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

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No. 556.

Read the following:—

No. 309-A.

MEMORANDUM.

THE following notes of a tour of inspection in the Kistna Delta, made between the 20th November and 15th December 1873, are submitted for the information of Government.

2. This work is generally in good order and requires only such ordinary repairs as are necessary after the freshes of each year. The apron appears to

Anicut.

have suffered no disturbance, and, except in rear of the spot where the fish-ladder was, there is now said to be no hole or any considerable depth of water below the apron. The lower part of the apron has a steep slope, but is regular. The District Engineer has been requested to have a few cross sections of the anicut taken annually, in order that changes, which might otherwise pass unnoticed, may be detected.

There was at one time a very deep hole to the north of the groyne on the north side of the southern set of under-sluices, and this has to a great extent filled up. It must be carefully watched. The usual rough stone raised crest had been put up for the dry season.

3. The state of the shoals is much better than was the case some years ago. The yearly changes are considerable, and not much can be done to affect them.

River bed above anicut.

On the north side the river near the head works has improved. About a mile or so higher up on this (the left) bank three groynes have been constructed to stop erosion; the water was not deep in the first instance, and it has since shoaled considerably; nanel or lunka grass should be planted.

The banks of the river generally, where not in advance of their proper line, should have a lunka grass (nanel) or wild cane (pey karumbu) facing.

4. This is the quarry hill on the Bezwada side, and is used to secure at a considerable height one end of the telegraph cables which span the river, the

Telegraph Hill.

distance from post to post being probably not far short of a mile and a quarter. The first wire was put up towards the end of 1857 during the Mutiny, and was blown away in the cyclone of 1864. Mr. Peters, the Range Officer, pointed out the great rapidity of vibration along the wire; this vibration passing to the opposite end and back again in seven seconds.

The view from the anchor posts over the river, the anicut, and head works and the canals is very good, and the arrangements can be well understood from this point.

5. This river is one of the difficulties of the Eastern Delta. It rises some 35 miles to the north of Bezwada and approaches to within a couple of miles of the Kistna at that place; then, after an abrupt turn to the northward again, it

The Budemair.

runs in a south-easterly direction to the Ellore Canal at about 3 miles from the head works, runs for 5 miles on the north side of the latter, and then crossing to the southward has a course of some 30 miles more to the Colair Lake. This river has been a source of constantly recurring damage to the Ellore Canal. In the north-east monsoon of 1872, it breached the canal extensively over a length of some miles. The first breach was at the third mile opposite Mutialampaud; but here, as there was a very strong bank with a revetment some 9 or 10 feet above the F. S. L. in the canal, it is believed that the breach was purposely made in the interest of the owner of the lands alongside, which were inundated to a considerable depth, and the crops on which were in danger of being destroyed. The bed proper of this river near Bezwada is only a good-sized ditch, and the freshes inundate a wide extent of country, a great deal of which is in consequence left waste. It has been suggested that this stream might be turned into the Kistna above the anicut, and such an arrangement would be practicable, but some little time would be needed to work out the arrangements, as high flood level in the Kistna is above the level of much of the ground on the banks of the Budemair. Such a diversion would make it much more easy to deal with the cross drainage of the upper part of the Ellore Canal, and it would probably answer to enlarge the bed and efficiently embank the Budemair in order to reclaim the valuable lands alongside, which cannot now be cultivated. The project should be examined as soon as the District Engineer may be able to undertake the investigation; as will be seen further on it will be practicable to prevent any considerable damage resulting from the relative positions of this river and the Ellore Canal, and so the question of the diversion, though by no means unimportant, is not so pressing as it would otherwise have been.

6. Some of the buildings are in a dilapidated state, and the roof where dangerous was being removed with a view to its repair. These shops, which Workshops at Bezwada. some 15 to 17 years ago were highly efficient, were, notwithstanding the need of the assistance which they are able to afford to the Delta works, for several years almost entirely disused. They are now being got into working order, and it will no longer be necessary to send dredges and other plant a distance of over 90 miles to Dowlaishweram for repair. Almost all work, except iron castings which should be obtained from Dowlaishweram, can be done in these shops. There is need of radical improvement in the yard arrangements. The machinery and plant have not been hitherto properly cared for. Component parts were lying about without order, and it is certain that much delay and inconvenience would be experienced from sundry small parts being missing. Crab winches and all plant of moderate size should be put together, or set up and placed under cover, so as to be available for issue at a moment's notice. No plant should be left out of repair longer than is absolutely unavoidable. There is a powerful crab winch which was broken in stretching the Telegraph cable; for it new castings should be obtained at once from Dowlaishweram, and the winch, instead of being left rusty, broken, and unserviceable, should be completely repaired and got ready for re-issue. A great deal of the yard is blocked up with chips and battens of wood, which should all be sorted and stacked, such as will be of future use being kept and the rest disposed of or used for fuel. Shavings and all such combustible material should be swept

up and placed where it can do no harm, at any rate twice a day or oftener if necessary. It is somewhat fortunate that the whole place has not been burnt down; the risk has been by no means insignificant.

In the yard there is a mill for hulling rice, which is intended to be driven by water-power and which was put up at Nedamole in 1865, but not being found to answer it was dismantled and sent up to Bezwada. I am not prepared to say that rice hulling by machinery is an operation for which there is likely to be a demand, but with the command of water-power which we have in this and the Godavery Delta, it is somewhat remarkable that nothing has been done to utilize it. Perhaps this machinery could be adapted to grind clay and lime for making hydraulic cement, of which a large quantity is likely to be needed in carrying out the Delta improvements. At any rate it will be well for the District Engineer to bear in mind that for six or eight months in every year there is a vast amount of unutilized power wasted at the several lock weirs, and that were even a fraction of this made use of for departmental purposes, it might lead ultimately to much more being taken up for private work.

Tip Wagons.—The iron work of twenty tip wagons was sent to this district from the Upper Godavery. One tip wagon has been constructed, but there is no suitable work for plant of this class, and it will be well to get rid of it. The Railways or the Madras Harbour might perhaps turn it to useful account.

7. The amount of plant of this class in the Kistna Delta is small, but it wants much more attention than it has yet received, and it will be necessary to

Floating Plant.

introduce order and system before the large increase which will be required when the completion estimates are finished and the extensive works provided for in them come to be carried out. Under a recent Order of Government a complete register of all such plant will soon be obtained, and provision for its up-keep will be annually made in the Budget. In addition to the information required by that order to be recorded, the district register should maintain a complete record of all considerable alterations and repairs, so that it may be known what this plant is likely to require. For the steamers and steam dredges boilers are from time to time required, and the indents for these should not be forwarded after, but a year or one and a half years before, they are needed. Spare boiler tubes and other fittings should always be kept available. The inefficiency of a boiler intended to work up to 50 or 60 lbs., but unable to bear more than 25 lbs, and with a third or a half of its tubes worn out and plugged may be readily understood, and such a state of affairs should not be possible in the future, but should be provided against by such measures as may reasonably be expected of intelligent officers. I am not here referring specially to any particular boiler, but to a condition which has been approached if not exceeded in several instances elsewhere, if not in the Kistna. All boilers should be tested periodically to 50 per cent. over working pressure by water pressure. This is a matter of no difficulty. The results should always be recorded and the working pressure, when necessary, reduced. The test will usually show when it is time to indent for a new boiler.

Dredges.—Dredges Nos. 3, 5, and 9, and lock dredge No. 2 were lying in the Main Canal and were inspected. Much requires to be done annually to keep this description of plant in an efficient state. The pins and links of the bucket chains

wear rapidly; the distance between the main pulleys can be adjusted to fit the constantly increasing length of the chain, and this adjustment should be frequently made; as far as I have been able to learn the means of adjustment have commonly been overlooked. Spare links, pins, main pulley bars (cast iron), rollers, roller axles and other fittings which wear rapidly should be always at hand to replace those which need renewal or repair; then a day or two will suffice instead of weeks to render a dredge again efficient. No. 3 dredge was in fair order; the buckets and bucket chains were absent.

No. 5 dredge wants extensive repairs, and one side of the main frame carrying the bucket ladder wants a new casting. Boiler wants new tubes.

Dredge No. 9.—Bucket chain rollers, etc., in very bad order indeed, the whole of the links, pins, etc., require renewal or thorough repair; quite unfit for use in its present state, and must have been so for a long time before work was discontinued. Engine and boiler in better order.

No. 2 Lock Dredge.—Bucket chain and rollers need thorough repair, as do the engine fittings. At the head lock of the Bank Canal, Western Delta, another small dredge was at work, and the minor fittings of the engine were not in good order.

Six old wooden dredge punts have been lying in an utterly unserviceable state for a long time on the right bank of the canal, they should be sold and removed. Unserviceable plant incapable of repair or further use would occasionally fetch something if disposed of at once. After years of rotting it will often not pay the cost of removal.

8. The rolling shutters are inefficient from the rollers having been insecurely fixed, so that they have become displaced. This should be put to rights and the shutters made thoroughly efficient. They require to be provided with suitable arrangements for working them: a great crab winch without any means of traversing was standing over one vent, but this is for all practical purposes a very clumsy way of setting to work, and it is almost as troublesome to get the winch from one vent to another as it would be to lift the shutters by manual labour. Within a few yards of the Delta Workshop something better ought to be possible. A small winch mounted on a carriage or truck, running on rails, would do; and, if the power be moveable, proper means of securing the shutters when lifted must be provided.

9. An early opportunity should be taken of fitting this sluice with proper shutters worked by screws. At present regulation is difficult, and it will cost less to make a single set of shutters perfectly efficient than to provide a double set as on the Bezwada side. Angle iron bearings should be given, and the holding down plates of the cross beams carrying the gear will need to be placed at least 6 feet below the platform; this may be done without dismantling the upper parts of the piers, as the stone can be drilled without much difficulty with an augur and the bottom plate can be inserted at a wide saw cut, which can afterwards be filled in with Portland cement.

10. The Main Canal, which is about 1,000 yards in length, is also called the Eastern Delta, Main Canal. Masulipatam Canal, though that commences properly speaking at the end of the thousand yards. It is being enlarged as fast as circumstances will permit, but

of course the necessity for conveying water for irrigation and navigation renders it difficult to get on with it as fast as would be desirable. A convenient quay with wall and steps to the canal, and a roadway with ramps to the main road above has been nearly completed. The merchants complain that the accommodation is insufficient, and undoubtedly the traffic is very considerable, but much may be done by regulation to make the most of the quay room. At present boats lie alongside much longer than is necessary, and it will be requisite to introduce order and system, and to limit the use of the stone quay to boats which can be rapidly loaded and unloaded, and to passenger boats. Timber is stacked near the head of the Ellore Canal. It will perhaps be advisable to put down moorings to facilitate the management of boats, as the current will be rather strong when a full supply is being carried. The District Engineer should draw up a set of rules for the regulation of the traffic at this terminus, and, after obtaining the Collector's concurrence, transmit them for sanction.

Ellore Canal.

11. Two questions, both of very considerable importance, had to be discussed during my visit.

1st.—The best way of improving this canal so as to allow of its irrigating as much land as is likely to require water, and to make it a thoroughly efficient line of navigation.

2nd.—The requirements for passing cross drainage in safety.

With regard to the first point it is clear that from want of sufficient attention to levels in carrying out the various works, which, during a long series of years, have been constructed, this canal is not as efficient as it should be. Following an example which was set by the late Colonel Anderson who was for some time in charge of this district, it has been proposed to carry the water in a channel distinct from the navigable canal, and Lieutenant McNeil Campbell has devoted a good deal of time and trouble to working out a project in this direction. The object is, by carrying the irrigation water at a higher velocity than is practicable in a navigable canal, to reduce the amount of silt deposited, and this arrangement is feasible and advantageous under the circumstances to which it was originally applied, viz, to canals running for the most part parallel to the drainage, but it is altogether inapplicable to those which cross the drainage of the country as does the Ellore Canal, for then this cross drainage has to be provided for twice over, and where the area drained is large, the additional cost is necessarily very great. This objection was pointed out in paragraph 17 of my Inspection Report, printed in Proceedings, Madras Government, of the 10th March 1871, No. 722, in connection with the similarly circumstanced Commamoor Canal in the Western Delta, and it is to be regretted that any time has been devoted therefore to the preparation of a scheme for a side channel for the Ellore Canal. There was no section of this canal available during my recent visit on which the details of the required improvements could be laid down, the longitudinal section which had been plotted being on too small a scale to show accurately what the present conditions are, but it will not be difficult to state approximately what is necessary.

The bed level at the head is to be at	...	...	...	37.50
And the upper sill of the Ellore Lock is	...	...	...	31.95
The full supply water surface at the head will be	...	...	...	45.50
A suitable depth of water on the upper sill of the Ellore Lock would be 6 feet, making the water surface there	...	...	...	37.95

At present, owing to the high level of the Tummelair Aqueduct at Ellore, it would not be practicable to fix the water surface at the lock as above-mentioned, for it would result in a depth of water of only about 2½ feet on the aqueduct, but the difficulty may be solved by removing the aqueduct, or rather by converting it into a set of sluices, an alteration which would result in such important advantages as regards disposal of drainage that, much as I regret advocating the dismantling of a perfectly sound work which has withstood repeated floods, it should be carried out, because practically the aqueduct has been useless for the purpose of passing floods under the canal, and after frequent alteration it continues to be as ineffective as ever, and its arches are and have been for long entirely blocked by sand, and the freshes go over it, occasion breaches, throw much silt into the canal; so that altogether, after full trial, the time has come when it will be well to get rid of a work which has not answered its purpose and which stands in the way of much needed improvements.

12. The surface fall then available will be 7.55 feet, and the distance being 40 miles, the average will be 0.189 feet a mile nearly. The bed fall will be from 37.50 at the head to 31.95 at the Ellore Lock, or 5.55 feet equivalent to an average of 0.139 feet a mile. The discharge required in the upper part of the canal is about 62,000 cubic yards per hour, and the bottom width of the canal is at present 60 feet. The surface fall for the first ten miles will be less than the average, or the discharge would be too great. A surface and bed fall of 0.08 feet a mile will give about the required discharge, and a mean velocity of about 0.8 feet a second. Below this point the surface fall available should be distributed with reference to the discharge required in each section, or between each considerable irrigation off-take, and to the present dimensions of the canal, which generally are probably in excess of those required. There will practically be no appreciable surface fall in the last five miles, which may be treated as a still-water canal. The depth of water will be 8 feet in the first section of about ten miles, and thereafter will decrease as may be found convenient. In the upper 20½ miles the remodelling will not affect the existing under tunnels, but below that there are several which will have to be re-built. How the levels of these latter were determined is a mystery, for they have no relation to any possible arrangement of the canal, seeing that some of those in the lower miles are higher than those in the upper miles. No under tunnel on which a depth of 6 feet with a full supply can be obtained need be reconstructed, even if the width and water-way be slightly less than that required, and works of this class on which the water-way with a depth of not less than 5 feet will be equal to or in excess of that necessary may be retained. These observations will, it is hoped, enable the remodelling of the levels of the canal to be worked out without difficulty, and the District Engineer may consider himself at liberty to modify the details within reasonable limits, should the distribution arrangements render this necessary or desirable.

13. The large area of country draining across this canal and the inadequate means of discharging flood-waters, have led to repeated accidents, to considerable damage, and to the closure of the navigation, with as a result much inconvenience to the trade and traffic of the Kistna and Godavery Districts. This canal is a great highway, and as such it is most desirable that it should be closed as seldom as possible, and only at such times as may be unavoidable owing to the supply of water in the Kistna running short. The requirements of the cross drainage have been carefully gone into, and what is proposed to be done will be detailed below. Circumstances render it impracticable to adopt for very heavy rainfalls the more perfect arrangement of passing all cross drainage under the canal; but, by allowing ample vent across the latter, all risk of damage will be avoided, and as the floods, instead of being obstructed and rising until the canal banks gave way, will be discharged at a level not exceeding 2 feet above ordinary full supply level, comparatively little silt will be deposited, and no injuries of importance will be sustained.

1st Section, Budemair and Avadapilly.

14. Commencing at the upper end of this canal the first drainages to be dealt with are the—

Budemair, draining 525 square miles, and the Avadapilly basin of 96 square miles, and these must be taken in connection, as the watershed between them is liable to submergence. If the greater part of the drainage of the Budemair can be turned into the Kistna above the anicut, the advantages will be great, but that arrangement will not materially affect the measures to be taken below, except that it will make the latter more efficient.

In calculating the discharging capacity of works passing drainage under the canal, it has been assumed that in extreme floods the water on the upper side of the canal may rise to 4 feet above that in the out-fall channels, and that the velocity through the works will consequently be about 10 feet a second. Maximum flood discharges have been calculated by the formula $D = 562.5 M^{\frac{3}{2}}$ = cubic feet per second.

The maximum flood discharge from the two basins forming the first division of the cross drainage to be disposed of is $36,607 + 11,790 = 48,397$ cubic feet a second.

	Cubic feet.
The existing means of discharge are Ryves' Channel, head sluice	630
Budemair aqueduct, through	5,330
Over walls	1,206
	6,536
Two under tunnels above lock	840
Kaserapilly escape sluices, two vents of 15 feet each which are un-serviceable	...
Escape in 16th mile	828
Avadapilly under tunnel	400
Total Cubic feet a second...	9,234

or less than one-fifth of that required. As will readily be understood the heavy rainfall of the end of 1872, though by no means a maximum, breached the canal

very extensively. It is unfortunately very difficult to provide altogether adequate means of passing this division of the drainage; what is proposed is:—

1st to allow free passage across the canal in the whole of the seventh mile. Here most of the breaches occurred, ground level approximates to, but is a little above canal full supply level, and the circumstances of the locality are therefore very favourable; the discharge across this mile may be taken to be ...	30,000
2nd to substitute for the Kaserapilly escape sluices, an aqueduct of 12 spans of 10 feet each of about the same height as the Budemair Aqueduct, and having also sluices in the lower side wall of a capacity of 500 cubic feet per second, for the discharge of water coming down the canal from the Budemair Aqueduct. The discharging capacity of this work will be, through the arches, cubic feet ...	6,360
Over side walls ...	1,453
Through side wall sluices ...	500
	8,313
Additional cubic feet per second...	38,313

In these calculations it has been assumed that the ordinary water-level in the canal may be raised 2 feet on the occurrence of extraordinary floods and that that depth will pass over the side walls of the aqueducts; as a fact this maximum level of the future has been more than once exceeded, and within the limit proposed but little harm beyond some silting will occur, as all aqueducts which may be submerged will have the ends of their wings, or rather the side walls from the faces of the abutments, stepped or ramped up to the tops of the embankments, and the common cause of failure of such works, viz., the turning of the wings, will be obviated. The seventh mile opening will be capable, if necessary, of discharging a larger quantity of water than that shown against it, for a few additional inches of depth would make a material difference in the discharge. It is, however, only to be considered as a safety valve, to come into play when the regular works are unequal to the disposal of the drainage, and nothing will be done beyond clearing away such portions of the banks as remain, and levelling the ground where necessary; the soil is good, and will not be washed away to any extent of importance during the few hours that water may be occasionally discharged.

2nd Section, Atkur Drainage.	15. The next separate section of the drainage is the Atkur with an area of five and a half square miles—
Maximum flood discharge ...	1,743 C. feet a second.
<i>Existing Works.</i>	
Atkur under tunnel, cubic feet ...	140
Atkur escape weir ...	648
Sluices ...	140
Prettipand escape weir ...	864
Sluices ...	360
	1,224
	2,152

so that the existing provision is more than sufficient. The Atkur escape might be made more convenient for regulation.

3rd Section, Ampapur Drainage.	16. The Ampapur drainage basin has an area of seven square miles:—
Maximum flood discharge, cubic feet a second ...	2,059
<i>Existing Works.</i>	
21st mile, under tunnel, cubic feet a second ...	280
21st mile, outlet ...	475
	755
	Difference, Cubic feet. 1,304

which can be disposed of by lengthening the outlet from 50 to 190 feet.

4th Section, Viravelly Drainage.	17. This drainage has an area of 48½ square miles, and will be taken as 50 square miles:—
Maximum flood discharge, cubic feet a second ...	7,633
<i>Existing Works.</i>	
Outlet, 22nd mile, 150 cubic feet ...	1,425
„ 23rd „ 75 „ ...	712
Viravelly vagu under tunnel ...	850
Escape, 24th mile, weir (4 feet on crest) ...	1,728
Sluices ...	720
	2,448
Under tunnel, 25th mile ...	280
Outlet, 26th „ ...	2,280
	7,995

and this drainage is sufficiently provided for. Some breaches occurred, but these were partly due to overflow from other drainages, and partly to the outlets having no wings. The escape in the 24th mile must be improved.

5th Section, Ramaleru Drainage.	18. The area of the Ramaleru drainage is 109 square miles, and for 110 square miles the—
Maximum flood discharge will be, cubic feet ...	12,910
<i>Existing Works.</i>	
Outlet, 238 feet, cubic feet ...	2,261
Ramaleru under tunnel, cubic feet ...	1,500
Tatigudiem do. do. ...	3,761

so that a great addition to the existing means of disposing of cross drainage is required. This can be provided by constructing an outlet 960 feet in length between the new bridge and the under tunnel.

6th Section, Peddapad Drainage.	19. The drainage of 25 square miles has here to be disposed of:—
Maximum flood discharge, cubic feet ...	4,809
<i>Existing Works.</i>	
Kulpurru outlet, 48 feet long, with self-acting shutters ...	1,800
Peddapad under tunnel ...	600
	2,400
	Difference, Cubic feet. 2,409

The self-acting shutters of the outlet cannot be relied on and they must be removed; it has been considered whether it would be advisable to raise the crest leaving sluices therein, or to let it be a simple weir with its crest flush with canal F. S. L., and it was decided that the better plan will be to omit sluice vents, and to provide for the required discharge by an additional outlet. The arrangements will then be—

Kulpurru outlet, cubic feet a second	456
Peddipad under tunnel, do. do.	600
Additional outlet, 395 feet long, do. do.	3,753
Cubic feet.	4,809

20. The 7th and last section is the Tummelair drainage with a catchment basin of 457 square miles. The canal has suffered repeatedly from this river, which divides into two branches above the town of Ellore, and inundates a great extent of country. It is perhaps somewhat surprising that more damage has not been sustained by the canal below the Ellore lock, as the spill of the river in that direction is considerable. It would not have been really very difficult to prevent the flood waters of the river breaching the canal banks; but, had these been maintained, the part of the town and station to the north of the canal would have been entirely swamped, and the necessity for relieving this part of the town has led more than once to the cutting of the banks to afford additional outlet to the flood waters.

The remodelling of the canal will carry with it a complete change of the arrangements and conditions. Full canal level will be lowered materially, and this will be an improvement; and the waterway will be very greatly increased and placed at a better level. What is supposed to be the full supply level at the escapes near the Ellore lock is 9.58 feet above the upper sill* of the lock. In the revised arrangements the ordinary water level will be reduced 3.58 feet or to

* 31.95.
37.95, and will never rise above 39.95.

In this case the lower escapes which have to be remodelled will be first considered, as the additional waterway to be provided to the westward will depend upon what can be done with the existing works.

The maximum flood discharge to be passed across the canal may be taken at cubic feet per second 33,520. The eastern branch of the Tummelair is admitted to the canal, and has two outlets. Of these the first is an escape weir with self-acting shutters, which do not act when most required. The masonry crest is at 3 feet below present F. S. L. or at 33.53, and the apron at 35.53. This latter is higher than is convenient, but the work is a substantial one of three bays of 48 feet each, and it would be a pity to dismantle it. It will be divided into sluice vents of 7'7½" each by constructing four additional piers each 2½ feet thick in each bay, and the sills of these vents will be at 35.53. The height of the shutters will be only 2.42 feet, and the maximum depth of water passing through 4.42 feet, at which height the arches will spring. The fall below the work is rapid, and the water level in rear will probably be at least 3 feet lower than that in the canal. On this

assumption the discharge per foot of length will be 29.58 cubic feet a second, and for the total clear length of 114 feet 3,372 cubic feet.

The shutters will be worked by ordinary screw gearing.

A little west of this there is an escape with its crest at 42.28 and a length of 60 feet, and there are three sluice vents 3 feet square in the body wall. Under existing arrangements with water level in the canal at 43.53, its discharging capacity is about 970 cubic feet a second, but it is not at a level suitable to the remodelled canal, and a much more powerful work is needed. It should therefore be dismantled, and in its place a set of sluices having their sills at bed level (31.95) should be constructed. The vents should be 6 feet wide and the shutters 6 feet high and they may be made to lift 6 feet or 8 feet as may be the more convenient for the roadway and shutter platform level. In the former case twenty vents and in the latter seventeen vents will suffice, and will give a discharge of about 6,250 cubic feet.

The total discharge to be provided for the eastern branch of the Tummelair will, therefore, be 9,622 cubic feet, which is about what the late Major Ryves contemplated, but is much more than the works constructed, had they answered in every respect the expectations of the designer, could have passed at the level at which they were built.

No inlet weir to prevent water leaving the canal on the north side will be needed with the revised levels. Across the west branch of the Tummelair, or rather on a new cut which superseded that branch, the aqueduct of twelve arches referred to in paragraph 11 above stands, and it is at present an inlet and outlet weir of some 225 feet in length. It probably discharged in 1872, with a depth of 3.60 feet going over the side walls, some 4,950 cubic feet a second, but the flood level was so high as to breach the canal banks in all directions. The bed level at the aqueduct is about 36.58, and the side walls are at 41.91; so with the revised flood levels the wings will be of ample height. My note-book does not contain the span of the arches, but it would seem to be 15 feet, with piers 4 feet high, and rise of arch 3 feet. So probably the river floor is 9 feet or 9½ feet below the present bed, or at 27.58 to 27.08. The revised bed level being 31.95, the sluice sills may conveniently be placed 18 inches lower or at 30.55, and the shutters will then be 7½ feet high, while to obtain full discharging power the lift must be 9½ feet, and the shutter platform at 47.45, which is 5.54 feet above the present roadway. Each archway or span of 15 feet will be divided into two sluice vents of 6 feet each by a 3 feet pier, the masonry of which and of the raised sill must be of picked stone extremely well fitted, and the sill must be bonded into the floor and main piers. It will be well to build it like a lock sill.

The twenty-four sluice vents will discharge cubic feet 10,584. The abutments of the existing aqueduct at the springing line are probably not far from revised bed level, with which they will be made to correspond. The piers may be shortened to the length required to carry the arches over the sluice vents, the springing of which may be placed at or above 39.95. The shutters will have angle iron bearings in the groove or shoulder, and should have iron straps to form the bearing surface of the shutter itself, so as to reduce the friction and power required to work

the shutters, for which powerful screws will be needed. The gain in discharging capacity by lowering the sill, and the advantage in preventing silt coming into the canal, are considerable enough to make it worthwhile to face the difficulty of working shutters, the area of which will approximate to 50 square feet. As the shutters will be lifted, or water will go over them, directly canal F. S. L. is exceeded, the calculated pressure on the shutters will not be exceeded.

There still remain cubic feet 13,414 to be disposed of, and of this probably about 3,500 cubic feet spills to the eastward of the eastern branch of the Tummelair, and is discharged by the surplus works of the Godavery portion of the canal, so that further provision for about 10,000 cubic feet is required. The old course of the western branch of the Tummelair affords one suitable site for an outlet, and it was originally proposed to place here an outlet of 200 feet in length, but it will be well to increase this to 360 feet, which is probably as great a length as the outfall channel will relieve. The discharge from this escape will be cubic feet 3,420.

The country then falls rapidly to the westward to the Wútlúr under tunnel, the floor of which is at 29.83, or 2.12 below revised bed level of canal. The under tunnel itself is too high for the revised levels, and its position will be well adapted for a powerful escape with a length of crest of about 300 feet, discharge cubic feet 2,850 and under sluices, the sills of which may be placed at 2 feet below bed level, the vents being 4 feet by 4 feet. The velocity through these sluices may be taken at 10 feet a second, and each vent will discharge 160 cubic feet; so the balance of drainage to be got rid of will require twenty-four vents, the discharge through which will be cubic feet 3,840. If room for 750 feet of outlet can be found, under sluices will not be required.

21. It is quite possible that, when these alterations come to be planned in detail, it may be found preferable to carry the lower part of the canal to the south of Ellore, returning to the present line above the escapes near the lock, for a portion of the present line is already in heavy cutting, and the space is confined.

22. The distribution arrangements should be distinct for the several areas between any two drainage outfalls.

Distribution arrangements.

Outlets and inlets.

23. Generally the outlets or escapes will be of the simple and inexpensive description recently constructed on this canal in the Godavery District. All of them will have their crests at full supply level, and the calculations have been made for allowing the maximum water level to exceed this by 2 feet, so the minimum height of the canal banks must be 5 feet above F. S. L. Care must be taken to provide ample openings in the upper or left bank to enable drainage to reach the outlets. If there be no obstruction the water will flow in at a low velocity, and will bring in but little silt. Many of the inlet openings will be simple gaps; elsewhere a small wall or a little rubble pitching will be needed at the inlets; and possibly in some cases contour banks may be required to prevent canal water spreading over cultivated land, but the fall of the country is so considerable, that these banks will nowhere be of any length.

24. It will readily be understood how great a change in the condition of the canal the provision of adequate means for the passage of cross drainage will effect. Moreover, as regards at least the lower part, not only will ample waterway be provided, but the much lower level at which the discharge will take place will put a stop to the accumulation of water, and as this comes down it will be at once got rid of. The conversion of the Tummelair Aqueduct, the building of an aqueduct near Kaserapilly, and the reconstruction of under tunnels, can be carried out only when the canal is closed, but by far the greater part of the works for affording additional waterway can be gone on with at any time, and if all materials for the rest be got ready beforehand, they may, without difficulty, be completed during the time that the canal is ordinarily closed for want of water.

Altered conditions of Canal.

Width of Canal.

canal a width of 60 feet at water surface should be allowed where practicable, and 50 feet should be considered the minimum admissible. Similarly the depth with a full supply must not be less than 6 feet.

26. The following remarks on the canal, as it was at the time of my inspection, may be useful, though in some cases they are applicable rather to the existing than to the intended arrangements.

Head Sluice, Ryves' Canal.—This sluice which has three vents of 5 feet is the present means of supplying Ryves' Canal, but when the new head near Bez-wada is opened, the supply will not be carried by the Ellore Canal at all, and this sluice will be available for surplusage into the Budemair. The arrangements for regulating the shutters are very defective, and it should be fitted with proper shutters and gearing. Lunka grass should be planted in the bays below the sluice.

Budemair Aqueduct.—The water did not quite top the up-stream wings in the floods of 1872, but it turned the other wings, though without damage to the masonry. The wing ends must be raised to a perfectly safe level, viz., 5 feet above F. S. L. The lower left wing (canal) is badly cracked. The state of the sub-structure is not known, and it is to be examined this year. The width between side walls is 48 feet, and the depth of water it can carry is 7½ feet.

Under tunnels above Lock.—There are two under tunnels each of two arches. A great breach occurred at one of these and the masonry was damaged.

Kaserapilly Lock.—This had 7½ feet on the upper and 3½ feet on the lower sill; it connects the Ellore Canal with the Budemair, and through the latter with the Colair Lake. I was informed that it is never used, and the navigation is no doubt difficult owing to the character of the river, but it will be well to see whether this be not easily capable of improvement, and at any rate tracking should be rendered possible by the removal of Tooma trees and bushes from the banks, so as to have a clear space of 4 or 5 yards on either side.

Kaserapilly Surplus Sluices.—These are all to pieces. The four wings have been successfully and ingeniously tied up, but the piers are also incapable of repair. As already mentioned it is intended to remove this work, and substitute a capacious aqueduct.

An abandoned *irrigation sluice* in the right bank just above the village of Budavarum appears to have been built on too high a level. If unsuited to the revised arrangements it should be removed.

Palmyra Spout Sluices for distribution purposes are altogether objectionable in a Main Canal, and none should be inserted for new irrigation, while those now in use should be superseded as soon as possible by masonry sluices. There is one in the 16th mile which is not at all safe.

Escape in the 16th mile, a work of considerable power, but somewhat difficult to work.

Alapuram Sluice, altogether inefficient. It has no proper shutter, and there is a considerable fall off the floor in rear. It has no rear wall or water-wings.

Avadapilly Under tunnel.—This work has water-wings which have kept up the banks. All under tunnels which may be retained, and which are without sufficiently long wings and water-wings should have such additions made to them as will keep the connections with the canal banks in proper order.

Atkoor Escape, 19th mile.—It has two bays of 12 feet with cast-iron posts and planks, and a sluice vent in each bay. The design of the work is not good, regulation being difficult. The canal here is single banked.

Prettipad Escape Sluice, four vents of 8 feet span each, with the crest 2 feet below F. S. L., and sluice vents 3 feet square. An efficient work except that the sluices must be difficult to use, and they were not used in the floods.

Outlet, 21st mile.—This has no wings, and the crest is a good deal below F. S. L., the water being retained by a small bank.

Under tunnel.—This is just below the outlet; the water-wings have retained the banks, and the revetments also have stood well.

Outlet, 22nd mile, 150 feet in length, with a corresponding inlet. Except that it has no wings, which are essential, this escape is effective. No breaches occurred in this part of the canal.

Outlet, 23rd mile, 75 feet in length, and being without wings the banks were washed away for about an equal distance. F. S. L. is somewhat above ground level, so a paved inlet will be required and its crest may be an inch or two above F. S. L.

Viravelly Under tunnel.—This is just below the outlet, and if its level be suitable it can with the addition of revetments be made efficient.

Escape Sluice, 24th mile, has eight bays of 8 feet each, with sluices 3 by 3 below, which probably are never opened. Crest is 2 feet below F. S. L. Breaches occurred in both banks above and below this escape. The inlet opening is about 120 feet.

Under tunnel, 25th mile, breaches occurred at three of the wings. With good wing revetments it may be made secure.

Outlet, 26th mile, a rough stone-work with no proper wings or anything to prevent breaches at either end.

Perikeed Bridge, 27th mile.—One span of 50 feet, rise of arch 14½ feet, springing one foot above present water-level. Arch turned, but superstructure not com-

pleted. Tow-paths not having been originally provided, timber-paths have been added. The work is creditable.

Irrigation Sluice, Kunamole.—An old work with the most common of rubble masonry, 3½ feet on upper, and 2½ feet of water on lower side. It requires a shutter.

Ramaleru Under tunnel.—Three feet of water, and more than one foot of silt. The revetments at the water-wings which bear no relation to the slopes they are to retain are very insecure. The banks above this work were breached for about 100 yards on both sides.

Ramaleru Inlet and Outlet.—The former consists of a little rough stone with revetments at the ends, which are on an insufficient scale being barely above F. S. L. The outlet is a wall with a small overfall on to a rough-stone apron, which is not likely to stand. Length 233 feet. Wings are 4 feet above body and ramps at either end, the tops of which are a good deal too low. There was a large breach above this escape.

Under tunnel, 29th mile, was breached round the upper right wing.

Inlet and Outlet, 31st mile.—These are fitted with self-acting shutters, and those of the inlet are out of repair. Canal water 6 or 7 inches below the tops of the shutters. The outlet shutters could not be moved by four men. A breach occurred round lower wing of outlet. Wings 4½ feet above F. S. L., and earthwork lower than the wings at both ends, which is not proper. Bunds above inlets when allowable at all should not be more than a few inches above F. S. L. As a rule the crest of the inlet where ground is below F. S. L. should be stone or masonry, and at or an inch above the level of full supply in the canal.

Bridge, 32nd mile.—An iron bridge with no tow-paths. It belongs to the Godavery District. The approaches are in very bad order, and are hardly practicable for a cart. The tunnel under the north approach is too small, and the water has formed a channel round the top of the incline.

Peddapad Under tunnel, very little water, and a great deal of silt on this tunnel. It was breached at upper right wing, this work being, as is too often the case, lower than any part of the banks, though not adapted to allow water to be discharged over it.

There is a very good site for an outlet between this under tunnel and the bridge.

Below this under tunnel the banks on both sides were breached in numerous places.

Wullur Under tunnel.—This was breached round on all sides, and the water would again turn the water-wings in a similar manner. The main wings should be carried up to the face of the abutment at not less than 4 feet above F. S. L. and should then be stepped down, the overfall will then be clear of the water-wings instead of on to and behind them. Below this under tunnel in the 36th mile there is a site available for an outlet of considerable length. The flood waters topped the left bank in this mile at many places in 1872, and an irrigation sluice at which the right bank was exceptionally low was destroyed; the irrigation of about a thousand acres is now carried on from several palmyra spouts.

Tummelair Aqueduct.—The arches are completely blocked, and the river-bed is practically flush with the upper side wall, so that the aqueduct has been converted into a weir. No clearance has been made for years, but so long as the work is retained the arches must be cleared annually or oftener if necessary.

27. The avenues must be so arranged as not to interfere with tracking. At present the trackers have at some places to walk in the water, owing to the trees being in the way. When the canal is remodelled the tow-paths should, wherever practicable, be placed at the water's edge, and at 1 foot to 18 inches above F. S. L.

28. Cattle crossings here and elsewhere require to be made efficient, and the banks in connection with them should, where there are no berms, be recessed and ramped, and the crossings should be fenced off from the canal on either side. Cattle very soon cut down a bank of ordinary section, and the crossings then become a source of danger.

29. The head sluice is completed except the fixing of the shutters and their gearing, and these are in store in readiness against the completion of the earth-works of the canal.

Brick-making with a Clayton machine had just been started at the head of this canal. It is a wire-cutting machine, and the soil hitherto used has not been suitable. In exceptional cases, where a large number of bricks is required, and where superintendence is available these machines may answer, and undoubtedly they will turn out excellent bricks. The first necessity, however, is a plastic clay of very even texture, and this is but seldom obtainable naturally, and artificial mixtures are apt to be costly. Table-made bricks are excellent, and sufficiently good for all purposes, and they can be made anywhere by any coolies after a very little instruction; any soil suited for bricks can be moulded on tables, and such bricks cost very little more than the wretched, porous, brittle, ill-shaped bricks which are made out of thick slush on the ground. Unfortunately few officers and subordinates have ever learnt how to mould bricks on tables, and consequently the introduction of improved building material is difficult. In Nellore table-moulded bricks were first made departmentally, and afterwards with but little trouble such bricks were supplied by contractors at a moderate price over a considerable part of the district. The new head of Ryves' Canal is 7 miles in length, and up to last September the progress made was—

	Rs.
Estimate, cubic yards 2,109,536, at 2 Annas	2,63,692
Work done, " 1,605,952	1,49,479

the average rate being rather under 1.43 Annas. The work has hitherto gone on very slowly, and its completion, at as early a date as possible, is of so much importance that I urged the District Engineer to see whether more labour could be obtained; and apparently the efforts made have been successful, for an additional allotment has been asked for and given. A very large section of the Eastern Delta will receive its supply from Ryves' Canal and its branches, and up to this time, although the branches are more advanced, no water except the small quantity

which can be conveyed by the Eillore Canal and passed through the sluices at the present head, is available. Moreover, not only is the section of the delta interested one in which there is much room for an extension of irrigation, but it is one in which successful cultivation is to a large extent dependent upon a water supply, the soil and circumstances not being adapted to dry cultivation.

The earth-work has not, so far as the spoil banks are concerned, been executed in a good way. These should be made up regularly over the whole area they are to occupy, and the drainage from the top should run outwards. As no provision has been made for draining the berms under the spoil banks, arrangements will be necessary for turning this drainage into the canal. The berms should slope towards the spoil banks, and a small channel should be made near the foot of the interior slope of the latter, and then at intervals the water can be let down into the canal by turf or other channels. A little care in preventing guttering and holes in the first instance will save much trouble and expense afterwards.

30. Extensive clearances of the berms of this canal near the head were in progress, and not before they were wanted.

Masulipatam Canal.
Kunkipad Lock, 12 miles.—The lock gearing is not in good order. The ground and banks in the neighbourhood are choked with croton and jungle; the lock establishment should keep the vicinity of the lock clean. The ground near the huts of the lock establishment also should be much cleaner than it is.

Water on upper sill	... 5' 0 1/2"
lower do.	... 4' 8"

Above the lock in the left bank are two sets of sluices for the supply of the Pulleru. Each set has six vents. The upper sluice may easily be fitted with proper shutters worked by screws, and the piers should be carried up to carry the beams. The 4th arch from the upper end is cracked right through. The lower sluices are in very bad order: the wings require to be entirely rebuilt.

On the opposite side of the canal there is a set of sluices formed in what was originally a weir of 10 bays. The lower bay has three sluice vents, and is in use for the supply of the next reach. The rest of the work is at present unused. Part of it will be adapted to surplus water, and part will probably be required to supply a portion of the irrigation between the Masulipatam Canal and the river.

The piers of the sluice supplying the lower reach are in very bad order; they have been knocked to pieces by unmanageable shutters, which should be replaced by others with screw gearing.

The banks and masonry works in the reach between Kunkipad and Veerunky locks are not in good order.

Veerunky Lock, 24 1/2 miles.—The gearing of the lower gate valves is in very bad order. The gates want renewal.

Water on upper sill	... 7' 2"
lower do.	... 3' 9"

The lock walls require a good coping; at present they are not high enough. Much leakage at lower gates. The upper gates have a wooden sill bar, and the leakage is small: the gate valves, however, leak a good deal, and the gearing is in very bad order. A lever of an improved pattern has recently been provided

for working the lower culvert shutter, but it is very unnecessarily heavy: a bar half an inch wider than the shutter spear with a plate on each side terminating in a hook to engage the pin passed through the shutter spear would be a better pattern, and much cheaper. A fulcrum consisting of a triangular block of wood with projecting pins at the base to fit into sockets in the masonry should be provided for each shutter.

Lock Weir, three arches each divided into four bays by cast iron posts. A sluice in the body wall at the west end should, if it is to be used, be fitted with screw gearing. The wide difference between the depths on the upper and lower sills of the lock indicates either that the regulation of the water is not properly managed, or that the surface fall in the reach below is too great for the quantity of water to be carried. The rear revetments of the weir are 3 feet too low.

Bridge of one small and one large arch over west side channel. A very rough work (old) and cracked. The earth-works of the roadway over tail-bay and side channel bridges are in very bad order, and are dangerous for carts.

Pamurru Junction Canal.—This is a short cut from the Masulipatam Canal to the Pulleru; on it there is a small lock, and it was at the time of its construction supposed that the water in the Pulleru would be higher than that in the Masulipatam Canal, but under existing circumstances, this condition is often reversed, and at the time of my visit water was running from the canal into the Pulleru.

Lock.—The gate valves want gearing; they are worked by levers at present.

Water on upper sill, Pulleru ... 2' 8"
lower do. 6' 6"

The completion estimates will, it is stated, secure a proper depth of water on the upper sill of this lock.

The Lock Superintendent and three lascars have very little work to do in connection with the traffic which is small, and they should be required to keep the banks, the trees, and the fencing round the latter in first rate order, and to clear away all bushes, etc.

Nidamole Lock, 37 miles.—The tail-bay bridge is being reconstructed with iron girders, the arch having failed. There is much leakage at the sill of the upper gates. The arrangements for opening the side culverts are still very defective. Gearing of upper gate valves better than is usual on this canal, but that of the lower gates is bad. The wall on the right side of the chamber has a crack about the middle, which should be filled in.

Water on upper sill ... 7' 2"
lower do. ... 4' 4"

In this delta it is noticeable that the angle of the gate sills is in many cases much too flat, and this throws an unnecessary strain on both the gates and their abutments. At the Nidamole Lock the angle at the lower gates is very obtuse, the vertical or perpendicular being only $\frac{1}{3}$ th of the base of 20 feet; at the upper gates the vertical is $\frac{1}{4}$ ths of the base. Variation of the angle is not needed, but of course the pressure on the lower being so much greater than that on the upper gates, the difference should, if considered necessary, have been reversed. At the

tail-bay an iron girder bridge is being substituted for the masonry arch which failed.

Lock Weir.—This work has two arches of 15 feet span each, divided into three bays each by cast iron posts. It can, without difficulty, be made into an efficient regulator.

Above this weir and lock in the right bank a sluice was constructed about 1866, in connection with the rice-hulling machine or mill referred to in a preceding paragraph; it is now in ruins and the work was indifferently constructed.

Bridge and Regulating Dam, East side Channel.—This regulator is a work of the same pattern as those of the side channels of the Nizampatam Canal: it is in good order. The channel above is much choked with bulrushes, which, however, were dug out last year. They should be pulled up yearly until eradicated. The revetments below the regulator are very dilapidated, and the alignment of the channel here should be improved.

The earth-works at the lock should be made up to the level of the side walls.

Huts of Rahadari Boat Coolies.—It is no doubt a convenience to the coolies to allow their huts to be located close alongside the canal, but they should be placed behind, and not within the canal banks, and it is essential that the arrangements of these and of the lock establishment huts should be made with some attention to cleanliness. Latrines must in all cases be provided, and filth within the canal boundaries must not be permitted to accumulate. Long trenches with a screen are as good a form of latrine as any, and the expense is nominal. The Rahadari coolies must of course provide latrines for themselves, at sites fixed by the Range Officer.

Aukamurru Lock, 43 miles.—The side walls of the lock are high enough to within 12 feet of the lower gates, where they are 18 inches lower; the higher level should be carried through.

Water on upper sill ... 6' 0"
lower do. ... 3' 10"

The lower sill was damaged this year by a dhony, owing to the depth of water being so much less than it should be. No water is passed below this lock for irrigation, and arrangements must be made for maintaining a minimum depth of 5 feet on the lower sill. There is a great deal of leakage under the upper gates; the valve gearing of these gates works fairly. The lower gates and gearing are not in good order; the gates fit badly, the mitre posts being at their lower edge 4 or 5 inches from flush. The abutments of the tail-bay bridge are being built up to receive girders.

The earth-works above the lock and the banks below are very untidy, and there is some prickly-pear which should be removed.

Aqueduct at Seetanagaram Swamp.—This requires repair and the making up of the earth-works at the wings.

Chin'aguntapolliem Bridge.—This is an iron lattice bridge which has recently been built out of Local Funds to replace an old bridge. With 4 feet of water in the canal the head-way was $11\frac{1}{2}$ feet, which is rather low; the girders might,

without difficulty, be raised 1 foot. There is a tow-path on either side, but these are not well connected with the canal tow-paths beyond.

Tidal Lock.—This is in good order generally, and the plastering where necessary was being renewed. New pinions required for the gate valve gearing. Lever arrangements for the side culverts should be put to rights.

31. It will be noticed from the depths on the lock lower sills of this canal, that the navigation is by no means as efficient as it should be. Apparently this is due to the canal carrying much less water than was anticipated when the surface fall of the water in the several reaches was fixed, and this again is accounted for partly by the circumstance that the canal traverses Zemindary lands for a great part of its length, and there water is not in demand, while partly it is due to the introduction of the side channel system of carrying irrigation water. A remedy must be applied by raising the water level at the upper sills of all the locks below Kunkipad, so as to ensure a minimum depth of 5 feet on all the lower sills.

32. A great many gates require to be replaced by new ones, and a great many new sets of gearing are required. The unsatisfactory state of many of the locks of this delta in this respect was noticed during the inspection made three years ago, and apparently but little, if any thing, has been since done to render them more efficient. There is no chance of this work being done within any reasonable time at the Bezwada Workshops, unless the number of Smiths and Carpenters at present at work there can be very largely increased, and the Dowlaisheram Workshops have already more than enough to do, so unless the District Engineer can see his way to getting much more work done at Bezwada, he had better send his orders to either the Public Works Workshops at Chepauk, or to the Gun Carriage Manufactory, at either of which places probably the work could be undertaken and completed in time for next year's closure of the canals.

33. A great deal has been done to this canal on an estimate of Rupees 1,87,990 which was sanctioned six years ago, and of which about 1½ lakhs have been expended, but much remains to be done before its banks, tow-paths, etc., will be in proper order. The tow-rope caught many times during the ascent to Pamurru, and a very little attention to the requirements of a navigable canal would remove all cause of this inconvenience.

At Kowtarum the Pulleru divides into three canals (1) the northern called the Polerazkoddu or Kyekalore Canal; (2) the Lower Pulleru or Kuldindy Canal; (3) the Buntoomilly Canal. There is no part of the delta which stands in greater need of improvement than the portion which will be served by these three canals. Their water supply for the extension of irrigation will be for the most part obtained through Ryves' Canal, and no very material improvement will be possible until the latter shall be opened,* but there is so much to be done in the way of drainage that I am very anxious to see the estimates for these sub-sections of the delta completed and sanctioned.

* Probably in time for the season of 1875.

Drainage of the Kyekalore, Kuldindy, and Buntoomilly sub-sections.

The Polerazkoddu Canal.—This is navigable after a fashion. At its head there is a regulating bridge, and material and range boats are passed through by means of strong ropes, there being a considerable fall through the bridge. Once through this, the canal is navigable nearly down to its present terminus. A head-lock and the conversion of the regulating bridge into a lock weir are the first requirements. Then the banks require thorough reformation, so as to make them safe, and to put a stop to the numerous breaches which now occur with a much less depth of water running down than what will be the full supply. One or two surplus weirs will also be needed, and there will be no difficulty in passing surplus into the drains which will run between the ridges. Bushes, a few trees, and all prickly-pear need removal. This canal will have to be extended some ten or eleven miles beyond its present terminus, and it will at its lower end surplus into the Ooputeru. Irrigation or distribution sluices are a pressing want on this canal, and without them the water, which is so greatly needed every where, cannot but be wasted. The drainage of the lands on the right bank for a considerable distance near Lingala (12th mile) is obstructed by the canal, and a cut should be made in rear of the bank down to the swamp at the 18th mile to relieve it. The soil can be used for making up and strengthening the canal bank, and this drain should be carried out at once as a minor new work.

Care should be taken that designs for bridges over navigable canals are suitable. Attention to the circular on the subject, bearing in mind that the minimum head-way admissible is not the maximum that may be given, will prevent such a mistake as that at the bridge in the 7th mile of this canal on the Buntoomilly road, which could only partially be remedied.

The Lower Pulleru is not navigable, and, with the Polerazkoddu on the north side and the Buntoomilly Canal on the south, which latter will probably connect the Eastern Delta of the Kistna with the navigable canals of the Western Delta of the Godavery, this tract of country will be well provided with water communications. The head sluice shutter arrangements require improvement.

The Buntoomilly Canal has a head lock, but the canal is in so incomplete a state that practically it is not of much use, and will not be so until, by the construction of other locks below, the water levels can be regulated without the temporary expedient of placing rough stone dams across its bed. The head sluice shutter arrangements must be modified, the groove is flush with the face wall, and the difficulty of working the shutters is great.

34. The drainage of this tract of country will not be difficult. At present all the rain-fall drainage stagnates in the swamps between the parallel ridges which run from south-west to north-east and what is required is the construction of capacious drains along the axes of these swamps, together with the embankment of the Ooputeru, so that freshes in that river may not as at present spread far and wide. There is a great deal of work to be done, but there is no doubt as to the natural and proper outfall of each portion, and that being the case the designing of the works will be comparatively simple, and the result of carrying them out will be most beneficial.

35.— I rode through this country with Major Hasted and Lieutenant McN. Campbell, the distance being about 17 miles. There is very little cultivation, Country between Masulipatam and Buntoomilly. and what there is in patches on the sand ridges is of the most wretchedly poor description. A very large proportion of the ground is swamp, and the radical improvement of this tract of country is dependent upon efficient drainage being provided simultaneously with the means of irrigation. The whole of the works required have been designed, and the estimates are in a forward state. The country north of the Ramarazupolliem Channel is full of old channels, and the provision of effective drainage and irrigation has thereby been rendered difficult and complicated, but the subject has been carefully studied, and a very great change for the better ought now not to be far distant. Possibly at some future time it may be found worthwhile to connect Masulipatam directly with the Buntoomilly Canal and to avoid the considerable detour by Pamurru, but the chief town of the district is out of the way of the regular course of trade, owing to its being such a difficult and expensive port at which to land and ship produce, and for the present, therefore, it is not proposed to estimate for any such junction canal.

36. This great shallow inland basin, which receives the drainage of about two thousand square miles of country, Kolair Lake. extending from near Condapilly on the west to the Yerracalwa on the east, has for many years engaged the attention of both the Revenue and Public Works Officers of the two districts, and the general opinion appears to be that the water level should be kept as low as possible, and that ultimately the greater part of the bed should be reclaimed. Major Hasted

On the 10th December 1873.

has, in connection with a visit I paid to the south-east end of the lake, where it discharges into the Ooputeru, given me several interesting papers on the subject to read, the first being the Proceedings of the Board of Revenue, No. 4,081, of the 2nd July 1864, containing a Memorandum by the then Collector of the Kistna,

* Proceedings Board of Revenue, No. 4,971, 4th August 1864.

† No. 259, 23rd April 1866, to Collector, Kistna.

‡ No. 73, 2nd July 1866, to Superintending Engineer, 2nd Division, and No. 287, 12th March 1868, to Collector, Kistna.

§ No. 21, 27th April 1867, to Collector, Kistna.

Mr. Thornhill, which sums up most of the facts of the case. Lieutenant-Colonel Chambers,* Colonel Winscom,† Captain Ryves,‡ and Captain Beckley§ have also recorded their opinions as to what should be done, and in what manner.

37. It may be noticed that large portions of the deltas of the Godavery and Kistna drain into the lake, and indeed cannot well if at all be drained in any other direction, and that the efficiency of the drainage depends in a great measure upon the water level in the lake during the south-west monsoon and thence up to October. All these tracts of country are, therefore, greatly interested in the water being allowed to run off freely and without obstruction. The interests of the inhabitants of the island and borders of the lake are conflicting and variable. In the event of the failure of the Sarwa or south-west monsoon crop, all appear to desire that the water level should be kept up to admit of a Dalwa or

cold weather crop being raised, and for this latter it appears necessary or convenient that, first, the lands should be submerged shortly before ploughing and sowing, and secondly, that the water level during the time that irrigation is needed should not be very much below the level of the lands on to which it has to be baled. The retention of the water at a level suitable for the Dalwa cultivation is not, however, under present arrangements favourable to the general interests of the cultivators, because it involves the retention of water at a level which renders impracticable the successful cultivation of the more valuable south-west monsoon crops on a considerable portion of the lands, on which these would otherwise be grown. If the lake surface could be kept down to, or allowed to rise above for

* Tidal.

a few days only at a time, high water level,* then the cultivation on its margin

could be largely increased, and the position of the land-holders greatly improved, and if, in addition, these marginal lands could be regularly irrigated from the delta canals, but little would remain to be desired. On the Godavery side the extension of irrigation has already reached close up to the lake, and will extend no doubt as far as the circumstances of the latter will permit, but in the Kistna it will be a long time before the canals will be sufficiently advanced to bring the marginal lands under regular irrigation.

38. Hitherto the recognized means of escape for flood waters consisted of an escape weir 300 feet long with iron posts at 10 feet intervals, the crest being somewhat above H. W. L., and the water thence passed at once into the Ooputeru. West of this however, close to the village of Alapad, there is a creek, the deep part of which is only a few feet wide, communicating between the lake and the river, and there were other low places by which water used to escape as shown on the Atlas sheet to the west of Jungampaud. In 1864 the water in the lake had become so brackish and impure that the villagers lost large numbers of cattle, and so, to the west of the calingulah, a breach was cut in the bund, and the passage close to Alapad was also opened, while at the end of the year, after the cyclone, in order to give the lake people an opportunity of raising a Dalwa or cold weather crop, the stream leading to the large breach was bunded. The breach channel has become a deep one, and the closing of the passage entails a considerable outlay. Last year, after much trouble, a bund was established across it at a cost of Rupees 4,000, and it is stated that the resulting revenue was Rupees 18,000. This year the Collector wished the bund, which had been partially swept away by the season's freshes, restored, but the requisition reached the District Engineer, I understood, after the proper time had gone by, and the Sub-Magistrate of Kyekalur, who accompanied us during the inspection, said that it would be useless to raise the water level at so late a date. Indeed it is evident that bunding after the subsidence of the freshes would have little or no effect in raising the water, though it would maintain a comparatively high level. The remains of the bund of last year had had the effect of keeping the water surface at about 1 foot above high water level.

39. It seems to be very desirable that it should be determined what is on the whole the best way of treating this great basin. Were the Irrigation Department prepared at once to supply water to the margins and islands, there would

probably be no room for any second opinion, but this, as already mentioned, is not the case. I take it that the 300 feet calingulah was constructed as a substitute for bunding, and in ordinary years it appears, owing to the enormous area of the lake and its consequent effect as a flood moderator, to have answered its purpose, but when the rain-fall over the drainage basin happens to be heavy, the water surface becomes so far raised as to swamp the cultivated lands and villages, and then other means of escape have to be provided. So far as the drainage of the country generally is concerned, the best arrangement would be either to leave the communications between the lake and the Ooputeru entirely free and open and to enlarge them considerably, which could be effected at a small expense during the freshes, or to increase the length of the escape weir to about 1,000 feet, with its crest at ordinary H. W. L., and with numerous self-acting sluices, having their sills $4\frac{1}{2}$ or 5 feet below that level, inserted in it. This additional length of surplus weir could be provided partly by lengthening the present calingulah, and partly to the west of the breach. The effect would be to reduce considerably the height to which the lake surface would rise during the rains, and to bring the water down after the freshes to a level 18 inches or 2 feet lower than would be the case with an open channel. It appears to me probable that were bunding entirely given up, and either of the arrangements just described adopted there would be but little loss of revenue, and an improved class of cultivation with greater security against the destruction of the south-west monsoon, or Sarwa, crop by inundation. The Dalwa crop as here grown is not, I am informed, one to be encouraged, as the grain affects prejudicially even those who are somewhat accustomed to it, while for others it is particularly unwholesome food. The effect on the health of the population, which would result from a general lowering of the lake surface, can only be surmised; as, however, the variations in level

extend, as it is, from some $3\frac{1}{2}$ feet* above H. W. L. to, in a long hot weather, a dry bed over a great part of the area, it seems improbable that any harm would result to the local inhabitants, while much good would be derived to the westward and eastward by the improvement of the drainage in those directions.

40. To deal with the whole lake comprehensively and thoroughly, and to arrange for confining the principal rivers within moderate bounds will be a work of the future—useful and necessary and probably remunerative also—but it would be unwise to take it up until the drainage and irrigation of the two deltas are much more advanced than at present. What is now required is a clear understanding of the objects to be desired, so that we may not attempt to work in the same or successive years in opposite directions, and that the population may know what are to be the intended arrangements of the future. It may be added that in the deltas employment is available nearly, if not quite, throughout the year for all labour which may possibly find its occupation gone in the immediate neighbourhood of the lake, though, I believe, that such occupation will be extended rather than diminished by the reduction of the water spread, if that course should be resolved on.

41. This canal is a work which will be provided for in the completion estimates. It has been designed to take off from the Masulipatam Canal about three miles from the head of the latter, instead of from Kunkipad as was formerly intended, it having been ascertained that it will be cheaper to carry out the former plan than to widen the Masulipatam Canal to the extent which would be necessary were the off-take placed at the Kunkipad sluices. On examining the designed arrangements considerable modifications were found to be desirable. While accepting the conclusion that the supply of the Bank Canal proper may advantageously be carried by a canal having its head where proposed, it appeared to me to be in every way desirable that the Masulipatam Canal should convey as much water as possible for the Pulleru on the one side, and for the eastern half of the tract of country between the Masulipatam and Bank Canals on the other side, in preference to taking this latter supply by a branch from the Bank Canal. This is desirable, not only as a matter of economy, but because it is much better to maintain a moderate surface fall in the Masulipatam Canal down to Kunkipad. Again, the Masulipatam Canal and its western side channel are capable even now of supplying a much larger quantity of water for irrigation than there is a demand for at present. Nearly all this tract of country is Zemindary, and it appears to be very doubtful whether water for even 100 acres per square mile will be taken, so that it would be far from wise to expend a large sum of money in the construction of irrigation and drainage works for the benefit of the Zemindary, until at least the capabilities of the existing works shall have been more fully utilized. Were the Bank Canal intended only or principally to serve the Zemindary lands, through which for some 35 miles or so it will run, its construction might be postponed indefinitely, but its chief use will be the amelioration of the condition of the island of Divi, which can be improved effectually by no other means, and in which it is expected that some 45,000 acres will be irrigated. The capacity of the Bank Canal therefore should be confined to that needed for these 45,000 acres, and for 100 acres per square mile in the part of the Zemindary which it will directly command, i.e., from the canal eastwards as far as the first main line of drainage running in a direction approximately parallel to the canal. The estimates as prepared for the whole section between the Masulipatam Canal and the Kistna amount to 19 lakhs, of which approximately seven lakhs appertain to the eastern sub-section under the Masulipatam west side channel, which was intended to irrigate 28,000 acres, all Zemindary; while the remaining 12 lakhs were for the irrigation and drainage of 15,000 acres of Zemindary and 45,000 acres in Divi. Under the arrangements now contemplated but little of the seven lakhs will be proposed for expenditure. Some of the 15,000 acres of Zemindary in the western sub-section will probably take water, but even if none be so taken, it is probable that the extension of irrigation in Divi will be some 35,000 acres, and the water rate of Rupees 4 on this would yield a return of over 9 per cent., even should the estimates when revised amount to as much as 15 lakhs.

42. This canal has been designed with a velocity of 2.15 feet a second or 2,580 yards an hour, but what may be termed the ruling velocity on a 2nd class line of navigation is 2,000 yards an hour, and this should not be exceeded.

Experience in the Godavery Delta has indicated that in low lying lands like Divi the water required for irrigation is considerably less than two cubic yards per acre per hour, and it may be assumed therefore that 81,000 cubic yards will suffice for the 45,000 acres in this island, which lies between the main river and the Puligudda branch. The aqueduct across this branch will unavoidably be a

costly work, and it may be designed to carry a depth of water of 9 feet, running with a velocity for this short distance of 3,000 yards an hour. Its width between the side walls will then be 27 feet, which will do very well. With the canal the island will be placed in a much more favourable position, as regards communications, than it has ever yet been, and it is thought therefore that there is no necessity for making a road bridge in connection with the aqueduct, which should be designed with a tow-path on either side having a clear width of 5 feet, and substantial iron railings in lieu of parapet walls. Of course if the Local Fund Board wish for a bridge, and are willing to pay for one, the tow-path on one side may be widened to 15 or 18 feet, but this additional cost should not be thrown on the irrigation works.

43. The canal, as designed, starts with a bed level at 36.82, and, with a fall of 6 inches a mile a depth of 6½ feet, and two locks with a drop of 2

feet each, arrives at the 35th mile, which is just above the site of the aqueduct over the Puligudda branch of the Kistna, with the bed at 15.32. The Kistna maximum flood level here is at 19.00; and, apart therefore from the convenience of the navigation already referred to, it is desirable, and indeed necessary, to raise the canal bed at the crossing considerably; for though the example of the Naggaram Aqueduct in the Central Delta of the Godavery might be cited as an instance of a work which has stood well though it has several times been submerged by the river floods, this result of a low level has not been without its inconveniences and attendant expense. It is only proper to notice that the levels as designed resulted from the desire to avoid high embankments in the approaches to the aqueduct, but it is essential that the canal should be carried well above river flood level, and so this difficulty cannot advantageously be avoided. A reduction of the surface fall of the canal to 4½ inches a mile, which would give the required velocity of 2,000 yards an hour, would raise the bed level in 35 miles 43½ inches, and it is thought that both the proposed locks may with advantage be omitted, and that the bed level of the canal at the aqueduct, if fixed at about 22.97, will be none too high. Remembering, however, that it has been proposed to make the depth of the water on the aqueduct 9 feet against 6½ feet in the canal, it must be noticed that this would, with the floor of the aqueduct at 22.97, virtually take off 2½ feet from the surface fall down to the 35th mile, which would then become 3.636 inches a mile, and it will be necessary to see therefore whether this reduction of fall with the corresponding increase to the dimensions of the canal, and to the height of the embankments across the low ground near the Puligudda branch, would involve a heavier outlay than maintaining a depth of 6½ feet on the aqueduct, and widening the water-way there from 27 to 38 feet. I have roughly estimated that the case of surface fall from 4.75 to 3.63 inches

would add 2,500 Rupees a mile to the cost of the canal or 87,500 to the 35 miles; and probably the difference, including the heavy embankments, would be not less than a lakh of Rupees; as the widening of the aqueduct would probably cost less and would be the preferable arrangement, it will be worth while to examine the conditions more thoroughly, and to see what will be the better arrangement, the level of the floor of the aqueduct being placed at a not lower level than say +23.00.

44. From the Bank Canal above the aqueduct it is proposed to carry a canal, called the Kistna branch north bank channel, for which a shorter name may with advantage be found, a distance of seven miles to a creek at Chinna Yadara. If, as appears probable, this channel is for the irrigation of Zemindary lands; the estimate may be completed, but the work had better be postponed until a greater demand for water for such lands arises. It should be designed for navigation with a view to its ultimate extension on the line of the old Chinnampooram Canal to Masulipatam.

45. Soon after passing the Puligudda aqueduct the Bank Canal will be divided into three branches, two of which will run as Bank Canals along the Kistna and Puligudda branch margins respectively, and the other across the island of Divi. If economically practicable all three should be made navigable, but, if the additional outlay required be found to be considerable, it will suffice to provide navigation on the central line.

Site for Puligudda Aqueduct.—The site selected is near, but a little above, the village, and the place is suitable, but it is evident that the bed of the river has changed since the survey was made two years ago, and the nature and direction of the changes should be recorded. The nose of the island at the bifurcation of the river has been wearing away by erosion for some time past, and a proper salient should be established by navel planting, as also the proper alignment of the branch from its head to about half a mile below the aqueduct site. Permanent benchmarks should be placed on both sides of the branch near that site.

46. Divi possesses, at least over a large part of its area, a highly fertile soil, and it will probably in time be as rich and well cultivated as the similarly situated island of Naggaram in the Godavery Delta. At present, as the Government are aware, it is dependent for its supply of water for irrigation on inundation channels, which are useless until the river rises to a height of many feet above its ordinary level, and which then are used for filling shallow tanks, many of which are ring bunded or entirely surrounded by bund, in which openings are made when the whole country is submerged; when filled the openings are closed, and the fall in the river freshes enables the water in the tanks to be gradually let out to irrigate the fields. In 1873 the Kistna freshes though very good were not high enough to allow the inundation channels to draw, and a great deal of land was consequently left uncultivated. It was not, however, clear why these rich lands should not have been cultivated with dry crops. Being classed as nunjah or

wet lands probably, under existing arrangements, dry crops could not be raised without the payment of the wet assessment and this may be prohibitory, but when the water supply is so little to be depended upon it would seem to be desirable to allow of some option to the land-holders, and to levy assessment according to the description of crop which it may, with reference to the season, be found practicable to cultivate. Both Government and the people would benefit; both would get something out of the land. If the estimates be sanctioned in time for the works to be commenced next season, it will take four years at least before water can be made available for irrigation in Divi, and ten years before the principal canals and drainages can be completed, so it is much to be desired that a commencement should be made.

Head of Modamudi Channel.—One of the temporary head sluices was being here constructed, but, as built, it was only a bridge with a central pier of palmyras and a stone floor with revetted side-slopes. It could not have been regulated, and the insertion of two more uprights with cross pieces at intervals of three or four feet, so as to divide the area into small openings capable of being easily closed, when necessary, by the villagers, is required, and an estimate for the alterations to this and other similar sluices has subsequently been submitted for sanction.

Surnamuki Channel.—This has a head sluice, but the bed of the channel both above and below the sluice is a yard higher than its sill, and so it is hardly surprising that the supply obtained is small. The bed of the channel was carpeted with grass, and it looked very unlike an efficient means of irrigation.

47. *Head Sluice and Lock for Bank Canal.*—When looking over the project it seemed doubtful whether these proposed works were necessary. Should, however, no lock be built between the head and the aqueduct it will be advisable to have a head lock; otherwise, unless there be special reasons for such a means of regulation, it will be better to have an open head. Surplus works should be provided at intervals to relieve the canal of water which may not at times be required for irrigation, in order that the depth at the upper end of the aqueduct may never exceed that of a full supply for the island.

48. The bed of the Kistna, both above and below the head of the Puligudda branch, appears to be much in need of regulation, and it will be well to employ two maistries on each bank of the river from the anicut downwards in looking after the planting of lunka grass, of which a great deal ought to be done yearly so as to preserve the banks and secure a right alignment which should be laid down on charts, which probably may with a little additional surveying and some levels be readily based upon the Revenue surveys. No part of the river bank, which is upon or within the proper alignment, should be left exposed to the action of the river without the protection of grass or wild cane; it is easy to preserve what it is difficult to restore. The arrangements to be worked up to should be determined, and then year by year as much as is practicable towards this complete definition of the boundaries of the river channels should be done.

49. The wild croton is becoming a nuisance in the delta. It and all scrub-jungle and weeds should be cleared away, and the croton especially should

Wild Croton and Underwood.

be rooted out directly it appears, for it spreads with marvellous rapidity, and not a single plant should be allowed to remain.

50. It would appear that some tree planting has in recent years been carried out from Local Funds, whereas formerly the avenues were planted from canal

Canal Plantations. funds. This latter is the best course, seeing that they must always be under the control of the canal officers. As a rule there should be no watering of young trees, which should first be well started in nurseries, transplanted at the proper season, and protected by the canal establishments, but otherwise left to take their chance which, if suitable descriptions of trees be selected, ought generally to be a good one. The value of wood cut on canal plantations should be credited either to Canal Revenue Miscellaneous or to Plantations; perhaps the latter head will be the best, as it is shown in the Government of India forms, and money under that head for new plantations or avenues can be provided in the annual Budget. The widening of the Masulipatam Canal has unfortunately necessitated the removal of some miles of remarkably fine avenues, and other trees should be grown further back in their place. The abolition of cattle grazing on the canal banks and berms will greatly facilitate the growth of trees, which at present, unless very securely fenced at much trouble and expense, are pretty sure to be eaten off and stunted if not destroyed.

51. This canal is also called the Nizampatam Canal, and in the current year's* Budget it is entered as the Western Delta Main Canal. Seetanagaram Canal. Down to Dugerala it is, and should be called, the Main

Canal, Western Delta. Widening has been in progress for five or six years on an estimate of Rupees 2,76,400, and this work is approaching completion, but a very considerable further enlargement will have to be carried out in due course to carry the full supply for the ultimate area of irrigation in this delta. The earth-works are not as regular as they should be, and the slope of the top surface should be away from the canal, so that only the inner slope may drain on to the berm. The left bank requires clearing.

Bank Canal Head Sluice.—This sluice is in good order. The first time the shutters need renewal they should be provided with screw gearing.

The Upper and Lower Sluices for the supply of the Commamore Canal, and the shutters of the lock weir, should be regulated by screw gearing; the shutters should slide on iron bearings, and all these works should be thoroughly repaired.

52. This canal commences at the Dugerala lock, and since the construction of side channels it carries little or no

Nizampatam Canal. irrigation water. The side channels are really fine canals. A mistake which must be guarded against in the future is the taking off of distribution channels at points much too low down on the side channels. As a consequence rough stone dams have to be placed across the latter to raise the water to a proper level, and these in a great measure neutralize the advantages which were to be secured by the construction of these channels, viz.,

carrying the water at a higher velocity, and so preventing the deposition of much of the silt. The canal was designed to carry irrigation water, and consequently, since this water has been otherwise conveyed, the surface levels have been materially altered, and the navigation has deteriorated. It was proposed in the completion estimates to insert two additional locks, so as to bring the water to a dead level, but the necessity for this appeared to need explanation, and it has since been found that the existing locks and the embankments can be raised so as to obviate the necessity for additional locks.

A couple of miles or so below Dugerala handsome bridges have been recently

Near Nundevalagur.

built over the canal and side channels from Local funds. They do credit to

Mr. Norris, who designed and built them. The left bank of the canal here will make an excellent road.

Kuchipudi Lock.—Some of the flooring of the tail bay has given way. Considerable repairs, costing about 1,000 Rupees, were executed in 1873, but this part of the lock must be entirely reform.

Water on upper sill 7' 2"
lower do. 4' 6"

ed. The angle of the gates is much too flat.

Lock Weir. Rough, and not in good order. The bridge has just been repaired. It is a pity that room was not left for a shutter platform. This may be obtained by removing the cut-water caps, building up the cut-waters, and laying shutter bars upon them.

Regulating Dam and Bridge over West Side Channel. A carefully built work, but with wings not adapted to the banks and slopes. A work of the same design on the East Side Channel.

In the 25th mile a Neem tree interferes with the towing. If the tow-path is to be placed at the edge of the berm, this alteration should be carried out from channel clearances.

Jutur Lock, 31½ miles. Upper gates leak far too much. The gearing needs repair and the masonry wants repointing. The headway of the bridge over the tail bay is 14½ feet with 6 feet of water on the lower sill.

It will be well to place a sluice or weir in the right bank above the lock to supplement the supply of the side channel when necessary. There is already a two vent sluice in the left bank which can be so used. The soil at and above the lock is a clay which could stand a considerable head of water. Canal banks above the lock are too low. The side channels are not yet provided with proper sluices.

Nullavada Lock.—The water above the lock is but little above the surface of

the country, and there would be no difficulty or risk in raising it a couple of

feet. A masonry surplus weir is about to be built in the right bank in place of the rough-stone dam which has hitherto served as an escape.

The Nullavada drainage, which now enters the canal below this lock, is to be taken outside the left bank into the Peddapully drain.

The reach of the canal between the Nullavada and tidal locks runs through two sand ridges, and except in the Peddapully swamp the soil is sand or sandy. At this swamp a breach had to be made in the left bank of the canal to reduce the level of the water outside, and this has been frequently done before. It involves lowering a great length of the bank to provide soil for closing the breach, and the sooner the necessity is obviated by the construction of the drains the better.

The banks in places require putting into section; a great deal of bulrush has been cleared away, and this work in the 36 to 41 miles will soon be completed. Prickly-pear must not be allowed on the canal banks, or on any irrigation works.

Tidal lock.—This is in fair order. The escape in the left bank just above the lock should be bridged as a foot-path, and to allow of the shutters being worked. Its wings are too low, and the banks are weak.

53. This swamp is bunded on the south side to form a tank, and the out-

fall on the south-west side being closed by the Nizampatam Canal, it is not sur-

prising that so much country is submerged at times. About 3,000 acres are irrigated, and it is intended to bring these under an extension of the East Side Channel, and then there will be nothing to prevent the draining of the swamp, which is provided for in the completion estimates, and which will effect a radical improvement in the condition of all the section of the delta between the Nizampatam and Bank Canals. As far as could be judged from the levels, this main drain should be carried between the Komarasole and Elapilly sluices to the southwards, instead of by a much more circuitous route to the east, and then back to the south-west, and this matter is being inquired into. It is to be hoped that the estimates for the matured arrangements will soon be ready, for at present this extensive tract of country is without any adequate means of getting rid of rainfall drainage. All requisite instructions have been given on a review of the estimate as originally prepared, which provided for arrangements which were in some essential particulars defective.

54. The Nizampatam Canal enters the Toongabudra about three miles above its junction with the backwater, and the Navigation between Tidal Lock and Nizampatam. distance to the town of Nizampatam is

about five or six miles. Here and there on the left bank of the lower part of the river, for short distances, tracking is practicable, but elsewhere the banks are covered with dense mangrove jungle, and poling is the only means of progression; this in deep water with, as on the occasion of my visit, a head wind is very slow and laborious work. A tow-path should be cleared all along, and facilities for towing afforded. It is bad policy to construct canals at a great outlay, and then to reduce their value to a minimum by omitting to carry out such trifling, but essential, works as convenient tow-paths in connection with the navigation.

55. It has been thought possible that it would be better to carry the through

line of navigation by the East Coast Nizampatam Backwater. Canal to meet the Nizampatam Canal,

rather than to make the Commamore Canal the main route, and advantage was therefore taken of a visit to Bapatla to see what the backwater was like. It is not now navigable for more than nine or ten miles west of Nizampatam.

The channel shown on the Atlas sheet north of Perala was dry; that to the south of the village had a little water in it, and occasionally the depth is a foot or perhaps more. Between this and the backwater an extremely dense prickly-pear jungle intervenes. The backwater itself has a wide and tolerably deep channel, and but for the impossibility of tracking the navigation would be easy. This difficulty could be overcome by clearing away the mangrove jungle and forming tow-paths, but it seems very doubtful whether this backwater and the swamps between it and Chinna Ganjam present any such advantages as would make it worthwhile to transfer the navigation to this line.

56. This has its head on the Main Canal at Dugerala. The Commamore Lock has gate valves and one lower side culvert, the shutter of which is worked by a lever; with a roller to the shutter spear the arrangement would be efficient. 5 feet of water on the lower sill of the lock.

Kolakalur Bridge.—This bridge, which has been so long in progress, has been completed up to the string course. The work since 1870 is better than that before that time. The sand stone is good but dirty looking.

The new cut on which the bridge stands does not fit well into the old channel at its junctions.

Jagerlamudi Escape Sluices.—An old work of seven vents 4 feet wide and 7 feet 10 inches high. The full supply level of the canal is about 10 feet on the sill. The sluices are efficient, but it has been proposed to substitute for them an under tunnel or aqueduct, in order to exclude the drainage which they discharge from the canal altogether. This drainage coming from the direction of Guntoor enters the canal a short distance below the sluices, and has to run up to get to them.

Jagerlamudi Lock.—This is at present the lowest lock on this canal, and the fall below being much greater than will be the case when the works are completed, the depth on the lower sill is always less than is desirable.

Water on upper sill	4' 6"
lower do.	2' 8"

Cross Drainage.—This canal like the Ellore Canal on the other side of the delta crosses a great deal of upland drainage, and this was, in the original estimate on which the canal was cut, provided for in an altogether inadequate manner. In the completion estimates for this delta also, the requirements of the case have not been fully recognized; on a rough calculation of the water-way needed, it appears that about 2½ lakhs, instead of 1½ lakhs the estimated cost of the works provided in those estimates, will be necessary to dispose of this drainage, and to avoid the risk of frequent damage to the canal.

57. Out of a distance of 22 miles, nearly all the country up to Poonnur nine miles and for five miles beyond that is under dry cultivation, and the crops, especially the cholum, looked very good. Further south the land is for the most part under irrigation. Up to about four miles from Baputla the road is a very

fair one, but then it runs into heavy sand. Since Ypurpolliem has become a port with a considerable trade there is a good deal of traffic, though the difficulties of transport over the sand ridges and swamps near and south-west of Baputla must be very considerable.

58. *Dumpakodu Calingulah and Kurlapolliem Tank.*—The Dumpakodu calingulah across the Toongabudra supplied not only the lands on the left bank of this river, which have now been provided for by the Budam project, but also the Kurlapolliem Tank on the right bank. This tank has this year been imperfectly supplied by one of the channels from the Baputla Tank, which is itself supplied by the Commamore canal. The Tahsildar and the ryots mentioned that the Kurlapolliem Tank supply had been inadequate, and that some lands had been thrown out of cultivation. The altered arrangements are confessedly incomplete, but they would probably have sufficed had the season been more favorable. As it was the absence of rain made the demand for water for ploughing, etc., enormous, added to which there are said to be fifteen sluices, and upwards of 100 palmyra spouts, in the eastern part of the Baputla Tank, and these must lead to waste. There appears to be great readiness to take up land for irrigation in this taluq. Until, however, the supply and distribution arrangements are more advanced, it will not be practicable to afford the water required, and it will be better, therefore, to postpone extension of irrigation.

59. The quantity of water carried by the main canal appeared to be very much more than ample, and yet there is difficulty in getting a proper supply down to the lower end of even a principal canal like the Commamore. In the present state of the channels there must of necessity be a good deal of waste, and it appears probable that much of this is due to high level lands being cultivated in positions where they can be commanded only when the channels are carrying more than a full supply. Kistna water carries so much silt that it is very undesirable that more water than is really required for the cultivation should be admitted to the canals; this subject is engaging the attention of the District Engineer, and measures are being taken for ascertaining all over the delta the actual quantities supplied to various channels; this information will soon lead to improvements and to economy in the use of water, with, as a consequence, extension of irrigation by means of that portion of the supply which is not at present utilized.

60. The drainage of the Kistna Delta is a matter of even greater importance than in the Godavery Delta; it is only necessary to look at the Atlas Sheet to see what a great extent of country is occupied by swamps, and though the exclusion of river floods by embankments has much improved the condition of the delta, adequate means of carrying away rainfall drainage, both local and upland, have still to be provided. When the estimates have been completed and sanctioned their execution will be the work of many years, but it will not be long before a great change for the better will take place, seeing that the first thing to be done is to remove obstructions, and the second to secure proper outfalls through

the ridges which at present absolutely bar the direct drainage, which has to find a circuitous route in some other direction; and, where the fall is small, the submergence of large tracts of ground for considerable periods is inevitable. Heavy losses of revenue occurred in 1872-73 from this cause, and it will certainly be advantageous financially to render the drainage efficient, for not only will remissions be avoided, but the extension of cultivation will be rapid.

61. Statements of irrigation and revenue, like those made out for the Godavery Delta, are under preparation, but have not yet been received; consequently no reliable information is at present available. It is however believed that the area of irrigation in 1872-73 was about 196,000 acres, and the District Engineer mentions, in a note just received, that the Collector estimates the increase of area in 1873-74 at 11,000 acres, and of revenue at Rupees 1,93,000. It is very possible that the revenue may be so much greater than that of 1872-73, but much of the difference must be due to the absence of remissions, and the circumstance appears to indicate that the delta gets on better, owing to defective drainage, in seasons of short rainfall, than when the monsoon is a good one. There must be a very important difference however in the outturn of the crops when, as in 1873-74, no rain falls until some two months after the commencement of the season of irrigation.

62. Much of the time (nearly four weeks) spent in the delta was devoted to the consideration of the arrangements to be provided for in the completion estimates. These for most of the sub-sections are in an advanced state, and it is now desirable that they should one by one be completed and submitted for sanction as soon as possible, commencing with those which it is intended first to carry into execution. This course has already been approved by Government in the order sanctioning the survey establishment for 1874-75, and it is the only way in which delay in carrying out many much needed improvements can be avoided, as it is impracticable for officers, who have also their current duties to attend to, to deal with such a number of heavy estimates at once.

OOTACAMUND, (Signed) JOHN MULLINS, Lieut.-Colonel, R.E.,
7th May 1874. Chief Engineer for Irrigation.

No. 557. ORDER THEREON, 29th September 1874, No. 2,732.

IRRIGATION, No. 65.

THE Memorandum of Inspection, dated 7th May 1874, of the Kistna Delta, containing the Notes of the Chief

Engineer for Irrigation, will be communicated to the Superintending Engineer, Kistna, for information and guidance.

2. The subject of the arrangements requisite for rendering the cross drainage of the Ellore in this district efficient has been fully examined into, and the Government wish to have the estimates submitted as early as possible for carry-

ing out the improvements, and for completing this canal in the manner decided upon.

3. Independently of the propriety of maintaining order and cleanliness where lock and other establishments are located, the health of these establishments, which it is understood has been far from good, is dependent in a great degree upon proper sanitary arrangements; and the Government look to the Superintending Engineer to introduce and enforce these in all such places.

4. Paragraphs 36 to 40 of the Memorandum, which treats of the circumstances of the Kolair lake, will be communicated to the Revenue Department for early consideration. The data for a final determination of the question, as to whether this lake should be allowed to fall to the lowest level practicable, or should continue to be artificially maintained at a higher level, appear to be fairly complete.

5. The arrangements proposed by the Chief Engineer for Irrigation for deferring the provision of irrigation, except on a very limited scale, for the Zemindary lands under the Bank Canal, Eastern Delta, and between that and the Masulipatam Canal, will be referred for early consideration and report to the Revenue Department. It is stated that existing means of irrigation to these Zemindary lands have been far from fully utilized, and until a decided demand for water arises it will probably be unwise to extend the supply.

6. The improvement of the condition of Divi-Purganah is of much importance, and the Government are glad to learn that there is a good prospect of a reasonable return from the outlay which will be required to provide for its wants as regards irrigation. In the meantime the observations of the Chief Engineer for Irrigation will be referred for consideration in the Revenue Department, to ascertain whether the wet assessment prevents the occasional cultivation of dry crops.

7. As in the Godavery Delta so in the Kistna Delta efficient drainage is of very great importance, not only to the safety and productiveness of the growing crops, but to the general health of the population, and so soon as the main drainage shall have been worked out, and some progress made with these drains, the Government will be prepared to make arrangements for providing for village drainage in detail. In the meantime the Superintending Engineer should give attention to this latter subject, and he will be at liberty to bring forward proposals for dealing with individual villages or groups of villages, which he may find to be exceptionally in need of improvement in this respect, and which it may be practicable to drain. Village drainage will not be chargeable against the system of irrigation of the delta, except in those cases in which the irrigation works themselves may have obstructed the natural, or may otherwise necessitate additional, drainage, but will be provided for under Agricultural Miscellaneous.

8. The early preparation of the detailed revenue statements for this delta, in the form decided upon for the Godavery, and made applicable to other systems of irrigation, is very desirable, and the subject will be remitted to the Revenue Department for such further orders as may be necessary. It is observed that

*Proceedings of the Madras Government, Public Works Department,
29th September 1874.*

these statements are due for 1871-72 and 1872-73 in addition to those for preceding years, the compilation of which latter may take same time, while those for recent years should be submitted as soon as possible after the close of each Fusly.

9. The thanks of Government are due to Colonel Mullins for the useful and complete report which is reviewed in these Proceedings.

(True Extract.)

Colonel, R.E.,

Secretary to Government.

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No. 309-A.

MEMORANDUM.

The following notes of a tour of inspection in the Kistna Delta, made between the 20th November and 15th December 1873, are submitted for the information of Government.

- This work is generally in good order and requires only such ordinary repairs as are necessary after the freshes of each year. The apron appears to

Anicut.

have suffered no disturbance, and, except in rear of the spot where the fish-ladder was, there is now said to be no hole or any considerable depth of water below the apron. The lower part of the apron has a steep slope, but is regular. The District Engineer has been requested to have a few cross sections of the anicut taken annually, in order that changes, which might otherwise pass unnoticed, may be detected.

There was at one time a very deep hole to the north of the groyne on the north side of the southern set of under-sluices, and this has to a great extent filled up. It must be carefully watched. The usual rough stone raised crest had been put up for the dry season.

- The state of the shoals is much better than was the case some years ago.

River bed above anicut. The yearly changes are considerable, and not much can be done to affect them.

On the north side the river near the head works has improved. About a mile or so higher up on this (the left) bank three groynes have been constructed to stop erosion; the water was not deep in the first instance, and it has since shoaled considerably; nanel or lunka grass should be planted.

The banks of the river generally, where not in advance of their proper line, should have a lunka grass (nanel) or wild cane (pey karumbu) facing.

- This is the quarry hill on the Bezwada side, and is used to secure at a considerable height one end of the telegraph cables which span the river, the

Telegraph Hill.

distance from post to post being probably not far short of a mile and a quarter. The first wire was put up towards the end of 1857 during the Mutiny, and was blown away in the cyclone of 1864. Mr. Peters, the Range Officer, pointed out the great rapidity of vibration along the wire; this vibration passing to the opposite end and back again in seven seconds.

The view from the anchor posts over the river, the anicut, and head works and the canals is very good, and the arrangements can be well understood from this point.

- This river is one of the difficulties of the Eastern Delta. It rises some 35 miles to the north of Bezwada and

The Budemair.

approaches to within a couple of miles of the Kistna at that place; then, after an abrupt turn to the northward again, it

runs in a south-easterly direction to the Ellore Canal at about 3 miles from the head works, runs for 5 miles on the north side of the latter, and then crossing to the southward has a course of some 30 miles more to the Colair Lake. This river has been a source of constantly recurring damage to the Ellore Canal. In the north-east monsoon of 1872, it breached the canal extensively over a length of some miles. The first breach was at the third mile opposite Mutialampaud; but here, as there was a very strong bank with a revetment some 9 or 10 feet above the F. S. L. in the canal, it is believed that the breach was purposely made in the interest of the owner of the lands alongside, which were inundated to a considerable depth, and the crops on which were in danger of being destroyed. The bed proper of this river near Bezwada is only a good-sized ditch, and the freshes inundate a wide extent of country, a great deal of which is in consequence left waste. It has been suggested that this stream might be turned into the Kistna above the anicut, and such an arrangement would be practicable, but some little time would be needed to work out the arrangements, as high flood level in the Kistna is above the level of much of the ground on the banks of the Budemair. Such a diversion would make it much more easy to deal with the cross drainage of the upper part of the Ellore Canal, and it would probably answer to enlarge the bed and efficiently embank the Budemair in order to reclaim the valuable lands alongside, which cannot now be cultivated. The project should be examined as soon as the District Engineer may be able to undertake the investigation; as will be seen further on it will be practicable to prevent any considerable damage resulting from the relative positions of this river and the Ellore Canal, and so the question of the diversion, though by no means unimportant, is not so pressing as it would otherwise have been.

6. Some of the buildings are in a dilapidated state, and the roof where dangerous was being removed with a view to its repair. These shops, which

Workshops at Bezwada.

some 15 to 17 years ago were highly efficient, were, notwithstanding the need of the assistance which they are able to afford to the Delta works, for several years almost entirely disused. They are now being got into working order, and it will no longer be necessary to send dredges and other plant a distance of over 90 miles to Dowlaishweram for repair. Almost all work, except iron castings which should be obtained from Dowlaishweram, can be done in these shops. There is need of radical improvement in the yard arrangements. The machinery and plant have not been hitherto properly cared for. Component parts were lying about without order, and it is certain that much delay and inconvenience would be experienced from sundry small parts being missing. Crab winches and all plant of moderate size should be put together, or set up and placed under cover, so as to be available for issue at a moment's notice. No plant should be left out of repair longer than is absolutely unavoidable. There is a powerful crab winch which was broken in stretching the Telegraph cable; for it new castings should be obtained at once from Dowlaishweram, and the winch, instead of being left rusty, broken, and unserviceable, should be completely repaired and got ready for re-issue. A great deal of the yard is blocked up with chips and battens of wood, which should all be sorted and stacked, such as will be of future use being kept and the rest disposed of or used for fuel. Shavings and all such combustible material should be swept

up and placed where it can do no harm, at any rate twice a day or oftener if necessary. It is somewhat fortunate that the whole place has not been burnt down; the risk has been by no means insignificant.

In the yard there is a mill for hulling rice, which is intended to be driven by water-power and which was put up at Nedamole in 1865, but not being found to answer it was dismantled and sent up to Bezwada. I am not prepared to say that rice hulling by machinery is an operation for which there is likely to be a demand, but with the command of water-power which we have in this and the Godavery Delta, it is somewhat remarkable that nothing has been done to utilize it. Perhaps this machinery could be adapted to grind clay and lime for making hydraulic cement, of which a large quantity is likely to be needed in carrying out the Delta improvements. At any rate it will be well for the District Engineer to bear in mind that for six or eight months in every year there is a vast amount of unutilized power wasted at the several lock weirs, and that were even a fraction of this made use of for departmental purposes, it might lead ultimately to much more being taken up for private work.

Tip Wagons.—The iron work of twenty tip wagons was sent to this district from the Upper Godavery. One tip wagon has been constructed, but there is no suitable work for plant of this class, and it will be well to get rid of it. The Railways or the Madras Harbour might perhaps turn it to useful account.

7. The amount of plant of this class in the Kistna Delta is small, but it wants

Floating Plant.

much more attention than it has yet received, and it will be necessary to introduce order and system before the large increase which will be required when the completion estimates are finished and the extensive works provided for in them come to be carried out. Under a recent Order of Government a complete register of all such plant will soon be obtained, and provision for its up-keep will be annually made in the Budget. In addition to the information required by that order to be recorded, the district register should maintain a complete record of all considerable alterations and repairs, so that it may be known what this plant is likely to require. For the steamers and steam dredges boilers are from time to time required, and the indents for these should not be forwarded after, but a year or one and a half years before, they are needed. Spare boiler tubes and other fittings should always be kept available. The inefficiency of a boiler intended to work up to 50 or 60 lbs., but unable to bear more than 25 lbs, and with a third or a half of its tubes worn out and plugged may be readily understood, and such a state of affairs should not be possible in the future, but should be provided against by such measures as may reasonably be expected of intelligent officers. I am not here referring specially to any particular boiler, but to a condition which has been approached if not exceeded in several instances elsewhere, if not in the Kistna. All boilers should be tested periodically to 50 per cent. over working pressure by water pressure. This is a matter of no difficulty. The results should always be recorded and the working pressure, when necessary, reduced. The test will usually show when it is time to indent for a new boiler.

Dredges.—Dredges Nos. 3, 5, and 9, and lock dredge No. 2 were lying in the Main Canal and were inspected. Much requires to be done annually to keep this description of plant in an efficient state. The pins and links of the bucket chains

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wear rapidly; the distance between the main pulleys can be adjusted to fit the constantly increasing length of the chain, and this adjustment should be frequently made; as far as I have been able to learn the means of adjustment have commonly been overlooked. Spare links, pins, main pulley bars (cast iron), rollers, roller axles and other fittings which wear rapidly should be always at hand to replace those which need renewal or repair; then a day or two will suffice instead of weeks to render a dredge again efficient. No. 3 dredge was in fair order; the buckets and bucket chains were absent.

No. 5 dredge wants extensive repairs, and one side of the main frame carrying the bucket ladder wants a new casting. Boiler wants new tubes.

Dredge No. 9.—Bucket chain rollers, etc., in very bad order indeed, the whole of the links, pins, etc., require renewal or thorough repair; quite unfit for use in its present state, and must have been so for a long time before work was discontinued. Engine and boiler in better order.

No. 2 Lock Dredge.—Bucket chain and rollers need thorough repair, as do the engine fittings. At the head lock of the Bank Canal, Western Delta, another small dredge was at work, and the minor fittings of the engine were not in good order.

Six old wooden dredge punts have been lying in an utterly unserviceable state for a long time on the right bank of the canal, they should be sold and removed. Unserviceable plant incapable of repair or further use would occasionally fetch something if disposed of at once. After years of rotting it will often not pay the cost of removal.

8. The rolling shutters are inefficient from the rollers having been insecurely fixed, so that they have become displaced. This should be put to rights and

Head Sluice, Bezwada.

the shutters made thoroughly efficient. They require to be provided with suitable arrangements for working them: a great crab winch without any means of traversing was standing over one vent, but this is for all practical purposes a very clumsy way of setting to work, and it is almost as troublesome to get the winch from one vent to another as it would be to lift the shutters by manual labour. Within a few yards of the Delta Workshop something better ought to be possible. A small winch mounted on a carriage or truck, running on rails, would do; and, if the power be moveable, proper means of securing the shutters when lifted must be provided.

9. An early opportunity should be taken of fitting this sluice with proper shutters worked by screws. At present regulation is difficult, and it will cost

Seetanagarum Head Sluice.

less to make a single set of shutters perfectly efficient than to provide a double set as on the Bezwada side. Angle iron bearings should be given, and the holding down plates of the cross beams carrying the gear will need to be placed at least 6 feet below the platform; this may be done without dismantling the upper parts of the piers, as the stone can be drilled without much difficulty with an auger and the bottom plate can be inserted at a wide saw cut, which can afterwards be filled in with Portland cement.

10. The Main Canal, which is about 1,000 yards in length, is also called the Masulipatam Canal; though that com-

Eastern Delta, Main Canal.

mences properly speaking at the end of the thousand yards. It is being enlarged as fast as circumstances will permit, but

of course the necessity for conveying water for irrigation and navigation renders it difficult to get on with it as fast as would be desirable. A convenient quay with wall and steps to the canal, and a roadway with ramps to the main road above has been nearly completed. The merchants complain that the accommodation is insufficient, and undoubtedly the traffic is very considerable, but much may be done by regulation to make the most of the quay room. At present boats lie alongside much longer than is necessary, and it will be requisite to introduce order and system, and to limit the use of the stone quay to boats which can be rapidly loaded and unloaded, and to passenger boats. Timber is stacked near the head of the Ellore Canal. It will perhaps be advisable to put down moorings to facilitate the management of boats, as the current will be rather strong when a full supply is being carried. The District Engineer should draw up a set of rules for the regulation of the traffic at this terminus, and, after obtaining the Collector's concurrence, transmit them for sanction.

Ellore Canal.

11. Two questions, both of very considerable importance, had to be discussed during my visit.

1st.—The best way of improving this canal so as to allow of its irrigating as much land as is likely to require water, and to make it a thoroughly efficient line of navigation.

2nd.—The requirements for passing cross drainage in safety.

With regard to the first point it is clear that from want of sufficient attention to levels in carrying out the various works, which, during a long series of years, have been constructed, this canal is not as efficient as it should be. Following an example which was set by the late Colonel Anderson who was for some time in charge of this district, it has been proposed to carry the water in a channel distinct from the navigable canal, and Lieutenant McNeil Campbell has devoted a good deal of time and trouble to working out a project in this direction. The object is, by carrying the irrigation water at a higher velocity than is practicable in a navigable canal, to reduce the amount of silt deposited, and this arrangement is feasible and advantageous under the circumstances to which it was originally applied, viz, to canals running for the most part parallel to the drainage, but it is altogether inapplicable to those which cross the drainage of the country as does the Ellore Canal, for then this cross drainage has to be provided for twice over, and where the area drained is large, the additional cost is necessarily very great. This objection was pointed out in paragraph 17 of my Inspection Report, printed in Proceedings, Madras Government, of the 10th March 1871, No. 722, in connection with the similarly circumstanced Commamoor Canal in the Western Delta, and it is to be regretted that any time has been devoted therefore to the preparation of a scheme for a side channel for the Ellore Canal. There was no section of this canal available during my recent visit on which the details of the required improvements could be laid down, the longitudinal section which had been plotted being on too small a scale to show accurately what the present conditions are, but it will not be difficult to state approximately what is necessary.

The bed level at the head is to be at	...	...	...	37-50
And the upper sill of the Ellore Lock is	...	...	...	31-95
The full supply water surface at the head will be	...	...	...	45-50
A suitable depth of water on the upper sill of the Ellore Lock would be 6 feet, making the water surface there	...	...	...	37-95

At present, owing to the high level of the Tummelair Aqueduct at Ellore, it would not be practicable to fix the water surface at the lock as above-mentioned, for it would result in a depth of water of only about $2\frac{1}{2}$ feet on the aqueduct, but the difficulty may be solved by removing the aqueduct, or rather by converting it into a set of sluices, an alteration which would result in such important advantages as regards disposal of drainage that, much as I regret advocating the dismantling of a perfectly sound work which has withstood repeated floods, it should be carried out, because practically the aqueduct has been useless for the purpose of passing floods under the canal, and after frequent alteration it continues to be as ineffective as ever, and its arches are and have been for long entirely blocked by sand, and the freshes go over it, occasion breaches, throw much silt into the canal; so that altogether, after full trial, the time has come when it will be well to get rid of a work which has not answered its purpose and which stands in the way of much needed improvements.

12. The surface fall then available will be 7.55 feet, and the distance being 40 miles, the average will be 0.189 feet a mile nearly. The bed fall will be from 37.50 at the head to 31.95 at the Ellore Lock, or 5.55 feet equivalent to an average of 0.139 feet a mile. The discharge required in the upper part of the canal is about 62,000 cubic yards per hour, and the bottom width of the canal is at present 60 feet. The surface fall for the first ten miles will be less than the average, or the discharge would be too great. A surface and bed fall of 0.08 feet a mile will give about the required discharge, and a mean velocity of about 0.8 feet a second. Below this point the surface fall available should be distributed with reference to the discharge required in each section, or between each considerable irrigation off-take, and to the present dimensions of the canal, which generally are probably in excess of those required. There will practically be no appreciable surface fall in the last five miles, which may be treated as a still-water canal. The depth of water will be 8 feet in the first section of about ten miles, and thereafter will decrease as may be found convenient. In the upper 20 miles the remodelling will not affect the existing under tunnels, but below that there are several which will have to be re-built. How the levels of these latter were determined is a mystery, for they have no relation to any possible arrangement of the canal, seeing that some of those in the lower miles are higher than those in the upper miles. No under tunnel on which a depth of 6 feet with a full supply can be obtained need be reconstructed, even if the width and water-way be slightly less than that required, and works of this class on which the water-way with a depth of not less than 5 feet will be equal to or in excess of that necessary may be retained. These observations will, it is hoped, enable the remodelling of the levels of the canal to be worked out without difficulty, and the District Engineer may consider himself at liberty to modify the details within reasonable limits, should the distribution arrangements render this necessary or desirable.

13. The large area of country draining across this canal and the inadequate means of discharging flood-waters, have led to repeated accidents, to considerable

damage, and to the closure of the navigation, with as a result much inconvenience to the trade and traffic of the Kistna and Godavery Districts. This canal is a great highway, and as such it is most desirable that it should be closed as seldom as possible, and only at such times as may be unavoidable owing to the supply of water in the Kistna running short. The requirements of the cross drainage have been carefully gone into, and what is proposed to be done will be detailed below. Circumstances render it impracticable to adopt for very heavy rainfalls the more perfect arrangement of passing all cross drainage under the canal; but, by allowing ample vent across the latter, all risk of damage will be avoided, and as the floods, instead of being obstructed and rising until the canal banks gave way, will be discharged at a level not exceeding 2 feet above ordinary full supply level, comparatively little silt will be deposited, and no injuries of importance will be sustained.

1st Section, Budemair and Avadapilly.

14. Commencing at the upper end of this canal the first drainages to be dealt with are the—

Budemair, draining 525 square miles, and the Avadapilly basin of 96 square miles, and these must be taken in connection, as the watershed between them is liable to submergence. If the greater part of the drainage of the Budemair can be turned into the Kistna above the anicut, the advantages will be great, but that arrangement will not materially affect the measures to be taken below, except that it will make the latter more efficient.

In calculating the discharging capacity of works passing drainage under the canal, it has been assumed that in extreme floods the water on the upper side of the canal may rise to 4 feet above that in the out-fall channels, and that the velocity through the works will consequently be about 10 feet a second. Maximum flood discharges have been calculated by the formula $D = 562.5 M^{\frac{3}{2}}$ = cubic feet per second.

The maximum flood discharge from the two basins forming the first division of the cross drainage to be disposed of is $36,607 + 11,790 = 48,397$ cubic feet a second.

	Cubic feet.
The existing means of discharge are Ryves' Channel, head sluice	630
Budemair aqueduct, through	5,330
Over walls	1,206
	6,536
Two under tunnels above lock	840
Kaserapilly escape sluices, two vents of 15 feet each which are un-serviceable	...
Escape in 16th mile	828
Avadapilly under tunnel	400
Total Cubic feet a second...	9,234

or less than one-fifth of that required. As will readily be understood the heavy rainfall of the end of 1872, though by no means a maximum, breached the canal

very extensively. It is unfortunately very difficult to provide altogether adequate means of passing this division of the drainage; what is proposed is:—

1st to allow free passage across the canal in the whole of the seventh mile. Here most of the breaches occurred, ground level approximates to, but is a little above canal full supply level, and the circumstances of the locality are therefore very favourable; the discharge across this mile may be taken to be ...	30,000
2nd to substitute for the Kaserapilly escape sluices, an aqueduct of 12 spans of 10 feet each of about the same height as the Budemair Aqueduct, and having also sluices in the lower side wall of a capacity of 500 cubic feet per second, for the discharge of water coming down the canal from the Budemair Aqueduct. The discharging capacity of this work will be, through the arches, cubic feet ...	6,360
Over side walls ...	1,453
Through side wall sluices ...	500
	<u>8,313</u>

Additional cubic feet per second... 38,313

In these calculations it has been assumed that the ordinary water-level in the canal may be raised 2 feet on the occurrence of extraordinary floods and that that depth will pass over the side walls of the aqueducts; as a fact this maximum level of the future has been more than once exceeded, and within the limit proposed but little harm beyond some silting will occur, as all aqueducts which may be submerged will have the ends of their wings, or rather the side walls from the faces of the abutments, stepped or ramped up to the tops of the embankments, and the common cause of failure of such works, viz., the turning of the wings, will be obviated. The seventh mile opening will be capable, if necessary, of discharging a larger quantity of water than that shown against it, for a few additional inches of depth would make a material difference in the discharge. It is, however, only to be considered as a safety valve, to come into play when the regular works are unequal to the disposal of the drainage, and nothing will be done beyond clearing away such portions of the banks as remain, and levelling the ground where necessary; the soil is good, and will not be washed away to any extent of importance during the few hours that water may be occasionally discharged.

2nd Section, Atkur Drainage.

Maximum flood discharge ...	1,743 C. feet a second.
<i>Existing Works.</i>	
Atkur under tunnel, cubic feet ...	140
Atkur escape weir ...	648
Sluices ...	140
	<u>788</u>
Prettipand escape weir ...	864
Sluices ...	360
	<u>1,224</u>
	<u>2,152</u>

15. The next separate section of the drainage is the Atkur with an area of five and a half square miles—

so that the existing provision is more than sufficient. The Atkur escape might be made more convenient for regulation.

3rd Section, Ampapur Drainage.

16. The Ampapur drainage basin has an area of seven square miles:—

Maximum flood discharge, cubic feet a second ...	2,059
<i>Existing Works.</i>	
21st mile, under tunnel, cubic feet a second ...	280
21st mile, outlet ...	475
	<u>755</u>
	<u>Difference, Cubic feet. 1,304</u>

which can be disposed of by lengthening the outlet from 50 to 190 feet.

4th Section, Viravelly Drainage.

17. This drainage has an area of 48½ square miles, and will be taken as 50 square miles:—

Maximum flood discharge, cubic feet a second ...	7,633
<i>Existing Works.</i>	
Outlet, 22nd mile, 150 cubic feet ...	1,425
„ 23rd „ 75 „ ...	712
Viravelly vagu under tunnel ...	850
Escape, 24th mile, weir (4 feet on crest) ...	1,728
Sluices ...	720
	<u>2,448</u>
Under tunnel, 25th mile ...	280
Outlet, 26th „ ...	2,280
	<u>7,995</u>

and this drainage is sufficiently provided for. Some breaches occurred, but these were partly due to overflow from other drainages, and partly to the outlets having no wings. The escape in the 24th mile must be improved.

5th Section, Ramaleru Drainage.

18. The area of the Ramaleru drainage is 109 square miles, and for 110 square miles the—

Maximum flood discharge will be, cubic feet ...	12,910
<i>Existing Works.</i>	
Outlet, 238 feet, cubic feet ...	2,261
Ramaleru under tunnel, cubic feet ...	1,500
Tatigudiem do. do. }	3,761

so that a great addition to the existing means of disposing of cross drainage is required. This can be provided by constructing an outlet 960 feet in length between the new bridge and the under tunnel.

6th Section, Peddapad Drainage.

19. The drainage of 25 square miles has here to be disposed of:—

Maximum flood discharge, cubic feet ...	4,809
<i>Existing Works.</i>	
Kulpurru outlet, 48 feet long, with self-acting shutters ...	1,800
Peddapad under tunnel ...	600
	<u>2,400</u>
	<u>Difference, Cubic feet. 2,409</u>

The self-acting shutters of the outlet cannot be relied on and they must be removed; it has been considered whether it would be advisable to raise the crest leaving sluices therein, or to let it be a simple weir with its crest flush with canal F. S. L., and it was decided that the better plan will be to omit sluice vents, and to provide for the required discharge by an additional outlet. The arrangements will then be—

Kulpurru outlet, cubic feet a second ...	...	...	...	...	456
Peddipad under tunnel, do. do. ...	...	...	...	...	600
Additional outlet, 395 feet long, do. do. ...	...	...	...	...	3,753
Cubic feet.					4,809

20. The 7th and last section is the Tummelair drainage with a catchment basin of 457 square miles. The canal

7th Section, Tummelair Drainage. has suffered repeatedly from this river, which divides into two branches above the town of Ellore, and inundates a great extent of country. It is perhaps somewhat surprising that more damage has not been sustained by the canal below the Ellore lock, as the spill of the river in that direction is considerable. It would not have been really very difficult to prevent the flood waters of the river breaching the canal banks; but, had these been maintained, the part of the town and station to the north of the canal would have been entirely swamped, and the necessity for relieving this part of the town has led more than once to the cutting of the banks to afford additional outlet to the flood waters.

The remodelling of the canal will carry with it a complete change of the arrangements and conditions. Full canal level will be lowered materially, and this will be an improvement; and the waterway will be very greatly increased and placed at a better level. What is supposed to be the full supply level at the escapes near the Ellore lock is 9.58 feet above the upper sill* of the lock. In the

* 31.95.

revised arrangements the ordinary water level will be reduced 3.58 feet or to

37.95, and will never rise above 39.95.

In this case the lower escapes which have to be remodelled will be first considered, as the additional waterway to be provided to the westward will depend upon what can be done with the existing works.

The maximum flood discharge to be passed across the canal may be taken at cubic feet per second 33,520. The eastern branch of the Tummelair is admitted to the canal, and has two outlets. Of these the first is an escape weir with self-acting shutters, which do not act when most required. The masonry crest is at 3 feet below present F. S. L. or at 38.53, and the apron at 35.53. This latter is higher than is convenient, but the work is a substantial one of three bays of 48 feet each, and it would be a pity to dismantle it. It will be divided into sluice vents of 7' 7½" each by constructing four additional piers each 2½ feet thick in each bay, and the sills of these vents will be at 35.53. The height of the shutters will be only 2.42 feet, and the maximum depth of water passing through 4.42 feet, at which height the arches will spring. The fall below the work is rapid, and the water level in rear will probably be at least 3 feet lower than that in the canal. On this

assumption the discharge per foot of length will be 29.58 cubic feet a second, and for the total clear length of 114 feet 3,372 cubic feet.

The shutters will be worked by ordinary screw gearing.

A little west of this there is an escape with its crest at 42.28 and a length of 60 feet, and there are three sluice vents 3 feet square in the body wall. Under existing arrangements with water level in the canal at 43.53, its discharging capacity is about 970 cubic feet a second, but it is not at a level suitable to the remodelled canal, and a much more powerful work is needed. It should therefore be dismantled, and in its place a set of sluices having their sills at bed level (31.95) should be constructed. The vents should be 6 feet wide and the shutters 6 feet high and they may be made to lift 6 feet or 8 feet as may be the more convenient for the roadway and shutter platform level. In the former case twenty vents and in the latter seventeen vents will suffice, and will give a discharge of about 6,250 cubic feet.

The total discharge to be provided for the eastern branch of the Tummelair will, therefore, be 9,622 cubic feet, which is about what the late Major Ryves contemplated, but is much more than the works constructed, had they answered in every respect the expectations of the designer, could have passed at the level at which they were built.

No inlet weir to prevent water leaving the canal on the north side will be needed with the revised levels. Across the west branch of the Tummelair, or rather on a new cut which superseded that branch, the aqueduct of twelve arches referred to in paragraph 11 above stands, and it is at present an inlet and outlet weir of some 225 feet in length. It probably discharged in 1872, with a depth of 3.60 feet going over the side walls, some 4,950 cubic feet a second, but the flood level was so high as to breach the canal banks in all directions. The bed level at the aqueduct is about 36.58, and the side walls are at 41.91; so with the revised flood levels the wings will be of ample height. My note-book does not contain the span of the arches, but it would seem to be 15 feet, with piers 4 feet high, and rise of arch 3 feet. So probably the river floor is 9 feet or 9½ feet below the present bed, or at 27.58 to 27.08. The revised bed level being 31.95, the sluice sills may conveniently be placed 18 inches lower or at 30.55, and the shutters will then be 7½ feet high, while to obtain full discharging power the lift must be 9½ feet, and the shutter platform at 47.45, which is 5.54 feet above the present roadway. Each archway or span of 15 feet will be divided into two sluice vents of 6 feet each by a 3 feet pier, the masonry of which and of the raised sill must be of picked stone extremely well fitted, and the sill must be bonded into the floor and main piers. It will be well to build it like a lock sill.

The twenty-four sluice vents will discharge cubic feet 10,584. The abutments of the existing aqueduct at the springing line are probably not far from revised bed level, with which they will be made to correspond. The piers may be shortened to the length required to carry the arches over the sluice vents, the springing of which may be placed at or above 39.95. The shutters will have angle iron bearings in the groove or shoulder, and should have iron straps to form the bearing surface of the shutter itself, so as to reduce the friction and power required to work

the shutters, for which powerful screws will be needed. The gain in discharging capacity by lowering the sill, and the advantage in preventing silt coming into the canal, are considerable enough to make it worthwhile to face the difficulty of working shutters, the area of which will approximate to 50 square feet. As the shutters will be lifted, or water will go over them, directly canal F. S. L. is exceeded, the calculated pressure on the shutters will not be exceeded.

There still remain cubic feet 13,414 to be disposed of, and of this probably about 3,500 cubic feet spills to the eastward of the eastern branch of the Tummelair, and is discharged by the surplus works of the Godavery portion of the canal, so that further provision for about 10,000 cubic feet is required. The old course of the western branch of the Tummelair affords one suitable site for an outlet, and it was originally proposed to place here an outlet of 200 feet in length, but it will be well to increase this to 360 feet, which is probably as great a length as the outfall channel will relieve. The discharge from this escape will be cubic feet 3,420.

The country then falls rapidly to the westward to the Wútlúr under tunnel, the floor of which is at 23.83, or 2.12 below revised bed level of canal. The under tunnel itself is too high for the revised levels, and its position will be well adapted for a powerful escape with a length of crest of about 300 feet, discharge cubic feet 2,850 and under sluices, the sills of which may be placed at 2 feet below bed level, the vents being 4 feet by 4 feet. The velocity through these sluices may be taken at 10 feet a second, and each vent will discharge 160 cubic feet; so the balance of drainage to be got rid of will require twenty-four vents, the discharge through which will be cubic feet 3,840. If room for 750 feet of outlet can be found, under sluices will not be required.

21. It is quite possible that, when these alterations come to be planned in detail, it may be found preferable to carry the lower part of the canal to the south of Ellore, returning to the present line above the escapes near the lock, for a portion of the present line is already in heavy cutting, and the space is confined.

22. The distribution arrangements should be distinct for the several areas between any two drainage outfalls.

Distribution arrangements.
Outlets and inlets.
description recently constructed on this canal in the Godavery District. All of them will have their crests at full supply level, and the calculations have been made for allowing the maximum water level to exceed this by 2 feet, so the minimum height of the canal banks must be 5 feet above F. S. L. Care must be taken to provide ample openings in the upper or left bank to enable drainage to reach the outlets. If there be no obstruction the water will flow in at a low velocity, and will bring in but little silt. Many of the inlet openings will be simple gaps; elsewhere a small wall or a little rubble pitching will be needed at the inlets; and possibly in some cases contour banks may be required to prevent canal water spreading over cultivated land, but the fall of the country is so considerable, that these banks will nowhere be of any length.

24. It will readily be understood how great a change in the condition of the canal the provision of adequate means for the passage of cross drainage will effect. Moreover, as regards at least the lower part, not only will ample waterway be provided, but the much lower level at which the discharge will take place will put a stop to the accumulation of water, and as this comes down it will be at once got rid of. The conversion of the Tummelair Aqueduct, the building of an aqueduct near Kaserapilly, and the reconstruction of under tunnels, can be carried out only when the canal is closed, but by far the greater part of the works for affording additional waterway can be gone on with at any time, and if all materials for the rest be got ready beforehand, they may, without difficulty, be completed during the time that the canal is ordinarily closed for want of water.

25. Looking to the importance of this line of navigation, in remodelling the canal a width of 60 feet at water surface should be allowed where practicable, and 50 feet should be considered the minimum admissible. Similarly the depth with a full supply must not be less than 6 feet.

26. The following remarks on the canal, as it was at the time of my inspection, may be useful, though in some cases they are applicable rather to the existing than to the intended arrangements.

Head Sluice, Ryves' Canal.—This sluice which has three vents of 5 feet is the present means of supplying Ryves' Canal, but when the new head near Bez-wada is opened, the supply will not be carried by the Ellore Canal at all, and this sluice will be available for surplusing into the Budemair. The arrangements for regulating the shutters are very defective, and it should be fitted with proper shutters and gearing. Lunka grass should be planted in the bays below the sluice.

Budemair Aqueduct.—The water did not quite top the up-stream wings in the floods of 1872, but it turned the other wings, though without damage to the masonry. The wing ends must be raised to a perfectly safe level, viz., 5 feet above F. S. L. The lower left wing (canal) is badly cracked. The state of the sub-structure is not known, and it is to be examined this year. The width between side walls is 48 feet, and the depth of water it can carry is 7½ feet.

Under tunnels above Lock.—There are two under tunnels each of two arches. A great breach occurred at one of these and the masonry was damaged.

Kaserapilly Lock.—This had 7½ feet on the upper and 3½ feet on the lower sill; it connects the Ellore Canal with the Budemair, and through the latter with the Colair Lake. I was informed that it is never used, and the navigation is no doubt difficult owing to the character of the river, but it will be well to see whether this be not easily capable of improvement, and at any rate tracking should be rendered possible by the removal of Tooma trees and bushes from the banks, so as to have a clear space of 4 or 5 yards on either side.

Kaserapilly Surplus Sluices.—These are all to pieces. The four wings have been successfully and ingeniously tied up, but the piers are also incapable of repair. As already mentioned it is intended to remove this work, and substitute a capacious aqueduct.

51

An abandoned *irrigation sluice* in the right bank just above the village of Budavarum appears to have been built on too high a level. If unsuited to the revised arrangements it should be removed.

Palmyra Spout Sluices for distribution purposes are altogether objectionable in a Main Canal, and none should be inserted for new irrigation, while those now in use should be superseded as soon as possible by masonry sluices. There is one in the 16th mile which is not at all safe.

Escape in the 16th mile, a work of considerable power, but somewhat difficult to work.

Alapuram Sluice, altogether inefficient. It has no proper shutter, and there is a considerable fall off the floor in rear. It has no rear wall or water-wings.

Aradapilly Under tunnel.—This work has water-wings which have kept up the banks. All under tunnels which may be retained, and which are without sufficiently long wings and water-wings should have such additions made to them as will keep the connections with the canal banks in proper order.

Atkoor Escape, 19th mile.—It has two bays of 12 feet with cast-iron posts and planks, and a sluice vent in each bay. The design of the work is not good, regulation being difficult. The canal here is single banked.

Prettipad Escape Sluice, four vents of 8 feet span each, with the crest 2 feet below F. S. L., and sluice vents 3 feet square. An efficient work except that the sluices must be difficult to use, and they were not used in the floods.

Outlet, 21st mile.—This has no wings, and the crest is a good deal below F. S. L., the water being retained by a small bank.

Under tunnel.—This is just below the outlet; the water-wings have retained the banks, and the revetments also have stood well.

Outlet, 22nd mile, 150 feet in length, with a corresponding inlet. Except that it has no wings, which are essential, this escape is effective. No breaches occurred in this part of the canal.

Outlet, 23rd mile, 75 feet in length, and being without wings the banks were washed away for about an equal distance. F. S. L. is somewhat above ground level, so a paved inlet will be required and its crest may be an inch or two above F. S. L.

Viravelly Under tunnel.—This is just below the outlet, and if its level be suitable it can with the addition of revetments be made efficient.

Escape Sluice, 24th mile, has eight bays of 8 feet each, with sluices 3 by 3 below, which probably are never opened. Crest is 2 feet below F. S. L. Breaches occurred in both banks above and below this escape. The inlet opening is about 120 feet.

Under tunnel, 25th mile, breaches occurred at three of the wings. With good wing revetments it may be made secure.

Outlet, 26th mile, a rough stone-work with no proper wings or anything to prevent breaches at either end.

Perikeed Bridge, 27th mile.—One span of 50 feet, rise of arch $14\frac{1}{2}$ feet, springing one foot above present water-level. Arch turned, but superstructure not com-

pleted. Tow-paths not having been originally provided, timber-paths have been added. The work is creditable.

Irrigation Sluice, Kunamole.—An old work with the most common of rubble masonry, $3\frac{1}{2}$ feet on upper, and $2\frac{1}{2}$ feet of water on lower side. It requires a shutter.

Ramaleru Under tunnel.—Three feet of water, and more than one foot of silt. The revetments at the water-wings which bear no relation to the slopes they are to retain are very insecure. The banks above this work were breached for about 100 yards on both sides.

Ramaleru Inlet and Outlet.—The former consists of a little rough stone with revetments at the ends, which are on an insufficient scale being barely above F. S. L. The outlet is a wall with a small overfall on to a rough-stone apron, which is not likely to stand. Length 233 feet. Wings are 4 feet above body and ramps at either end, the tops of which are a good deal too low. There was a large breach above this escape.

Under tunnel, 29th mile, was breached round the upper right wing.

Inlet and Outlet, 31st mile.—These are fitted with self-acting shutters, and those of the inlet are out of repair. Canal water 6 or 7 inches below the tops of the shutters. The outlet shutters could not be moved by four men. A breach occurred round lower wing of outlet. Wings $4\frac{1}{2}$ feet above F. S. L., and earthwork lower than the wings at both ends, which is not proper. Bunds above inlets when allowable at all should not be more than a few inches above F. S. L. As a rule the crest of the inlet where ground is below F. S. L. should be stone or masonry, and at or an inch above the level of full supply in the canal.

Bridge, 32nd mile.—An iron bridge with no tow-paths. It belongs to the Godavery District. The approaches are in very bad order, and are hardly practicable for a cart. The tunnel under the north approach is too small, and the water has formed a channel round the toe of the incline.

Peddapad Under tunnel, very little water, and a great deal of silt on this tunnel. It was breached at upper right wing, this work being, as is too often the case, lower than any part of the banks, though not adapted to allow water to be discharged over it.

There is a very good site for an outlet between this under tunnel and the bridge.

Below this under tunnel the banks on both sides were breached in numerous places.

Wuttur Under tunnel.—This was breached round on all sides, and the water would again turn the water-wings in a similar manner. The main wings should be carried up to the face of the abutment at not less than 4 feet above F. S. L. and should then be stepped down, the overfall will then be clear of the water-wings instead of on to and behind them. Below this under tunnel in the 36th mile there is a site available for an outlet of considerable length. The flood waters topped the left bank in this mile at many places in 1872, and an irrigation sluice at which the right bank was exceptionally low was destroyed; the irrigation of about a thousand acres is now carried on from several palmyra spouts.

Tumme
~~Finlay~~ *Aqueduct*.—The arches are completely blocked, and the river-bed is practically flush with the upper side wall, so that the aqueduct has been converted into a weir. No clearance has been made for years, but so long as the work is retained the arches must be cleared annually or oftener if necessary.

27. The avenues must be so arranged as not to interfere with tracking. At present the trackers have at some places to walk in the water, owing to the trees being in the way. When the canal is remodelled the tow-paths should, wherever practicable, be placed at the water's edge, and at 1 foot to 18 inches above F. S. L.

28. Cattle crossings here and elsewhere require to be made efficient, and the banks in connection with them should, where there are no berms, be recessed and ramped, and the crossings should be fenced off from the canal on either side. Cattle very soon cut down a bank of ordinary section, and the crossings then become a source of danger.

29. The head sluice is completed except the fixing of the shutters and their gearing, and these are in store in readiness against the completion of the earth-works of the canal.

Brick-making with a Clayton machine had just been started at the head of this canal. It is a wire-cutting machine, and the soil hitherto used has not been suitable. In exceptional cases, where a large number of bricks is required, and where superintendence is available these machines may answer, and undoubtedly they will turn out excellent bricks. The first necessity, however, is a plastic clay of very even texture, and this is but seldom obtainable naturally, and artificial mixtures are apt to be costly. Table-made bricks are excellent, and sufficiently good for all purposes, and they can be made anywhere by any coolies after a very little instruction; any soil suited for bricks can be moulded on tables, and such bricks cost very little more than the wretched, porous, brittle, ill-shaped bricks which are made out of thick slush on the ground. Unfortunately few officers and subordinates have ever learnt how to mould bricks on tables, and consequently the introduction of improved building material is difficult. In Nellore table-moulded bricks were first made departmentally, and afterwards with but little trouble such bricks were supplied by contractors at a moderate price over a considerable part of the district. The new head of Ryves' Canal is 7 miles in length, and up to last September the progress made was—

	Rs.
Estimate, cubic yards 2,109,536, at 2 Annas ...	2,63,692
Work done, " 1,605,952 ...	1,49,479

the average rate being rather under 1.43 Annas. The work has hitherto gone on very slowly, and its completion, at as early a date as possible, is of so much importance that I urged the District Engineer to see whether more labour could be obtained; and apparently the efforts made have been successful, for an additional allotment has been asked for and given. A very large section of the Eastern Delta will receive its supply from Ryves' Canal and its branches, and up to this time, although the branches are more advanced, no water except the small quantity

which can be conveyed by the Ellore Canal, and passed through the sluices at the present head, is available. Moreover, not only is the section of the delta interested one in which there is much room for an extension of irrigation, but it is one in which successful cultivation is to a large extent dependent upon a water supply, the soil and circumstances not being adapted to dry cultivation.

The earth-work has not, so far as the spoil banks are concerned, been executed in a good way. These should be made up regularly over the whole area they are to occupy, and the drainage from the top should run outwards. As no provision has been made for draining the berms under the spoil banks, arrangements will be necessary for turning this drainage into the canal. The berms should slope towards the spoil banks, and a small channel should be made near the foot of the interior slope of the latter, and then at intervals the water can be let down into the canal by turf or other channels. A little care in preventing guttering and holes in the first instance will save much trouble and expense afterwards.

30. Extensive clearances of the berms of this canal near the head were in progress, and not before they were wanted.

Masulipatam Canal.
Kunkipad Lock, 12 miles.—The lock gearing is not in good order. The ground and banks in the neighbourhood are choked with croton and jungle; the lock establishment should keep the vicinity of the lock clean. The ground near the huts of the lock establishment also should be much cleaner than it is.

Water on upper sill ...	5' 0 1/2"
lower do. ...	4' 8"

Above the lock in the left bank are two sets of sluices for the supply of the Pulleru. Each set has six vents. The upper sluice may easily be fitted with proper shutters worked by screws, and the piers should be carried up to carry the beams. The 4th arch from the upper end is cracked right through. The lower sluices are in very bad order: the wings require to be entirely rebuilt.

On the opposite side of the canal there is a set of sluices formed in what was originally a weir of 10 bays. The lower bay has three sluice vents, and is in use for the supply of the next reach. The rest of the work is at present unused. Part of it will be adapted to surplus water, and part will probably be required to supply a portion of the irrigation between the Masulipatam Canal and the river.

The piers of the sluice supplying the lower reach are in very bad order; they have been knocked to pieces by unmanageable shutters, which should be replaced by others with screw gearing.

The banks and masonry works in the reach between Kunkipad and Veerunky locks are not in good order.

Veerunky Lock, 24 1/2 miles.—The gearing of the lower gate valves is in very bad order. The gates want renewal.

Water on upper sill ...	7' 2"
lower do. ...	3' 9"

The lock walls require a good coping; at present they are not high enough.

Much leakage at lower gates. The upper gates have a wooden sill bar, and the leakage is small: the gate valves, however, leak a good deal, and the gearing is in very bad order. A lever of an improved pattern has recently been provided

for working the lower culvert shutters, but it is very unnecessarily heavy: a bar half an inch wider than the shutter spear with a plate on each side terminating in a hook to engage the pin passed through the shutter spear would be a better pattern, and much cheaper. A fulcrum consisting of a triangular block of wood with projecting pins at the base to fit into sockets in the masonry should be provided for each shutter.

Lock Weir, three arches each divided into four bays by cast iron posts. A sluice in the body wall at the west end should, if it is to be used, be fitted with screw gearing. The wide difference between the depths on the upper and lower sills of the lock indicates either that the regulation of the water is not properly managed, or that the surface fall in the reach below is too great for the quantity of water to be carried. The rear revetments of the weir are 3 feet too low.

Bridge of one small and one large arch over *west side channel*. A very rough work (old) and cracked. The earth-works of the roadway over tail-bay and side channel bridges are in very bad order, and are dangerous for carts.

Pamurru Junction Canal.—This is a short cut from the Masulipatam Canal to the Pulleru; on it there is a small lock, and it was at the time of its construction supposed that the water in the Pulleru would be higher than that in the Masulipatam Canal, but under existing circumstances, this condition is often reversed, and at the time of my visit water was running from the canal into the Pulleru.

Lock.—The gate valves want gearing; they are worked by levers at present.

Water on upper sill, Pulleru ...	2' 8"	The completion estimates will, it is stated, secure a proper depth of water on the upper sill of this lock.
lower do....	6' 6"	

The Lock Superintendent and three lascars have very little work to do in connection with the traffic which is small, and they should be required to keep the banks, the trees, and the fencing round the latter in first rate order, and to clear away all bushes, etc.

Nidamole Lock, 37 miles.—The tail-bay bridge is being reconstructed

Water on upper sill ...	7' 2"	with iron girders, the arch having failed. There is much leakage at the sill of the upper gates. The arrangements for opening the side culverts are still very defective. Gearing of upper gate valves better than is usual on this canal, but that of the lower gates is bad. The wall on the right side of the chamber has a crack about the middle, which should be filled in.
lower do. ...	4' 4"	

faild. There is much leakage at the sill of the upper gates. The arrangements for opening the side culverts are still very defective. Gearing of upper gate valves better than is usual on this canal, but that of the lower gates is bad. The wall on the right side of the chamber has a crack about the middle, which should be filled in.

In this delta it is noticeable that the angle of the gate sills is in many cases much too flat, and this throws an unnecessary strain on both the gates and their abutments. At the Nidamole Lock the angle at the lower gates is very obtuse, the vertical or perpendicular being only $\frac{1}{11}$ th of the base of 20 feet; at the upper gates the vertical is $\frac{1}{11}$ ths of the base. Variation of the angle is not needed, but of course the pressure on the lower being so much greater than that on the upper gates, the difference should, if considered necessary, have been reversed. At the

tail-bay an iron girder bridge is being substituted for the masonry arch which failed.

Lock Weir.—This work has two arches of 15 feet span each, divided into three bays each by cast iron posts. It can, without difficulty, be made into an efficient regulator.

Above this weir and lock in the right bank a sluice was constructed about 1866, in connection with the rice-hulling machine or mill referred to in a preceding paragraph; it is now in ruins and the work was indifferently constructed.

Bridge and Regulating Dam, East side Channel.—This regulator is a work of the same pattern as those of the side channels of the Nizampatam Canal: it is in good order. The channel above is much choked with bulrushes, which, however, were dug out last year. They should be pulled up yearly until eradicated. The revetments below the regulator are very dilapidated, and the alignment of the channel here should be improved.

The earth-works at the lock should be made up to the level of the side walls.

Huts of Rahadari Boat Coolies.—It is no doubt a convenience to the coolies to allow their huts to be located close alongside the canal, but they should be placed behind, and not within the canal banks, and it is essential that the arrangements of these and of the lock establishment huts should be made with some attention to cleanliness. Latrines must in all cases be provided, and filth within the canal boundaries must not be permitted to accumulate. Long trenches with a screen are as good a form of latrine as any, and the expense is nominal. The Rahadari coolies must of course provide latrines for themselves, at sites fixed by the Range Officer.

Akamurru Lock, 43 miles.—The side walls of the lock are high enough

Water on upper sill ...	6' 0"	to within 12 feet of the lower gates,
lower do. ...	3' 10"	where they are 18 inches lower; the higher level should be carried through.

The lower sill was damaged this year by a dhony, owing to the depth of water being so much less than it should be. No water is passed below this lock for irrigation, and arrangements must be made for maintaining a minimum depth of 5 feet on the lower sill. There is a great deal of leakage under the upper gates; the valve gearing of these gates works fairly. The lower gates and gearing are not in good order; the gates fit badly, the mitre posts being at their lower edge 4 or 5 inches from flush. The abutments of the tail-bay bridge are being built up to receive girders.

The earth-works above the lock and the banks below are very untidy, and there is some prickly-pear which should be removed.

Aqueduct at Seetanagaram Swamp.—This requires repair and the making up of the earth-works at the wings.

Chintaguntapolliem Bridge.—This is an iron lattice bridge which has recently been built out of Local Funds to replace an old bridge. With 4 feet of water in the canal the head-way was $11\frac{1}{2}$ feet, which is rather low; the girders might

without difficulty, be raised 1 foot. There is a tow-path on either side, but these are not well connected with the canal tow-paths beyond.

Tidal Lock.—This is in good order generally, and the plastering where necessary was being renewed. New pinions required for the gate valve gearing. Lever arrangements for the side culverts should be put to rights.

31. It will be noticed from the depths on the lock lower sills of this canal, that the navigation is by no means as efficient as it should be. Apparently this is due to the canal carrying much less water than was anticipated when the surface fall of the water in the several reaches was fixed, and this again is accounted for partly by the circumstance that the canal traverses Zemindary lands for a great part of its length, and there water is not in demand, while partly it is due to the introduction of the side channel system of carrying irrigation water. A remedy must be applied by raising the water level at the upper sills of all the locks below Kunkipad, so as to ensure a minimum depth of 5 feet on all the lower sills.

32. A great many gates require to be replaced by new ones, and a great many new sets of gearing are required. New lock gates and new gearing. The unsatisfactory state of many of the locks of this delta in this respect was noticed during the inspection made three years ago, and apparently but little, if any thing, has been since done to render them more efficient. There is no chance of this work being done within any reasonable time at the Bezwada Workshops, unless the number of Smiths and Carpenters at present at work there can be very largely increased, and the Dowlashweram Workshops have already more than enough to do, so unless the District Engineer can see his way to getting much more work done at Bezwada, he had better send his orders to either the Public Works Workshops at Chepauk, or to the Gun Carriage Manufactory, at either of which places probably the work could be undertaken and completed in time for next year's closure of the canals.

33. A great deal has been done to this canal on an estimate of Rupees 1,87,990 which was sanctioned six years ago, and of which about 1½ lakhs have been expended, but much remains to be done before its banks, tow-paths, etc., will be in proper order. The tow-rope caught many times during the ascent to Pamurru, and a very little attention to the requirements of a navigable canal would remove all cause of this inconvenience.

At Kowtarum the Pulleru divides into three canals (1) the northern called the Polerazkodu or Kyekalore Canal; (2) the Lower Pulleru or Kuldindy Canal; (3) the Buntoomilly Canal. There is no part of the delta which stands in greater need of improvement than the portion which will be served by these three canals. Their water supply for the extension of irrigation will be for the most part obtained through Ryves' Canal, and no very material improvement will

be possible until the latter shall be opened,*

* Probably in time for the season of 1875. but there is so much to be done in the way of drainage that I am very anxious to see the estimates for these sub-sections of the delta completed and sanctioned.

The Polerazkodu Canal.—This is navigable after a fashion. At its head there is a regulating bridge, and material and range boats are passed through by means of strong ropes, there being a considerable fall through the bridge. Once through this, the canal is navigable nearly down to its present terminus. A head-lock and the conversion of the regulating bridge into a lock weir are the first requirements. Then the banks require thorough reformation, so as to make them safe, and to put a stop to the numerous breaches which now occur with a much less depth of water running down than what will be the full supply. One or two surplus weirs will also be needed, and there will be no difficulty in passing surplus into the drains which will run between the ridges. Bushes, a few trees, and all prickly-pear need removal. This canal will have to be extended some ten or eleven miles beyond its present terminus, and it will at its lower end surplus into the Ooputeru. Irrigation or distribution sluices are a pressing want on this canal, and without them the water, which is so greatly needed every where, cannot but be wasted. The drainage of the lands on the right bank for a considerable distance near Lingala (12th mile) is obstructed by the canal, and a cut should be made in rear of the bank down to the swamp at the 18th mile to relieve it. The soil can be used for making up and strengthening the canal bank, and this drain should be carried out at once as a minor new work.

Care should be taken that designs for bridges over navigable canals are suitable. Attention to the circular on the subject, bearing in mind that the minimum head-way admissible is not the maximum that may be given, will prevent such a mistake as that at the bridge in the 7th mile of this canal on the Buntoomilly road, which could only partially be remedied.

The Lower Pulleru is not navigable, and, with the Polerazkodu on the north side and the Buntoomilly Canal on the south, which latter will probably connect the Eastern Delta of the Kistna with the navigable canals of the Western Delta of the Godavery, this tract of country will be well provided with water communications. The head sluice shutter arrangements require improvement.

The Buntoomilly Canal has a head lock, but the canal is in so incomplete a state that practically it is not of much use, and will not be so until, by the construction of other locks below, the water levels can be regulated without the temporary expedient of placing rough stone dams across its bed. The head sluice shutter arrangements must be modified, the groove is flush with the face wall, and the difficulty of working the shutters is great.

34. The drainage of this tract of country will not be difficult. At present all the rain-fall drainage stagnates in the swamps between the parallel ridges which run from south-west to north-east and what is required is the construction of capacious drains along the axes of these swamps, together with the embankment of the Ooputeru, so that freshes in that river may not as at present spread far and wide. There is a great deal of work to be done, but there is no doubt as to the natural and proper outfall of each portion, and that being the case the designing of the works will be comparatively simple, and the result of carrying them out will be most beneficial.

35. I rode through this country with Major Hasted and Lieutenant McN. Campbell, the distance being about 17 miles. There is very little cultivation, and what there is in patches on the sand ridges is of the most wretchedly poor description. A very large proportion of the ground is swamp, and the radical improvement of this tract of country is dependent upon efficient drainage being provided simultaneously with the means of irrigation. The whole of the works required have been designed, and the estimates are in a forward state. The country north of the Ramarazupolliem Channel is full of old channels, and the provision of effective drainage and irrigation has thereby been rendered difficult and complicated, but the subject has been carefully studied, and a very great change for the better ought now not to be far distant. Possibly at some future time it may be found worthwhile to connect Masulipatam directly with the Buntoomilly Canal and to avoid the considerable detour by Pamurru, but the chief town of the district is out of the way of the regular course of trade, owing to its being such a difficult and expensive port at which to land and ship produce, and for the present, therefore, it is not proposed to estimate for any such junction canal.

36. This great shallow inland basin, which receives the drainage of about two thousand square miles of country, extending from near Condapilly on the west to the Yerracalwa on the east, has for many years engaged the attention of both the Revenue and Public Works Officers of the two districts, and the general opinion appears to be that the water level should be kept as low as possible, and that ultimately the greater part of the bed should be reclaimed. Major Hasted

On the 10th December 1873.

has, in connection with a visit I paid to the south-east end of the lake, where it discharges into the Ooputeru, given me several interesting papers on the subject to read, the first being the Proceedings of the Board of Revenue, No. 4,081, of the 2nd July 1864, containing a Memorandum by the then Collector of the Kistna,

* Proceedings Board of Revenue, No. 4,971, 4th August 1864.

† No. 259, 23rd April 1866, to Collector, Kistna.

‡ No. 73, 2nd July 1866, to Superintending Engineer, 2nd Division, and No. 287, 12th March 1868, to Collector, Kistna.

§ No. 21, 27th April 1867, to Collector, Kistna.

Mr. Thornhill, which sums up most of the facts of the case. Lieutenant-Colonel Chambers,* Colonel Winscom,† Captain Ryves,‡ and Captain Beckley§ have also recorded their opinions as to what should be done, and in what manner.

37. It may be noticed that large portions of the deltas of the Godavery and Kistna drain into the lake, and indeed cannot well if at all be drained in any other direction, and that the efficiency of the drainage depends in a great measure upon the water level in the lake during the south-west monsoon and thence up to October. All these tracts of country are, therefore, greatly interested in the water being allowed to run off freely and without obstruction. The interests of the inhabitants of the island and borders of the lake are conflicting and variable. In the event of the failure of the Sarwa or south-west monsoon crop, all appear to desire that the water level should be kept up to admit of a Dalwa or

cold weather crop being raised, and for this latter it appears necessary or convenient that, first, the lands should be submerged shortly before ploughing and sowing, and secondly, that the water level during the time that irrigation is needed should not be very much below the level of the lands on to which it has to be baled. The retention of the water at a level suitable for the Dalwa cultivation is not, however, under present arrangements favourable to the general interests of the cultivators, because it involves the retention of water at a level which renders impracticable the successful cultivation of the more valuable south-west monsoon crops on a considerable portion of the lands, on which these would otherwise be grown. If the lake surface could be kept down to, or allowed to rise above for

* Tidal.

a few days only at a time, high water level,* then the cultivation on its margin

could be largely increased, and the position of the land-holders greatly improved, and if, in addition, these marginal lands could be regularly irrigated from the delta canals, but little would remain to be desired. On the Godavery side the extension of irrigation has already reached close up to the lake, and will extend no doubt as far as the circumstances of the latter will permit, but in the Kistna it will be a long time before the canals will be sufficiently advanced to bring the marginal lands under regular irrigation.

38. Hitherto the recognized means of escape for flood waters consisted of an escape weir 300 feet long with iron posts at 10 feet intervals, the crest being somewhat above H. W. L., and the water thence passed at once into the Ooputeru. West of this however, close to the village of Alapad, there is a creek, the deep part of which is only a few feet wide, communicating between the lake and the river, and there were other low places by which water used to escape as shown on the Atlas sheet to the west of Jungampaud. In 1864 the water in the lake had become so brackish and impure that the villagers lost large numbers of cattle, and so, to the west of the calingulah, a breach was cut in the bund, and the passage close to Alapad was also opened, while at the end of the year, after the cyclone, in order to give the lake people an opportunity of raising a Dalwa or cold weather crop, the stream leading to the large breach was bunded. The breach channel has become a deep one, and the closing of the passage entails a considerable outlay. Last year, after much trouble, a bund was established across it at a cost of Rupees 4,000, and it is stated that the resulting revenue was Rupees 18,000. This year the Collector wished the bund, which had been partially swept away by the season's freshes, restored, but the requisition reached the District Engineer, I understood, after the proper time had gone by, and the Sub-Magistrate of Kyekalur, who accompanied us during the inspection, said that it would be useless to raise the water level at so late a date. Indeed it is evident that bunding after the subsidence of the freshes would have little or no effect in raising the water, though it would maintain a comparatively high level. The remains of the bund of last year had had the effect of keeping the water surface at about 1 foot above high water level.

39. It seems to be very desirable that it should be determined what is on the whole the best way of treating this great basin. Were the Irrigation Department prepared at once to supply water to the margins and islands, there would

probably be no room for any second opinion, but this, as already mentioned, is not the case. I take it that the 300 feet calingulah was constructed as a substitute for bunding, and in ordinary years it appears, owing to the enormous area of the lake and its consequent effect as a flood moderator, to have answered its purpose, but when the rain-fall over the drainage basin happens to be heavy, the water surface becomes so far raised as to swamp the cultivated lands and villages, and then other means of escape have to be provided. So far as the drainage of the country generally is concerned, the best arrangement would be either to leave the communications between the lake and the Ooputeru entirely free and open and to enlarge them considerably, which could be effected at a small expense during the freshes, or to increase the length of the escape weir to about 1,000 feet, with its crest at ordinary H. W. L., and with numerous self-acting sluices, having their sills $4\frac{1}{2}$ or 5 feet below that level, inserted in it. This additional length of surplus weir could be provided partly by lengthening the present calingulah, and partly to the west of the breach. The effect would be to reduce considerably the height to which the lake surface would rise during the rains, and to bring the water down after the freshes to a level 18 inches or 2 feet lower than would be the case with an open channel. It appears to me probable that were bunding entirely given up, and either of the arrangements just described adopted there would be but little loss of revenue, and an improved class of cultivation with greater security against the destruction of the south-west monsoon, or Sarwa; crop by inundation. The Dalwa crop as here grown is not, I am informed, one to be encouraged, as the grain affects prejudicially even those who are somewhat accustomed to it, while for others it is particularly unwholesome food. The effect on the health of the population, which would result from a general lowering of the lake surface, can only be surmised; as, however, the variations in level

extend, as it is, from some $3\frac{1}{2}$ feet*
* $2\frac{1}{2}$ feet on iron posts of calingulah. above H. W. L. to, in a long hot

weather, a dry bed over a great part of the area, it seems improbable that any harm would result to the local inhabitants, while much good would be derived to the westward and eastward by the improvement of the drainage in those directions.

40. To deal with the whole lake comprehensively and thoroughly, and to arrange for confining the principal rivers within moderate bounds will be a work of the future—useful and necessary and probably remunerative also—but it would be unwise to take it up until the drainage and irrigation of the two deltas are much more advanced than at present. What is now required is a clear understanding of the objects to be desired, so that we may not attempt to work in the same or successive years in opposite directions, and that the population may know what are to be the intended arrangements of the future. It may be added that in the deltas employment is available nearly, if not quite, throughout the year for all labour which may possibly find its occupation gone in the immediate neighbourhood of the lake, though, I believe, that such occupation will be extended rather than diminished by the reduction of the water spread, if that course should be resolved on.

41. This canal is a work which will be provided for in the completion estimates. It has been designed to take

Bank Canal.

off from the Masulipatam Canal about three miles from the head of the latter, instead of from Kunkipad as was formerly intended, it having been ascertained that it will be cheaper to carry out the former plan than to widen the Masulipatam Canal to the extent which would be necessary were the off-take placed at the Kunkipad sluices. On examining the designed arrangements considerable modifications were found to be desirable. While accepting the conclusion that the supply of the Bank Canal proper may advantageously be carried by a canal having its head where proposed, it appeared to me to be in every way desirable that the Masulipatam Canal should convey as much water as possible for the Pulleru on the one side, and for the eastern half of the tract of country between the Masulipatam and Bank Canals on the other side, in preference to taking this latter supply by a branch from the Bank Canal. This is desirable, not only as a matter of economy, but because it is much better to maintain a moderate surface fall in the Masulipatam Canal down to Kunkipad. Again, the Masulipatam Canal and its western side channel are capable even now of supplying a much larger quantity of water for irrigation than there is a demand for at present. Nearly all this tract of country is Zemindary, and it appears to be very doubtful whether water for even 100 acres per square mile will be taken, so that it would be far from wise to expend a large sum of money in the construction of irrigation and drainage works for the benefit of the Zemindary, until at least the capabilities of the existing works shall have been more fully utilized. Were the Bank Canal intended only or principally to serve the Zemindary lands, through which for some 35 miles or so it will run, its construction might be postponed indefinitely, but its chief use will be the amelioration of the condition of the island of Divi, which can be improved effectually by no other means, and in which it is expected that some 45,000 acres will be irrigated. The capacity of the Bank Canal therefore should be confined to that needed for these 45,000 acres, and for 100 acres per square mile in the part of the Zemindary which it will directly command, i.e., from the canal eastwards as far as the first main line of drainage running in a direction approximately parallel to the canal. The estimates as prepared for the whole section between the Masulipatam Canal and the Kistna amount to 19 lakhs, of which approximately seven lakhs appertain to the eastern sub-section under the Masulipatam west side channel, which was intended to irrigate 28,000 acres, all Zemindary; while the remaining 12 lakhs were for the irrigation and drainage of 15,000 acres of Zemindary and 45,000 acres in Divi. Under the arrangements now contemplated but little of the seven lakhs will be proposed for expenditure. Some of the 15,000 acres of Zemindary in the western sub-section will probably take water, but even if none be so taken, it is probable that the extension of irrigation in Divi will be some 35,000 acres, and the water rate of Rupees 4 on this would yield a return of over 9 per cent., even should the estimates when revised amount to as much as 15 lakhs.

42. This canal has been designed with a velocity of 2.15 feet a second or 2,580 yards an hour, but what may be termed the ruling velocity on a 2nd class line of navigation is 2,000 yards an hour, and this should not be exceeded.

Experience in the Godavery Delta has indicated that in low lying lands like Divi the water required for irrigation is considerably less than two cubic yards per acre per hour, and it may be assumed therefore that 81,000 cubic yards will suffice for the 45,000 acres in this island, which lies between the main river and the Puligudda branch. The aqueduct across this branch will unavoidably be a

About three lakhs of Rupees.

costly work, and it may be designed to carry a depth of water of 9 feet, running

with a velocity for this short distance of 3,000 yards an hour. Its width between the side walls will then be 27 feet, which will do very well. With the canal the island will be placed in a much more favourable position, as regards communications, than it has ever yet been, and it is thought therefore that there is no necessity for making a road bridge in connection with the aqueduct, which should be designed with a tow-path on either side having a clear width of 5 feet, and substantial iron railings in lieu of parapet walls. Of course if the Local Fund Board wish for a bridge, and are willing to pay for one, the tow-path on one side may be widened to 15 or 18 feet, but this additional cost should not be thrown on the irrigation works.

43. The canal, as designed, starts with a bed level at 36.82, and, with a fall of 6 inches a mile a depth of 6½ feet, and two locks with a drop of 2

Levels of the Bank Canal.

feet each, arrives at the 35th mile, which is just above the site of the aqueduct over the Puligudda branch of the Kistna, with the bed at 15.32. The Kistna maximum flood level here is at 19.00; and, apart therefore from the convenience of the navigation already referred to, it is desirable, and indeed necessary, to raise the canal bed at the crossing considerably; for though the example of the Naggaram Aqueduct in the Central Delta of the Godavery might be cited as an instance of a work which has stood well though it has several times been submerged by the river floods, this result of a low level has not been without its inconveniences and attendant expense. It is only proper to notice that the levels as designed resulted from the desire to avoid high embankments in the approaches to the aqueduct, but it is essential that the canal should be carried well above river flood level, and so this difficulty cannot advantageously be avoided. A reduction of the surface fall of the canal to 4½ inches a mile, which would give the required velocity of 2,000 yards an hour, would raise the bed level in 35 miles 43½ inches, and it is thought that both the proposed locks may with advantage be omitted, and that the bed level of the canal at the aqueduct, if fixed at about 22.97, will be none too high. Remembering, however, that it has been proposed to make the depth of the water on the aqueduct 9 feet against 6½ feet in the canal, it must be noticed that this would, with the floor of the aqueduct at 22.97, virtually take off 2½ feet from the surface fall down to the 35th mile, which would then become 3.636 inches a mile, and it will be necessary to see therefore whether this reduction of fall with the corresponding increase to the dimensions of the canal, and to the height of the embankments across the low ground near the Puligudda branch, would involve a heavier outlay than maintaining a depth of 6½ feet on the aqueduct, and widening the water-way there from 27 to 38 feet. I have roughly estimated that the decrease of surface fall from 4.75 to 3.63 inches

would add 2,500 Rupees a mile to the cost of the canal or 87,500 to the 35 miles; and probably the difference, including the heavy embankments, would be not less than a lakh of Rupees; as the widening of the aqueduct would probably cost less and would be the preferable arrangement, it will be worth while to examine the conditions more thoroughly, and to see what will be the better arrangement, the level of the floor of the aqueduct being placed at a not lower level than say +23.00.

44. From the Bank Canal above the aqueduct it is proposed to carry a canal, called the Kistna branch north bank channel, for which a shorter name may

Chinna Yadara Canal.

with advantage be found, a distance of seven miles to a creek at Chinna Yadara. If, as appears probable, this channel is for the irrigation of Zemindary lands, the estimate may be completed, but the work had better be postponed until a greater demand for water for such lands arises. It should be designed for navigation with a view to its ultimate extension on the line of the old Chinnapooram Canal to Masulipatam.

45. Soon after passing the Puligudda aqueduct the Bank Canal will be divided into three branches, two of which will run as Bank Canals along the Kistna

Canals in Divi.

and Puligudda branch margins respectively, and the other across the island of Divi. If economically practicable all three should be made navigable, but, if the additional outlay required be found to be considerable, it will suffice to provide navigation on the central line.

Site for Puligudda Aqueduct.—The site selected is near, but a little above, the village, and the place is suitable, but it is evident that the bed of the river has changed since the survey was made two years ago, and the nature and direction of the changes should be recorded. The nose of the island at the bifurcation of the river has been wearing away by erosion for some time past, and a proper salient should be established by navel planting, as also the proper alignment of the branch from its head to about half a mile below the aqueduct site. Permanent benchmarks should be placed on both sides of the branch near that site.

46. Divi possesses, at least over a large part of its area, a highly fertile soil, and it will probably in time be as rich and well cultivated as the similarly

Condition of Divi.

situated island of Naggaram in the Godavery Delta. At present, as the Government are aware, it is dependent for its supply of water for irrigation on inundation channels, which are useless until the river rises to a height of many feet above its ordinary level, and which then are used for filling shallow tanks, many of which are ring bunded or entirely surrounded by bund, in which openings are made when the whole country is submerged; when filled the openings are closed, and the fall in the river freshes enables the water in the tanks to be gradually let out to irrigate the fields. In 1873 the Kistna freshes though very good were not high enough to allow the inundation channels to draw, and a great deal of land was consequently left uncultivated. It was not, however, clear why these rich lands should not have been cultivated with dry crops. Being classed as nunjah or

wet lands probably, under existing arrangements, dry crops could not be raised without the payment of the wet assessment and this may be prohibitory, but when the water supply is so little to be depended upon it would seem to be desirable to allow of some option to the land-holders, and to levy assessment according to the description of crop which it may, with reference to the season, be found practicable to cultivate. Both Government and the people would benefit; both would get something out of the land. If the estimates be sanctioned in time for the works to be commenced next season, it will take four years at least before water can be made available for irrigation in Divi, and ten years before the principal canals and drainages can be completed, so it is much to be desired that a commencement should be made.

Head of Modamudi Channel.—One of the temporary head sluices was being here constructed, but, as built, it was only a bridge with a central pier of palmyras and a stone floor with revetted side-slopes. It could not have been regulated, and the insertion of two more uprights with cross pieces at intervals of three or four feet, so as to divide the area into small openings capable of being easily closed, when necessary, by the villagers, is required, and an estimate for the alterations to this and other similar sluices has subsequently been submitted for sanction.

Surnamuki Channel.—This has a head sluice, but the bed of the channel both above and below the sluice is a yard higher than its sill, and so it is hardly surprising that the supply obtained is small. The bed of the channel was carpeted with grass, and it looked very unlike an efficient means of irrigation.

47. *Head Sluice and Lock for Bank Canal.*—When looking over the project it seemed doubtful whether these proposed works were necessary. Should, however, no lock be built between the head and the aqueduct it will be advisable to have a head lock; otherwise, unless there be special reasons for such a means of regulation, it will be better to have an open head. Surplus works should be provided at intervals to relieve the canal of water which may not at times be required for irrigation, in order that the depth at the upper end of the aqueduct may never exceed that of a full supply for the island.

48. The bed of the Kistna, both above and below the head of the Puligudda branch, appears to be much in need of regulation, and it will be well to employ two maistries on each bank of the river from the anicut downwards in looking after the planting of lunka grass, of which a great deal ought to be done yearly so as to preserve the banks and secure a right alignment which should be laid down on charts, which probably may with a little additional surveying and some levels be readily based upon the Revenue surveys. No part of the river bank, which is upon or within the proper alignment, should be left exposed to the action of the river without the protection of grass or wild cane; it is easy to preserve what it is difficult to restore. The arrangements to be worked up to should be determined, and then year by year as much as is practicable towards this complete definition of the boundaries of the river channels should be done.

49. The wild croton is becoming a nuisance in the delta. It and all scrub-jungle and weeds should be cleared away, and the croton especially should

Wild Croton and Underwood.

be rooted out directly it appears, for it spreads with marvellous rapidity, and not a single plant should be allowed to remain.

50. It would appear that some tree planting has in recent years been carried

Canal Plantations.

out from Local Funds, whereas formerly the avenues were planted from canal funds. This latter is the best course, seeing that they must always be under the control of the canal officers. As a rule there should be no watering of young trees, which should first be well started in nurseries, transplanted at the proper season, and protected by the canal establishments, but otherwise left to take their chance which, if suitable descriptions of trees be selected, ought generally to be a good one. The value of wood cut on canal plantations should be credited either to Canal Revenue Miscellaneous or to Plantations; perhaps the latter head will be the best, as it is shown in the Government of India forms, and money under that head for new plantations or avenues can be provided in the annual Budget. The widening of the Masulipatam Canal has unfortunately necessitated the removal of some miles of remarkably fine avenues, and other trees should be grown further back in their place. The abolition of cattle grazing on the canal banks and berms will greatly facilitate the growth of trees, which at present, unless very securely fenced at much trouble and expense, are pretty sure to be eaten off and stunted if not destroyed.

51. This canal is also called the Nizampatam Canal, and in the current

Western Delta Main Canal.
*1874-75.

year's* Budget it is entered as the Seetanagaram Canal. Down to Dugerala it is, and should be called, the Main

Canal, Western Delta. Widening has been in progress for five or six years on an estimate of Rupees 2,76,400, and this work is approaching completion, but a very

Estimate between five and six lakhs.

considerable further enlargement will have to be carried out in due course to

carry the full supply for the ultimate area of irrigation in this delta. The earth-works are not as regular as they should be, and the slope of the top surface should be away from the canal, so that only the inner slope may drain on to the berm. The left bank requires clearing.

Bank Canal Head Sluice.—This sluice is in good order. The first time the shutters need renewal they should be provided with screw gearing.

The Upper and Lower Sluices for the supply of the *Commamore Canal*, and the shutters of the lock weir, should be regulated by screw gearing; the shutters should slide on iron bearings, and all these works should be thoroughly repaired.

52. This canal commences at the Dugerala lock, and since the construction

Nizampatam Canal.

of side channels it carries little or no irrigation water. The side channels are

really fine canals. A mistake which must be guarded against in the future is the taking off of distribution channels at points much too low down on the side channels. As a consequence rough stone dams have to be placed across the latter to raise the water to a proper level, and these in a great measure neutralize the advantages which were to be secured by the construction of these channels, viz.,

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carrying the water at a higher velocity, and so preventing the deposition of much of the silt. The canal was designed to carry irrigation water, and consequently, since this water has been otherwise conveyed, the surface levels have been materially altered, and the navigation has deteriorated. It was proposed in the completion estimates to insert two additional locks, so as to bring the water to a dead level, but the necessity for this appeared to need explanation, and it has since been found that the existing locks and the embankments can be raised so as to obviate the necessity for additional locks.

A couple of miles or so below Dugerala handsome bridges have been recently built over the canal and side channels from Local funds. They do credit to Mr. Norris, who designed and built them. The left bank of the canal here will make an excellent road.

Kuchipudi Lock.—Some of the flooring of the tail bay has given way. Considerable repairs, costing about 1,000 Rupees, were executed in 1873, but this part of the lock must be entirely reformed. The angle of the gates is much too flat.

Lock Weir. Rough, and not in good order. The bridge has just been repaired. It is a pity that room was not left for a shutter platform. This may be obtained by removing the cut-water caps, building up the cut-waters, and laying shutter bars upon them.

Regulating Dam and Bridge over West Side Channel. A carefully built work, but with wings not adapted to the banks and slopes. A work of the same design on the East Side Channel.

In the 25th mile a Neem tree interferes with the towing. If the tow-path is to be placed at the edge of the berm, this alteration should be carried out from channel clearances.

Jutur Lock, 31½ miles. Upper gates leak far too much. The gearing needs repair and the masonry wants repointing. The headway of the bridge over the tail bay is 14½ feet with 6 feet of water on the lower sill.

It will be well to place a sluice or weir in the right bank above the lock to supplement the supply of the side channel when necessary. There is already a two vent sluice in the left bank which can be so used. The soil at and above the lock is a clay which could stand a considerable head of water. Canal banks above the lock are too low. The side channels are not yet provided with proper sluices.

Nullavada Lock.—The water above the lock is but little above the surface of the country, and there would be no difficulty or risk in raising it a couple of feet. A masonry surplus weir is about to be built in the right bank in place of the rough-stone dam which has hitherto served as an escape.

The Nullavada drainage, which now enters the canal below this lock, is to be taken outside the left bank into the Peddapully drain.

The reach of the canal between the Nullavada and tidal locks runs through two sand ridges, and except in the Peddapully swamp the soil is sand or sandy. At this swamp a breach had to be made in the left bank of the canal to reduce the level of the water outside, and this has been frequently done before. It involves lowering a great length of the bank to provide soil for closing the breach, and the sooner the necessity is obviated by the construction of the drains the better.

The banks in places require putting into section; a great deal of bulrush has been cleared away, and this work in the 36 to 41 miles will soon be completed. Prickly-pear must not be allowed on the canal banks, or on any irrigation works.

Tidal lock.—This is in fair order. The escape in the left bank just above the lock should be bridged as a foot-path, and to allow of the shutters being worked. Its wings are too low, and the banks are weak.

53. This swamp is bunded on the south side to form a tank, and the out-fall on the south-west side being closed by the Nizampatam Canal, it is not surprising that so much country is submerged at times. About 3,000 acres are irrigated, and it is intended to bring these under an extension of the East Side Channel, and then there will be nothing to prevent the draining of the swamp, which is provided for in the completion estimates, and which will effect a radical improvement in the condition of all the section of the delta between the Nizampatam and Bank Canals. As far as could be judged from the levels, this main drain should be carried between the Komarasole and Edapilly sluices to the southwards, instead of by a much more circuitous route to the east, and then back to the south-west, and this matter is being inquired into. It is to be hoped that the estimates for the matured arrangements will soon be ready, for at present this extensive tract of country is without any adequate means of getting rid of rainfall drainage. All requisite instructions have been given on a review of the estimate as originally prepared, which provided for arrangements which were in some essential particulars defective.

54. The Nizampatam Canal enters the Toongabudra about three miles above its junction with the backwater, and the distance to the town of Nizampatam is about five or six miles. Here and there on the left bank of the lower part of the river, for short distances, tracking is practicable, but elsewhere the banks are covered with dense mangrove jungle, and poling is the only means of progression; this in deep water with, as on the occasion of my visit, a head wind is very slow and laborious work. A tow-path should be cleared all along, and facilities for towing afforded. It is bad policy to construct canals at a great outlay, and then to reduce their value to a minimum by omitting to carry out such trifling, but essential, works as convenient tow-paths in connection with the navigation.

55. It has been thought possible that it would be better to carry the through line of navigation by the East Coast Nizampatam Backwater. Canal to meet the Nizampatam Canal, rather than to make the Commamore Canal the main route, and advantage was therefore taken of a visit to Baputla to see what the backwater was like. It is not now navigable for more than nine or ten miles west of Nizampatam.

The channel shown on the Atlas sheet north of Perala was dry; that to the south of the village had a little water in it, and occasionally the depth is a foot or perhaps more. Between this and the backwater an extremely dense prickly-pear jungle intervenes. The backwater itself has a wide and tolerably deep channel, and but for the impossibility of tracking the navigation would be easy. This difficulty could be overcome by clearing away the mangrove jungle and forming tow-paths, but it seems very doubtful whether this backwater and the swamps between it and Chinna Ganjam present any such advantages as would make it worthwhile to transfer the navigation to this line.

56. This has its head on the Main Canal at Dugerala. The Commamore Lock has gate valves and one lower side culvert, the shutter of which is worked by a lever; with a roller to the shutter spear the arrangement would be efficient. 5 feet of water on the lower sill of the lock.

Kolukalur Bridge.—This bridge, which has been so long in progress, has been completed up to the string course. The work since 1870 is better than that before that time. The sand stone is good but dirty looking.

The new cut on which the bridge stands does not fit well into the old channel at its junctions.

Jagerlamudi Escape Sluices.—An old work of seven vents 4 feet wide and 7 feet 10 inches high. The full supply level of the canal is about 10 feet on the sill. The sluices are efficient, but it has been proposed to substitute for them an under tunnel or aqueduct, in order to exclude the drainage which they discharge from the canal altogether. This drainage coming from the direction of Guntoor enters the canal a short distance below the sluices, and has to run up to get to them.

Jagerlamudi Lock.—This is at present the lowest lock on this canal, and the fall below being much greater than will be the case when the works are completed, the depth on the lower sill is always less than is desirable.

Water on upper sill	4' 6"
lower do.	2' 8"

Cross Drainage.—This canal like the Ellore Canal on the other side of the delta crosses a great deal of upland drainage, and this was, in the original estimate on which the canal was cut, provided for in an altogether inadequate manner. In the completion estimates for this delta also, the requirements of the case have not been fully recognized; on a rough calculation of the water-way needed, it appears that about 2½ lakhs, instead of 1½ lakhs the estimated cost of the works provided in those estimates, will be necessary to dispose of this drainage, and to avoid the risk of frequent damage to the canal.

57. Out of a distance of 22 miles, nearly all the country up to Poonnur nine miles and for five miles beyond that is under dry cultivation, and the crops, especially the cholam, looked very good. Further south the land is for the most part under irrigation. Up to about four miles from Baputla the road is a very

fair one, but then it runs into heavy sand. Since Ypurpolliem has become a port with a considerable trade, there is a good deal of traffic, though the difficulties of transport over the sand ridges and swamps near and south-west of Baputla must be very considerable.

58. *Dumpakodu Calingulah and Kurlapolliem Tank.*—The Dumpakodu Calingulah across the Toongabudra supplied not only the lands on the left bank of this river, which have now been provided for by the Budam project, but also the Kurlapolliem Tank on the right bank. This tank has this year been imperfectly supplied by one of the channels from the Baputla Tank, which is itself supplied by the Commamore Canal. The Tahsildar and the ryots mentioned that the Kurlapolliem Tank supply had been inadequate, and that some lands had been thrown out of cultivation. The altered arrangements are confessedly incomplete, but they would probably have sufficed had the season been more favourable. As it was the absence of rain made the demand for water for ploughing, etc., enormous, added to which there are said to be fifteen sluices, and upwards of 100 palmyra spouts, in the eastern part of the Baputla Tank, and these must lead to waste. There appears to be great readiness to take up land for irrigation in this taluq. Until, however, the supply and distribution arrangements are more advanced, it will not be practicable to afford the water required, and it will be better, therefore, to postpone extension of irrigation.

59. The quantity of water carried by the Main Canal appeared to be very much more than ample, and yet there is difficulty in getting a proper supply down to the lower end of even a principal canal like the Commamore. In the present state of the channels there must of necessity be a good deal of waste, and it appears probable that much of this is due to high level lands being cultivated in positions where they can be commanded only when the channels are carrying more than a full supply. Kistna water carries so much silt that it is very undesirable that more water than is really required for the cultivation should be admitted to the canals; this subject is engaging the attention of the District Engineer, and measures are being taken for ascertaining all over the delta the actual quantities supplied to various channels; this information will soon lead to improvements and to economy in the use of water, with, as a consequence, extension of irrigation by means of that portion of the supply which is not at present utilized.

60. The drainage of the Kistna Delta is a matter of even greater importance than in the Godavery Delta; it is only necessary to look at the Atlas sheet to see what a great extent of country is occupied by swamps, and though the exclusion of river floods by embankments has much improved the condition of the delta, adequate means of carrying away rainfall drainage, both local and upland, have still to be provided. When the estimates have been completed and sanctioned their execution will be the work of many years, but it will not be long before a great change for the better will take place, seeing that the first thing to be done is to remove obstructions, and the second to secure proper outfalls through the ridges which at present absolutely bar the direct drainage, which has to find a

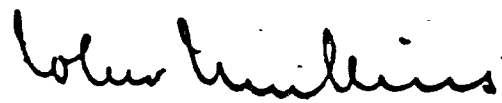
• circuitous route in some other direction; and, where the fall is small, the submergence of large tracts of ground for considerable periods is inevitable. Heavy losses of revenue occurred in 1872-73 from this cause, and it will certainly be advantageous financially to render the drainage efficient, for not only will remissions be avoided, but the extension of cultivation will be rapid.

61. Statements of irrigation and revenue like those made out for the Godavary Delta are under preparation, but have not yet been received; consequently no reliable information is at present available. It is however believed that the area of irrigation in 1872-73 was about 196,000 acres, and the District Engineer mentions, in a note just received, that the Collector estimates the increase of area in 1873-74 at 11,000 acres, and of revenue at Rupees 1,93,000. It is very possible that the revenue may be so much greater than that of 1872-73, but much of the difference must be due to the absence of remissions, and the circumstance appears to indicate that the delta gets on better, owing to defective drainage, in seasons of short rainfall, than when the monsoon is a good one. There must be a very important difference however in the outturn of the crops when, as in 1873-74, no rain falls until some two months after the commencement of the season of irrigation.

62. Much of the time (nearly four weeks) spent in the delta was devoted to the consideration of the arrangements to be provided for in the completion estimates. These for most of the sub-sections are in an advanced state, and it is now desirable that they should one by one be completed and submitted for sanction as soon as possible, commencing with those which it is intended first to carry into execution. This course has already been approved by Government in the order sanctioning the survey establishment for 1874-75, and it is the only way in which delay in carrying out many much needed improvements can be avoided, as it is impracticable for officers, who have also their current duties to attend to, to deal with such a number of heavy estimates at once.

OOTACAMUND,

7th May 1874.



Lient.-Colonel, R.E.,

Chief Engineer for Irrigation.

P. W. 1874 Dept
No: 4554

From

The Chief Eng^r
for Irrigation

Dated 7 May 1874
Recd 23 July 1874

Notes of a tour of
inspection made in
the Kistna Delta
between the 20th.
Novr. & 15th. Decr. 1873

U. No: 2732.29-9-74.

Ch 556

Recd 16 Oct 26 July 1874

Public Works Department
Proceedings of the Madras Government
Read the following
From The Chief Eng^r
for Irrigation. The Encl^d dated
7 May 1874

2732

The Memorandum
of Inspection dated 7th
May 1874 of the Kistna
Delta, containing the
notes of the Chief Engineer
for Irrigation, will be
communicated to the
Superintending Engineer,
Kistna, for information
and guidance.

The subject of the
arrangements requisite
for rendering the crop
drainage of the Ellore
in this District efficient.

Md.
89

has been fully examined
into and the Govern-

ment wish to have
the estimates submitted
as early as possible
for carrying out the
improvements and for
completing the Canal
in the manner decided
upon.

3. Independently of
the propriety of main-
taining order and
cleanliness where lock
and other establish-
ments are located,
the health of these
establishments, which
it is understood has
been far from good,

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independent in a great
degree upon proper san-
itary arrangements,
and the Government
look to the Superintending
Engineer to introduce
and enforce these in
all such places.

4. Paras 36 to 40 of
the Memorandum
which treats of the
circumstances of the
Kolour Lake will be
communicated to the
Revenue Department
for early consideration.
The data for a final
determination of the
question as to whether
this lake should be
allowed to fall to the
lowest level practicable

or should continue to be artificially maintained at a higher level, appear to be fairly complete.

5. The arrangements proposed by the Chief Engineer for Irrigation for deferring the provision of irrigation, except on a very limited scale, for the Zemindari lands under the Bank Canal Eastern Delta, and between that and the Manaliptam Canal will be referred for early consideration and report to the Revenue Department. It is stated that existing means of

93
irrigation to these Zemindari lands have been far from fully utilized, and until a decided demand for water arises it will probably be unwise to extend the supply.

6. The improvement of the condition of Dine Pur-garahi is of much importance, and the Govt are glad to learn that there is a good prospect of a reasonable return from the outlay, which will be required to provide for its wants as regards irrigation. In the meantime the

the observations of the
Chief Engineer for Irriga-
tion will be re-
ferred for considera-
tion in the Reve-
nue Department
to ascertain whether
the wet assessments
prevent the occasional
cultivation of dry
crops.

f. As in the Co-
davery Delta so in
the Kistna Delta efficient
drainage is of very
great importance
not only to the safety
and productiveness
of the growing crops
but to the general
health of the popu-
lation, and so soon

45
as the main drainage
shall have been worked
out, and some progress
made with these drains,
the Govt. will be pre-
pared to make arrange-
ments for providing
for village drainage
in detail. In the
meantime the Super-
intending Engineer
should give attention
to this latter subject,
and he will be at
liberty to bring for-
ward proposals
for dealing with in-
dividual villages
or groups of villages,
which he may find
to

be exceptionally in
need of improvement
in this respect, and
which it may be
practicable to drain.
Village drainage will
not be chargeable
against the system
of irrigation of the
Sella, except in those
cases in which the
irrigation works
themselves may have
obstructed the natural
or may otherwise
necessitate additional
drainage, but will
be provided for under
Agricultural Miscellaneous.

8. The early preparation
of the detailed revenue

6.
statements for the
Sella, in the form
decided upon for the
ledgers, and made
applicable to other
systems of irrigation,
is very desirable,
and the subject will
be remitted to the
Revenue Department
for such further or-
ders as may be neces-
sary. It is observed
that these statements
are due for 1841-42
and 1842-43, in ad-
dition to those for
preceding years, the
compilation of which
latter may take some
time,

Reuben H. Hoag

Memorandum.

time, while those
for recent years should
be submitted as soon
as possible after
the close of each study.
The thanks of Govt
are due to Colonel
Gullins for the useful
and complete report
which is reviewed
in these Proceedings.

Lyman

Jan 20 1884

1. In accordance
 2. with the order
 3. No 2003
 4. dated 26 July 74
 5. on the classification
 6. of expenditure
 7. under Orbital
 8. Revenue and
 9. Miscellaneous

I would submit, with reference to the alteration directed to be made in the 7th para. of the draft order reviewing the Ins-pection Report, Kistwa Selta, of the Chief Engineer for Irrigation, that somewhat grave and inconvenient results may occur from considering village drainage works as part of the irrigation system of the Selta.

2. The irrigation works proper, that is those required for the supply of water to land, would certainly yield a large percentage on the Capital outlay required for their construction, and as the provision of communications is deemed to be a matter of much importance and advantage, the canals are made navigable at a very considerable increase of cost. Navigation is thus the first extra work with which the irrigation is saddled.

3. In the next place delta lands are

Don't not
pay? Pro-
enhances the p
of organization

S.L. Kistner ✓
Chas. Egan ✓
Charles H. R. ✓
Rev. Deane ✓
L. J. duBois 7/10/76

556-557

from their physical circumstances in-
-differently drained and liable to submergence.
This condition is irrespective of irri-
-gation operations, and not, as the
Honorable Mr Robinson has sup-
-posed, in a great measure due to
such operations. Very small drains
would carry off the surplus irrigation
water, drains much smaller than
the Canals, the fall being greater.
On the other hand for ridding the Delta
lands of rainfall drainage upon them,
and of similar drainage from the
uplands very large drains are required.
Irrigation is not responsible for the
rainfall, nor for the water which comes
from the uplands. Here again how-
-ever it has been proposed to make this
general drainage a part of the irri-
-gation scheme, and the estimates are
being prepared accordingly. I am by no
means certain however that it will
be practicable for the irrigation works
to carry this ~~extra~~ burden in its

I know Mr Robinson has no doubt been misled by the flood poured on the land.

entirely, and if not some other way of
finding the money will have to be
devised, or improvements and ad-
-vantages, which are of themselves
capable of attainment, will be lost
by trying to make too much out of
irrigation.
So. Now the Honorable Mr Robinson
has expressed the opinion, in which
His Excellency the Governor concurs,
that the effectual and healthful drain-
-age of an artificially watered
area is as much a part of the
Imperial and Loan scheme as its
irrigation, and that consequently
village drainage should be changed
to the Delta completion estimates.
That the irrigation estimates should
provide for getting rid of the water
which the canals introduce may be
admitted, and that they may, as far
as possible, help to get rid of the
water which is from other, and

natural causes in excess and a
 nuisance, and which renders land
 unfit for cultivation is perhaps
 reasonable, but they cannot do
 every thing. It would be really
 more reasonable to decide that
 the irrigation works must bear
 the expense of constructing the
 roads; the necessity for which arises
 in part from the increase of
 produce and of prosperity generally,
 which irrigation works and the
 outlay upon them occasion; or to
 require that harbours should be
 changed to irrigation, because the
 Delta wants outlets for its surplus
 produce. The irrigation works
 are directly concerned in making
 roads and harbours a necessity,
 but they are in no way responsible
 that villages have been established
 on low swampy ground rich and
 therefore attractive, but from the
 nature

The works are paid
 for by the people -
 the government.

nature of its formation and posi-
 tion ill-drained and sometimes
 far from healthy.

5. Whether or no village drainage
 should be deemed an agricultural
 work at all, any more than the
 drainage of the town of Madras
 which, apart from sewage, needs
 to be drained for the same reason
 and causes as the Delta village,
 may perhaps be determinable
 on considerations of convenience,
 but it appears to me that it is
 very unlikely that the Delta
 irrigation works will be able
 to afford to pay for it, and that
 if they could it would be a pity to
 change to them work with which
 they have so remote a connection
 or any connection at all costs
 generally be traced

many of the
 works are not
 agricultural
 all but a few
 are for
 water works
 for
 the
 government

2200
 for met-
 the
 the
 the
 the

25/9/74

My argument in the Robinson's
case was based on the supposition
that the greater part at least
of the swampy which existed
for village drainage was
caused by our irrigation
works. If, as ^{inferred from} the
case, this is not only not
the case, but in fact the greater
part of such swampy arises
from causes entirely distinct
from our irrigation, it is certainly
not desirable to charge the
drainage of villages indiscriminately
to irrigation. ~~But~~ if actually because
to do so would give an erroneous
impression as to the true financial
aspect of our ~~irrigation~~ ^{irrigation works}
I think that the ~~proper~~ ^{proper} purpose of the ~~project~~
draft ~~made with the work added~~
by the ~~work~~ ^{may stand} ~~may stand~~

Public Works Department
Proceedings of the Madras Government
From the Chief Engineer
for the (H.C. dated 7th
May 1874)

The memorandum
of inspection dated 7th
May 1874 of the District
Officer, containing the
notes of the Chief En-
gineer for irrigation,
will be communicated
to the Superintending
Engineer, Madras, for in-
formation and guidance.
2. The subject of the
arrangements requisite
for rendering the crop
drainage of the Eloor
Canal in this District
efficient has been fully
examined into, and the
Government wish to have
the estimates submitted
as early as possible,
for

for carrying out the improvements, and for completing this canal in the manner decided upon.

3. Independently of the propriety of maintaining order and cleanliness where lock and other establishments are located, the health of these establishments, which it is understood has been far from good, is dependent in a great degree upon proper sanitary arrangements, and the Government look to the Superintending Engineer to introduce and enforce these in all such places.

4. Paras 36 to 40 of the memorandum, which treats of the circumstances of the Kolair Lake.

will be referred for early consideration & report to the Rev. Spt.

lake will be communicated to the Revenue Department for early consideration. The data for a final determination of the question as to whether this lake should be allowed to fall to the lowest level practicable, or should continue to be artificially maintained at a higher level, appear to be fairly complete.

5. The arrangements proposed by the Chief Engineer for irrigation for deferring the provision of irrigation, except on a very limited scale, for the Zemindary lands under the Bank Canal Eastern Delta, and between that and the Masulipatam Canal, are approved. It appears that

a decided demand
for water arises it will probably

In the mean time the observations of the C. & E. Association will be reported for consideration - The Ad. Dept. is as certain whether the bet assessors present the occasional collector to

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Delta efficient drainage is of very great importance not only to the safety and productivity of the growing crops, but to the general health of the population, and so soon as the main drainage shall have been worked out, and some progress made with these drains, the Government will be prepared to make arrangements for providing for village drainage in detail. In the meantime the Superintending Engineer should give attention to this latter subject, and he will be at liberty to bring forward

forward proposals for dealing with individual villages or groups of villages, which he may find to be exceptionally in need of improvement in this respect, and which it may be practicable to drain. Village drainage will not be chargeable against the system of irrigation of the Delta, except in those cases in which the irrigation works themselves may have obstructed the natural drainage, but will be provided for under Agricultural Miscellaneous.

7. The early preparation of the detailed revenue statements for this Delta, in the form

I do not think the principle sought to be laid down here is sufficiently certain for the Government to commit themselves to its implementation in the broad way proposed.

The effective & beneficial drainage of an artificially watered area is, I submit, as much a part of the Imperial scheme as its irrigation - indeed the need of drainage arises in a great measure out of the irrigation itself. I think therefore that the two operations should as a rule be treated as branches of one general scheme both debitable to the same source of expenditure - Exceptional cases only being admitted to the category of works properly debitable to our small annual allowance for agricultural works Miscellaneous.

If my Honorable Colleagues have decided upon agreeing in this view, the Parliamentary authorities according to the Godavery, and made applicable to other systems of irrigation, is very desirable, and the subject will be remitted to the Revenue Department for such further orders as may be necessary - It is observed that these statements are due for 1871-72 and 1872-73, in addition to those for preceding years the compilation of which latter may take some time, while those for recent years should be submitted as soon as possible after the close of each Fushy.

Ph. W. of Gov. on due to Cpl. Mutton of the useful & complete report which is reviewed in the Press.

P. The J. Eng. Vesting - - - - -
- - - - -
- - - - -

by - 4/8/74
C. J. M.

If my Honorable Colleagues have decided upon agreeing in this view, the Parliamentary authorities according to the Godavery, and made applicable to other systems of irrigation, is very desirable, and the subject will be remitted to the Revenue Department for such further orders as may be necessary - It is observed that these statements are due for 1871-72 and 1872-73, in addition to those for preceding years the compilation of which latter may take some time, while those for recent years should be submitted as soon as possible after the close of each Fushy.

4534 ✓

Govt. of 1874 Madras.

PUBLIC WORKS.



To

The Sup: Engr.
District

Dated

Recd.

Encl.

G. O. 25 Sept 1874, No. 2732

No. 556-557

Thosha Dellā

Passing orders on the
Report of the Chief Engr
for Irrigation on an In-
spection of the ~~Dellā~~

Thosha Dellā made
between the 20th Nov. &
15th Decr/73