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MADRAS RECORD OFFICE.**Government of Madras.***Public Works* **DEPARTMENT.**

G.O. No.	2591	Press
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132-133		
Dated	7-9-	1864.

Not to be folded or roughly handled

*Proceedings of the Madras Government, Public Works Department,
7th September 1864.*

No. 132. Read the following letter from the Consulting Engineer for Irrigation and Canal Company:—

Reports on the works in the Pennair and Nellore Divisions } (Here enter 5th August 1864, No. 65.)
inspected between the 1st and 20th July 1864.

No. 133. ORDER THEREON, 7th September 1864, No. 2,591.

1. In the foregoing letter the Consulting Engineer continues his interesting report on the works of the Irrigation and Canal Company, noticing the divisions of the Pennair and Nellore. It will be communicated to the Agent, with a view to the suggestions and remarks contained in paragraphs 22, 30, 32, 36, 37, 44 to 1st clause of 50, 51 *et seq.* being transmitted to the Chief Engineer for his consideration.
2. The Collector of Cuddapah will be requested to take steps for the preservation of the Company's marks above and below Dhoor, as suggested in paragraph 9.
3. The correspondence and tracing of the re-arranged section of the Somaiswaram Anicut, referred to in paragraphs 41 and 42, will be returned to the Consulting Engineer.

(True Extract.)

(Signed) J. H. M. SHAW STEWART, Major, R. E.,
Deputy Secretary to Government.

To the Consulting Engineer, Irrigation and Canal Company.

„ Agent for do. do.
„ Collector of Cuddapah.
„ „ of Nellore for information.

Exd. S. T. Augustin.

Pro: 15 May / 63. ²⁵⁸
 " 31 March / 64. ⁸⁸⁹
 " 30 May ——— ⁵⁶⁸⁻⁵⁶⁹
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Copy in a letter to England
 21 9th Sept. 1864 No. 50.

787 V 1864 Depo
 Pro: 15 May / 63. ²⁵⁸
 " 31 March / 64. ⁸⁸⁹
 " 30 May ——— ⁵⁶⁸⁻⁵⁶⁹
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 The Comptroller for the
 The Secy to Govt. D. P. W.

Rates 5th } Aug / 64
 Recd 9 }

Pres. letter in orig. No. 25911
 Encl. No. 1167
 " 1 " " No. 546
 Encl. No. 272
 " 1 Copy of letter to Govt. of 15th May
 " 1 Drawing showing the section
 of the dome of the
 Amiens.

No. 2591- 7th September

Reports on the works in
 the Pennair & Kallur
 inspected between the 1st & 20th
 July / 64.

1. Submitted for the information and
 order of Government.
 2. The report was printed prior to being
 circulated. This will account for the
 state of the original - 2 ceps of the
 printed report is enclosed.
 Wm. Hastings
 28 Aug 64

No. 132

62. Such being the state of the case with regard to this portion of the canal, it will not be necessary at present to transcribe for the information of Government the notes made when going over the part of the original line to the eastward of the point where the high level canal would diverge. I have examined the surveys and levels with the Executive and Assistant Engineers, and as regards details, the direct and contour lines of most of the spurs and valleys have been investigated so as to obtain the best line at a moderate cost. I have seen also the plans of the major works of the 2nd section and the estimates are very nearly ready. —

I am, Sir,
Your most obedient servant,
Wm. Mullins, Captain,
Engineering & Co.

Proceedings of the Madras Government, Public Works Department,
1864.

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 Public Works, dated Madras, 5th August 1864, No. 65:—

SIR,

• Letter No. 40, dated 2nd July 1864.

1. My last report* concluded with the Kúndár Division, and the Pennáir and Nellore Divisions remain to be noticed.

Lower part of section has been revised.

2. According to the sanctioned arrangements the 8th Section terminates at the 146th mile, but, since the Estimates were sanctioned in the Order of Government, No. 1,232 of the 15th May 1863, the lower part of Section 8 from the 139th mile has been re-laid out to the southward of the original line, and, I believe, the Rajoly Anicut across the Kúndár 144th mile and the part of the canal from the 140th mile downwards have been included in the Estimates of the 9th Section, which ends at the Pennáir in the 178th mile.

The Estimates for the 9th Section.

3. These have been completed in the Division, and they were submitted to the Chief Engineer in April last, so that probably they will be ready for the approval of Government within a short time.

The general arrangements.

4. This section of the canal is intended to carry 50,000 cubic yards of water per hour, the depth of water being 5 feet, the width of water surface 70 feet, and the average fall 3 inches per mile. It will draw its supply for the most part from the Rajoly Anicut, which will throw into the canal a further portion of the water turned into the Caulee from the 72nd mile of the canal. I am disposed to think that it is a pity that the depth of water in this section should have been reduced from 6 to 5 feet. The former is little enough for a first class line of navigation, and any falling off from the latter would seriously interfere with the traffic.

Remarks on course of the Canal and the country.

5. The Canal will run for some distance, in close proximity to the Kúndár, and the ground there is much cut up by small ravines; then crossing the water shed between Kúndár and the Vaikalúr, it will run nearly due east to the latter river, and cross it by an aqueduct; then turning south it will run for 6 or 7 miles to Dhoor, passing close to the village on the east side, and then curving to the south-west it will cross the Cuddapah road about a mile south of the village and here a bridge will be built. The soil below the Vaikalúr and the road crossing is very much better, the country is somewhat rough, and there is a good deal of cross drainage but on the whole the ground may be considered favorable.

6. After crossing the Cuddapah road the line runs westwards for a short distance, gets on to a water shed and turning south again runs over cotton soil for several miles in almost a straight line. Again sweeping round to the east it passes half a mile north of the village of Júlpad, and thence south-west and south, over soil varying from bad to very bad, up to a considerable nullah, below which the soil at once changes from black cotton to sandy loam. Half a mile further on, the line of the canal re-crosses the Cuddapah road at the beginning of the 23rd mile† of the road, and a few yards further on it will span the Kodairu,

† From Cuddapah.

a large nullah, by an aqueduct, and half a mile beyond this re-cross the road and take a south-westerly direction, gain the crest of a long gently sloping spur, and then take a southerly and perfectly straight line down to the Pennáir, opposite Adamapilly.

Proposed diversion of Cuddapah road.

7. It is proposed to divert the road in the 22nd and 23rd miles, keeping it entirely east of the canal line, which was selected when the road was in an unimproved state, in order to obtain good foundations for the aqueduct. The road, however, has lately been improved and the

Superintending Engineer, 3rd Division, estimates the cost of the diversion at Rupees 3,600, and I have written to know whether, supposing this to be the cost, the Chief Engineer will prefer changing the line of the canal, which, I think, could be done without any great difficulty, or incurring the expense of the road diversion.

Country favourable for Canal works, but soil bad.

8. The country below Dhoor is favourable for the construction both of the main canal and the irrigation channels, in all respects except the soil, which, like that in the Kúndár Division, is very bad.

Lockspitting, &c., ploughed over.

9. I found considerable difficulty, both above and below Dhoor, in tracing the line of canal at some places, owing to the Ryots having ploughed over the lockspitting and also over the mounds denoting the boundaries of the different classes of land required: this is much to be regretted, and I think the Collector of Cuddapah would not find it difficult to induce the Ryots to respect these marks, although the land has not yet been made over to the Company.

Designs for works in this Section.

10. The works for this section have been carefully designed, and much pains have been taken and with success to obtain a good line for the canal. I looked over the plans when I was in Cuddapah and they appeared generally well suited to the requirements of the canal. The question of communications, as well as the more detailed investigation of this part of the project, will be taken up when the Plans and Estimates are received from the Chief Engineer.

10th Section of the Main Canal.

* Procs. Madras Govt. No. 889, dated 31st March 1864.

11. The Estimates for this section have been already submitted to Government, and their sanction has been postponed* pending the completion of the Estimates, &c., for the remaining sections up to Somaiswaram. The late Consulting Engineer examined the proposed works in detail, and I will therefore simply render this report continuous by noticing the general direction of the canal and the country through which it will run.

Direction of the Canal.

12. After leaving the proposed Anicut across the Pennáir at Adamapilly the canal will take a south-easterly direction for about 5 miles, crossing in the 3rd mile a large nullah by an aqueduct of seven arches of 30 feet span, then curving by a long sweep round a spur it will follow a more southerly course and run over waste land up to the Cuddapah and Kurnool road, under which it will pass very near its junction with that from Bellary; then, skirting the Military Cantonment, it will run to the Booga a little below its junction with the Ralla, then across low ground liable to inundation, through an outlying part of the town of Cuddapah, across the old Kurnool road, over the supplying channel of the Cuddapah tank, and thence in a direction nearly parallel with the Madras road up to the termination of the section in the 189th mile.

Principal dimensions of canal in 10th Section.

13. In this section the surface water width will be 70 feet, the depth 5 feet, the average fall per mile $\frac{1}{10}$ th of a foot; 30,000 cubic yards per hour are to be carried for irrigation.

The nature of the country.

14. The country is on the whole favourable for the construction of a canal, but the masonry works will be costly; and for a canal carrying but a small quantity of water for irrigation Rupees 46,000† a mile are a formidable amount.

† Taken from the Estimate, Rupees 4,81,000 for 10 miles and 28 chains.

Main Canal below the 10th Section.

15. From the 190th mile to the beginning of the 195th the line is continued first eastwards, and then curving round it is taken along the foot of the western slope of the low range of hills called the Guindy spurs, and here the direction is to the west of the north. So far there will be no difficulty.

The Guindy Spurs.

16. There are three sets of these extending from 194½ to 195½th miles. The rock varies much in character, it is nearly, however, all more or less quartzose, and the greater part is either quartzite or hornstone. The most difficult to cut through is the quartzite. The centre line has been carefully marked out with stone in chunam pillars, the greatest depths of rock cutting on the centre line are, in the first spur, 14½ feet, in the second, 19½ feet, and in the third, 39½ feet; these depths extend only for a few feet in length, but they will give some idea of the sort of work to be got through in carrying the canal round. The curves are necessarily very sharp in some cases; one for a short distance will be on a radius of 200 feet, others on a radius of 4 chains or 264 feet; they are unavoidable except at a cost for rock cutting which would be prohibitory.

There are no villages between the spurs, but the villagers have taken advantage of the rich alluvial soil here and there to plant many fine Mangoe trees. At two places, at the end of the 195th mile and middle of 196th small tanks will be formed, but the water-spread will be small, and the space thus given will be advantageous as the canal in the rock cutting will be very confined.

17. From the 196th to the 201st mile the line for the canal runs over comparatively easy ground. It skirts the foot of the hills up to the 198½ mile, then curves round just above the Thacolly tank and past the village, and at 199½ it is proposed to end the double-bank, which will occasion a water-spread of about 300 yards, up to the village of Tárkapully at the beginning of the 201st mile, between which village and Ukagapully the line will run. At 200½ miles it will pass between some detached rocky hills and the main chain, the canal below this being again single-banked with a water-spread of about 150 yards, until near the end of the mile it becomes somewhat wider, but covers for the most part waste land. Between the first and second quarters of the 202nd mile a rocky spur is crossed and just above this at a low rocky fidge the drainage water will be discharged. The line is continued in single bank up to the village of Sentigarpully at the beginning of the 204th mile, and very little cultivated land will be submerged; then for half a mile it will be double-banked, and again the right bank will be discontinued nearly up to the end of the mile, close to the village of Mátapulli. Here there are alternative lines the one, that plotted and scored, to the north of the village and occupying a part of the narrow strip of cultivation between the village and the river, and the other which would do equally well would run through the upper part of the village in 5 to 8 feet cutting. The question for consideration is whether the villagers prefer saving some arable land, having a few houses removed and being on the same side of the canal as their fields, or whether they would rather have the village left intact. The former arrangement would, I should think, be the best for them. Thence the line of the canal is curved towards the hills to avoid, as far as possible, the destruction of valuable, and in these parts very limited, cultivation, and it is again curved out at the ¼ mile to round a rocky spur, whence it is carried by a single bank to the first of the Sidhout spurs, the water-spread averaging about 200 yards, of which about one-half is dry cultivation.

18. Care has been taken all along to preserve as much land as possible for cultivation, and the single bank, where proposed, will not submerge land the value or extent of which would warrant the extra cost of a double bank with the necessary provision of culverts for the numerous small nullahs. This part of the line presents no considerable difficulties; its course is generally good with moderately easy curves.

19. From the 205½ to 206 miles the line crosses by double banks the valley east of the first spur and which has been much covered by drift sand, then crossing a large nullah it comes to the second spur, and thence up to 206½ the line runs with a single bank close to the hills and occupies but a few yards in width of cultivated land, after which it rounds the third spur, and at the end of the mile it passes the fourth and last of these spurs.

Character of the Guindy Spurs.

20. These spurs will not prove very difficult, the first contains some hard rock, but there is a good deal of soft shale intermixed, and it will not be difficult to get out the requisite section.

The second spur is much the same but rather easier, and the deepest cutting will be 16 feet. The third spur is nearly all slate shale, and the deepest cutting 14½ feet, and the fourth spur will, at the deepest, involve nearly 12 feet cutting and the material is a loose shale.

The works planned to the end of 207th mile.

21. Up to this point the works have been planned in detail and the Estimates are under preparation. The arrangements proposed have all been most carefully investigated and both the line and level of the canal at the spurs have been selected after taking very detailed cross sections of the slopes.

Principal dimensions, &c.

22. The difference of level of the bed of canal at end of 10th Section and at end of 207th mile will be 62 feet, which it is intended to overcome by locks as follows:—

		Miles.	
No. 1	at the 189½	10	feet
" 2	" 192	6	"
" 3	" 197½	15	"
" 4	" 201½	20	"
" 5	" 203½	11	"
		62 feet	

The depth of water is to be 5 feet, the width of water surface at that depth 70 feet, except in rock cutting where the width, according to the Chief Engineer's orders, will be 40 feet. The latter width, however, where the curves are in radii of less than 8 or 10 chains will, I am afraid, prove very inconvenient, and I have suggested to the Executive Engineer the advisability of so arranging the outer line of the canal that its future widening to 50 feet may not entail too great an expense, for in some places, were this not attended to, it would be impracticable to widen the canal at all without re-constructing it. This would be not absolutely the case either at the Guindy or Sidhout spurs, though even there the expense might be very great, but lower down where there are scarps, the point is one of very great importance.

23. Mr. Clarkson could not give me any idea of what the estimates would amount to, but as the very difficult places are of limited extent and the rest of the line is tolerably favourable, I do not anticipate that the total for the 18½ miles will compare very unfavorably with the cost of some of the upper sections of the canal.

From 208th mile to Bundalapulli spurs.

24. After leaving the last of the Sidhout spurs the line from the 208th to the 211th miles presents no difficulties. The width of land between the hills and the river gradually expands.

Near Gungapairoor it will cross a low saddle by a cutting about 8 feet deep in shale, and then it will curve northwards to round the Bundalapulli spurs. Here the canal will be double-banked, and just short of the spur a considerable stream will be crossed by an aqueduct.

Bundalapulli spurs.

25. The first spur will not be very difficult. Between it and the second spur there is a narrow strip of land, much of which is rocky. At the second spur for a length of 700 yards there will be rock cutting, some of which is difficult; and at one part a wall will probably be found preferable to cutting out the rock, as the place is favorable for this arrangement. Carrying the canal round these spurs will undoubtedly be costly, but as the length is not very great the average rate per mile for the first 5 or 6 miles of this section will not be very excessive.

From Bundalapulli spurs to Kúmalur spur.

26. Thence for about two miles the line of the canal will run over tolerably easy ground, past the village of Bundalapulli, to a remarkable single spur stretching out far from the main

chain in a northerly direction. To turn this spur would be a very difficult matter for the river sweeps down on to its left flank at a long distance from its salient point, so that a line carried in this direction would have to be cut into the rock for a great length; fortunately however the spur affords two comparatively low saddles. The more northerly one of the two has been levelled, and it has been proposed to tunnel it, but the southern saddle appears much more favorable, as it would shorten the length of the canal greatly, and bring it at once on to better ground on the eastern side. A tunnel would not, I think, be necessary here, and the rock, so far as a surface inspection enabled Mr. Clarkson and myself to judge, is not likely to prove difficult. This alternative line will be investigated in due course.

From the Kúmalur spur.

27. Beyond the spur there are no difficulties for some miles, and the ground will admit of the canal being laid out on any level which may suit best for the upper works. It would probably pass above the Cotapad tank, and above the village of Madawáram, but beyond this point there is at present not sufficient information available to enable an opinion to be formed as to the arrangements which will be found most advisable.

The Cheyár above its junction with the Pennáir.

28. The Cheyár, for the last 5 miles of its course before its junction with the Pennáir, runs between two parallel ranges of hill, but these hills on its left bank extend only so far, and are succeeded by a low saddle across which, it is said that, water finds its way in extreme freshes both of the Pennáir and Cheyár.

The Pennáir immediately above and for some miles below the Cheyár.

29. The hills on the left bank of the Cheyár terminate in what is called the Kulligherry spur, which is by far the most difficult feature of the line up to this point. The first part of the spur is difficult enough, but this is succeeded by a precipice, which could only be turned by a wall built up from the bed of the river, and this may be successfully done, should it be found advisable, for the precipice face stands at an angle from the river and the two ends of the built up portion would be protected by rocky promontories. Below the Cheyár the hills slope down at 1 to 1, and sometimes steeper than this right into the river, and so continue for between 2 or 3 miles, and to cut out a canal in the face of these hills would necessarily be a very expensive work. It is proposed to build an Anicut 20 feet high near Dúngasonni, where the hills on the right bank of the Pennáir recede far enough to allow of a canal being formed, and thus to pond up the water, so as to make the river navigable to as far as the Cheyár, or perhaps to above the Kulligherry spur.

Chief Engineer's proposed line for Canal.

30. I learnt from the Executive Engineer that the Chief Engineer is, at present, of opinion that the best plan would be to avoid the Kulligherry spur, by carrying the line of the canal from Madawáram across the saddle* into the Cheyár, then along the left bank of this river to a little above the large village of Hoblumpett, then across the Cheyár by an Anicut and along its right bank down to the Pennáir. This detour however would increase the length of the canal by some 7 miles, and, supposing the average cost per mile to be only 35,000 Rupees, and the cost of the Cheyár Anicut one lac, there would be an expenditure of nearly 3½ lacs incurred for the sole purpose of avoiding one spur, and most certainly the canal could be carried round the spur on the shorter and better line for half the money. So far then as I could judge after examining the Cheyár valley, I see no reason for preferring so circuitous an arrangement.

* Paragraph 27 above.

Levels required to determine effect of an Anicut at Dúngasonni.

31. The levels at present available, or which the Executive Engineer had in his possession, do not show to what distance a 20 feet Anicut near Dúngasonni would pond the Pennáir, and it is therefore not yet known whether it will be necessary to touch the Kulligherry spur at all, so that it will be necessary to ascertain this point before any conclusions, as to the best arrangements for the canal immediately west of the Cheyár, can be formed.

32. There is another question of much importance in connection with the subject of a lofty Anicut at Dúngasonni, and one which indeed affects every portion of the proposed works below the Pennáir at Adamapilly, and that is from what source is the supply for navigation to be obtained? In the absence of some definite information on this point it is quite impossible to say what arrangements are feasible, and what would, though in all other respects admirable, prove useless for want of a sufficient quantity of water. We have no data to show what the leakage under a 20 feet Anicut would be, but from observations made at several low Anicuts, I am convinced that a very considerable quantity in the Pennáir would be needed to keep the water up to the level of the crest of an Anicut 20 feet high. Much more water would in fact be needed to compensate for such leakage than for the supply of a still-water canal. There will be another cause of leakage. At the point where the regular canal is dropped into the river, and the latter becomes the line of navigation, the minimum depth of water must be 5 feet, and when the river is in high flood or when its waters are heavily laden with silt it will be essential that the under-sluices should be of such capacity as to make the current at bottom powerful enough to prevent the raising of the river bed. To do this probably a length of 80 to 100 yards of under-sluices will be needed, and however well built and fitted with shutters, the leakage with a head of 16 to 20 feet must be great.

Character of the rocks at the Kulligherry spur and Dúngasonni gorge.

33. The material of the rocks of these hills varies very greatly. The hills were probably at the time of their formation subjected to great and also irregular forces, so that the strata are in parts much distorted, the general dip of the strata is however from west to east. By the upheaval of the strata to their present inclined position a thickness of 500 to 600 feet is clearly visible. There are hornstone, quartzite, veins of pure quartz, slate shales of various degrees of hardness and a peculiar looking stone which looks as if it had been over-burnt, and probably it is a burnt slate.

The country below the Dúngasonni gorge.

34. The hills below the proposed site of the Anicut rapidly recede from the river, and the line of the canal will probably curve southwards so as to get away from the river floods, which, between this point and Ogúr, evidently cover a large extent of land in extreme freshes. For about 8 or 9 miles no difficulties present themselves, and at the end of that distance the canal must again be dropped into the Pennáir to get through the Somaiswaram gorge, the hills on the right bank of which would be about as difficult to cut into as those near Dúngasonni. The Somaishweram Anicut will, it is supposed, pond up the river sufficiently far to give a depth of 5 feet of water at the point where a nullah from the south drains into the Pennáir, and here will be the tail-lock of the canal. The under-sluices proposed to be put into the Somaiswaram Anicut, while sufficiently powerful to clear the head sluices of the canals below it, will not, however, be of any material use in keeping down the level of the bed of the river through the gorge, and in what manner a sufficient depth of water to admit of navigation is to be maintained I have not heard.

The north or left bank of the Pennáir.

35. While examining the south side of the river in detail, I took care to notice the character of the opposite side, and my impression is that while a difficulty on the south bank is very often opposed by comparatively easy hills on the north, that side has obstacles, which are nearly, if not quite, as difficult to overcome. Had the idea of carrying the main canal to Cuddapah been abandoned, no doubt a much shorter line on the north side could have been selected, and probably this saving in length, together with the consequent omission of an Anicut across the Pennáir at Adamapilly, would have made the cost of this part of the Canal less by eight or ten lacs than will now be the case.

Effect of wind.

36. When marching through this part of the Cuddapah District, and especially when standing on the rocky spurs which jut out into the river, I was particularly struck with the great

force of the wind. The ordinary westerly winds certainly blow much harder than those in the open country and, as in all mountainous places, the wind comes in heavy gusts, which for a few minutes at a time are really violent. This circumstance will have to be taken into consideration in designing the outer or retaining wall of the canal, where the line is carried round the spurs: for were the water spread much wider than it is, and the curves less sharp, it is certain that boats would be driven frequently against the wall, and as the canal will at these parts be contracted, boats will come very often in contact with these walls, and however much care is taken the force of the blow must be great. Very massive masonry will therefore be required.

Alternative to rock cutting in some places.

37. At parts of some of the spurs the general line of the rock recedes from the river leaving a bay between two projecting points. To carry the line in cutting in such cases would be both expensive and inconvenient, because the amount of solid rock to be removed would be greater, and the curves more frequent and sharper. In such cases it would seem to be advisable to build up a base for the canal, and to do this it is proposed to throw down as much stone as is required, to allow this to settle down into the bed of the river beyond the reach of scour, and to build up on the line of the projecting points of solid rock a massive dry stone revetment to within 2 or 3 feet of the level of the sole of the canal. All the interior to this level would be filled in with rubble stone, and upon this would be constructed a masonry flooring for the canal, an inner water-tight lining and an outer retaining wall. There is, upon the slopes of these hills, any quantity of loose stone of all sizes which can readily and at a small expense be tipped or rolled down, and the rock cutting on either side would supplement this material. By building up all the lower part of the work in dry stone all danger of the action of a head of water resulting from leakage would be avoided; the lower work can be allowed to settle and assume a permanent position and the work would be the cheapest that could be arranged under the circumstances. Where, below the level of the bed of the canal, the rocks project so as to form a base for a retaining wall or revetment, it is also proposed to adopt a similar arrangement and thus reduce the cutting out of the solid to a minimum. I think under skilful management very stable work may thus be obtained, and perhaps it is the only safe alternative plan to a cutting of the full width of the canal.

Probable cost of Canal from the beginning of 10th Section at Adamapilly to Somaiswaram.

38. The Estimates of the 10th Section show that the cost of that portion of the canal, 10 miles in length, will be at the rate of 46,000 Rupees a mile. The probable cost of the remainder of the canal down to Somaiswaram, about 43 miles, cannot of course be accurately stated, and the Executive Engineer of the Division, though he has selected the line and prepared the sections for the rock cutting, could not give me even a rough approximate Estimate, but it may safely be assumed that, looking to the extremely expensive portions, to the necessity for either a lofty Anicut at Dúngasonni or much additional scarping along the face of rocky hills, the average cost of the whole 53 miles will exceed the estimated cost of the first 10 of those miles. If the average then be taken at 50,000 Rupees a mile, the cost of the main canal, exclusive of all expenditure on irrigation distribution, would amount to 26½ lacs of Rupees. The quantity of water to be carried is 30,000 cubic yards per hour, and supposing the whole of this to be available for irrigation, about 20,000 acres could be irrigated, and this area at 4 Rupees an acre would give a gross revenue from irrigation of Rupees 80,000 per annum or just 3 per cent. The net revenue would be considerably below this, as the cost of maintenance, if taken at 2 per cent. only on the cost of construction, would amount to 55,000 Rupees a year. I have not overlooked proceeds from navigation, but it will be advisable to leave these out of consideration for the present, because it is certain that water for the navigation must be obtained from a separate and additional outlay on reservoirs. I am aware also that opinions have been expressed that one cubic yard per acre per hour is enough for rice land, but this is so much below the allowance hitherto made in cases which have come under my notice, that, in the absence of much more accurate information than is at present available, I think the 1½ yards per acre per hour, which have been allowed above

are as little as it would be prudent to consider necessary. Of course this estimate of cost and returns will be considered admissible, as some guide to the formation of an opinion, only until the estimates under preparation have been completed. I have considered in making the supposition of half a lac a mile as the cost, the information that is available for the first 146 miles of the main canal, and as the average of that

* And it will perhaps be much more. portion will not be under* 30,000 Rupees per mile, including supplemental works, it appeared to me that the half lac per mile would not be too much for confessedly the most difficult and expensive part of the whole line.

NELLORE DIVISION.

Somaiswaram Anicut.

39. The construction of the Anicut has made but little progress. Previously to the current working season a line of rubble stone about 4 yards base and 1 yard high was laid along the line of the upper edge of the outer or lower rubble apron right across the river, to ascertain the effect of the freshes. This settled a good deal and was breached in some few places, but along most of the line it is still visible.

Design of the work.

40. It can hardly be said that this has yet been determined. The section originally sanctioned was found to require revision, owing to changes in the bed of the river, and, in making this alteration, the Chief Engineer proposed to construct a wider dam. The late Consulting Engineer considered some additions requisite, and, in transmitting the Estimate to Government, added Rupees 12,993 thereto, to provide for these modifications. This section of the Anicut was sanctioned in Proceedings of the Madras Government, No. 40 of the 6th January 1864.

41. General Ludlow forwarded to the Chief Engineer, through the Agent, a copy of the altered plan and corrected Estimate and received from the Chief Engineer, with the letter as per margin,† the re-arranged section now submitted for the information of Government; General Ludlow's letter No. 45 of the 15th March last, containing his views on the improved section, is also enclosed, and that Officer on the 20th April 1864, No. 48, requested the Chief Engineer to state whether he wished finally to adopt it, and, if so, to forward an Estimate for the sanction of Government.

No. 553, 12th February 1864.

† No 45, 11th March 1864.

42. No Estimate having been received, I wrote to the Chief Engineer on the 2nd July, and in reply the Chief Engineer intimates that until the cost of the block wells has been ascertained a reliable estimate cannot be prepared; should these wells be found too expensive it is probable that the section will be again modified.

† No. 3.

§ No. 5, dated 6th July.

43. The block wells to which the Chief Engineer refers are being put down, and on the 12th July 9 wells out of the 110 required had been sunk to various depths, two or three being as low as it had been found practicable to get them down. The section supposes the wells to be put down to 19 feet below bed, but the soil at a depth of 8 or 9 feet is found to be too hard to admit of this being done, and probably no well will reach below 10 feet. The blocks go down tolerably rapidly for the first 3 or 4 feet, but after that the progress becomes very slow, 2 or 3 inches a day being about the average, after the first yard has been reached. The cost of the wells per foot appears from the Resident Engineer's accounts to be about Rupees 27 to 28. Supposing therefore the average depth of 110 wells to be 8 feet, the cost per well will be Rupees 220 and the cost of the line of wells Rupees 24,200. This does not include the cost of the plant used in sinking, and the filling will be a considerable item.

Sinking of block wells.

44. General Ludlow has, in his letter of the 15th March, noticed those portions of the proposed section which appeared to suggest discussion.

Principal features of revised section.

* Paragraph 8 of No. 45.
General Ludlow, paragraph 2 of No. 45.

The Chief Engineer is, I think, mistaken* in supposing that no acceleration of the velocity of the water will occur with a slope of 1 in 8.

He has in fact provided against the effects of a considerable force by putting the deep block wells at the tail of the slope in his section. The actual velocity with any given depth on the crown will depend, first, upon the level of the tail water or the difference of level of the water on and below crown. This would not be the case were there no acceleration of velocity. Second, upon the velocity of approach; third, upon the nature of the surface of the slope or upon the resistance offered by friction.

The retarding effect of friction will be in inverse proportion to the depth of water passing over.

* Paragraph 4.

45. I concur with the late Consulting Engineer in his opinion* that the body wall, as designed, would not be stable. It would rest on soft sand, it would certainly settle and crack, and its sole usefulness would then be lost. A body wall is not an essential feature of an Anicut, for there would be no particular difficulty in constructing a section differing but slightly, except in this particular, from that intended, without such a wall, but if one is to be built at all, it should be firmly founded.

† Paragraphs 5 and 6.

46. The late Consulting Engineer gives† two reasons for considering that intermediate rows of wells would be advisable, the one in order to admit of the sand on which it is proposed to lay the slope of the Anicut being thoroughly consolidated, and the second to allow of the work being gradually carried up to full height in two or more seasons. Supposing the principal features of the Chief Engineer's section to be in all respects adapted to the locality and material available, these suggestions would be of much importance, for I think the immobility of sand confined at transverse distances of about 85 feet and practically unlimited intervals longitudinally, could not be ensured, and the arrangement for progressive construction sketched out by Colonel Cotton in paragraph 4 of his letter would leave the unfinished slope exposed to the full force of the water, and, I am afraid, lead to frequent damage.

47. With regard, however, to this section of the Anicut the points that are, I think, of primary importance are the nature of the material available, and the distance from which it has to be brought. The rocky hills which are to furnish the stone will yield any quantities of rubble stone of almost any size. The rock is quartzite and hornstone. It is admirably adapted for packing dry, but it will not turn so as to make sound masonry, and it does not give a good holding surface for the mortar. It is not likely, therefore, that a durable masonry slope could be constructed with this stone, and if not this part of the section will need modification. The quarries are about four or five hundred yards from the south end of the Anicut, and therefore the cost of carriage by rail will be small, and, taking therefore together the nature of the material and its position so near the works, the inference would appear to be that a roughstone slope would be a more advantageous arrangement. There would be three additional advantages, first, the rougher surface of the slope would diminish velocity, and therefore reduce action at the tail; second, the work could be carried on progressively without liability to accident, the front body wall being kept low and the stone spread out and always affording an adequate protection, while the freshes would interfere far less with the progress of the work, and would be of advantage by settling the stone, added to which, thirdly, the description of labour required would be unskilled instead of skilled, and it could always be employed on quarry work when the state of the river put a stop to construction.

48. I have no doubt that the block wells at the tail of the slope would, if carried down to the full depth intended, run little or no risk of accident. It may be doubted however whether they are really necessary at all. From the original Estimate of the Anicut I gather that the Chief Engineer intended to provide an outer rubble apron having an ultimate square section

of $24 \times 3 = 72$ yards, and this quantity of stone would, if well arranged, of itself give more than ample protection to the tail of the slope, but to obtain this desirable result it would be better during the first season to lay down a greater width than 8 yards and a lesser thickness than 3 yards, as the Estimate leads one to suppose was intended.

49. Supposing rubble stone packed to be used in lieu of masonry for the surface of the sloping apron it would be necessary to increase the ratio of slope to 1 in 15 at least, and beyond the toe of the slope a level apron 25 yards wide and averaging 1 yard in thickness would suffice. This latter would not require careful packing, and only the portion near the foot of the slope need be of large size.

Works at Somaiswaram in connection with the Anicut.

50. These are:—

First.—The quarry railway.

This is a short line of four or five hundred yards. It was originally laid with square bar-iron welded, but now light foot rails of a very excellent pattern are being substituted, and this will be a very great improvement. The present line is on too low a level, as it will be submerged by even moderately high freshes, and it will be better, therefore, to lay down an upper line, as soon as may be convenient, and to continue working the present line until the sleepers become useless. These sleepers are hardly as good as it would be advisable to put down, they are merely very crooked small wood, and heavy traffic will, I think, soon displace the rails, and occasion much additional wear and tear as well as increased cost of draught.

Second.—The quarries.

These are just being opened out; all the stone hitherto quarried has cost but very little, as it is detached stone, taken from the surface. Even when the solid rock is worked up to there will be a good deep face, and the quarrying may be economically carried on. The stone is admirably adapted for Anicut work.

Third.—Railway to limestone quarries.

This has been constructed with welded bar-iron. It is perhaps worse than useless, as it costs much for perpetual repairs, and the material could be brought at a cheaper rate by bandies. It will be replaced by foot rails as soon as these are received. It is a great pity that bar-iron rails were ever sent up, their transport must have cost a great deal, and instead of saving expense they have caused additional outlay.

The lime stone makes very fair lime and the supply is very abundant.

Fourth.—Brick fields.

Very excellent bricks are moulded on the ground a few yards from the Anicut, and shape, quality and cost are all creditable to the officer in charge; the size is 9 inches $\times$ $4\frac{1}{2}$ inches $\times$ 3 inches, and the cost Rupees 1-10-6 per thousand. I unfortunately omitted to ask whether this rate was obtained from the number moulded or from that obtained fit for use from the kilns, but, even supposing a very liberal allowance for a mistake on this point, the cost would not exceed $2\frac{1}{2}$ Rupees a thousand, and this would still make very cheap brick masonry.

Fifth.—Station buildings.

An Office with good accommodation has been completed. It is built on ground liable to inundation in high freshes. It is thatched. The Hospital with tiled roof is under construction and will be finished in the course of a month.*

* From middle of June.

Three Overseers' bungalows have been finished, and one is under construction. These have or will have thatched roofs.

Of the above buildings sanction for the Hospital only was asked for and given in the Order as per margin,† and I suppose therefore that the other buildings have been charged to the Anicut expenditure.

† Procs. Madras Govt, No, 1,552, 30th May 1864.

Head Sluice.

51. The design for this work has not as yet been finally prepared, but it is expected that this with the Estimate will shortly be ready. I pointed out to the Executive Engineer that the original design would not admit of a railway being laid over the sluice and on to the Anicut, and as this is a matter of some importance, as enabling the line up to this point to be always ready for the apron work, which will certainly be necessary for several seasons, I suggested that in preparing the revised design this point should be attended to. A block of earth can be left at the lock channel to carry the rail there should any part of that channel be touched for some years to come, which is not likely to be necessary.

Main Canal.—1st Section.

52. This extends to a little beyond the 4th mile. The Estimates are in this Office and will be submitted to Government immediately. It will run over tolerably easy ground and occupy for the most part waste land up to the $1\frac{1}{2}$ miles. Beyond this, in the 2nd mile, it will pass through the paddy fields under the Kullur tank, most of which lying to the north of the line will be taken up under class B; the small strip not so taken up is under wells, but

• Profits for embankments.

probably one crop is obtained under the tank, and, if so, a sluice for canal water, or a culvert to pass that of the tank under the canal, should be given. It is possible that much of the class B land may be re-brought under cultivation. In the 4th mile a small extent of land under the same tank will lie to the north of the canal, and this will be supplied with canal water.

The canal is intended to have a fall of 4 inches per mile, a maximum depth of 6 feet, a water surface width when full of 102 feet, and it will carry about 1,20,000 cubic yards per hour. Other points will be noticed when submitting the Estimates for sanction.

Second Section at present arranged from the 5th to the 15th miles.

53. In the 5th mile the canal will cross a ridge which involves a cutting 30 feet in depth as the maximum. There is hard rock in it, but much of the material is easy. A trial pit has been sunk to a depth of 19 feet. The length of deep cutting will not be great. After crossing the ridge the line runs across a small valley, then over the end of a spur across a very narrow valley and then a second spur. At this latter point a lock of 10 feet drop is proposed. The river, or left, bank below the drop will require raising beyond the level allowed.

A trial pit has been cut in the first spur; the material met with is not very difficult and the rock strata are thin.

The village of Budwail stands on the second spur, and the greater part of it will require to be removed.

The line will then cross the cultivation under the Kalavoy tank, and at the eastern end of this a large aqueduct of six arches for the tank surplus will be required.

At $7\frac{1}{2}$ miles the line will cross the ridge south of Iskapulli, and the cutting there will be 9 feet in depth in rather soft shale.

54. Beyond this the line runs over undulating ground, and in the 9—10 miles, as at present laid out, it passes below the Thalagapore* tank, occupying a very large portion of the paddy lands.

• Thalagaroyapooram.
I think it would be of advantage to every one were the tank incorporated with the Canal; first, it would save much land which is of value now, and capable of being made much more valuable. It would save the Company much expense for high double banks and for a large masonry work to pass the tank surplus, and the holders of the land would obtain an improved supply. The crown of the calingulah of the tank is six inches above the bed of the canal so that the tank bund, or that part of it which would be used, would require raising about six feet.

55. In the 11th mile it is proposed to place a lock giving a further drop of ten feet in this section. It appears to me, however, that the line of the canal below this is much of it so unfavourable, that it is very necessary to see whether a much better one cannot be obtained.

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Present line selected for Canal.

56. The intention of the Chief Engineer no doubt was to keep the line up as much as possible, and get across the water shed dividing the valleys of the Pennair and Kundleirú as soon as possible. The difficulties, however, were the depth of cutting, some 70 feet for $2\frac{1}{2}$ miles, required to cross the water shed without previously crossing the valley of the Nulla Vágú in the 16th mile, and on the other hand the enormous expense that the crossing that valley by double banks 50 feet high, and a large aqueduct for the river, would entail. Such being the case the line has been laid out to be dropped 10 feet, as above mentioned, in the 11th mile, 30 feet in the 16th mile, and 10 feet in the 17th mile, or a loss of level of 50 feet, and the consequence is that the water shed cannot be reached for some 25 or 30 miles to the eastward, added to which a very serious additional amount of cross drainage has to be provided for. The country, moreover, is very unfavorable for the formation of a canal of navigation. It is a succession of ridges and valleys extending down almost to the brink of the Pennair, and only by keeping the line quite close to the river, and within reach therefore of every high fresh, could a tolerably direct line be obtained. That selected, so far as a selection has been made, winds greatly, and will have to be made still more circuitous in order to reduce the embankments across the valleys and the cuttings on the spurs.

Runs over unfavourable ground.

Nulla Vágú and tank formerly proposed.

57. It will be seen from the above short description that the Nulla Vágú and its low level is the great difficulty to be got over. Some years ago* I took levels for throwing a bund across this river between the hills on either side of it, so as to form a large tank. These levels with instructions were sent to the Range Officer for the completion of the project, but the time and means at his disposal would not admit of the requisite information being got ready up to the time that I left the District. The bund would have been rather a longer one than was convenient, but there were two objects to be obtained which I thought would make it worth while to construct the tank. The first was to do away with the submergence of the cultivated lands of Cummupad, Oolavapully, &c., by every fresh in the Nulla Vágú, and also with the destruction or deterioration of the river channels by those floods, and the second was to supplement the very irregular and inadequate supplies obtained from these channels, and to extend the area of irrigation to the eastward towards Paramatapad and other villages. My rough calculations showed that the tank would pay tolerably well† though not very well, and it seemed to me that the radical improvement of a considerable extent of country would make the project one likely to obtain the approval of Government.

* When District Engineer of Nellore.

† $1\frac{1}{2}$ Miles.

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Irrigation Company might be allowed to make the tank if levels suit.

58. I believe that were the Company allowed to make this tank a part of their line it would at once enable the Chief Engineer to select a line for the canal in every way superior to that now alone open to him. I cannot, in the entire absence of levels over the line, which I suppose the canal would take, say what the relative merits of the two lines actually are, and what I recommend is that preliminary levels should be run to show where the canal if once placed at its high level on the east side of the Nulla Vágú could be carried, and where it would reach the water shed. This done the Chief Engineer would be able to show the estimated cost of a part of the original line, and a fair approximation of the cost of the remainder down to the neighbourhood of Parchellapadú, and to compare this with the probable cost on the alternative line.

Land would be submerged.

59. The land in the valley of the Nulla Vágú, which would be submerged, is not very valuable, though much of it is, and has been, at any rate for many years, under dry cultivation.

Three villages would require removal.

Three small villages, Yerrabully near the bund, Pedda Billápad and Kakevoy would have to be removed, and perhaps Nagalatoor would require a low bank for part of its lands, though the village itself would be out of reach of the water.

Collector of Nellore approves of the arrangement.

60. I have discussed the subject with the Collector of Nellore, and he is prepared to support the proposed arrangement should the levels show it to be as desirable as is supposed. I should not in any case recommend that the submerged lands should be considered as land required for the canal, and to be given therefore free of charge to the Company; but it is probable that the matter might be arranged so as to prove advantageous both to the Government and the Company, by providing that the Company should compensate the Government for the cost of the land by affording adequate irrigation to the lands referred to in paragraph 57 above. Probably in the event of the canal being carried on the high level in the manner proposed the removed villages might be located, with advantage to their inhabitants, on lands under the influence of the canal. The population of that part of the Nellore District is by no means very numerous, and these villagers would therefore find no difficulty in taking up new wet cultivation, in lieu of their dry lands submerged by the tank.

61. It does not appear to me that the modification above suggested will be in opposition to the intentions of Government regarding single banked canals and the formation of tanks. It is a very different thing to make a tank as an exceptional arrangement, where the object to be attained is really of importance, and the running single banks across wide valleys wherever a regular canal would occasion a circuitous line.

62. Such being the present state of the case with regard to this portion of the canal, it will not be necessary at present to transcribe for the information of Government the notes made when going over the part of the original line to the eastward of the point where the high level canal would diverge. I have examined the surveys and levels with the Executive and Assistant Engineers, and, as regards details, the direct and contoured lines of most of the spurs and valleys have been investigated so as to obtain the best line at a moderate cost. I have seen also the plans of the masonry works of the second Section and the Estimates are very nearly ready.

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Public Works Department.
No. 2591
Proceedings of the Madras Government
Under date of 14th Sept 1864 No.

Read the following
From the Cons. Engineer for I. Canal Co.

Reports on the works in
the Pennair & Nellore Divisions
inspected between the 14th
20th July 1864. } Here enter 5th Augt/64. No. 65-

Pro: 24th Aug: 1864, No. 2438.

In the foregoing
letter the Consulting
Engineer continues
his interesting report
on the works of the
Irrigation & Canal
Company, noticing
the divisions of the
Pennair and Nellore
It will be com-
municated to the
Agent, with a view
to the suggestions
and remarks, in
paragraphs 22, 30,
32, 36, 37, 44 to 1st clause

JP

of 50, 54 et seq. being
transmitted to the Chief
Engineer for his con-
sideration.

2. The Collector of
the District of Jud-
dah will be
requested to take
steps for the
preservation of
the Company's marks
above and below
Oheer, as suggested
in para 9.

3. The correspond-
ence, and tracing
of the re-arranged
section of the Somai-
warum Ameen,
referred to in paras
41 & 42 will be
returned to the
Consulting Engr.

To The Com. Engr. of the
Agent
Collector of the District
Mellane for
information
Dated 5th September.

Copy in a letter
of 9th Sept. 1864. No. 50.

9th 1864 Depart
Pro. of the Govt. for Sept

No. 2591.

Pro. of the Alout
of 7 Sept 1864

Reporting on
the Companies Works
in the Penair & Aella
Divisions.

No. 132: 133.