out, the traffic in various directions becoming large, forming very tolerable communications for many months in the year. With the best possible arrangements probably one half of these roads will be closed, and it is necessary to consider briefly whether anything like a fair amount of accommodation will be provided by the crossings proposed.

148. Below the 30 mile the bridges are -

1. Probably at Ulux in the 35 mile - this is under discussion -
2. Jagator bridge - 45 - do
3. Enghais - 60 - do
4. Metacandal culvert - 72 - do
5. Metacandal culvert - 78 - do
6. Bridge over nullah flooded by Sootoor Umint, and not over the canal.
7. Nundial road bridge - 92 - do
8. Cumbin and Cudrapatin Road Bridge - 93 - do
9. Wipaguntah - 112 - do
10. Bonapand station - 123 - do
11. Sungalpilly - 139 - do

149. The 3rd class crossings are the culverts or under bridges in connection with the locks. These occur in the 6 section only at the locks in the 79, 81, 82, and 83 miles. They will be very fair crossings, for though carts and cattle will have to descend into nullahs, and that again much difficulty may be made easy. -

150. The 2nd class crossings, they will be placed

placed at the 31.79, 38.78, 41.8, 52.70, 58.13, 70.31, 85.31, 87.35 m. Ch. 95.78, 99.9, 102.47, 115.8, 119.8, 126.8, 134.8, 142.0 m. Ch. on 16 furlongs for 116 miles. -

The design for the boats shows that they are intended to be 25 feet in length and 8 feet wide. The ends are pointed, so that a staging or platform of corresponding shape will be necessary, shallow gears to being places on them without difficulty. As moreover carts can not be put upon them, except at the ends, and as below the 70 mile the canal is comparatively narrow, while above that point the current is considerable, it will be necessary to provide recesses of depth corresponding with the length of the boats, and the embankments & banks at least to be thrown back sufficiently far to admit of ramps of 1 in 12 for carts, and 1 in 6 where only foot passengers & cattle are intended to cross. I would also recommend that a slipway landing should be made on each side of the canal at some of the ferry stations so shallow as to take the water without difficulty. I have no doubt the cattle will very soon learn to cross the canal in this way, and when they do so, much of the loss of time in getting to and from the fields which would occur, even with the best made ferry boat, will be avoided.

In the part of the canal below the 30 mile, the culverts must be considered as the least efficient crossings, and any of those at present considered as likely to be useful for that purpose, will, I believe be of no use. They are generally on a very low level, and will be wet and muddy, the outfall channels, will in some cases be very long, their size both as regards breadth and height, is too limited, for a bullock gate is often six feet long, and sometimes more, and with culverts lower, their size but small margin, and a cart laden with straw or a bullock cart, will not pass through a shallow water which they are long and dark, and will in many cases be very wet from leakage. - The idea was suggested by the railway culverts, but the circumstances are entirely different, and no rail-way culvert, situated as are most of them, would be used as a crossing at all.

In connection with this subject, it should also be remembered, that in very low, what is now a dry country will be irrigated, that between all the numerous villages on either side of the line, roads will then be an absolute necessity, that if the greatest benefit to the traffic may be obtained at the least possible cost, but that, if neglected now, there will be much opportunity

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In connection with this subject, I should also be reminded, that in very low, what is now a dry country will be irrigated, that between all the numerous villages on either side of the line, roads will then be an absolute necessity, that if the junctions of communications be now taken up thoroughly, the greatest benefit to the traffic may be obtained at the least possible cost, but that, if neglected now, there will be much opportunity

1540-27 May 1864

again, and I would suggest therefore, that the Range Officers of the Department of Public Works & Roads, in communication with the divisional officers of the Company, prepare a scheme of village roads, adapting the arrangements so as to make the most of each of the masonry works, whether over or under bridges, now about to be built, as may be possible, and then settling what further provisions will be necessary. The Collectors of the several districts would then be able to understand, what is proposed, and to ascertain whether the several villages would be enabled without unnecessary difficulty, to carry on their agriculture and transport their produce. At present were the Government to require all the different means of carrying the produce, and were the Company's Officers to agree that once there, there would be no certainty that the communications would be available for the use of the people for whose benefit they were constructed. I am quite convinced that the arrangements proposed at present are inadequate, but I think, that a proper opinion can be formed, without maps showing all the villages within the intended areas of irrigation, and exhibiting the connections of the several villages with each other, and with the canal and existing made roads. The schemes for roads which have been prepared in the several districts under the orders of Government, would form a basis, in Madras, there is no time for delay, and each section, commencing, I would suggest, in the 3rd, might be disposed of by great extent separately and successively, in the Cuddalore and Kallakurichi Districts there will be more leisure. Probably the villages, within 2 or 3 miles of the canal on either side, would determine the arrangement and position of all the roads crossing the canal and the connection of these villages with those more remote, might be taken up, after this first point had been determined.

149. While passing through the several divisions, it has struck me that much good would result, were the Chief Engineer to take measures for ascertaining the relative cost of work in the several sections of the canal. I have remarked a great difference in rates for similar work, not only in different divisions, but in the different sections of the same division, and were the experience gained in one locality made available for works elsewhere, very great benefit would be the consequence. - In some parts of the canal, work of each description is being done, both well and cheaply, in other parts, the reverse is the case, and what is required is to ascertain the best management prevails. -

150. It has been stated that three buildings, though in the first instance used for office and store accommodation, are intended afterwards

afterwards as traffic stations, and if they should be placed close to the canal in such a position as will be most convenient for the traffic. This would be, I think, on the opposite side to the towing path, and just as far removed from the canal as shallow of a loading basin being formed. In the Stundar Division the buildings are tolerably near the canal but in the other divisions they are much too far away, and at Romanassey they are half a mile distant. The goods have to be taken out of carts, weighed and loaded, and these operations require the station to be situated like a railway station. -

Precautions required in making excavations. 151. It would be well were the Chief Engineer to impress upon all his Executive Officers the necessity for precautionary measures in making deep excavations. I have noticed cuttings for masonry works several yards deep with perpendicular sides, and the spoil placed close to the edge of the cutting. Many slips occurred during the recent rains, and one accident occurred, though fortunately without serious results. -

152. The expenditure up to the 30th April last on the Lumbudra project, was about 42 lacs of rupees, and as yet the returns have been nothing. The first 30 miles of the canal were necessarily very expensive, and up to the end of the 3rd section or 45th mile, the whole possible irrigable area is but 10,000 acres. Up to the Metacondal cut however, this area becomes increased to 50,000 acres, and below that the extent of land is very large. The importance of getting land under irrigation is so great, that I would bring this point prominently forward, with a view to attention being given, during the current year, to the completion as far as is necessary for irrigation purposes, of the first 78 miles of the canal, and to the pushing forward the distribution works. The irrigation canal ends at the end of the 78th mile, below that, the canal down to the Canler 91 mile is one of navigation only. At present, beyond the construction of a few sluices, nothing has been done towards getting ready for irrigation, and yet undoubtedly much has to be done before any area worth mentioning can be watered. - If very great exertions be used, the main canal may be opened to the end of the 78th mile by May 1865, and sufficient water for all the possible irrigation of the water, it will be useless to expect results from the whole. Concurrently, the distribution works be not advanced. In a letter dated the 10th February last, the Chief Engineer appeared to think, that water could be carried to the Stundar valley by the present cut, but he must have been quite unaware of the state of progress of the works on the main canal, especially in the 3rd section, where in the 20th mile, within 2 miles of the Central Office, the backward state of the cutting presents an insuperable barrier, and in the embankments, where in June the walls in several miles were still several feet

...of the bed of the canal... with regard to
...it is only by fully recognizing the work to be got through and
...taking adequate steps to get such work done, that the anticipations
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...year to report that much has been accomplished, and I have
...written strongly on this subject, because there is no chance of re-
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...and that work has not yet been commenced.
153. I have not yet received from any of the divisions the informa- Information not yet
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...report therefore with the illustrative sketch map required, will be submitted as soon as possible.
...and each of the works as required with estimated cost.

I have the honor to be,
Sir,
Your most obedient servant,
Wm. J. G. Jones, Captain, R.E.
Colonel for S. C. Company.

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No. 10
 " 15" Sept
 " 29" April 186
 " 27" May
 " 30 June

This is a letter in relation to the
 canal works and the suggestions made by Capt Mullens
 should be adopted.

and order of the
 submitted for the information
 of the Government.

Copy in a letter to England
 dated 9th Sept 1864 No. 50.

No. 50

c. 262 2nd 1864 R. 285

7th 1864 Dept
 No. 49
 P. 40 of Govt. for the
 from
 The Engineer for S. C.
 The Secretary to Government
 D. P. Works.

Dated 2nd
 Recd 19
 Recd 22
 July 1864.

Recd 1866
 Recd 24/7/64
 No. 2138-24th Aug 1864

Report on the Sunkasala
 Anicut and Head Works, and
 on the 1st to 8th sections of the
 Main Canal Sea Sea -
 Inspected between the 30th
 May and 30th June 1864.

For B. C.

Public Works Department
 No. 2138
 Proceedings of the Madras Government
 Under date the 21st August 1864
 Read the following

From the Engineer S. C. Company
 Report on the Sunkasala Anicut
 and Head Works, and on the 1st to
 8th sections of the Main Canal
 Inspected between
 the 30th May and 30th June 1864.

H. E. 2nd July 1864 No. 40

The Government
 has perused the
 foregoing report on the
 state of the Sunkasala
 and Canal Company's
 works with much
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 clear and ~~valuable~~
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 be communicated
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 The Agents
 attention

JP

attention will be
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paragraphs 4, 5, 7, 9,
10, 13, 15, 26, 27 (re-
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(Ullur Aqueduct), 63,
65, 68, 78, 82, 90, (re-
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104, 105, (irrigation
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proposed in para. 90,
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canal, to be made,
reporting the result
to Govt. thro' the Cons.
Engineer.
4. The report shows
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will not be sufficient,
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the views on this
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Officers of the Compt.,
prepare a scheme of
village roads, adapting
the arrangements to
the

The masonry work is in
progress, or about to
be built, and settling
what further provision
will be necessary.
5. The Supp. Engrs
of the 2^d & 3^d Divs will
be furnished with
copies of the foregoing
report, in view of their
issuing the ~~respective~~^{respective}
orders to the Range
Officers concerned. &
~~Capt Mullins will~~
~~communicate to the~~
~~Range Officers any~~
~~further instructions~~
~~which may be~~
~~necessary.~~

6. The report will
also be communicated
thru the Rev. St. to
the Collectors of Har-
not, Cuddalore &
Nellur.

It should also be sent
home at an early date
with the dispatch
on the canal
by post. C. J.

To The Commanding Engr I.H. Coy
41 Agm
5 Supp Engr 2^d Div
3^d Div
21 Rev St
49

25th August

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Wm. L. G. Jones Captain, R.E.
Care Engineer & Co. Company.

No. 10. 15th Sept
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 " 3rd June

This is a clear statement
 and the suggestions made by Capt Mullens
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and order of the
 submitted for the information
 of the Government
 Major General
 26th July 1864

17th 1864 Dept
 No. 40
 From the Co. of Engineers
 The Secretary to Government
 D.P. Wodeyar

Dated 2nd
 Recd 19
 Recd 22
 July 1864

Recd 1596
 Recd 2417/15

No 24138-24th August 1864

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For B. Co.

Copy in a letter to England
 Dated 9th Sept 1864 No. 50.

No 526

C. 26th July 1864 No. 285

Public Works Department
 No 24138
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 Under date the 24th August 1864

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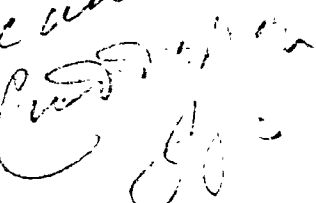
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Range Officers of the
B.P.W. should, in com-
munication with Divisional
Officers of the Compt.,
prepare a scheme of
village roads, adapting
the arrangements to
the

The masonry work is in progress, or about to be built, and settling what further provision will be necessary.

5. The Supy. Engrs of the 2^d & 3^d Divs will be furnished with copies of the foregoing report, in view of their issuing the ~~respective~~ ^{respective} orders to the Range Officers concerned. & ~~Capt. Mullins will communicate to the Range Officers any further instructions which may be necessary.~~

6. The report will also be communicated thro' the Rev. St. to the Collectors of Karnool, Cuddapah & Bellary.

It should also be sent home at an early date with the dispatch on the canal beyond 

To The Consulting Engr I.H.C. of
Agum
5 Supy Engr 2^d Div
3^d Div
21 Rev St
49

26th August

153. I have not yet received from any of the divisions the information asked for, furnable me to report on this subject. - A separate report therefore with the illustrative sketch map required, will be submitted as soon as possible. -

Have the honor to be,
Sir,
Your most obedient servant,
Wm. Lyndell, Captain, R.E.
Care Engineer & Co. Company, -

of the 92nd mile. The canal will have a water surface width of 70 feet, a maximum depth of water of 6 feet, and a fall of 6 inches per mile. The head works commenced, or to be built, are, 1st the Lock-
Ancient across the Canal, 2nd a head sluice, 3rd a navigation head-
with a regulating lock.

The right wing of the ancient has been completed to full height, the left wing in progress; the body of the dam will not be com-
menced until after the rains, it will be 10 feet high above the
floor of the under sluices, and its length between the wings will be
346 feet. In the original design no apron whatever was provided,
but this addition was made by the late Consulting Engineer before
submitting the estimates for sanction. This apron is shown as
18 inches thick, and until the river bed is cleared, I cannot say
whether the rock there will, with this protection, be strong enough
to resist the overfall, but judging from that on which the head
sluice is founded, I am disposed to think a stronger work will be
necessary. The under sluices will be close to the left wing of the
ancient, and the head sluice is to be connected with that wing by
a wall 120 feet in length. The floor of the head sluice is on the
same level as that of the under sluices, and, with this considera-
ble space between them, inconvenience is likely to be expe-
rienced from silting.

Just above the site of the ancient a nullah falls into the Canal,
and it is proposed to use this as the navigation head, but the lower
part of it is very unsuitable for that purpose as it is very
winding; it would oblige the boats to approach within an unsafe
distance of the ancient and under sluices, and it would certainly
silt up. A head much higher up would be preferable, and there
is no advantage, even as regards economy, in bringing the head
down so low. As some embankments are required on the left
bank of the Canal, I request the Executive Engineer to place
these banks so as not to interfere with a revised navigation head,
should the Chief Engineer think a change desirable.

The excavation for the Regulating head lock has been made, good
hard soil has been found. The Bridge No. 1 for the nullah which, as a road crossing,
will be unfavourable when the ancient has been built, has been
completed to the springing, and the arch would have been turned,
had not a fresh sandstone quarry the cutting; it will be finished
after the rains.

The canal in the latter half of the mile, have made considerable
progress, soil tolerably good. 106. 93rd mile. - Very little earthworks done; bridge No. 2 for the
Hindial Road not commenced.

107. 94th mile. -

107. 94th mile. - First half ground broken, nothing else done. This doubtful
whether the culverts provide sufficient waterway. 108. 95th mile. - Earthworks about half done. A large drainage crosses the
line, and at the 54th chain a culvert is to be built. The nullah is
some feet below the bed of canal, and its banks will require embanking
for one to one and a quarter miles. The direction of the drainage is to
be improved, and the heavy banks across the old course will require to
be reworked.

109. 96th mile. - Excavations nearly finished, and banks being made up
from outside pits.

110. 97th mile. - In the first half mile excavation nearly finished, below
this half the cutting, which will be from 4 to 4 1/2 feet, has been completed.
There will be a culvert for a cross drainage at the half mile. Ma-
terials under preparation. There will be a considerable overfall,
as the nullah is about 10 feet below surface water of canal. The
plan provides a simple body wall, and therefore the estimate will
necessarily be considerably exceeded, in providing a suitable apron,
retaining walls &c.

111. 98th mile. - Throughout the excavations, which are 4 to 5 feet deep, are
nearly finished.

112. 99th mile. - At the 8th chain excavation for a treble culvert com-
pleted, and materials under preparation. - Hence nearly up to the
Byap Sadur Tank, earthworks nearly done. The canal is arranged to
be carried through the tanks, the water of the latter being passed under it
by a culvert. The difference of level of the canal and tank water is about
5 feet, the latter being the higher, so that no other arrangement was feasi-
ble on the present line. Nothing has been done inside the tanks.

113. 100th mile. - This begins in the middle of the tanks. From the tank
bank to the 3/4 mile, about half the earthworks done; the last 1/4 mile
is only commenced. A bed of limestone and slate occurs in the middle
of this mile.

114. 101st mile. - There are 4 culverts to be built in this mile, and the
excavations for two are in progress; in one case several feet of hard
slate rock, suitable for masonry have to be excavated. Cuts were
at work with crowbars, blasting would be quicker and cheaper. Up to
half mile canal cutting of the stone below the banking complete, and
embankments 3/4 finished. Soil moderately good.

115. 102nd mile. - Excavation finished except levelling. Embankments
about one yard below full height. Soil good - red.

116. 103rd mile. - Excavation nearly finished. The embankments,
except last part of mile, want a good deal of raising. Excavations
for a culvert at 20 in progress, and part of the stone for the masonry
is being obtained therefrom. Soil for last 1/4 of mile, bad.

117. 104th mile. - Very little done to the earthworks, and masonry work
not commenced beyond preparatory excavations.

118. 105th mile. - Near

118. 105th mile. - Nearly all the earthwork in this mile has been finished. The aqueduct across the Hundral tank supply channel, has not been commenced. Materials should be collected in good time for the foundations, for the period during which such work can be done is very limited, and if any portion of this be lost, the completion will be delayed for an additional year. - Soil bad.

119. 106th mile. - The cutting in this mile is rather deep, and at the ridge it is 7 feet. The earthworks are well advanced, and the deep cutting is down to full depth. - Soil indifferent. Masonry works not commenced.

120. 107th mile. The Lyalur station buildings are in this mile, at the junction of the new Cuddapah and Kurnool Road with that from Cumbum. Up to the bridge site on this road, the earthworks have made good progress, below bridge one half the cutting has been completed. The foundations of the bridge are partly laid.

121. 108th mile. - In the first half of this mile, half the cutting done, earthwork below this not commenced. The culvert of 3 vents of 10 feet, the excavations for which are in progress, will not make a good crossing. The village road from Chabot to Gungarasa a little below the $\frac{1}{4}$ mile, does not appear to be provided with any crossing.

122. 109th mile. - Half the full depth $\frac{1}{4}$ of cutting done for a few yards at commencement of mile - ground not broken beyond this.

123. 110th mile. - Ground not broken. - About the $\frac{1}{4}$ mile, culvert No. 7 is to be built, this will probably do for a crossing, and one is very much needed hereabouts. The sketch map of crossings shows this culvert as one of 3 vents near the end of the mile, but this does not agree with the arrangement pointed out by the Executive Engineer.

124. 111th - 112th & 113th miles. - Canal formation not commenced. In the former mile the canal crosses the line of the old Cuddapah road, but no bridge is to be built there, the late District Engineer having considered either side to be where several village roads meet to the west of Dipayintla, and there excavations for a bridge are being made. The bandy track at 50 chains, in the 113th mile, is as stated in the section, but little used, but it is also a drainage, and as the ground slopes towards this point for a long distance, both north and south, this drainage will be much increased, and an 8' culvert will be required. Soil at lower part indifferent.

125. 114th mile. - Work not commenced. There are 3 village roads crossing this mile, 2 of which carry some bandy traffic. No provision has been made for this, unless the intended ferry in the next mile be supposed to be sufficient.

126. about

Summary of the 7th section of the canal. 92nd to 114th miles. 1st Excavations and 2nd Bankments. 3rd Revetments.

126. About $\frac{1}{3}$ of the total quantity of the earthworks have been completed. The supply of labor is not very abundant, but it will probably suffice to complete these works by the end of another year. There is no provision in the estimate for any work of this description. Some will be required at the irrigation head, for the banks immediately below the head sluice, for the banks near the calingulaha, for the bank across the old course of the nullah in the 95th mile, probably for the banks through the Ryap Kundur tank, and for the banks above and below the Hundral channel aqueduct. The soil throughout this section is much of it very bad, but the line has been well selected, and there are very few places where the bankments will be high.

3rd Masonry works.

The ancient and head sluice, and the foundations of the bridge at Lyalur, are the only works actually commenced. Excavations and preparations for others are in progress. It is not improbable that extra masonry will be required for the ancient. The head sluice will need a lower flooring and waterings of some description.

The two calingulahas have, as designed, little to do with the sides where they are to be built, additions to provide for an overfall of 10 feet are necessary, and probably nearly double the quantity of masonry allowed will be required. The culverts generally appear to be likely to prove of sufficient size for the drainage, several changes in dimensions and arrangement appear to have been made since the sketch plans in my office were prepared. An additional culvert of 8' span will certainly be required in the 113th mile.

Probable date of completion.

Looking to the backward state of the masonry works, and seeing that two of them at least the culvert in the Ryap Kundur tank, and the Hundral Aqueduct cannot be commenced for six months to come, I don't think that the whole of the works of this section can be finished under 2 years and probably this time will be exceeded.

2nd section of the Main Canal. 115th to 126th miles forming the Hundral tank.

127. 115th mile. - The cutting is almost entirely, and the embankment nearly finished. There is met with at middle of mile, and line tank near the end.

128. 116th mile. - First quarter excavation done to half depth. From $\frac{1}{4}$ to $\frac{1}{2}$ mile, but little done. The remainder of mile earthwork well advanced. At about $\frac{3}{4}$ of the mile the Kotapad and Tillala Road crosses. No provision has been made for this, but it will be near the commencement of this mile.

129. 117th mile. - First half of the mile, earthworks nearly completed. The 2nd half will be just below the 118th mile. Latter part of mile, earthwork just commenced. The Talon station building has been completed. Here the Talon and Kotapad roads cross, it carries much traffic, and requires a serviceable crossing of some kind.

130. 118th mile. - Down to the 118th mile, the earthwork is nearly finished. Soil

Lock construction in progress, parts of the walls are nearly 5 feet above floor - Stone work very good. The rates allowed are 10 paces for the face work, and 10 paces for the rubble backing, and the Executive Engineer considers these insufficient. My own opinion is, from seeing what is doing in other sections, that the higher rate is more than sufficient, and that the rubble requires perhaps a very small addition, on account of carriage.

Earthwork's end of mile finished, all but bank dressing. A small drainage cut in rear of banks will be required to drain the pools which would otherwise form behind the bank in this mile.

131. 119th mile. - Earthwork nearly finished.

132. 120th mile. - Lock No. 11 will be in this mile. No work commenced.

133. 121st mile. - The 3/4 of the mile, 1/2 of the earthwork done. Excavation for lock No. 12 at the 3/4 chain commenced. Stone being collected; this brought 3 miles from Horakandim, the rates will be affected by carriage.

134. 122nd mile. - A little stone collected for Lock No. 12. No work commenced.

135. 123rd mile. - Lock No. 13 with calingulak and the Donapans Bridge will all be close together at about the 3/4 chain. Earthwork up to this point continued all along, and in parts well advanced, and thence to the end of the mile are making rapid progress. - The Donapans station building at the Head Quarters of the Division, is nearly ready to receive the roof. Walls are of stone in mud.

136. 124th mile. - Some stone collected for Lock No. 13. No work done.

137. 125th mile. - Earthwork in embankment about 2/3 done, as far as the 5/8 mile, where Lock No. 14 will be, and which has not been commenced. At end of mile, road from Donapans to Houdapuram crosses and carries a good deal of traffic, which requires a proper crossing. This I think would have been a better position for both bridge and station, and it is close to the village of Donapans, whereas the station is close to nothing but the canal. Below lock site, earthwork all but finished.

138. 126th mile. - In the first half of the mile the earthwork is finished, beyond that ground not broken.

The 17 feet drop lock No. 15 is planned for the end of this mile, and the Executive Engineer proposes to add 10 feet of this to lock No. 14, whereby some 8,000 cubic yards of earthwork would be saved, and very high banks in very bad soil avoided. - Excavation for the lock has been commenced.

139. 127th and 128th miles. - Ground not broken in the former, and in the latter only for a length of a few yards. It is at the end of the latter mile that the balance of 17 feet fall from lock No. 15 is proposed to be placed. A culvert will, I think, be required in the 127th mile.

140. 129th - 130th & 131st miles. - Canal works not commenced. In the first mile a culvert No. 16 is proposed to be considered as a crossing. It would only be used in dry weather, and should not be taken into account. About the middle of

of the 131st mile, the road from Chintagunta to Lingamding crosses - provision has been made for this.

141. 132nd mile. - Lock No. 16 will be at the 1/4 chain and the excavations are in progress. Excellent dark blue limestone obtained for the last excavation. Below this canal formation commenced here and there all along. Soil red and much better.

142. 133rd to 141st miles. - A little earthwork has been commenced in the 133rd mile, and in the 136th mile preparations are being made for lock No. 17 of 15 1/2 feet drop, while below this 1/2 of the earthwork has been done for 2 or 3 chains. Beyond this no work has been done in the section.

143. - Up to the 141st mile from the beginning of this section the canal will run along the water shed, the longitudinal fall is considerable, but the ground is remarkably even in all directions, and the trouble in laying out irrigation canals, will be very small, as also will be the labor of forming ready fields.

From the beginning of the 142nd mile, the ground falls rather rapidly towards the Hindar, to which river the canal approaches, and considerable cross drainage, with ground cut into ravines, is met with. - Opposite the village of Rajoli, on the right bank of the Hindar in the 144th mile, the bed of the river is a vast mass of blue limestone rock, and here it is intended to build an ancient to take up another portion of the water, to be turned into the Canal in the 145th mile. - The river is a very favorable one, and the ancient ought to cost but little. The channel from the river to the canal has been looked after. It is not more than 300 to 350 yards in length. Below this to the end of the section, the canal will run very close to the Hindar, and will for the most part be cut on the face of a very steep incline, the ground here rising very rapidly from the river. It is at present full of little ravines.

End of the section.

145. The soil of this section from end to end, is, with the exception of a few trifling patches, the dark clay called black cotton soil. The only variations are, from bad to very bad, and much of it is nothing but the worst sort of silt. At some parts the banks will be very high, I must confess that I view the experiment of trying if loose banks without any puddling, of such soil, will stand, especially with slopes of 1 1/2 to 1, with considerable anxiety.

There is no doubt whatever about the slope altering itself, and additional work on this account having to be done, but it may be said that the banks themselves are an experiment, for banks are differently circumstanced, being subjected to the alternate presence and absence of water, whereas perhaps if water be admitted very carefully at first, these canal banks may puddle themselves, and prove perfectly water tight. If such prove to be the case it will be a matter of rejoicing for all, for the expense, should this soil prove suitable, of making an efficient canal would be enormous.

146. This section is the last portion of the Main Canal which has been sanctioned, and I will therefore hasten to conclude this already

overgrown report, by adding a few remarks on some points affecting the canal generally. -

147. This question has occupied the attention of Government a good deal, and, in their order as per margin, the arrangements proposed for the first 112 miles of the canal, more generally approved. An inspection however of the canal, the country and its circumstances, has convinced me, that these arrangements are, or will be, very far from adequate. - In the first 30 miles of the canal, the ground on the right bank is either rocky and unimproved, or, as in the part west of Hurmoor, the villages are small and not cut off from their chief market by the canal, and the only inconvenience they will suffer, is in some cases a difficulty in reaching their fields, a difficulty to be remembered, which, however annoying at first, will constantly diminish, for the cattle will doubtless soon take to swimming across the canal, if a suitable take off and landing, with ramps over the banks, be provided, and this will cost very little. It may be also remarked that many of the culverts in the western sections are lofty, well drained, and at the lower end their floors are flush with the natural ground level. - As the canal however proceeds to the eastward, the country opens out, the traffic in various directions becoming large, the country is crossed by many village roads used by bandits, and forming very tolerable communications for many months in the year. With the best possible arrangements probably one half of these roads will be closed, and it is necessary to consider briefly whether anything like a fair amount of accommodation will be provided by the crossings proposed.

148. Below the 30 mile the bridges are -
1. (probably) at Hurmoor in the 35 mile - this is under discussion. -
 2. Sagor bridge - 45' - down
 3. Enpand - 60' - down
 4. Metasandal culvert - 72' - down
 5. Metasandal - 78' - down
 6. Bridge over nullah flooded by bottom Amint, and not over the canal.
 7. Sundial road bridge - 92' - down
 8. Cumbin and Cuddapatin Road Bridge - 93' - down
 9. Wipaguntah - 112' - down
 10. Dorepand station - 123' - down
 11. Sunalpilly - 139' - down
- The 2nd class crossings are the culverts or under bridges in connection with the locks. These occur in the 6 section only at the locks in the 79, 81, 83, and 85 miles. They will be very fair crossings, for though carts and cattle will have to descend into nullahs, and get up again out of them, there will be room enough, and the approaches can, without much difficulty, be made easy. - The 3rd class crossings, they will be placed

placed at the 31.79, 38.78, 41.8, 52.70, 58.13, 70.31, 83.31, 87.35 m. ch. 95.78, 99.9, 102.47, 115.1, 119.1, 134.1, 134.1, 142.0 m. ca. on 16 furlongs for 116 miles. 54

The design for the boats shows that they are intended to be 20 feet in length and 8 feet wide. The ends are pointed, so that a slugsy or flat point or corresponding shape will be necessary, shallow of ends being placed on them without difficulty. As moreover carts can be put upon them, except at the ends, and as below the 70 mile the canal is comparatively narrow, while above that point the current is considerable, it will be necessary to provide recesses of a depth corresponding with the length of the boats, and the embankments should also be thrown back sufficiently far to admit of ramps of 1 in 12 for carts, and 1 in 6 where only foot passengers or cattle are intended to cross. I would also recommend that a sloped landing should be made on each side of the canal alongside the ferry stations shallow of cattle taking the water without difficulty, for I have no doubt the cattle will very soon learn to cross the canal in this way, and when they do so, much of the loss of time in getting to and from the fields which would occur, even with the best managed ferry boat, will be avoided.

In the part of the canal below the 30 mile, the culverts must be considered as the least efficient crossings, and many of those at present considered as likely to be useful for that purpose, will, I believe, be of no use. They are generally on a very low level, and will be wet and muddy, the outfall channels will in some cases be very long, their size both as regards breadth and height, is too limited, for a bullock gate is often six feet long, and sometimes more, and 8 feet high, leaves, therefore, but a small margin, and a cart laden with straw or cotton it indeed cotton, would not pass through at all, to which they are long and dark, and will in many cases be very wet from leakage. The idea was suggested by the railway culverts, but the circumstances are entirely different, and no rail-way culvert, situated as are most of them, would be used as a crossing at all. -

In connection with this subject, it should also be remembered, that in connection with this subject, what is now a dry country will be irrigated, that ere very long, what is now a dry country will be irrigated, that between all the numerous villages on either side of the line, raised roads will then be an absolute necessity, that if the questions of communications be now taken up thoroughly, the greatest benefit to the traffic may be obtained at the least possible cost, but that, if neglected now, there will be no such opportunity again

again, and I would suggest therefore, that the Range Officers of the Department of Public Works should, in communication with the divisional officers of the Company, prepare a scheme of village roads, adapting the arrangements so as to make the most of such of the masonry works, whether over or under bridges, now about to be built, as may be possible, and then settling what further provisions will be necessary. The Collectors of the several districts would then be able to understand, what is proposed and to ascertain whether the several villages would be enabled without unnecessary difficulty, to carry on their agriculture and transport their produce. At present were the Government to require all the different means of carrying to be doubled, and were the Company's Officers to agree at once thereto, there would be no certainty that the communications would be available for the use of the people for whose benefit they were constructed. I am quite convinced that the arrangements proposed at present are inadequate, but I think, that no proper opinion can be formed, without maps showing all the villages within the intended areas of irrigation, and exhibiting the connections of the several villages with each other, and with the canal and existing made roads. The schemes for roads which have been prepared in the several districts under the orders of Government, would form a basis, in detail, there is no time for delay, and each section, commencing, I would suggest, with the 3rd, might be disposed of to a great extent separately and successively, in the Cuddapah, and Bellary Districts there will be more leisure. Probably the villages, within 2 or 3 miles of the canal on either side, would determine the arrangement and position of all the roads crossing the canal and the connection of these villages with those more remote, might be taken up, after this first point had been determined.

157. While passing through the several divisions, it has struck me that much good would result, were the Chief Engineer to take measures for ascertaining the relative cost of work in the several sections of the canal. I have remarked a great difference in rates for similar work, not only in different divisions, but in the different sections of the same division, and were the experience gained in one locality made available for works elsewhere, very great benefit would be the consequence. - In some parts of the canal, work of each description is being done, both well and cheaply, in other parts, the reverse is the case, and what is required is to approximate the cost everywhere to that which is good and sufficient, where the best management prevails.

158. It has been stated that some buildings, though in the first instance made for office and other accommodation, are intended afterwards

Position of station afterwards

Precautions required in making excavations.

Necessity for carrying out irrigation details without delay

afterwards as traffic stations, and if so they should be placed close to the canal in such a position as will be most convenient for the traffic. This would be, I think, on the opposite side to the towing path, and just so far removed from the canal as to allow of a loading basin being formed. In the Kundar Division the buildings are tolerably near the canal but in the other divisions they are much too far away and at Romanassery they are half a mile distant. The goods have to be taken out of carts, weighed and loaded, and these operations require the station to be situated like a railway station.

151. It would be well were the Chief Engineer to impress upon all his Executive Officers the necessity for precautionary measures in making deep excavations. I have noticed cuttings for masonry works several yards deep with perpendicular sides, and the spoil placed close to the edge of the cutting. Many slips occurred during the recent rains, and one accident occurred, though fortunately without serious results.

152. The expenditure up to the 30th April last on the Loombudra project, was about 42 lacs of rupees, and as yet the returns have been nothing. The first 30 miles of the canal were necessarily very expensive, and up to the end of the 3rd section or 45th mile, the whole possible irrigable area is but 10,000 acres. Up to the Metacondal cut however, this area becomes increased to 50,000 acres, and below that the extent of land is very large. The importance of getting land under irrigation is so great, that I would bring this point prominently forward, with a view to attention being given, during the current year, to the completion, as far as is necessary for irrigation purposes, of the first 78 miles of the canal, and to the pushing forward the distribution works. The irrigation canal ends at the end of the 78 mile, below that, the canal down to the Canler 91 mile is one of navigation only. At present, besides the construction of a few sluices, nothing has been done towards getting ready for irrigation, and yet undoubtedly much has to be done before any area worth mentioning can be watered. - If every greater extent be accorded, the main canal may be opened to the end of the 78 mile by May 1865, and sufficient water for all the possible irrigation carried, but it will be useless to expect results from the utilization of the water, concurrently, the distribution works be not advanced. In a letter dated the 10th February last, the Chief Engineer appeared to think, that water could be carried to the Kundar valley, i.e. to below the 78 mile, by the present July, but he must have been quite unaware of the state of progress of the works on the main canal, especially in the 2nd section, where in the 20th mile, within 2 miles of the Central Office, the backward slope of the cutting presented an insuperable barrier, and below

again, and I would suggest therefore, that the Range Officers of the Department of Public Works should, in communication with the divisional officers of the Company, prepare a scheme of village roads, adapting the arrangements so as to make the most of such of the masonry works, whether over or under bridges, now about to be built, as may be possible, and then settling what further provisions will be necessary. The Collectors of the several districts would then be able to understand, what is proposed and to ascertain whether the several villages would be enabled without unnecessary difficulty, to carry on their agriculture and to transport their produce. At present were the Government to require all the different means of carrying to be doubled, and were the Company's Officers to agree at once thereto, there would be no certainty that the communications would be available for the use of the people for whose benefit they were constructed. I am quite convinced that the arrangements proposed at present are inadequate, but I think, that no proper opinion can be formed, without maps showing all the villages within the intended areas of irrigation, and exhibiting the connections of the several villages with each other, and with the canal and existing made roads. The schemes for roads which have been prepared in the several districts under the orders of Government, would form a basis, in detail, there is no time for delay, and each section, commencing, I would suggest, with the 3rd, might be disposed of to a great extent separately and successively, in the Cuddapah, and Bellary Districts there will be more leisure. Probably the villages within 2 or 3 miles of the canal on either side would determine the arrangement and position of all the roads crossing the canal and the connection of these villages with those more remote, might be taken up, after this first point had been determined.

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afterwards as traffic stations, and if so they should be placed close to the canal in such a position as will be most convenient for the traffic. This would be, I think, on the opposite side to the towing path, and just so far removed from the canal as to allow of a loading basin being formed. In the Kundar Division the buildings are tolerably near the canal but in the other divisions they are much too far away and at Romanassey they are half a mile distant. The goods have to be taken out of carts, weighed and loaded, and these operations require the station to be situated like a railway station.

151. It would be well were the Chief Engineer to impress upon all his Executive Officers the necessity for precautionary measures in making deep excavations. I have noticed cuttings for masonry works several yards deep with perpendicular sides, and the spoil placed close to the edge of the cutting. Many slips occurred during the recent rains, and one accident occurred, though fortunately without serious results.

152. The expenditure up to the 30th April last on the Loom Buddha project, was about 42 lacs of rupees, and as yet the returns have been nothing. The first 30 miles of the canal were necessarily very expensive, and up to the end of the 3rd section or 45th mile, the whole possible irrigable area is but 10,000 acres. Up to the Metacondal cut however, this area becomes increased to 50,000 acres, and below that the extent of land is very large. The importance of getting land under irrigation is so great, that I would bring this point prominently forward, with a view to attention being given, during the current year, to the completion, as far as is necessary for irrigation purposes, of the first 78 miles of the canal, and to the pushing forward the distribution works. The irrigation canal ends at the end of the 78 mile, below that, the canal down to the Canter 91 mile is one of navigation only. At present, besides the construction of a few sluices, nothing has been done towards getting ready for irrigation, and yet undoubtedly much has to be done before any area worth mentioning can be watered. - If every greater extent be made, the main canal may be opened to the end of the 78 mile by May 1865, and sufficient water for all the possible irrigation carried, but it will be useless to expect results from the utilization of the water, concurrently, the distribution works be not advanced. In a letter dated the 10th February last, the Chief Engineer appeared to think, that water could be carried to the Kundar valley i.e. to below the 78 mile by the present July, but he must have been quite unaware of the state of progress of the works on the main canal, especially in the 2nd section, where in the 20th mile, within 2 miles of the Central Office, the backward slope of the cutting presented an insuperable barrier, and below

...of the bed of the canal, and in relation with regard to
navigation, it is only by fully recognizing the work to be got through and
taking adequate steps to get such work done, that the anticipations
of success can be realized. I hope that it will be possible this time
next year to report that much has been accomplished, and I have
written strongly on this subject, because there is no chance of re-
sults anticipating the work, on which alone those results depend,
and that work has not yet been commenced.

153. I have not yet received from any of the divisions the informa-
tion asked for, to enable me to report on this subject. A separate ^{information not yet}
report therefore with the illustrative sketch map ^{received regarding expenditure} required, will ^{and cost of work as compared}
be submitted as soon as possible. -

I have the honor to be,
Sir,
Your most obedient servant,
Wm. J. G. Jones, Captain, R.E.
Long Engineer & Co. Company.

No. 30
 " 15" Sept
 " 29" April 186
 " 27" May
 " 27" June

This is a clear and distinct
 and the suggestions made by the
 should be adopted

and orders of the
 submitted for the information

Messrs Messrs Messrs
 Messrs Messrs Messrs

11, 7 1864 Dept
 No. 40
 No. of Govt. for
 From
 The Engineer for C. C.
 The Secretary to Government
 D. P. Wode.

Dated 2nd
 Recd 19
 Recd 22
 July 1864

Recd 1896
 Recd 24/7/18
 No. 21382 24th Aug 1864

Report on the Sunkasala
 Anicut and Head Works, and
 on the 1st to 8th sections of the
 Main Canal for the
 Inspected between the 30th
 May and 30th June 1864.

For B. C.

Copy in a letter to England
 Dated 9th Sept 1864 No. 50.

No. 500

c. 265 2nd 1864 2nd 2nd

Public Works Department
 No. 2138
 Proceedings of the Madras Government
 Under date the 21st August 1864
 Read the following

From the Engineer I. C. Company
 Report on the Sunkasala Anicut
 and Head Works, and on the 1st to
 8th sections of the Main Canal
 Inspected between
 the 30th May and 30th June 1864.

H. E. 2nd July 1864 No. 40

The Government
 has perused the
 foregoing report on the
 state of the Sunkasala
 and Canal Company's
 works with much
 interest. It is a
 clear and ~~and~~ ^{well} ~~document~~
 document, and will
 be communicated
 to the Co's Agent, with
 a request that the
 suggestions made
 by Capt. Mullins
 may be adopted.
 The Agent's
 attention

JP

attention will be
specially drawn to
the suggestions in
paragraphs 4, 5, 7, 9,
10, 13, 15, 26, 27, (re-
ments to interior slope
of canal and on ex-
terior of bank) 35, (Ra-
jabagh Aqueduct) 51,
(Ullur Aqueduct) 63,
65, 68, 78, 84, 90, (re-
ments) 91, 100, 101,
104, 105, (irrigation
sluices, ferries and
width of channel) 106,
119, 125, 148 to 153,
and to the omission
in many instances
to provide rear aprons
to Calingulaho. ~~Sup-~~
~~plementary~~ ~~Estimates~~
should be submitted
if necessary, to
supply this omission.
The Agent will
also be requested to

58
cause the investigation
proposed in para 90,
in connection with
the discharge of irri-
gation waters into the
Canalee, to be made,
reporting the result
to Sub. Insp. the Cons.
Engineer.
4. The report shows
that the number of
crossings to be pro-
vided for the accom-
modation of the ^{villagers} ~~people~~
will not be sufficient,
and concerning in
the views on this
subject expressed
by the Cons. Engr. in
paras 148 & 149, the
Govt. directs the
adoption of the
suggestion that the
Range Officers of the
D.P.M. should, in com-
munication with Divisional
Officers of the Compy,
prepare a scheme of
village roads, adapting
the arrangements to
the

The masonry works in
 progress, or about to
 be built, and settling
 what further provision
 will be necessary.
 5. The Supy. Engrs
 of the 2^d & 3^d Divs will
 be furnished with
 copies of the foregoing
 report, in view of their
 issuing the ~~necessary~~ ^{requisite}
 orders to the Range
 Officers concerned. &
~~Capt. Mullins will~~
~~communicate to the~~
~~former Officers any~~
~~further instructions~~
~~which may be~~
~~necessary.~~

6. The report will
 also be communicated
 thro' the Rev. St. to
 the Collectors of Har-
 not, Cuddalore &
 Bellary.

It should also be sent
 home at an early date
 with the baggage
 on our march
 beyond Coimbatore

To The Commanding Engr I & C of
 Agum
 5 Supy Engrs 2^d Div
 3^d Div
 21 Rev St 49

25th August

...of the bed of the canal, in early with regards to
navigation, it is only by fully recognizing the work to be got through and
taking adequate steps to get the work done, that the anticipations
of results can be realized. I hope that it will be possible this time
next year to report that much has been accomplished, and I have
written strongly on this subject, because there is no chance of re-
sults anticipating the work, on which alone those results depend,
and that work has not yet been commenced.

153. I have not yet received from any of the divisions the information not yet
asked for, favorable me to report on this subject. A separate ^{received regarding expenditure}
report therefore with the illustrative sketch map ^{and cost of works as compared} required, will ^{with estimated cost}
be submitted as soon as possible.

I have the honor to be,
Sir,
Your most obedient servant,
Wm. J. Mullins Captain, R. E.
Engineer St. C. Company.

revelment required, a very expensive work, and while at the
trends the breadth of land submerged will be small, in the
middle the water though not deep will spread out for
about $1\frac{1}{2}$ miles. By carrying the line more to the south
from Malayala, the height of the banks might have been
reduced at least 4 feet. Their present average is about
24 feet, and the sectional area 120 square yards. The
reduced area of one bank on the higher level, would have
been about 50 square yards. In the low part in the middle
this would however have been increased considerably, and
perhaps the saving in height there would not have exceeded
3 or 4 feet. On the whole therefore the double banks ar-
rangement on the higher ground would probably have
taken 10 to 20 per cent more earth, and there would have
been the necessity for a culvert of considerable dimensions.
On the other hand the calingalah might have been dispensed
with, or its dimensions much curtailed. The two scouring sluices
would not have been needed for any purpose, and the revelment
might have been not only less in height, but of a much lighter
description. Much valuable land would have been saved from
submergence, and ^{this} part of the canal would have been far safer.
The extra length of line would perhaps have been $\frac{1}{4}$ of a mile.
The advantages as regards water storage by the bank arrangement
are here almost nominal, and the extra cost if any, of regular
canal would have been so small, that, I think, it is much to be
regretted that the original arrangement was not revised. It
is too late now to do anything more than make the present em-
bankment secure.

50. 43rd mile. - The cutting, which commenced a little above the
calingalah, is continued for 3 or 4 hundred yards into this mile. A gap
for an irrigating sluice has been left about the middle of the mile.
The earthwork of the embankment has been completed,
slopes sufficient, soil at upper part of mile decomposed
clay, and at the lower part line and clay. The mile and
the division end at the Nagabore bank bund, which has been
cut into a gap, as to render a breach into the canal probable,
this is not wanted while gaps for sluices remain
unfilled.

Summary of the 3rd Section Main Canal
3rd Section Main Canal
3rd Section Main Canal
Embankments and
excavations -

Embankments to interior
slopes -

61. With the exception of the embankments in the 3rd section
mile, on the new line near Ullur, nearly all the earthworks
are in an advanced state, and the time required for their
completion will not be long. Near Ullur also there is
nothing to prevent their being finished within 6 months.
These have made good progress on the whole. A large extent
of this description of work remains to be done in the 3rd, 3⁴th,
and 35th/₃ miles, and also in the 41st, 42nd, and 43rd miles.
The revelments executed are in all respects very satisfactory,
except in the matter of cost. As regards this too it is only
right to repeat that all the work recently commenced, com-
pleted for, is a help for the quantity and style of the work. The
error, where there has been any, is in the provision of an un-
necessarily substantial protection. In other sections of the
canal the work done has often been paid for at far too high
a rate, here the contractors have done good work for the money,
and I have dwelt somewhat particularly upon the point,
because, when estimates have been so greatly exceeded in all
directions, it is absolutely necessary that all practicable
economy should be exercised. The calingalahs, the rear aprons, executed, are generally either
completed or likely to be so within a few months. This neces-
sary that the rear aprons, where not already provided for in
the estimates, should be included in supplemental estimates,
and carried out at an early date. The failure of these works
would be a great misfortune, and the loss would be very great,
were the supply to be stopped pending restorations.
The walls in view of embankments are much behind hand,
and it will be well to push forward their construction as
far as may be practicable.
There is only one culvert, which will be completed very
shortly. The Ullur aqueduct will probably be completed
by a wall and a bridge - these works will rarely be completed
before the next irrigation season.
The irrigation sluices are much behind hand, and it is a pity
that they were not built at an earlier date, because the gaps
in the embankments will now be filled in after the earthwork
on either side has settled, and where the soil is bad, these places
will at all events for one season, be weak points.

62. I have not even one rammer on the works, from
one end of the division to another. In the case of
the reventments the omission of tamping is one of
much importance, as has been already noticed in a
former part of this report. I hope this point will
receive due attention for the future and that care
will be taken to select soil for the backing of the
reventments, where this can be done without much
extra expense.

63. The works of the first and third sections may
very well be completed within a year, and two years
will be required to finish the second section, but by
the 1st May 1865, the canal throughout ought to be
able to carry at least 5 feet of water.

64. 44th mile. - The bank along, and immediately
below, the Nagatore Tank, should be completed at once,
as it is not safe in its present state. A gap for an
irrigation sluice has been left here. Since the im-
bankment has been very nearly completed, including
the extra 1/2 allowed for settlement, up to the end
of the mile. Reventment not commenced - soil not very
good - a decomposed slate for the most part.

65. 45th mile. At the beginning of this mile, a cul-
vert of 3 feet span has been completed. The double
banked canal commences just above this point.
The masonry work of the bridge of three arches, each
arch 32 feet span, side arches 30 feet each, is complete,
the approaches have hardly been commenced, and the
embankments immediately above and below bridge
are incomplete.

Two irrigation sluices have been completed.
An under-tunnel of 8 feet span has been finished.
It is on too low a level for a crossing.

Probable date of
completion of the
whole of the works
up to the 43rd mile
inclusive.

Nagatore Division
Main Canal. at bridge
44 to 60 miles

Nagatore Bridge

Just

Just below this the embankments are very soft, and will
be some time before they become properly consolidated.
66. 46th and 47th miles. - Cutting is for the most part
behind hand, and the right embankment is in parts
hardly commenced. The soil improves in these miles.
Two irrigation sluices have been completed in the 46th
mile. The 1st calingulah in this division, is in the 47th
mile. The masonry work is finished: there is no
rear apron, though the overfall is 6 feet. Stone good-
workmanship not as good as on the similar works
in the Hindry Division. There is an under-sluice of
5 feet in the centre of this calingulah - About 800
yards below the calingulah an under-tunnel of one yard
span has its side walls finished - arch not commenced.
The excavation up to this point is very incomplete.
The left bank below the under-tunnel is much out of
line - this was unintentional. About 200 yards of
reventment done at this point, rate 7 annas per cubic
yard - the courses are laid horizontally instead of at
right angles to the slope, and this is the case through-
out the division, wherever work of this sort has been
commenced.

67. 48th and 49th miles. - The double bank ends imme-
diately below the under-tunnel just noticed, and a
single bank is carried across a narrow valley. A
small tank will be formed. The land submerged will
be neither extensive nor valuable, but I doubt whether
any considerable saving will be effected by the
arrangement.

At the lower side of the valley, excavations for a cul-
vert of 8 feet have been completed: no masonry
work commenced - from this point the double banks
recommence. For the first half mile below culvert
the cutting and embanking are only just commenced.

for the next half mile about half this work is finished.
In the 49th mile, excavations for a culvert of 8 feet span
have been made, construction not commenced. Care will
be necessary in letting down the drainage into the tunnel,
as the soil is easily washed away, and both to prevent
damage to the lands by the formation of gullies, and to the
rear of the embankments by a channel, it will be dispe-
sible to build a semi-circular rubble masonry wall
around the entrance. Up to the end of the mile, the earth-
works are more than half done.

68. 50th mile. Up to the 3 feet culvert the earthworks
are more than half done. Excavations ready for culvert,
masonry not commenced. The soil in this part is very
bad black cotton. Thence, up to the end of the double
banks, the earthworks are more than half finished.
Soil has cutting averages one yard in depth. Thence a
single bank crosses the valley, and up to the end of the
mile, a good deal of earthwork has to be done to com-
plete. A small piece of slate stone revetment has
been done - rate six annas.

69. 51st mile. - The single bank is continued, and just
below the drainage nullah, a so-called sluice, consisting
of two walls 10 feet apart at bottom, has been com-
menced. The space between these walls is to be
filled in with earth, and I am informed that the object
with which they have been built, is to enable the
bank to be breached with safety, if necessary. The
work will entail extra care in the earthwork, and even
then there will be some additional risk of leakage
at the junction of earth and masonry. - For one half
of the single bank below the sluice, a great deal
more earth is required. - beyond this the earthwork
is nearly finished, and red soil supercedes the black
cotton. The revetments are not commenced. The
70. 52nd mile. - A small length of revetment has
been commenced; it is well done - rate six annas. The

13
bank ends, and at recommencement of double banks, the prepar-
ations for a culvert are ready - masonry work not commenced.
Thence up to the calingulah No. 2, which is on the same plan
as No. 1, the soil is good, and the cutting, averaging 4 feet in
depth, is rather more than half done. The calingulah, with
the exception of the under-sluices of 5 feet, and a part
of the keeking which are under construction, is completed.
The overfall will be about 4 feet, and a rear apron is re-
quired up to the end of the mile - the cutting is nearly
finished to half width.

71. 53rd mile. Cutting diminishes in depth, and is nearly
completed to full width. Soil for banks short, and
the additional required is being brought by train from the
deeper cutting. The double banks terminate just below
the village of Puggol, and there a culvert of 6 feet span with
provision for the drainage. Thence to the end of the mile, a
single bank, part of which is on the bank of an old tank, has
been completed, and the revetment is just commenced.
The embankment will average 20 feet in height.

72. 54th mile. - In this there is to be another sluice, or wall
of the same dimensions and description as that in
the 51st mile - one side has been commenced and is now 14
feet high, the full height being 32 feet. average height of
bank in this mile 20 feet. 2/3rd of earthwork done up to the
sluice, and 1/3rd below that point. - Revetment not commenced.

73. 55th to 57th miles. - In the upper part of the 55th mile the
embankment is behind hand, and a very large amount of
earthwork is required to complete, in the latter half of
the mile, earthwork nearly finished. - Revetment not
commenced - only the first few yards of the 56th mile with
require re-setting. The earthwork of this mile in an ad-
vanced state, Calingulah No. 3, is 200 yards in length,
and on the same plan as Nos. 1 and 2. The body will be
about 7 feet in height above ground, and a substantial
rear apron will be required, this now a little short of the
full height, and the superstructure remains to be built,
and sluices not commenced - an irrigation sluice is to be

be built at the end of this mile. In the 59th mile the earthwork has been about $\frac{3}{4}$ done in the rough.

58th mile. In the first half of this mile the earthwork is all but finished. A small piece of revetment has been commenced with brown slate, quarried close by, but it has turned out indifferently, and it has broken up on exposure, so that a better material will be sought for for the rest of this work. There are a few gaps in the embankment, but most of the earthwork to end of mile, is well advanced. A lime or wall rent has been ordered near the lower end of the mile, it is not yet commenced.

59th mile. For the first 32 chains the embankment is almost finished. at 34 chains the double embankments recommence, and a culvert of 8 ft span is to be built, the excavations for which are ready, but the construction not commenced. Below the culvert up to calingulah the excavations and banks have not commenced. Below the calingulah the earthwork is about $\frac{1}{6}$ done. The calingulah excavations have been made, the masonry work has not been commenced.

60th mile. Up to the site of the Inpad Bridge, about $\frac{1}{4}$ of the earthwork done. Materials for the bridge under preparation. Construction not commenced. A short distance below bridge site, a six feet culvert is to be built. This not yet commenced. Earthwork at this point only just commenced, and for some distance ground has not been broken.

77. The earthworks present no difficulties, and the time of their completion is dependent upon the labor obtainable. They are in very many miles in a backward state and much work remains to be done before any water can be passed down the canal. It is of importance that the very heavy embankments in the 50th to 59th miles, should be completed as soon as possible. The banks are all open at present, and as gaps filled in after the banks have been completed, and settled, are less stable than would be the case, were the earthwork completed continuously. Care will have to be taken to prevent accidents. Out of the 17 miles in this division, about one half the canal

Summary of the
Nagatone Division
being the 4th section of
Main Canal.
1st Excavations and
Embankments.

2nd Revetments to
interior slopes.

improving earthwork.

3rd Masonry works.

is double banded. The canal has been well laid out in the double banded parts. Nada lines for the single banded portion been laid out somewhat higher up the sloping ground, about half the water spread would have been got rid of, and the length of the bank from 52 $\frac{1}{4}$ to 59 $\frac{1}{4}$ would not have been increased by more than about $\frac{1}{16}$ of the present length. There would have been one rather deep cutting, but great saving in embankments and revetment.

The amount of work done, compared with that to be done, is so small, that these must be considered as just commenced. They will require to be pushed on very vigorously, if it be desired that anything like a fair supply should be sent down the canal next year. In the banks, on the average, about 2 yards in height have to be built to reach level of canal bed, and 2 yards above that to admit of $\frac{1}{2}$ yards of water being passed down, and there being some 8 miles of bank or single embankment, the work up to that height alone, will require over 50,000 cubic yards of stone, while, as the level of the water in the tanks is liable to be increased by land drainage, it would require an addition of 10 or 12 thousand cubic yards, to make these banks quite safe. The rates of the portions of work done, are not very high, and care should be taken that they be not allowed to become excessive, and also that where the water spread is not large, and regular stone is not to be had close at hand, the best perfect protection of shingling be given on a somewhat flatter slope.

The use of rammers to consolidate the earthwork immediately in rear of revetments is equally necessary in this division. Stone have been used at present, and no more revetment should be put up without first ramming the earth. Backing of the best soil obtainable, such as lime running gravel, or red soil should be given where the soil of the embankments is black cotton, or otherwise inferior and easily soluble.

There will be two bridges for this division, one at Nagatone which is finished, the approaches completed, and the other opposite Inpad, the construction of which has not yet been commenced.

The number of culverts will be 10, and taking the sizes of those completed into consideration, not more than $\frac{1}{4}$ of the under-drainage has been completed. The rate, Rupees 2-2-0, for the walls is reasonable, and the work is sufficiently good. - None of the culverts in this part of the canal will make crossings, which can be considered as providing for the wants of the villagers. The tunnels are dark and on a low level, and some, as No 2 for instance, will always be wet. Those of 3 feet span are not intended to be used. In the Hindry Division, where the lower end of the flooring is generally on a level with the ground, the case was different. Of the 10 irrigation sluices provided for, 5 have been completed, and the others have been commenced. - The number allowed appears to be less than is desirable. -

Depth of water and
fall.

1. Romanasay Division
1 section - 61 7/2 miles

790 63rd mile. Up strike of Cerapipila Agueduct one bank, the left one, is about $\frac{3}{4}$ ²⁰⁰ done, the other not yet commenced. Agueduct 3 arches of 25 feet not commenced. Below the nullah, the left embankment is nearly finished, the right not

The position of the banks is such that the sectional area above ground

ground level, added to that of the canal in cutting, gives the required waterway. The cutting is placed near the left bank for convenience of towing, and to obtain sufficient soil for the right bank; pits are dug in the broad bottom between them and the canal. It would have been an improved arrangement, had the banks been placed rather closer together, and the cutting of the canal proper increased sufficiently to provide the soil required, as thus the navigation would have been improved, and the excavations would have answered the double purpose. This of small consequence where the cutting is shallow, but elsewhere, when the water is low, the width for navigation will be more restricted than was necessary. Earthwork of latter part of mile $\frac{1}{10}$ done. The excavation for an $\odot$ culvert has just been commenced.

84. 68th mile. Irrigation sluice No. 3 is at the $\frac{1}{10}$ mile, rubble masonry rough, a crack of no great importance in the face wall. The excavation and banks of the latter part of the mile require a good deal of levelling and sectioning - and at some places ground has not yet been broken. There is some laterite boulder of a hard description to be got about towards end of mile.

85. 69th mile. Up to the $\odot$ culvert in the middle of the mile the earthwork is incomplete all along, but the greater part of the work is done. The culvert was built 2 years ago, and looks sound, and is said to be water-tight, but, as the banks have not been connected with it, a full trial has not been made. Thence up to sluice No. 4 a small one, the greater part of the earthwork has been done, but no part is finished. Most of this work was done nearly 2 years ago. Just below sluice the cutting through the ridge, on which the canal / Punalpau is situated, commences. The greater part done.

86. 70th mile. The canal runs south of the village, the greatest depth of the cutting is 9 feet. About the half mile a set of scouring sluices of 3 feet - is $\frac{3}{4}$ completed. Stone and work of fine good. The rate for cut stone is 7-2. The wings are rough rubble in human rate Rupers 7-2. Near a few more allowed, but one will be absolutely necessary. At end of this mile a small irrigation sluice completed and earthwork finished.

87. 71st mile. Up

87. 71st mile. Up to culvert excavation and earthwork nearly finished. In parts the same cross section of the canal, as that mentioned in the 67th mile, has been adopted. The culvert side walls are up to the level of springing, work stopped by water from the sluice. Up to the end of the mile the canal is in cutting all along, and the earthwork is finished all like little cutting on the banks.

88. 72nd mile. The Mabacondal Cut may be considered done in the previous mile, and this continues throughout this mile. The greater part of the work has been completed in a very satisfactory manner, and it was undoubtedly a work of some difficulty. At the deepest part is a bridge of 2 arches of 30 feet span, which has been finished, and is open for traffic. The piers and abutments are of cut stone, as also the arch facing, the rest of the work is the rubble stone cutting, and this is not good enough to stand exposure without plastering, so that the upper part of the arches and soffits of the arches are plastered. At the bridge, and a few feet above and below, a considerable mass of stone has been cleared out, and the cut is some feet short of its full width throughout - 200 yards from the lower end of the mile, the calingulah hadice large the greater part of the water into the Canter will be built, and below this point the width of the canal is reduced from 70 to 40 feet.

Notes for discharging about 300000 cu ft of water per hour into the Canter

89. From the calingulah just referred to and the working plan of which has not yet been drawn out, a channel about $\frac{1}{2}$ mile in length, 500 feet wide, and intended to run 2 feet deep, will conduct nearly all the irrigation water into the Canter, a tributary of the Mundav. The banks of this channel have just been commenced. The fall of the ground to the Canter is 3 1/2 feet, and that of the river itself for the first mile, is said to be about 2 1/2 feet. The surplus channel will join the Canter about $\frac{1}{4}$ mile above the village of Kanatacherla, which stands on the right bank. The land on the right bank of the river, is about 7 feet above its bed, that on the left, is low. The villagers informed me that after heavy falls of rain, the Canter rises to 7 feet, that communication across it is then stopped for a few hours at a time, and that the lands on the left bank are flooded for a considerable distance. The drainage basin of the Canter above Kanatacherla, Mr. St. Cathow told me, is about

No. 11 a double drop will be at about the $\frac{1}{4}$ mile - soil bad all along, and embankments near the locks will be very high, and require much care.

103. 91st mile. - The canal joins the Cawler in this mile. Lock No. 12, a single drop of 10 feet, bringing it down to the required level. A great deal of the earthwork has been done. The part below the lock approaches the river at too great an angle. It would be far better to curve it round for with any current in the river, boats will find considerable difficulty in getting into and out of the canal.

104. - In some of the miles a large part of the earthwork has been done, but generally the formation of the canal has been little more than commencing and the ground is unbroken for nearly half the length of the section. -

Summary of the 6th section - miles 73 to 91 - 1st Excavation & Embankments.

Earthwork of this description has been done. This is intended to reach 2nd Revetments. The banks above the head works in the 73rd mile with stone from the Metacoudal cut, any quantity of which is available. There are many parts of the banks in the section, however, which will have to be revetted sooner or later, and this is the case especially in the last six miles where the soil is very bad, and the lower half of each length between the locks has high banks, which will be seriously injured when water comes to be admitted. - If the upper miles of the section be finished continuously, stone might be brought down at a very small expense by the canal. -

There is only one bridge allowed for this section. This in the 75th mile, and will very soon be finished, as the arches are turned, and the superstructure is in progress. -

3rd Masonry works.

Of the 12 locks Nos. 1, 3 and 7 are actually under construction, the first is completed as far as it can be, without the valves, which are expected shortly, the other two are about one fourth done. Preparations are being made for the other locks, but it is probable that Nos. 8 and 9 will be somewhat modified, and I think a change is desirable, with a view to reduce the height of the embankments, the soil being very bad. Locks Nos. 3, 5, 7 & 8 will have culverts or under bridges attached, which will serve both for drainage and for crossings. The total lockage of the section will be 194 $\frac{1}{2}$ feet in culverts. Two have been completed in the 74th and 75th miles, they would have served as crossings had the headway been sufficient, but as constructed, they are useless for this purpose. There is a bridge, however in the latter mile. Another culvert has been partially built in the 80th mile. The other works of this description included in the estimate, have not been commenced. Two or three additional culverts will probably be found necessary. -

105. 92nd mile. - Works of this sort will only be needed at the 78th mile, below which the canal will not carry irrigation. There

There is a considerable area of land available, and it is of course probable that the sluices should be planned and constructed as early as possible. The irrigation details are, generally, much behind hand, and, even when water becomes available, I am afraid the means of distributing it will be wanting, until a much later date than is advisable, added to which it must not be expected that the villagers will even ask for a supply, until the channels are laid out, and each man can see from exactly what point he will obtain the water for his fields. - This is not like an extension of irrigation in an irrigated country. The people know little about the subject, and are rather disposed to doubt the advantages of irrigation, and therefore every care is requisite to give them timely notice, and to show them that the distribution arrangements will be ready. -

The sluicing sluice at the upper end of the section is about half finished; the head sluice near it has been completed, as far as the estimate allows, but both these works require additions in the way of water wings and rear aprons. -

Probable time of completion.

Ferries.

Present width of channel.

Section 7 of the canal 105. 92nd mile. - The still water navigation canal will terminate 92nd to 114th miles, at the right bank of the Cawler, and this section will, from an ancient stone thrown across that river, take off 100,000 cubic yards of the water turned into it by the surplus works at the lower end of

again, and I would suggest therefore, that the Range Officers of the Department of Public Works should, in communication with the divisional officers of the Company, prepare a scheme of village roads, adapting the arrangements so as to make the most of each of the masonry works, whether over or under bridges, now about to be built, as may be possible, and then settling what further provisions will be necessary. The Collectors of the several districts would then be able to understand, what is proposed, and to ascertain whether the several villages would be enabled without unnecessary difficulty, to carry on their agriculture and transport their produce. At present were the Government to require all the different means of carrying to be doubled, and were the Company's Officers to agree at once thereto, there would be no certainty that the communications would be available for the use of the people for whose benefit they were constructed. I am quite convinced that the arrangements proposed at present are inadequate, but I think, that no proper opinion can be formed, without maps showing all the villages within the intended areas of irrigation, and exhibiting the connections of the several villages with each other, and with the canal and existing made roads. The schemes for roads which have been prepared in the several districts under the orders of Government, would form a basis, in Kurnool, there is no time for delay, and each section, commencing, I would suggest, with the 3rd, might be disposed of to a great extent separately and successively, in the Cuddapah and Bellary Districts there will be more leisure. Probably the villages, within 2 or 3 miles of the canal on either side, would determine the arrangement and position of all the roads crossing the canal, and the connection of these villages with those more remote, might be taken up, after this first point had been determined.

149. While passing through the several divisions, it has struck me that much good would result, were the Chief Engineer to take measures for ascertaining the relative cost of work in the several sections of the canal. I have remarked a great difference in rates for similar work, not only in different divisions, but in the different sections of the same division, and were the experience gained in one locality made available for works elsewhere, very great benefit would be the consequence. - In some parts of the canal, work of each description is being done, both well and cheaply, in other parts, the reverse is the case, and what is required is to appropriate the cost every where to that which is going sufficient, where the best management prevails.

150. It has been stated that some buildings, though in the first instance made for office and store accommodation, are intended afterwards

Economy would result from comparison of rates.

Position of station afterwards

Precautions required in making excavations.

Necessity for carrying out irrigation details without delay

afterwards as traffic stations, and if so they should be placed close to the canal in such a position as will be most convenient for the traffic. This would be, I think, on the opposite side to the main path, and just as far removed from the canal as to allow of a loading basin being formed. In the Kurnool Division the buildings are tolerably near the canal but in the other divisions they are much too far away and at Rowanassery they are half a mile distant. The goods have to be taken out of carts, weighed and loaded, and these operations require the station to be situated like a railway station.

151. It would be well were the Chief Engineer to impress upon all his Executive Officers the necessity for precautionary measures in making deep excavations. I have noticed cuttings for masonry works several yards deep, with perpendicular sides, and the spoil placed close to the edge of the cutting. Many slips occurred during the recent rains, and one accident occurred, though fortunately without serious results.

152. The expenditure up to the 30th April last on the Loom Buddha project, was about 42 lacs of rupees, and as yet the returns have been nothing. The first 30 miles of the canal were necessarily very expensive, and up to the end of the 3rd section or 40th mile, the whole possible irrigable area is but 10,000 acres. Up to the Metacoudal cut however, this area becomes increased to 50,000 acres, and below that the extent of land is very large. The importance of getting land under irrigation is so great, that I would bring this point prominently forward, with a view to attention being given, during the current year, to the completion as far as is necessary for irrigation purposes, of the first 78 miles of the canal, and to the pushing forward the distribution works. - The irrigation canal ends at the end of the 78 mile, below that, the canal down to the Canter 91 mile is one of navigation only. At present, beyond the construction of a few sluices, nothing has been done towards getting ready for irrigation, and yet undoubtedly much has to be done before any area which mentioning can be watered. - If every greater section be used, the main canal may be opened to the end of the 78 mile by May 1865, and sufficient water for all the possible irrigation carried, but it will be useless to expect results from the utilization of the water, if concurrently, the distribution works be not advanced. In a letter dated the 10th February last, the Chief Engineer appeared to think, that water could be carried to the Kurnool valley by the present cut, but he must have been quite unaware of the state of progress of the works on the main canal, especially in the 3rd section, where in the 20th mile, within 2 miles of the Central Office, the backward state of the cutting presents an insuperable barrier, and in lieu of embankments, where in June the walls in several miles were still several feet below

P D 1064 Dept.
Proc of Govt for August
P. 2430.

Proc of the Madras Govt
Of 24th August/64.

Letter from the Commr.
Engg Irrigation and Canal
Company, reporting on the
State of the Company's works,
with orders thereon.

P. 506-507.

c. 19th Aug. 164 or 19th