M.R.O. 14—13,000—27-8-24

MADRAS RECORD OFFICE.

Government of Madras.

Revenue **DEPARTMENT.**

G.O. No. 1588 — Press / ~~Mis.~~

15—26

Dated 1—9- 1864.

Not to be folded or roughly handled

Proceedings of the Madras Government, Revenue Department,
1st September 1864.

No. 15. Read the following Proceedings of the Madras Government in the Public Works Department :—

Communicating the Report on the Sunkasala Anicut and Head Works and on the 1st to 8th Sections of the Main Canal, &c., &c., inspected between the 30th May and 30th June 1864. } (Here enter 24th August 1864, No. 2,438.)

No. 16. ORDER THEREON, 1st September 1864, No. 1,588.

Miscellaneous.

Forwarded to the Board of Revenue for communication to the Collectors of Kurnool, Cuddapah and Nellore.

(True Extract.)

(Signed) C. G. MASTER,
Deputy Secretary to Government.

To the Board of Revenue, with Proceedings Public Works Department, No. 2,438.

Exd. S. T. Augustin.

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 crossings 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.

No. 2,668, dated 15th September 1863, reported in No. 1,540, dated 27th May 1864, paragraph 6.

* 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 Súnkésala.

Súnkésala Anicut.

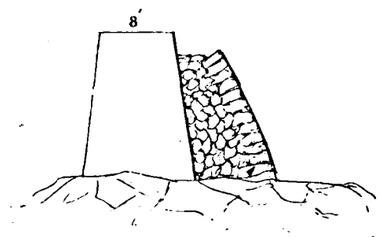
3. Both branches have been completed to their full height, no gaps remain, and that which formerly existed at the north end of the north branch has been closed by altering the line of the extreme end of the Anicut, in the direction of a more favourable ledge of rock, and raising across the deep channel 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-submitted, 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.

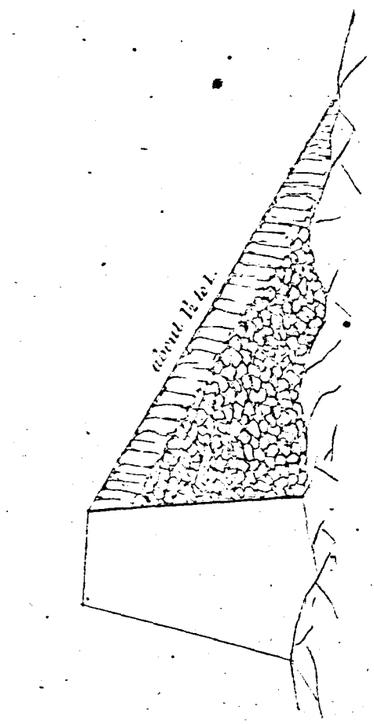
§ See the cost of the very superior work noticed in paragraph 35, viz., Rupees 2¼.

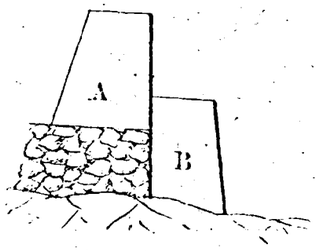


short retaining walls of small height being built a few yards below the work, and there are close at hand great boulders of rock which, if packed as an apron between the Anicut, and such retaining walls, or the contiguous masses of rock, would form a secure apron. It must be added also that it is very 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 rough stone in rear might be removed, and a 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 1863. Proceedings of Government, No. 2,668, 15th September 1863..





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.

Referred to in paragraph 6 of General Ludlow's Report.

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 of the bank 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 diamater 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 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 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 derangments as, without occasioning damage perhaps, would render a shutter useless.

	Rs.
* Original Estimate shows shutters	768
Raising gear	600
	1,368
Supplemental Estimates gives	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.

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 2¼ Rupees per candy* of 12 parahs or three Annas a parah, a very cheap rate. The stone, a laminated lime stone, comes from Kulgúntlah 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 1¾ 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 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.

* Probably of 5 Parahs though stated to be 12.

† Equivalent to 7½ Annas per ton per mile.

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 17¼ 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 Mungalpaud, 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 Mámdialpaud 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 Mámdialpaud 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 Mámdialpaud 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 Mússamasíd 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 Yedarúr 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. I obtained* practical evidence of the correctness of this opinion, in the second section of this division.

* 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 asphalte 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.

* 8th—10th June.

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

29. 18*th mile.*—Between the Aqueduct and the Kúllúr 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 Kúllúr 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. 19*th 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 „ „ 2¾ „ „

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

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 ⅓rd 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 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 Súnkésalah 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 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 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 2¼ 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.

Kadrabagh 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 Gardidimadúgú 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 2½ 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 4½ 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 7½ 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 ¼ 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 6½ feet at base, 2½ at top, out side batter 1 in 12. At 9½ feet from the back of this wall is the outer wall 4 feet at base, 1½ 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.

* Vide cost of that in the 26th mile.

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 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 $\frac{3}{4}$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 $\frac{1}{4}$ 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 $\frac{1}{4}$ 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 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 $\frac{3}{4}$rds 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.

31*st 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.

41. 32*nd 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 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.

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 undoubtedly is a very difficult one. The levels obliged the line to be carried above the narrow 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.

47. Should it not be considered advisable to divert labour to other descriptions of work, it is probable that these will be completed within a year from this date,* but at any rate 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.

June 1864.

2nd.— Revetments to interior slopes of embankments.

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.

The Hindry Aqueduct will probably not be completeted much within two years, 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 ¼th 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 2⅔ 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,

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

and diverges from the line partially worked out originally, in order to avoid submerging* the large extent of land below Ullúr. 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 Ullúr 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

Ullúr Aqueduct.

founded, the expenditure being about 1,100 Rs. The plan provides four arches of 25 feet, the

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 Ullúr 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-sluices 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 Ullúr 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 5½ 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 4½ 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 ⅔rds 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 21 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 ⅔ths 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 Malayála 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 Madigútla 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.

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

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.

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

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 Malayála 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 Malayála, 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 Madigútla. At

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 1¼ 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 ¼th 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. 43*rd 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.

62. With the exception of the embankments in the 35th mile, on the new line near Ullúr, nearly all the earth-works are in an advanced state, and the time required for their 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.

Nagatore Division Main Canal, or 4th Section, 44 to 60 Miles

65. 44*th 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 ¼th 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. 45*th 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. 46*th and* 47*th 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-sluice 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-feet 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 $\frac{3}{4}$ths 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; $\frac{3}{8}$rds of earth-work done up to the sluice and $\frac{3}{8}$ths 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 $\frac{3}{4}$rds 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 $\frac{1}{8}$th 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 $\frac{1}{4}$th 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; 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$\frac{3}{4}$ to 59$\frac{1}{4}$ would not have been increased by more than about $\frac{1}{15}$ of the present length. There would have been one rather deep cutting but great saving in embankments and revetment.

Summary of the Nagatore Division, being the 4th Section of Main Canal.

1st Excavations and embankments.

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 ⅔rds 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 ¼th 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.

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

78. 61*st 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.

79. 62*nd 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 ¼ to ½ done. Soil, brown cotton.

80. 63*rd mile.*—Up to site of Teragopila aqueduct one bank, the left one, is about ⅔rds 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.

81. 64*th 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 ⅛ 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 ⅓ths done.

82. 65*th 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. 66*th 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. 67*th mile.*—An additional culvert at 66th mile and 30th chain is required, as there is a considerable drainge to be provided for. Up to this earth-work ⅓ths 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 ⅞ths done. The excavation for an 8 feet culvert has just been commenced.

85. 68*th mile.*—Irrigation Sluice No. 3 is at the ⅛th 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. 69*th 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) Pumálpaud is situated, commences. The greater part done.

87. 70*th 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 ⅔rds completed. 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. 71*st 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. 72*nd 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 1½ 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 Kundar. 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 ¼ 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.

* For the scouring sluices in the 73rd mile will sometimes discharge all the rest of the canal water into the Caulee.

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 Súnkésala 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 ¾ths 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-sluices 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 ⅔rds 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 30 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 thorough black cotton soil, 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.

Irrigation Channel above 3 drop lock.

93. *79th mile.*—At the beginning of this mile, is the site of a treble 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 limestone and slate. The stone will be used, and is well suited for all the lock, except the quoins, which will be of the dark blue limestone Below this point up to the ¾ mile, about ⅓rd of the Canal has been cut. The upper part is in rock, which quickly, however, is superseded by Cotton soil. At the ¾ 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 ⅔rds finished ; soil bad, black cotton, and some pitching will be needed.

95. *81st mile.*—At the 5 th 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 Valapanúr 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. 88*th 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. 89*th mile.*—Portions of excavation and embankment done down to the 60th chain, the site of No. 10 lock, double, with 20 feet drop.

103. 90*th mile.*—A considerable part of the earth-work done. Lock No. 11, a double drop, will be at about the ¾ mile; soil bad all along, and embankments near the locks will be very high, and require much care.

104. 91*st 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.

105. In some of the miles a large part of the earth-work 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.

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.

Section 7 of the Canal, 92nd to 114th mile, being the 3rd Section of the Bowanassy Division.

106. 92*nd 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. 93*rd mile.*—Very little earth-work done; Bridge No. 2 for the Nundial road not commenced.

108. 94*th mile.*—First half, ground broken, nothing else done. It is doubtful whether the culverts provide sufficient waterway.

109. 95*th 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. 96*th mile.*—Excavations nearly finished, and banks being made up from outside pits.

111. 97*th 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. 98*th mile.*—Throughout, the excavations, which are 4 to 5 feet deep, are nearly finished.

113. 99*th 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. 100*th 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. 101*st 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 ¾ths done, below that cutting complete, and embankments ⅓rd finished. Soil moderately good.

116. 102*nd 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 ⅝ths of mile, bad.

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

119. 105*th 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 limitted, and if any portion of this be lost the completion will be delayed for an additional year. Soil bad.

120. 106*th 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. 107*th 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. 108*th 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 Gungáram, a little below the ¾ mile, does not appear to be provided with any crossing.

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

124. 110*th 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. 111*th*, 112*th and* 113*th 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 Dipagúntla, 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. 114*th 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.

127. About three-eights 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.

Second.—Revetments.

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.

Third.—Masonry works.

The Anicut and head sluice and the foundations of the bridge at Iyalúr 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 head sluice will need a lower flooring and water wings of some description.

The two calingulahs have, as designed, little to do with the sites where they are to be built, additions to provide for an over-fall of 10 feet are necessary, and probably nearly double the quantity of masonry allowed will be required. The culverts generally appeared to me to be likely to prove of sufficient size for the drainages; 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 feet 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 Byap Gudur tank, and the Nundial aqueduct cannot be commenced for six months to come, I do not think that the whole of the works of this section can be finished under two years, and probably this time will be exceeded.

8th Section of the Main Canal, 115th to 146th mile, forming the Kundar Division.

128. 115*th mile.*—The cutting is almost entirely, and the embanking nearly finished. Slate is met with at middle of mile and lime kunkur near the end.

129. 116*th mile.*—First quarter, excavation done to half depth. From ¼ to ¾ but little done. Thence to end of mile earth-work well advanced. At about one-third of the mile the Kotapad and Jillala road crosses. No provision has been made for this. Lock No. 1 will be near the commencement of this mile.

130. 117*th mile.*—First half of the mile, earth-works nearly completed. Lock No. 2 will be just below the ⅝ mile. Latter part of mile, earth-works just commenced. The Yaloor Station building has been completed. Here the Yaloor and Kotapad road crosses, it carries much traffic, and requires a serviceable crossing of some kind.

131. 118*th mile.*—Down to Lock No. 3 the earth-work 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 Rupees 7 for the face work, and Rupees 3 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.

Earth-works to end of mile finished, all but bank dressing. A small drainage cut in rear of banks will be required lower down to drain the pools which would otherwise form behind the bank in this mile.

132. 119*th mile.*—Earth-work nearly finished.

133. 120*th mile.*—Lock No. 4 will be in this mile. No work commenced.

134. 121*st mile.*—For ¾ of the mile, one-third of the earth-work done. Excavation for Lock No. 5 at the 34th chain commenced. Stone being collected; it is brought 3 miles from Worrakandinny; the rates will be affected by carriage.

135. 122*nd mile.*—A little stone collected for Lock No. 6. No work commenced.

136. 123*rd mile.*—Lock No. 7, with Calingulah and the Donapaud bridge will all be close together at about the 25th chain. 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 station building at the head quarters of the division is nearly ready to receive the roof. Walls are of stone in mud.

137. 124*th mile.*—Some stone collected for Lock No. 8. No work done.

138. 125*th mile.*—Earth-work in embankment about two-thirds done, as far as the ⅝ mile, where Lock No. 9 will be, and which has not been commenced. At end of mile road from Donapaud to Kondapuram 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 Donapaud, whereas the station is close to nothing but the Canal. Below lock site earth-work all but finished.

139. 126*th 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. 127*th and* 128*th 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. 129*th*, 130*th and* 131*st 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. 132*nd 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. 133*rd to* 141*st 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 Kundar, 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 Kundar 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 Kundar, 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.

Soil of the section

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 1½ 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.

148. 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 Ullúr in the 35th mile; this is under discussion.
2. Nagatore 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.
9. Dipaguntah do. 112th do.
10. Donapaud station, 123rd 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	or 16 ferries for 116 miles.
38·78	99· 9	
41· 8	102·47	
52·70	115· ?	
58·18	119· ?	
70·21	126· ?	
85·51	134· ?	
87·25	142· 0	

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 Bowanassy 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 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 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. 1,285, 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.

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

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

No. 507. ORDER THEREON, 24th August 1864, No. 2,138.

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 (Kadrabagh 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.)

J. Macdonald

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.

Revenue 1864 No 56
Pro: of Govt for Sept.
No 2280

Proceedings of the Inspr
ras Govt in the Public
Works Departt.

Dated 24th Augt.
Recvd 29th " 1864

No 2438.

Communicating the Report
on the Sankasala Ancient Head
Works & on the 1st 68th Sections of
the Main Canal, &c, &c, inspected
between the 30th May & 30 June
1864 —

No 1588. 1st Sept

Written order Dd

No 1588.

Inspr of Works Revenue for comm-
-unication to the Board of Revenue

and Settlers

Inspr Genl's
1st Sept 1864

re Sections 1st to 68th Coasting Canal

No 1546.