30/4/35

Govt. of {1891} Madras.

LOCAL AND MUNICIPAL.

Issued

Recd. *Encl.*

G.O., 11th March 1891, No. 349 M.

MARCH.

Cooum River.

Forwarding to the Chief Engineer with Government, for very early remarks, Mr. Jones' scheme for the improvement of the —, and stating that paragraph 98 of the report will be considered in the Public Works Department with a view to the repair of the Napier Bridge, if found necessary, being carried out at the earliest possible date.

With orders

No 753 M of 11th March 1891

Communicated to the Consulting Architect who will as soon as possible submit an estimate for securing the Napier bridge.

The consideration of the scheme for the improvement of the Cooum will be taken up on receipt of the Chief Engineer's report called for in para 1.

Sd. J. P. W.

C. A. to Govt

98-1-87—One

11TH MARCH 1891, No. 349 M., LOCAL AND MUNICIPAL.

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

READ—again the following paper:—

G.O., dated 27th February 1890, Mis. No. 328 M., Local and Municipal.

Order—dated 27th February 1890, Mis. No. 328 M., Local and Municipal.

The Government desires that Mr. Jones will prepare and submit, with as little delay as possible, a detailed scheme for the improvement of the River Cooum with a view to preventing it in future from becoming a nuisance during the dry months of the year. Mr. Jones' previous proposals on the subject, which are printed in G.O., dated 2nd July 1877, No. 1811, are not sufficiently elaborated to be of value, and, moreover, appear to Government to be unsatisfactory in themselves.

(True Extract.)

(Signed) J. GROSE,
Ag. Chief Secretary.

To J. A. Jones, Esq.
„ the President, Municipal Commission, Madras.

READ—also the following paper:—

From J. A. JONES, Esq., M.I.C.E., F.R.S.E., Sanitary Engineer to Government, to the Chief Secretary to Government, dated Fort St. George, 9th December 1890, No. 649.

I have the honor, in compliance with G.O., dated 27th February 1890, Mis. No. 328 M., Local and Municipal, to forward a scheme for the improvement of the River Cooum.

2. The papers sent herewith consist of—

(1) The report.	(3) One large scale plan.
(2) Estimates.	(4) One book of plans.

3. These very fully show the works which I consider are necessary to put the Cooum, between Munro's bridge and the sea, into the state it ought to be.

4. It will be found that there are alternative estimates for the work, viz.:—

		RS,
No. 1, amounting to	.. ..	12,25,000
„ 2 „	.. ..	10,90,000

Both of these amounts, however, include Rs. 1,70,000 for plant—a railway line and a dredger—both of which will be useful for other purposes and may, after completion of work, be handed over to other departments.

5. The actual cost of the works proposed stands therefore—

	Rs.
No. 1 estimate	10,55,000
„ 2 „	9,20,000

6. The alternative estimates are based on two different designs for connecting the Cooum with the sea—No. 1 by the Cooum bar, No. 2 by a canal starting from St. Mary's bridge and passing round the west side of the Fort to the south arm of the harbour.

7. It has no doubt not escaped the notice of Government that statements have been made that, while Mr. Pogson's scheme (which, as far as is known, is still *in nubibus*, at least it is so far as I am concerned) for cleansing the Cooum is estimated to cost 1½ lakhs, Mr. Jones' scheme is to cost no less than 10 lakhs.

8. I cannot claim for my scheme even half the advantages claimed for Mr. Pogson's; my scheme will cost more than a lakh and a half; it cannot be carried out in three months, nor will it allow of the drains being flushed with sea-water as they run up hill from the sea.

9. But, while I do not claim these advantages by its execution, I must point out to Government that the estimates which I send forward are for vastly more extensive works than the mere junction of the Cooum with the sea—*that* is a very necessary portion of any scheme, but it is at the same time a portion of the scheme the cost of which does not exceed one-sixth of the whole amount. The actual cost of opening the Cooum bar, or of forming a canal in connection with the harbour, amounts to about 1½ lakhs, and while one can only surmise what Mr. Pogson's scheme is, I believe it must be of this nature. In any case there cannot be much difference of cost between one scheme and another in respect to the bare proposal for securing circulation in the Cooum.

10. While the estimates are to some extent approximate, they have been prepared in considerable detail, and the various items are not to a large extent dependent one on the other. Thus Government may propose to execute only the portion of the work up to Harris bridge, and even from this portion may omit, mean time, wharves, training walls, the extension of St. Andrew's bridge, &c., and merely execute the opening of the bar or formation of the canal, the dredging of the main and the filling of the north branch of the river. But while that is so, yet I would earnestly urge that the works in the lower portion of the scheme be sanctioned in their entirety if the scheme is sanctioned at all. The cost could be spread over three or more years, and even if the whole scheme is executed, the expenditure will not, I think, be out of proportion to the results which, I believe, will be attained.

11. Although I have advanced many arguments in my report to show that the north branch of the river ought to be filled up, there is a still stronger one, and that is, that there will be very great difficulty in disposing of the stuff excavated from the main branch, if that is not done, as the stuff would have in such case to be carried out to sea at a much greater cost.

12. In my report I have but lightly touched on the great advantages which would accrue to Madras by the closing of the north branch. An examination of the plans will show that, taking advantage of the extra ground added to the river, I have suggested a new race-course; this particular item naturally does not fall within purview of the scheme, but the improvement of the island does so, and I venture therefore to throw out the suggestion as to the race-course, because I believe that the Race Committee, in view of this improvement, might be inclined to move all their meetings to Madras, and might be able to make a handsome contribution to the

scheme as they could then get rid of Guindy. This question affects to some extent the proposal for raising the level of the island (as an island to be abolished), and hence my allusion to the subject.

13. The report, though comparatively short, is one which has for its preparation required considerable investigation on many points; but it does not, I fear, of itself justify the time taken in its preparation. It has had to be prepared at a time when many other pressing works had to be kept up to date, and the small staff at my command has been unable to get out the plans and estimates at an earlier date than that at which it is now presented.

14. I send the report forward with some diffidence, for I am aware that some of the measures proposed may lead to considerable discussion; and seeing the importance of the subject and that the amount of money involved is large, I would desire that Government will, before sanctioning or disapproving the scheme, consider the advisability of associating with me (I presume to suggest) the Chief Engineer and Captain Street, R.N.R., for a consideration of any point which to Government may seem to demand further investigation.

15. Except perhaps an improved water-supply—for drainage is very closely associated with the improvement of the Cooum—there is probably no other work which can be undertaken in the City of Madras which will, in a higher degree, tend to ensure not only better health but also greater comfort and enjoyment to its people. The river, a large portion of which is adjacent to one of the largest air spaces—Madras' most important play-ground, constantly reminds us in no uncertain tone of its filthy condition. It tells indeed that—

"The sewage that should feed the land
"Makes poison for the town;
"The stream, a sewer for the strand,
"To drink its ordure down."

That is what the river has been called upon to do for years past. Improved drainage will prevent its being called upon to do that work in future, and the works I have in this report recommended will, when carried out, wash away, I trust, all remembrance of the treatment the river has received during the greater part of a century.

16. The reproach lately cast at the river by a writer in the *Madras Mail*, viz.:—

"Ignoring all that science proves
"Or sanitation teaches,"

will, I hope, be not much longer applicable, and the river, I trust, will soon be able to possess in truth, and not in ridicule, as at present, that name to which it, though many years ago, must have been rightly entitled, viz., "The Silvery Cooum."

17. As the scheme is one of perhaps more than local interest owing to some of the professional details, I trust the report may be printed and the plans lithographed.

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Enclosure.

The River Cooum.

Scheme for its improvement within the limits of the City of Madras.

The River Cooum takes its rise some 29 miles to the west of Madras. At the Coratoor anicut, which is about 9 miles from the sea, the river has attained a length of 20 miles, and it receives in that length the drainage of 200 square miles of country. The maximum observed discharge at the Coratoor anicut amounts to 10,614 cubic feet per second. The length of the river from the Coratoor anicut to the sea is about 9 miles and the drainage area below the anicut does not exceed 15 square miles. The area drained within the City of Madras amounts to 8 square miles, so that on the river entering the municipal limits it has a drainage area of 207 square miles. The course of the river within the municipal limits is extremely tortuous. Its course with windings extends to 6·3 miles, while the distance in a straight line from the place where it crosses the municipal limits to its mouth is only 3·9 miles. At about one mile from its mouth it

is connected by a narrow cut with the Buckingham canal which occupies the valley of what used to be known as the North river, which river skirted the south of Fort St. George and joined the Cooum river near its mouth. In the plans to be found in "Orme," the cut, already spoken of, appears to have been different in position from that it now occupies, but there has always been a connection somewhere near this point, and that portion of the north river which skirts Fort St. George is now designated as a portion of the River Cooum. The Buckingham canal is in free connection with both branches of the Cooum, and during floods sends a considerable body of water down the Cooum. There is a lock on the canal at Shadayankuppam, 7 miles from Madras. Its purpose is said to be to keep the water high in the canal when the Kortalayár bar is open to the sea. It also limits the area of the flood discharges which affect the Cooum.

2. It has been proposed—*vide* paragraph 61 of report on Buckingham canal (G.O, dated 14th March 1883, No. 841 W.), to divert the drainage flow south of Shadayankuppam lock by a drainage channel and drain into the canal north of the lock. This can, I think, refer only to that portion of the canal between Cotton's canal and the lock mentioned, because on the other portion of the canal between Cotton's canal and the Cooum such an arrangement does not seem feasible. I am doubtful, however, if any portion of the arrangement has been carried out, and for the purposes of this report, I have considered the whole of the drainage south of Shadayankuppam lock as still entering the canal and finding an exit to the sea *via* the Cooum. The additional drainage area which has to be included on this account is that of about 8 square miles.

3. It may be taken therefore that on entering municipal limits, the Cooum drains 207 square miles and that at Law's bridge, just above its junction with the canal, it drains 207+8 square miles and below this point 215+8 square miles. These figures are not strictly accurate, as 215 square miles is the area drained to the mouth, less that brought in by the Buckingham canal, while Law's bridge is one mile from the mouth; again it has not been shown that all the drainage from the canal will enter by the cut near the Penitentiary and does not pass down by the north branch of the Cooum to join it just above its mouth at Napier bridge; the figures, however, given above are in excess and may, for the purpose of this report, be accepted.

4. Until I again refer specially to the north branch of the Cooum, my observations in the following paragraphs must be considered to relate to the main branch alone.

5. As before stated, the Cooum within the municipal limits is of an exceedingly tortuous character.

6. This circumstance causes the formation of large banks which are formed of course on the convex side, while the concave side is scoured out to considerable depths. The formation of these banks and consequent scours above the bridges necessarily endanger these structures, and on the concave side of the river just below the bridges, the bed has been scoured to great depths—*vide* Cooum sections Nos. 3 to 3-B.

The river, though partly a tidal stream for a part of the year, and during that time filled with sea water, is for the greater portion a mere lagoon filled with a mixture of fresh and sea water with no outlet, but liable to sudden variation on each occasion of rainfall.

7. The Cooum is in connection with the sea usually only for portions of the months of October to January. The following table shows the date of cutting and closing the Cooum bar during the last ten years:—

Year.	Month and date.		Particulars.	Number of days open.	Remarks.
1880	November	4	Opened	59	
	January	1	Closed		
1881 ..	November	12	Opened	40	
	December	21	Closed		
1882	November	16	Opened	62	
1883 ..	January	16	Closed		
	October	16	Opened	99	
1884 ..	January	22	Closed		
	October	19	Opened	95	
	January	21	Closed		
1885 ..	November	16	Opened	31	Closed of itself.
	December	16	Closed		
1886 ..	November	9	Opened	30	Do.
	December	8	Closed		
1887	October	28	Opened	86	
1888 ..	January	21	Closed		
	October	30	Opened	82	
	January	19	Closed		
	October	15	Opened		
1889 ..	Do.	19	Closed	15	
	December	18	Opened		
	Do.	27	Closed		

The river has also usually during this period indirect connection with the sea *via* the Junction canal, the Adyar, the Buckingham canal and the Kortalayár bar, and during the hot season sometimes at high spring tides with the Adyar bar open that river may rise from ·50 to ·70 above mean sea level. When the Junction canal and the Cooum is lower than the Adyar, the gates of the lock which is placed at the junction of the Adyar and Junction canal are opened and a flow down the Junction canal to the Cooum takes place. The result, however, to the level of the Cooum is insignificant, as the water has to spread a considerable distance up the main branch of the Cooum itself, up the north branch and up the Buckingham canal for 7 miles. Similarly with the Ennore bar open and the Cooum and canal lower than the water to the north side of the Shadayankuppam lock with the lock open a similar action takes place. Looking to the infrequency of these supplies to the Cooum and the very slight result when the supplies do take place we may consider the Cooum for nine months of the year to be a mere tank or backwater without motion through it of any sort.

8. Throughout the summer months, though it seldom receives direct supplies of flood or sea-water, it is unfortunately continually receiving large supplies of polluted water; and the City of Madras, I calculate, passes into the Cooum (excepting the canal) through 21 sewers on the right bank and 13 sewers on the left bank—no less than 1,000,000 gallons of sewage daily. The Cooum is not, however, during the months its bar and the bars of the Adyar and the Kortalayar at Ennore are closed totally unaffected by the sea, for I have observed a very distinct rise and fall in the Cooum during the hot season; this I believe is caused by the sea-water finding its way inland through the substratum at high tides, and this water, when the tide falls, escapes into the Cooum from the adjacent surrounding land instead of returning to the sea.

9. The constant delivery of sewage into the river naturally renders it the breeding ground for all kinds of organisms, and the want of circulation in its waters and the consequent small exposure of the organisms to the air are circumstances eminently favorable to their production. As soon, however, as any very slight circulation takes place, such as may be caused by a shower of rain, the organisms are at once exposed in large numbers to the atmosphere and their oxygenation and consequent destruction which the late Dr. McNally described as "of the nature of fermentation and analogous to the conversion of sugar into alcohol by the action of microphytes in the presence of oxygen," results in the production of offensive and poisonous substances of the nature of ammonia. When such results are produced, the inconvenience and nuisance to those who live in, or may come to the vicinity of, the Cooum is very great. Several of the most prominent of the Madras buildings, such as the "Senate House," "Government House," the Penitentiary, the "General Hospital," the "Women and Children's Hospital" and a large number of buildings on the Mount road are adjacent to the Cooum; it is evident, therefore, that the existing state of matters is a question of no small importance.

10. The state of the Cooum has for many years been a source of constant complaint, and during these years as many suggestions have been made for its remedy.

11. In the year 1882, owing to the Cooum being in the state which has been previously described, the then Senior Medical officer of the General Hospital proposed the admission of sea-water at high tides. Dr. Cornish, who was then Surgeon-General, in his order on that suggestion said: "The remedy suggested was tried on one occasion within the Surgeon-General's recollection, but instead of abating the nuisance only increased it. On this occasion (1870) the sea-water was let in at a time when the sea was full of a species of oscillatoria producing the phenomenon of phosphorescence. These minute creatures died by myriads under the changed conditions of their existence, and produced so fearful a stench that many persons having to pass near the river on any portion of its tidal length were attacked by sickness. Fortunately, heavy rain fell early in June of that year sufficient to force open the bar and remove the offensive matter."

12. It will have been noticed that the cause for the ordinary recurring offensive smells described by Dr. McNally and on the special occasion noticed by Dr. Cornish is the want of circulation in the river. In the ordinary case the animalculæ breed undisturbed until some rainfall or other cause brings them into contact with the atmosphere and oxygenation occurs; in the special case the oxillatoria were unable to live because their condition of life was changed by their being thrown into water comparatively fresh. There is therefore but one remedy and one alone which can prevent this recurring nuisance, and that remedy is circulation; if the water in the river is in constant circulation, the animalculæ if they die will die in average numbers throughout the year unnoticed and at the same time their productiveness will be exceedingly decreased and the nuisance will in fact disappear. The cause of the increased nuisance in the case referred by Dr. Cornish was not the letting in the sea-water alone, but the want of more water and a constant influx of sea-water so that the conditions of life in the Cooum and the sea would not have been very materially different; the remedy therefore recommended is the constant admission of sea-water to the Cooum and a corresponding daily rise and fall of the tide. How I propose to effect this I reserve until I come to discuss the engineering details of my scheme.

To change the water in the Cooum daily is the object to be effected and it is necessary to attain this as quickly as possible and to limit the flow to as small an area as possible. For this purpose it will be necessary to place a lock across the Buckingham canal near St. Mary's bridge and a

weir must also be placed somewhere in the river, because it is impracticable to keep the whole river within municipal limits as a tidal river; the upper portion of the river therefore must be treated in a different method from the lower. In the upper I propose to retain the water in tanks gradually ascending one above the other, the lower portion will be continually tidal.

13. The point where the dividing line should be has been of course a matter for much consideration, and my reason for fixing the site for the dividing line a short distance above Harris bridge, where a weir will be constructed, is that the ordinary tides when freely admitted will flow up to this point, and this weir will be above any of the points of entrance of sewage drains into the river.

14. In para. No. 8 I have already stated that 21 drains enter on the right bank and 13 on the left bank of the river. All these drains enter the river below the site I propose for the permanent weir.

15. That these drains are the most predominant cause of the production of organisms and animalculæ of all sorts need hardly be stated, and until these drains are wholly diverted from the river, the river will never be in the condition it ought to be. These drains in floods bring down large quantities of silt into the river; at other times they bring down sewage much of which is deposited at or near their mouths. It will be many years before the municipality are able to divert all the sewage from the river, but as the villages of Triplicane and Chintadrepet are most flagrant in respect to their steady discharge of sewage into the river, it seems to me that these villages might well first, before any other parts of the city, receive attention at municipal hands; pending such measures, it is my duty to suggest certain arrangements which will, without diverting the drainage from the river, tend to filter it before entering the river and also allow of the removal by the municipality from time to time of the solid sludge which I propose to arrest. These measures I shall refer to later on in this report.

16. When the measures I have suggested are carried out, they will prevent the pollution of the river in the future, but the deposits of many past years and the consequent present state of the river have yet to be dealt with.

17. To a certain extent no doubt the river gets cleared by annual floods; but it is just as certain that large deposits in the river never get cleared at all and also that a large amount of silt deposit is merely annually moved from its original site and re-deposited on the convex curves of the river, where large banks are formed which go on increasing, thus narrowing the river and causing an increased scour and encroachment in the concave banks at the bends and also cause the flooding of the lands adjacent to its banks.

18. Further radical improvements necessary therefore are these:—

(1) The removal of the banks referred to.
(2) The restoration of the banks where eroded.
(3) Deepening and re-sectioning of the river.
(4) The proper training of the river so that at ordinary seasons it will be confined to the centre of its bed and during floods will cease to deposit the silt it carries down on the convex side and scour away the concave side, and for this purpose the erection of groynes, &c., is necessary.
(5) The formation at certain places of wharves which would, to some extent, serve as groynes or training walls and afford facilities for the landing of goods at present effected in the muddy foreshore.
(6) The restoration, improvement and re-sectioning and turfing of existing banks and their future protection.

19. The acceptance of proposal No. (3) will allow of cargo boats proceeding up the river much further than at present and of No. (5) will ensure an income to Government probably in excess of the expenditure on the construction of wharves which would, I believe, be productive works. An instance in the point is the wharf erected by the municipality at Trevelyan basin, Black Town, where the cost of the wharf was covered by the profits from two or three years' income.

20. These recommendations do not, at first glance, seem to demand any great expenditure, but it will be seen, when engineering details are discussed, that they absorb a large proportion of the total amount of the estimate.

21. The Cooum when in floods at times rises higher at certain points than its banks; this, as regards that part of Madras called Lang's Garden, in the village of Chintadrepet, and on the left bank of the Cooum, is due to the very small waterway afforded by St. Andrew's bridge; a reference to paragraph No. 71, where the waterways of the various bridges are compared, will at one show how limited the waterway is at that bridge.

22. Below St. Andrew's bridge and still on the left, the bank, the roadways, &c., are also flooded; the floods affect the site of the Women and Children's Hospital; this, it is believed, will shortly be removed, but the roadway along the river between St. Andrew's bridge and Law's bridge is very often submerged much to the inconvenience of, and danger to, the public and on this account and for the proper training of the river the road ought to be raised.

23. Above the point where I propose to place the weir the river assumes a different aspect to that which it has in the lower reaches. It is very broad with a sandy bottom, and practically no sewage enters it. It is extremely shallow, and in the hot season is, in fact, a series of shallow pools. Its appearance is decidedly ugly; its banks are very ragged. and large expanses of sand encourage the growth of noxious vegetation and the commission of nuisance. Dhobies wash in these pools containing only small bodies of water, and as they are seldom replenished, the state of water in which the clothes are washed is not uncertain. The iron weir sluices which have been erected at the Commander-in-Chief's and Andrew's bridges are much too low to dam up the water for any distance back so as to completely cover the bed, and it has been remarked that these sluices probably let out more water than they retain. However that may be the principle on which their erection was based, viz., the retention of bodies of water so as to keep the bed of the river covered throughout the hot season is a good one and it is the principle I still propose to adopt, but as to the means of attaining that end my proposals will be slightly different. A greater depth of water is necessary to be of any use, and the manner in which I propose to secure their object will be found among engineering details.

24. When the river has been dealt with according to my scheme it will be found that—

(1) There will be a gradually increasing depth below the proposed Harris bridge weir with a constant circulation of the waters and the river will become a tidal one.
(2) The river will be trained and flow in the centre of its bed whether in flood or otherwise.
(3) The banks will be improved and will have proper slopes, and the present exposure of silted sewage banks will disappear.
(4) The river will be navigable to traffic from its mouth to Harris bridge and greater facilities will be placed at the disposal of the public for the import of firewood and other commodities.
(5) The periodical smells which arise from the river will, I believe, disappear.
(6) The upper reaches will be a series of lakes suitable for boating, and bathing might be allowed at certain places. The washing of cattle should, however, be prohibited.

25. I have now to consider what steps should be taken in regard to the north arm of the Cooum.

The points for consideration are these—

(1) What is the necessity for this branch of the Cooum at all?
(2) If there is no necessity, is there any advantage?
(3) Whether there would be greater advantages where this branch closed?
(4) If the branch cannot be closed, can any steps be taken to improve it?

26. What is the necessity? It serves at present to discharge or to partially discharge the flood waters brought down by the Buckingham canal. In para. 3 I stated that the figures I gave were not strictly accurate, because I based them on the supposition that all the drainage of the canal passed down the main branch of the Cooum. If the drainage can so pass, then one necessity for the north arm or branch of the Cooum disappears. While this may be so, there are circumstances which may call for the retention of the north branch, viz., that it may receive the storm drainage from certain portions of Madras. It in fact at present does do so for the "Scoop-drain" which drains the esplanades and which is also a storm overflow for part of the Black Town drainage scheme, discharges into the Cooum (north branch) between the Wallajah bridge and the Medical College. This branch of the Cooum also during floods brings down a supply to the Fort ditches.

27. As to the Scoop-drain, if the north arm of the Cooum were filled up the drain can be carried to the other branch at St. Mary's bridge; but I have no plan to suggest for the filling* the Fort ditches with water unless from the sea if the north arm ceases to fill them; perhaps as a sanitary measure it might be suggested that they would be better filled up altogether with earth. Whether military exigencies will allow of that I cannot determine; this, however, is a small matter, and I think it may be taken for granted that no necessity exists for the north arm if the main branch of the Cooum is sufficient to carry off all flood waters, and that is so because—

* They can be filled from the proposed canal if scheme No. (2) is adopted.

(1) Both branches discharge through the Napier bridge.
(2) Because the proposed improved section at Government House bridge will allow of a similar discharge.
(3) Because the improved sectional area of the river above Government bridges will be also sufficient.

28. What then is the advantage of the north branch? The only advantage that I can see is that it affords a course for boating, but if it be done away with, the improvement of the main branch will compensate for the loss of the north. It will perhaps be necessary to supply a small open channel to carry off to the sea the drainage from the slope of the south glacis and a portion of the island and this is provided for in the estimate.

29. What would be the advantages if the north arm were filled up? They are, namely:—

(1) There would be a more direct connection between Black Town and Mount road.

(2) A much-wanted communication from Body-guard road would be afforded.

(3) A large piece of land would be added to the island, making it much more valuable for military purposes and for public amusements.

(4) A much-wanted addition to the grounds of the General Hospital and College would be obtained, though by the present position of the South Indian Railway the access would require to be across that line.

(5) The summer odours, now thrown out by this branch of the Cooum, which in proportion to its length has a considerable area, would cease to pollute the air to the inconvenience of the Fort, the Medical College, the General Hospital and the general public.

(6) The flow of the tide up the main branch of the Cooum would be at a much greater speed and the circulation obtained much greater. This object might also be effected by a weir where the north and main branches of the Cooum join.

30. The filling of the branch would be effected by depositing, by means of a light railway, the excavated earth from the northern branch; to cover this, sufficient soil could be dug from the banks before filling up the river.

31. If the closing of the branch is objected to, this branch can, of course, be dealt by measures similar to those proposed for the main branch, but I strongly advocate its complete closure. The full benefits to be attained by the adoption of that measure will be more readily appreciated by a study of the plan of the present island with the branch closed.

32. The Buckingham canal extends from the north branch of the Cooum for a distance of 7 miles before the Shadayankuppam lock is reached. If the tide is to be allowed to flow up the canal, the Cooum will never obtain the full effects of the tide, and as this, I venture to think, is a necessity, as I have already indicated, I am strongly of opinion that lock gates ought to be erected near St. Mary's bridge. A design has been prepared for the site at St. Mary's bridge, which bridge requires renewal and widening. The design effects both these objects.

33. This is not the first proposal to place a lock near the Central station. His Grace the Duke of Buckingham, when Governor of Madras, had a temporary bund erected at the Central station. The main objection to this lock, which would be most useful as regards the Cooum and probably also in keeping the canal at a high level during a part of the year, is that the canal for half a mile above this point is much polluted with sewage. No doubt a large number of drains flow into the canal, but these shortly will be diverted from it, and as there is practically at present (except in flood times during which time the gates would be open) no circulation, it does not appear that the erection of a lock at the point indicated will, from a sanitary point of view, tend to aggravate the present condition of the canal.

34. For reasons similar to those already stated, a lock should also be placed at the north end of the Junction canal. The lock at the Adyar is no doubt a double lock and, while flood-waters of the Adyar can be sent to the Cooum, at the same time the Cooum can be prevented from flowing to the Adyar; but the question is how best to obtain the full benefit of the tide in the Cooum, and there can be no doubt that in proportion to the less area to be filled, will depend our success in keeping up more or less perfect circulation by the in and out flow of the tide.

35. With these remarks I may conclude what I may call the preliminary portion of my report, which embodies generally my proposals; the latter portion details with the engineering features of the scheme and details regarding the manner in which it is proposed to carry out the work.

Engineering Details, &c.

36. This report has been prefaced by a small scale plan of the Cooum within Municipal limits.

37. It is accompanied by—

Particulars.	Number of sheets.
1. Large scale-plan showing the river at present and as proposed ..	1
2. Longitudinal section of river showing present and proposed levels of bed, &c.	1
3. Cross sections of the river showing the proposed new sections of the river	7
4. Plan and sections of the proposed arrangement at the mouth of river	1
5. Sketch-plan and elevation of the lifting bridge at the Napier's bridge	1
6. Plan and sections of the weir at Harris bridge and cross section of wharf wall	1

Particulars.	Number of sheets.
7. Plan and sections of lock gates at and improvement at St. Mary's bridge	1
8. Plan showing the extension of St. Andrew's bridge	1
9. Plan of the place now called island as proposed to be improved ..	1
10. Sections across the island showing relative levels, high and low water mark, and the flood level as proposed	

38. The first question to be considered is the method of opening and keeping open the Cooum bar and this is a question which must be considered at some length.

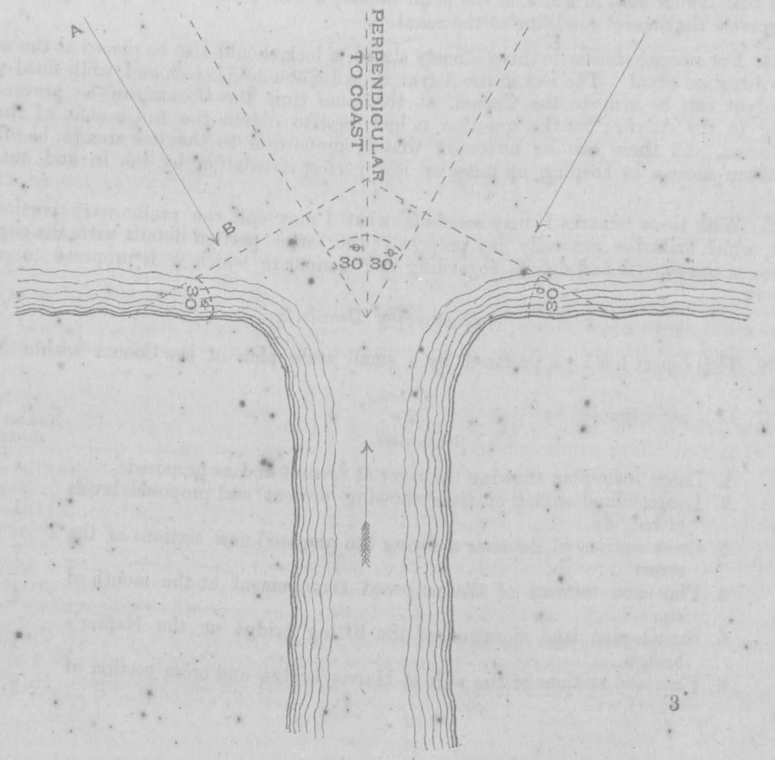
39. The experience gained in the construction of the Madras Harbour has shown that, as a rule, a groyne projecting from the coast will have the effect of accumulating sand to the south of it, while causing a scour to the north of it, because we may consider that the two groynes of the harbour as one groyne of great breadth.

40. Undoubtedly a groyne at the mouth of the Cooum would have had a similar effect before the construction of the harbour; the first question to be considered is, will it have it now?

41. We have first to consider to what, at the accumulation of sand and scour, are respectively due.

42. In evidence (55—p. 4) before the committee appointed to inquire into the question of the position of the entrance to the Madras Harbour, the late Mr. Parkes said, in reply to a question as to the general direction of the sea: "It seems to be quite independent of the wind so far as I can see" and (56—p. 4) "It varies a little to the north of a line perpendicular to the coast and a little south of that line;" but if paragraph 104 (p. 6) is referred to, we find the Chairman, with reference to a letter by Captain Taylor, saying: "This all rather seems to me to point to the sea accompanying the wind and not to the independent swell that is always setting on the entrance." Mr. Parkes: "There is no doubt that the seas do come from the south of east during the south-west monsoons and from north of east during the north-east monsoon" and in paragraph 108 (p. 6) we have the Chairman saying: "In no case," he says here, "is it believed that the angle exceeds 30° to the general line of the coast?"

43. This is an important point The Cooum, when its mouth is open and when discharging into the sea with any great velocity, discharges at right-angles, or almost at right-angles, to the coast, and in the following sketch is shown the maximum limits of the direction of the sea and accordingly the line of the waves breaking on the coast:—



44. Now the bar of the Cooum within the last ten years was open during portions of the months of November and December usually, but sometimes from October and sometimes as late as 21st of January. During these periods the direction of the sea and, accordingly, the waves breaking on the coast, has been that from the north of east or as indicated by the arrow A B, and it has been observed that, before the bar is closed, the river flows more and more away to the south side of the channel which the river in the high floods scours out.

45. There is also a series of currents passing up and down the coast parallel to it, which are calculated to run at a velocity of from 1 to 3 miles per hour. These are not necessarily always in the direction of the wind, but generally when the wind is from north of east the current runs south and when the wind is south of east the current runs north.

46. We have at the mouth of the Cooum, therefore, two facts to deal with—the currents which convey the sand up and down the coast which, owing to their reversed direction, lodge at one time sand on one side of any projection from the coast while removing it on the other, and, at another time, reversing the operation. The southerly current, however, acting for the longer period, is the cause of the deposit of a larger quantity of sand than the northern current.

47. Having seen how the sand is lodged, I now return to the original questions—Will the harbour have any effect on the lodgement of sand at the mouth of the Cooum? As the harbour is north of the Cooum it is not likely to affect in any degree the action of the southerly currents, and, from what follows, I do not think that it will much affect the northerly currents. The outermost point of the harbour bears from the Cooum mouth 33° east of north, so that the mouth is unprotected from the north-eastern winds and as 33° is only 3° more than the maximum angle at which the waves may approach the shore, there will be little or no change in their direction. I am of opinion, therefore, that the harbour will not cause any difference in the result which would occur from the placing of a groyne at the Cooum than if such groyne were elsewhere. The small increase to the general shore line, caused by the harbour, of course, will continue, but harbour groynes will not prevent the scouring action which will take place to the north of a groyne erected near the mouth of the Cooum similar to the action which takes place and has taken place to the north of the north harbour groyne.

48. My proposals, therefore, for keeping open the mouth of the Cooum are—

(1) The improvement and extension to high water mark of the groyne now existing on the south bank at the Cooum mouth.

(2) A groyne 100 feet north of this (thus taking up two spans of the existing bridge) and widening out to 200 feet at high water mark and extending no further than that point.

(3) A breakwater groyne starting from near the end of No. 1 groyne on south of the south bank of the Cooum from high water mark and extending to a length of 650 feet at a point some 530 feet from high water mark.

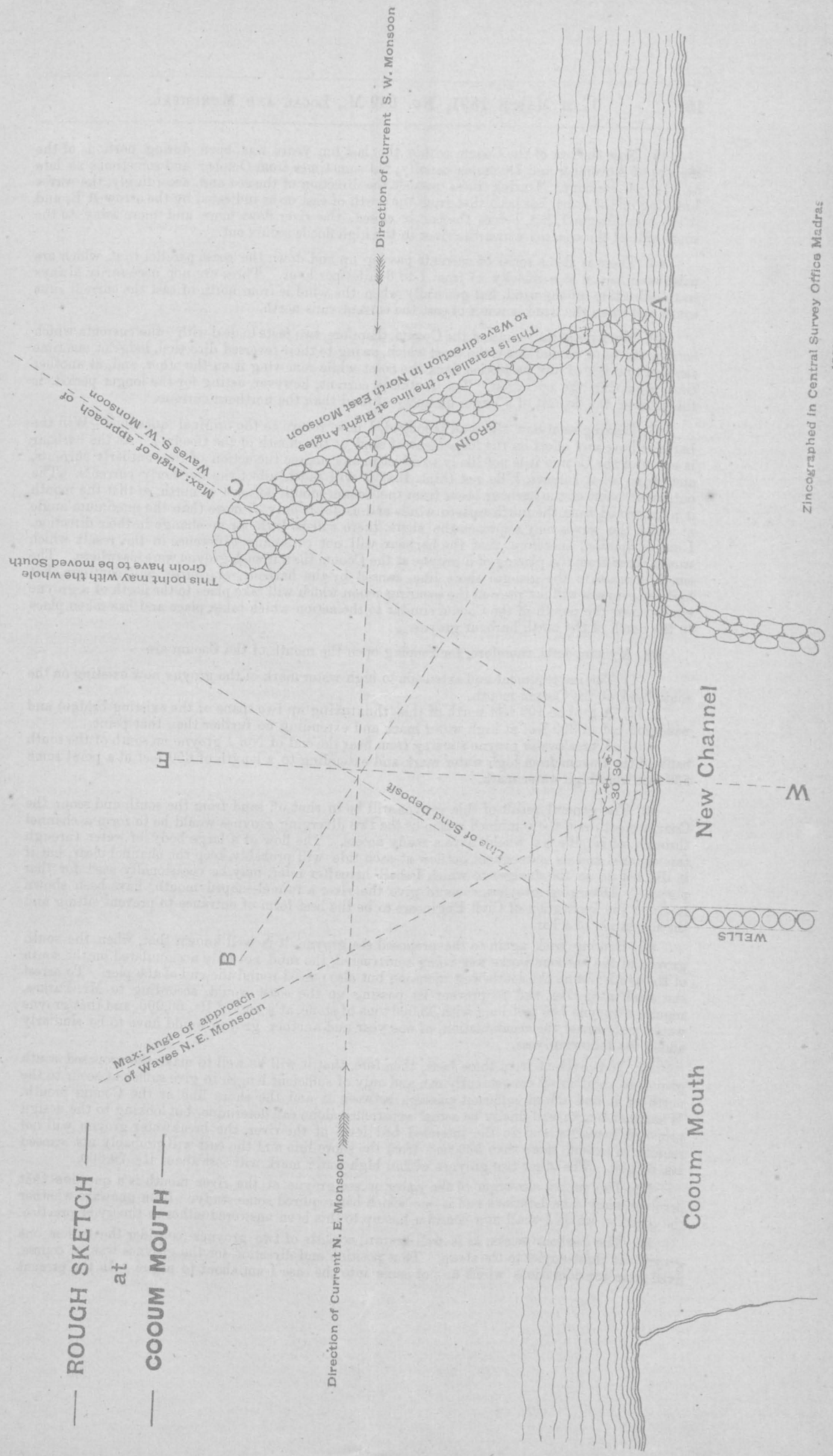
49. The general result of this groyne will be to shut off sand from the south and scour the Cooum mouth and the combined action of the two diverging groynes would be to form a channel through which the sea would have a ready access. The flow of a large body of water through this channel and its subsequent outflow at each tide will probably keep the channel clear, but if it did not do so the dredger to which I shall hereafter refer, may be occasionally used for that purpose. Diverging groynes, so as to give the river a funnel-shaped mouth, have been shown lately at the Institution of Civil Engineers to be the best form of entrance to prevent silting and the formation of a bar.

50. Coming back again to the proposed sea groyne, it is well known that, when the south groyne of the harbour works was being constructed, the sand not only accumulated on the south of the south pier in the south-west monsoon but also passed round the end of the pier. To arrest the sand altogether, and to prevent its passing up the coast would, according to Mr. Parkes, require a groyne 700 feet long with 33,000 tons of stone, at a cost of Rs. 66,000, and that groyne would only arrest the accumulation of one year and another groyne would have to be similarly added the following year.

51. It is evident from these facts, therefore, that it will be well to make the proposed south groyne as short as we conveniently can and only of sufficient length to give sufficient scour to the north of it and afford sufficient passage between it and the shore line at the Cooum mouth. What that length will finally be actual experience alone can determine, but looking to the design proposed hereafter and to the intended bed level of the river, the breakwater groyne will not require to extend more than 530 feet from the shore line and the cost will probably not exceed Rs. 69,000. The other two groynes within high water mark will cost about Rs. 70,000.

52. The proper direction of the outer or sea groyne at the river mouth is a question that involves many considerations and is one which has required some study. I am unaware whether the question which I shall now consider has up to this been answered either in theory or practice.

53. The harbour works, as is well known, consists of two groynes (consider the two as one groyne) at right-angles to the shore. That position and direction for the groynes was, of course, fixed from considerations which do not come into the case I am about to argue. In the present



case the real question is—What direction should the breakwater groyne take with reference to the shore line? Now it is well known that a groyne at right-angles to the shore, arrests the sand on one side and scours it away in the other, the action being reversed from time to time according to the season of the year. We may, however, leave the north-east monsoon out of the question and consider it in relation only to the south-west monsoon. Then the current is from the south and the waves strike the shore from the south-east more or less. Will a groyne at right-angles to the shore give the greatest scour to the north of it? The greatest scour can only be achieved if there is no lodgement of sand to the north of the groyne. Now the sand which would be lodged to the north of the groyne must come from the south and it would be sand washed round the end of the groyne.

54. The groyne then ought to be in such a position and have such a direction that the sand from the south will be arrested as slightly as possible and in such a position that the current carrying the sand will be diverted from the shore as much as possible and be also in a direction which would secure the mouth of the river from sand which has passed north of the groyne being carried towards it by the waves. Now these objects, during the south-west monsoon, would be secured to the greatest extent by placing the groyne at angle not less than the angle at which the line of the waves meet the shore during the south-west monsoon or in sketch accompanying the line A B.

55. There are, however, objections to the groyne in that position; firstly, it would have to be a long groyne; secondly, during the north-east monsoon its position is likely to cause a larger deposit of sand than if the groyne were inclined at a less angle to the shore. The north-east monsoon, it must, however, be remembered, is not so important a consideration as that of the south-west, because during a long period of the former, the river is ordinarily in flood and keeps its mouth open by its own action.

56. Taking all these considerations into account, I believe that the best position for the groyne is that shown as A C. The line of it is such that the southerly current will be diverted without being arrested or causing the sand to deposit at the back of groyne to the same extent as it would do if the groyne were at right-angles to the course of the current. The scour inside the groyne, owing to the greater area of slack water which will exist, will probably be greater. The position of the end of the groyne has been fixed with reference to the new level of the Cooum bed, the depth at the end being slightly greater than the depth at the mouth of the Cooum. The point is also fixed with regard to the necessity for ensuring that a scour will take place at the mouth and not only north as might be the case were the end of the groyne too far north, for, as is known, the scour at the north arm of the harbour works has not so much affected the line of shore close into the breakwater.

57. The funnel mouth of the groyne in shore will produce the greatest possible scouring effect through the channel and keep the channel clear, the bottom of it being laid with boulders. The effect of the outgoing tide can, if necessary, be improved by the use of scouring shutters which would be shut at high, and opened only at low, tide and the aid of the dredger still to be referred to can also be called in when necessary. I am therefore of opinion that the bar can be kept open and, such being so, circulation in the lower reaches of the Cooum will be secured.

58. The two in-shore groynes, as I have already stated, will be 100 feet apart at the Napier bridge and widen out to 200 feet at the sea margin. The south groyne may be formed by large boulders cemented with cement concrete but the north groyne must be of different construction. When the mouth of the river, except the narrow entrance to be maintained, is shut, that is, except when the river is in high flood, the north groyne must form a retaining wall to keep back the sand. When the river is in flood and the full breadth of the mouth is required for the discharge, that groyne will be in the centre of the flood waterway and must be such as not to take up more or little more than the breadth of the bridge piers, and, for this reason, I propose to form it of cement concrete cylinders sunk well down below a depth affected by scour. Between these two groynes at ordinary times the tide would run in at the rate of about two feet per second, calculated thus:—Under the new condition of the river yet to be described the area to be affected by the tide will be about $4\frac{1}{4}$ millions square feet. This would be filled in six hours, and, taking the average rise of the tide as 3 feet, and the sectional area of the channel as $100 \times 3 = 300$ feet, the rate of flow would average—

$$\frac{4,250,000 \times 3}{300 \times 6 \times 60 \times 60} = \frac{12,750,000}{648,000} = 2 \text{ feet per second.}$$

59. The rate would be less than this at the beginning of the flow and the ebb, but much greater during a large portion of the 6 hours, and the velocity will be quite sufficient, I believe, to keep the channel clear. If not, it will be easy to put up gates at the Napier bridge and dam up the tide in the river until low tide when the gates would be opened and a very high scouring action would occur.

60. The scour from the sea groyne proposed is not likely to affect the coast line to the north very much, but there is plenty of land to come and go on, and it is not likely that there will be more removed by the Cooum groyne than will be filled up again beyond the area of action of that groyne by the action of harbour South pier, probably indeed not so much.

61. That portions of the proposals just detailed are not new will probably not discount but increase their value and I would refer Government to a similar proposal by the late Mr. Clark—*vide* Memorandum on the Cooum (Drainage of Madras, 1872) and to the evidence of late Mr. Parkes and Captain Taylor before the Madras Harbour Committee.

Mr. Clark says: "As the quantity (of flood water in the Cooum) diminishes at the cessation of the rains, the water of the flood tide gradually finds its way in, and it becomes a contest between the loose sand thrown up by the surf at the mouth of the river, and the entering and issuing tidal water; as this process goes on during the north-eastern monsoon current, the river is forced towards the southern end of the bridge, where there is a short groyne, and the drift sand occupies four-fifths of the waterway of the bridge, leaving a narrow channel only; this channel is kept open for several months by the scouring action of the tidal water in passing to and from the *reservoir* of the Cooum.

"As the river succeeds in forcing for itself a channel through the enormous quantity of loose shifting sand for several months, it may, I think, be expected that, if some comparatively small means of assistance were afforded, it would remain permanently open.

"Those who have known the river before the rough groyne of granite boulders, above alluded to, was placed on the sea side of the bridge at its southern end, will be able to say how far, or for what period, the closing of the 'bar' has been protracted.

"My observations during the past two months have shown that the outlet of the channel into the sea shifts towards the north. A quantity of sand accumulates on the 'bar' side at the head of the groyne, and gradually increases in extent, causing the opposite or north side of the channel to scour away the sand by the action of the waves which break on its face during flood tide, and carrying the sand nearer to the bridge, where a very considerable eddy is formed, and a quantity of sand is piled up at the back of the shoal first formed as above; as this action proceeds, the northern side of the channel becomes more and more exposed to the action of the waves, and the silting up of the channel is more and more rapid, until the time when the projecting shoal on the south side will overlap the northern side of the channel completely (it now extends to a point opposite the seventh arch from the southern end of the bridge) and will soon completely overlap the channel; in this condition of things the waves (which break nearly parallel to the shore) will commence to cut the point of the shoal itself and drive it bodily in towards the bridge, and the 'bar' will then at once be closed.

"I am of opinion that, if a channel of suitable width be formed by the construction of groynes on both sides, and the entering and issuing water be confined to this channel during the dry season, a quantity of water, moving at sufficient velocity, will be obtained to keep the channel open throughout the year, by the scouring action of the tidal water alone.

"I have roughly estimated the quantity of water which the river Cooum will contain between the South beach and Harris bridge.

"The ordinary rise of the tide, I learn, is about 3 feet; for purposes of calculation I have taken 2 feet 6 inches as spread over the area of the Cooum between the above points, and I find the quantity to be about 16½ millions of cubic feet which must enter through the channel at the 'bar' in 6 hours; this quantity in a channel having a sectional area of 300 square feet would give an average velocity of 2½ feet per second. Of course this velocity is not uniform; it is greatest about half tide of both flood and ebb; and at extreme high or low water the velocity for a brief period is *nil*, but for a very considerable portion of the 6 hours the velocity will be much higher—from 4 to 5 feet per second—and I consider quite sufficient to keep the channel with a capacity such as I have mentioned open, if the loose sand at the mouth be so far confined and controlled as to admit of the scouring action of the water being concentrated on its sectional area only, and in a direction at right-angles to the general shore line.

"I have repeatedly observed the water entering with a velocity at the surface of 4 feet per second (and the channel I take to be about the size I have indicated) under the present condition of things, but the mass of sand it has to contend with, on both sides, along its whole length, is too great to be overcome by the small stream opposed to it."

Mr. Parkes said, in reply to Sir George Nare's question No. 2923*—What groynes are being constructed south of the harbour now?"—"I saw that Captain Taylor mentioned that one groyne had been made at the mouth of the Cooum. I do not think that he quite explained the state of affairs at the Cooum, but the Cooum is a river which comes round at the back of Madras and discharges itself some little distance to the south of Fort St. George, and, during the south-west monsoon, the mouth of the Cooum is completely closed by the drift of sand across it. Generally with the rains of the north-east monsoon, and the consequent floods in the Cooum, that bank is burst open; sometimes the floods are not sufficient to do that. The first time I was at Madras in 1873 it never opened; sometimes it is nearly open, and then they help it by casting out the sand. But lately, since I have been at Madras, I imagine, from what Captain Taylor said, they have attempted to keep this opening permanent by a groyne on the south side of it, which he seemed to say was 150 feet long. If so, I feel pretty certain that it is insufficient. He seems to think that it is on the wrong side, but I do not know what are his grounds for thinking so."

*Minutes of evidence taken before the Harbour Committee.

Captain Taylor said, in reply to Sir George Nare's No. 3090—"The southerly current passing the east face of the harbour must strike the land somewhere to the north to scour out the sand on the north side and carry it northward, do you think that it would strike anywhere south of the railway works?"—"It comes right into the corner."

No. 3091.—"It runs at present along the north pier, and curls right round there?"—"Yes, it curls round on to the revetment and the Railway Company's beach."

No. 3092.—"But with strength sufficient to carry the sand along?"—"With strength enough in stormy weather to displace the stone of the revetment. It is almost impossible to give you a clear idea of the thing without seeing it. On this particular occasion the revetment was washed away in many places; in the case of the Sailors' Home all the wall was gone, and the sea came up within a few feet of the house itself."

No. 3093.—"There is no doubt whatever of the movement of the shore; but what I cannot understand is, how that small amount of sand that is lodged in the corner between the north side of the north pier and the railway jetty can possibly be carried northward by the southerly monsoon current striking round there."—"This is matter of experience; I am certain it is so; I do not know how I can convey my opinion in any other language than that I am certain it is so. The tendency of the groynes on this coast is that, after the sand is deposited on the one side of the groyne, the waves cut close round, *so much so that you could keep the mouth of the Cooum open there*, and you could keep the canal open, thereby choosing a proper position for the groynes."

62. The proposal, therefore, is one which has the approval of no mean authorities, but I think it advisable to recommend that the construction of the sea groynes should be undertaken only after some experience has been gained of the results of the two in-shore groynes, the sea groyne it is just possible may not be found necessary.

63. Many years ago I made a proposal, I think at the time of the famine, to construct a canal *viâ* Ráyapuram from the Harbour works to the Canal basin; that certainly would have been a better means of communication with the harbour than *via* the Cooum bar and the sea. The Collector of Madras lately called for a copy of that plan showing the line of the canal proposed. Many buildings have sprung up in the intervening 13 years and the line then proposed would now involve the destruction of much property.

64. Seeing, however, that circulation in the canal and Cooum would have been secured by that proposal and looking to the fact that the proposed method of keeping open the Cooum bar may be the cause of controversy, and that, however, much discussion may take place, it is not likely that the matter can ever be decidedly settled until the experiment (if it be so called notwithstanding the strong arguments I have used and the proofs of its probable success which I have put forward) is ventured upon. I have, therefore, an alternative to suggest to Government which, perhaps, from the fewer undetermined factors in probable results, will more favorably commend itself to Government. An alternative estimate has been worked for this scheme now about to be detailed, taking the cost of the canal as proportionate to the cost of the Junction canal (I do not think that the cost will be more) and it will be seen that the total cost of this scheme is less than that for opening the bar.

65. The alternative scheme is this, also a canal from the harbour, but in a different direction. I propose to start this canal 50 to 60 feet wide (perhaps 100 feet would be better) from the south arm of the harbour and continue it along the coast through the newly-formed foreshore as far as the north-east angle of the Fort. The canal would then pass along the Fort and to the west thereof *viâ* the Fort ditches until it joined the north arm of the Cooum near the Medical College, thence it would pass on at the back of the General Hospital taking up only 100 feet breadth of the north arm until it joined first the Buckingham canal and then the Cooum near St. Mary's bridge and the Penitentiary. The route taken is an economical one. No property, except Government property, would be interfered with and by passing through the Fort ditch a great deal of excavation is avoided. The following special works would have to be executed:—

(1) The harbour would require dredging on its eastern side.

(2) An intercepting sewer for storm water should be constructed or arrangements made to pass storm water under the canal by means of syphons.

(3) The Fort engine, which lifts the sewage from the main drain, would require to be moved to a new site.

(4) The line of the intercepting sewer at or near this point might have to be slightly altered.

(5) A syphon to carry the storm waters of the main drain would be required.

(6) Bridges to carry the Beach and Benfield roads over the canal would be necessary.

(7) A lock near St. Mary's bridge would be required to shut off the Cooum when in floods from the sea canal.

66. While the elements of uncertainty are less in this scheme than in the one of opening the Cooum bar, the benefits to be derived from it will probably not be so great as it brings some compensating evils in its train. It may silt up to some extent and its mouth in the harbour may silt up. When the boats are passing to and fro, some of the draw-bridges in the Fort would have to be opened. The substitution of the canal for the river near the hospital would not be so advantageous as the complete abandonment of the whole north arm, &c.

67. The plan has, however, much to commend it.

68. I have in paragraph 49 spoken of having the assistance of a dredger to keep open the mouth of the Cooum, and for the improvement, and for the maintenance of that improvement in the lowest parts of the river, I consider a dredger will be the most economical method.

69. Before dealing with the mode of dredging, sectioning the river, &c., it is convenient to consider first what sectional area is required in the river, for on that area depends the amount of material which has to be removed.

70. As the river is bridged at many points, it is evident that the dimensions of the sectional area to be adopted must be, to a great extent, dependent on the waterway now existing at the various bridges.

71. Taking the bridges in order (I do not propose to deal with the river above Munro's bridge), we find them as follows with the lineal feet of waterways as noted :—

	Lineal feet.
Munro's bridge	170
Anderson's bridge	160
Commander-in-Chief's bridge	200
Harris bridge	192
St. Andrew's bridge	144
Law's bridge	220
Government House bridge	318
Napier bridge	450

72. To pass the same quantity of water in the same time through each of these bridges, requires a varying depth and a varying velocity, and the quantity of water to be dealt with naturally increases as the mouth is approached, but unfortunately the waterways of the bridges are not so arranged.

73. As before stated, St. Andrew's bridge is the most flagrant example of this anomaly ; for, while it has fully four more square miles of drainage area to serve than Munro bridge, it has 26 feet less waterway, while the river banks are not so high ; it has 56 less lineal feet of waterway than Commander-in-Chief's bridge which has 2 to 3 square miles less area to drain ; and Law's bridge just below St. Andrew's bridge has 78 more lineal feet of waterway.

74. That St. Andrew's bridge has quite insufficient waterway is further proved by the cross section of the river immediately below it which has been scoured out so deep as to be a danger to the bridge, and we have also the fact of the extreme flooding of Lang's Garden village above the bridge on the left bank.

75. In considering, then, what ought to be the proposed sectional area of the Cooum, this bridge, as it at present stands, may be omitted from consideration, for its extension is evidently a matter of great necessity and this has been provided for in the rough estimate.

76. Accepting the figures given in paragraph No. 1 of this report, we have at Coratoor anicut 200 square miles drainage and a maximum discharge of 10,614 cubic feet per second. Deducing the co-efficient for the formulæ $D = C M^{\frac{2}{3}}$, we find that it comes to 310·35, and applying this co-efficient for the other areas, we have to provide for the discharge as follows :—

Names of bridges.	Drainage area.	Discharge = 310·35 $M^{\frac{2}{3}}$.
Munro bridge	207 sq. miles.	10,831 c. ft. per second.
Commander-in Chief's bridge	211 ,,	10,986 ,, ,,
Law's bridge	215 ,,	11,161 ,, ,,
Government House bridge	223 ,,	11,420 ,, ,, if canal drainage is included.
Napier bridge	223 ,,	11,420 ,, ,, per second if canal drainage is included.

77. From the cross sectional maximum flood level areas and fall of the river, the velocity of the discharge in the river is found to vary from 5 to 6½ feet per second. It is advisable to keep the velocity at the lower figure, if possible ; and in the calculations which follow, a velocity of 5 feet per second has been adopted. Taking the discharge at the bridges as above, the sectional area required at these points will be :—

Munro bridge	$\frac{10,831}{5}$ = 2,166 sq. ft.
Commander-in-Chief's bridge	$\frac{10,986}{5}$ = 2,197 ,,
Law's bridge	$\frac{11,161}{5}$ = 2,232 ,,
Government House and Napier bridges	$\frac{11,420}{5}$ = 2,284 ,,

and dividing these latter amounts by the waterways, we get the depths during floods as follows :—

		Flood depth.	Hydraulic mean depths.
Munro bridge	$\frac{2,166}{170}$ =	12·7 ft.	11·0 ft.
Commander-in-Chief's bridge	$\frac{2,197}{200}$ =	10·9 ,,	9·9 ,,
Law's bridge	$\frac{2,232}{220}$ =	10·1 ,,	9·2 ,,
Government House bridge	$\frac{2,284}{318}$ =	7·1 ,,	6·8 ,,
Napier bridge	$\frac{2,284}{450}$ =	5·1 ,,	4·9 ,,

78. The next point to be considered is the level at which the bed of the river ought to be fixed and the gradient of the various portions of that bed.

79. The depths and hydraulic mean depths and velocity at certain of the bridges having been fixed from the formulæ—

$$F = \frac{\left(\frac{V}{\cdot 9}\right)^2}{2\ H.M.D.}$$

when F is the fall in feet per mile and V the velocity in feet per second, it is found that the fall of the river above the bridges, as undernoted, must be as detailed ; the total falls are calculated and noted in the last column :—

Names of bridges.	Distance from sea.	Intermediate distance.	Fall required above bridges feet per mile.	Total fall between each bridge.	Increasing total.
Napier	650	..	..	..	..
	..	3,570	3·1	2·08	2·08
Government House	4,220	..	..	..	..
	..	3,210	2·3	1·38	3·46
Law's	7,430	..	..	..	..
	..	9,320	1·7	3·00	6·46
Commander-in-Chief	16,750	..	..	..	..
	..	8,870	1·6	2·67	9·13
Munro	25,620	..	..	..	..
	..	..	1·4	..	..

80. It is curious to observe that the Cooum has a less slope in the upper reaches than in the lower, the reverse of what is usually the case ; but this is to be accounted for by the fact that, in the upper reaches, the Cooum flows more in the direction of a line parallel to the coast, while below Law's bridge it is flowing almost eastwards in the line of natural slope of the country.

81. In the above table it will be observed that the waterways of the bridges between Munro's and Commander-in-Chief's bridges and between the latter bridge and Law's bridge have been omitted from consideration and they have been so because, while the discharge must naturally be an increasing quantity, some of the waterways of these bridges are less than those higher up, while the river banks are lower, and to introduce them for the purpose of calculation would only tend to vitiate, or at least complex, the calculations above made, while no satisfactory result would be obtained by their inclusion.

82. Indeed, the figures obtained in the above cases can only be approximated to as there are many additional considerations which, to a great extent, determine the depth and breadth especially through the city, other than those just referred to.

83. It is not intended (except in regard to St. Andrew's and St. Mary's bridges, which require consideration by themselves) to make any proposal for the increase of the waterways of the bridges.

84. It is desirable that the gradients, as above calculated, should be fixed with reference to the levels of the bed of the river at the bridges, omitting the scour depths ; that is to say, to fix the new bed level as nearly as possible at the level at which the top of the floors would have been placed in the bridges when originally designed and it is found that to do so it will be necessary to start from the Napier bridge with the bed of the river at a level of 10·50, which is 6 feet above the lowest point of scour at present.

85. It should be here observed that all the levels in this report have reference to DeHavilland's datum, and not to the Trigonometrical Survey datum, and, for this reason, that some of the survey work was done so long ago as 1883-84 and the bench marks in Madras City are on the DeHavilland datum ; and it was therefore more convenient to work out the scheme on that datum

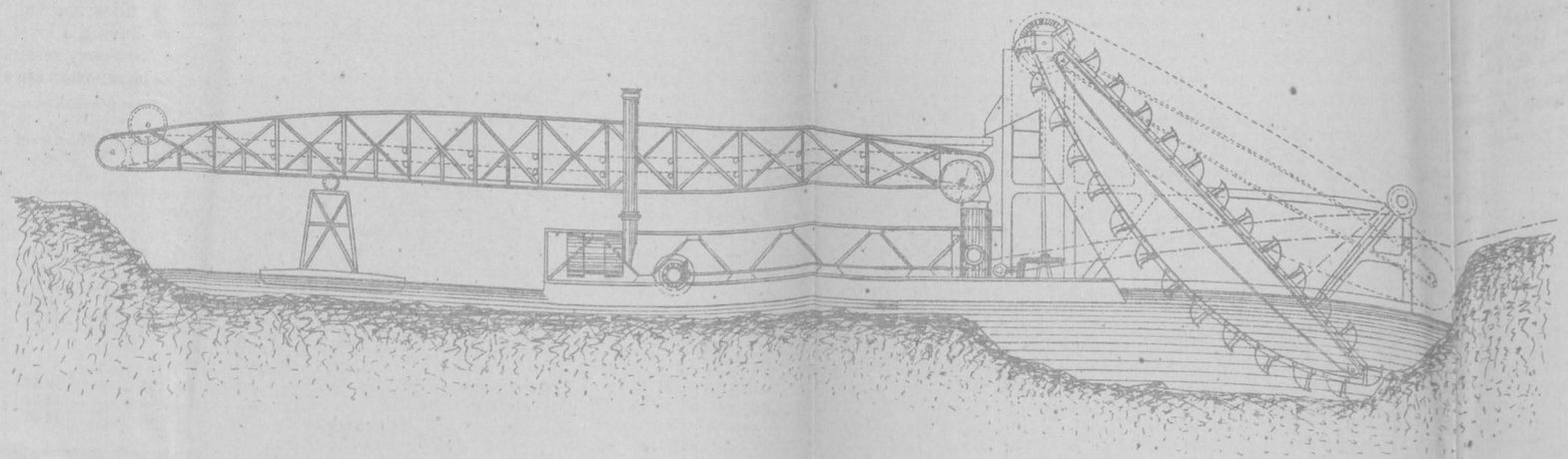
IMPROVEMENT OF RIVER COOUM

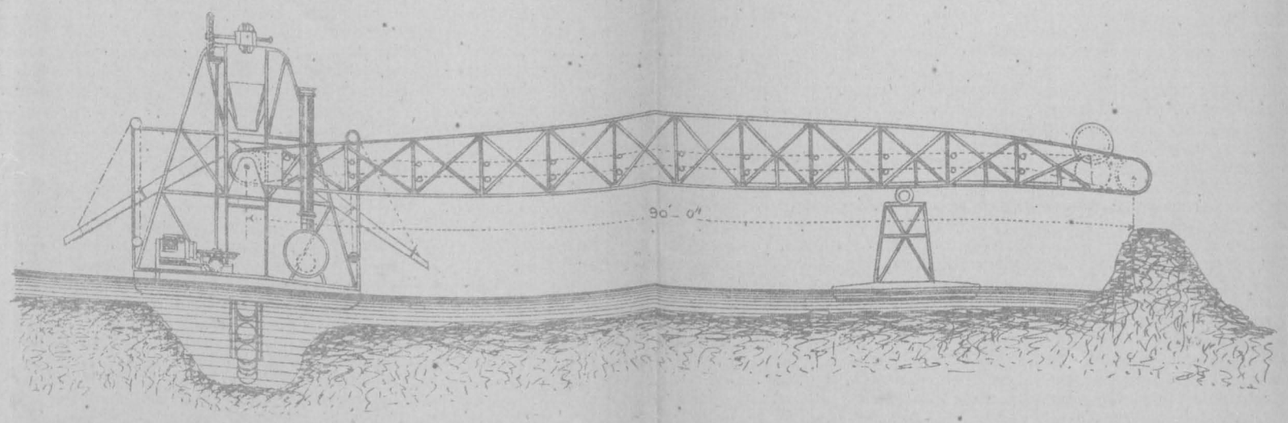
SKETCH PLAN

SHEWING CLASS OF

DREDGER

PROPOSED TO BE USED





OFFICE OF THE SANITARY ENGINEER TO GOVT:
FORT ST. GEORGE DECR 1890

J. Lowe MEM: INST: C.E.
SANITARY ENGINEER TO GOVT.

Note—To facilitate Photo-Zincography Para 100

Photo-Zincographed in Central Survey Office Madras
1891

86. The mean sea level as fixed by De Haviland would be at a level of 20·00; it has, however, been shewn by the erection of a tide guage at Madras that the correct level of mean sea according to De Haviland's datum is 18·97 or 1·03 feet lower than De Haviland calculated it. The proposed level of 10·50 for the bed of the river at Napier bridge is therefore 8·47 feet below mean sea level, and taking the range of tides as 3 feet, the lowest spring tide would fall to a level of 18·97—1·50 = 17·47, so that a level of 10·50 gives the bed at the Napier bridge about 7 feet below the lowest spring tide.

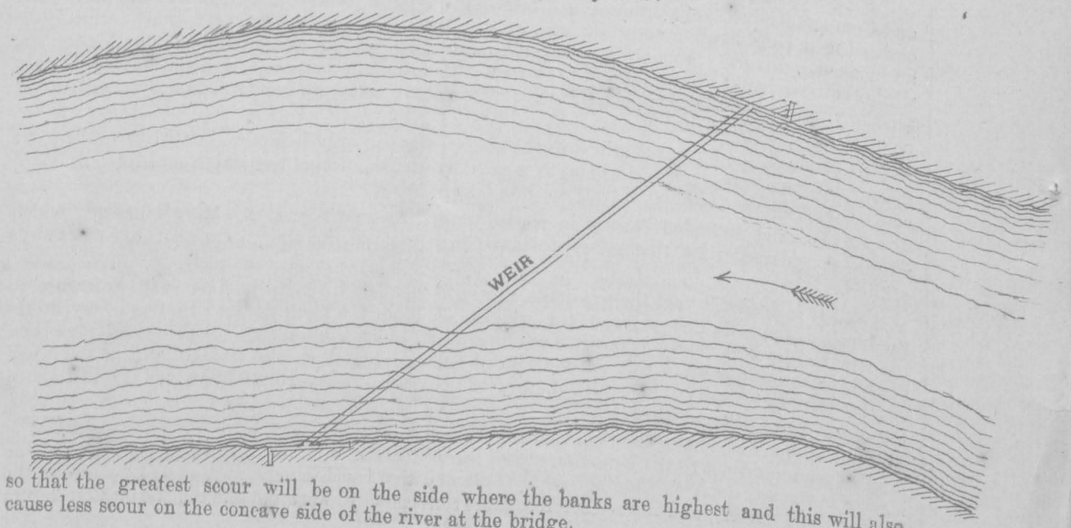
87. From the table in paragraph 79 it will be seen that the total proposed rise in the river is 9·13 up to Munro bridge, so that the spring tides starting with a level of 18·97 + 1·50 = 20·47 would reach that bridge; the bed there having a level of 19·63, this would cover it by about 20·47—19·63 = 0·84 feet, that is if the necessary minimum gradients are not exceeded. The calculated gradients and levels proposed to be adopted are shown below:—

—	Calculated rise.	Mean level of sea.	Calculated level of bed.	Depth below H. S. tide 20·47.	Depth below L. S. tide 17·47.
Tidal.					
Napier	0	18·97	10·50	9·97	6·97
Government House	2·08	18·97	12·58	7 89	4·89
Law's	1 38	18·97	13·96	6·51	3·51
St. Andrew's	·79	18·97	14·75	5·72	2·72
Harris'	1·01	18·97	15·76	4·71	1·71
Not Tidal.					
Commander-in-Chief's	1·20	18·97	16·96	3·51	0·51
Anderson's	1·21	18 97	18·17	2·30	— 0·70
Munro Bridge	1·46	18·97	19·63	0·84	— 2·16

88. In paragraph 13 I have given certain reasons for selecting a point above Harris' bridge for a dividing weir, and that the point selected is the proper one is shown by the fact that, in addition to the reasons given in the paragraph referred to, there is the fact that the river bed at this point will have a level of 16·00, so that with a L. S. T. (17·47) we will have about 1·5 feet of water in depth at the foot of the weir. The exact point is 700 feet above Harris' bridge, cross section No. 16. The plans of this weir will be found in sheet No. 6 and training walls will have to be built below the weir as far as Harris' bridge, one of these training walls will be the front wall of the wharf which it is proposed to form at this point.

89. The floods will not cause a rise over this weir of more than 2 feet in depth, but in case the rise in the river over this weir is greater than this, I propose to have self-acting sluice doors in the weir, as in all other weirs, so that the area of obstruction will be reduced and the maximum overflow limited. The river, at the place where I propose to place the weir, has a cross sectional flood area of 2,935 square feet against 2,163 square feet at Harris' bridge just below and 2,163 square feet higher up.

90. The weir, as other weirs, I propose to place diagonally thus:—



so that the greatest scour will be on the side where the banks are highest and this will also cause less scour on the concave side of the river at the bridge.

91. The determination of the gradients allow of the proposed cross section of the river being fixed and these will be found in sheets No. 3 to No. $\frac{3}{6}$, where the area of earth to be removed from the river bed and to be embanked is shown. The amount of earth to be excavated between the proposed weir and the sea is estimated at 808,770 yards and above that point at 333,000 yards. This is a very large quantity and the question which naturally presents itself is — What is to be done with it ?

92. It must be remembered that all the foregoing calculations are based on the idea of the acceptance of the proposals for closing the north arm, for, if the north arm be not closed, there will be less water coming down the main branch below Law's bridge and less provision for it will be required to be made.

93. Assuming, however, that the north arm is to be closed, we have to fill into that arm 723,040 cubic yards of earth, and for banking the sides of the Cooum we require 47,319 cubic yards, a total of 770,359, which is less than what will be removed from the main branch below Harris' bridge, viz., 808,770. But there is one improvement that I think very desirable, and that is the improvement of the Island itself. Sections sheet No. 10 show that it lies extremely low and it is very liable to floods ; by stripping the low portions 12″ deep and burying the stuff to be removed from the Cooum, a great improvement will be effected, and that improvement will be for the benefit of the Military and the general public.

94. There may be some fear that the stuff to be removed from the Cooum will be deleterious when exposed and may cause an outbreak of disease. I do not anticipate any such result, and I feel certain that the stuff when removed and exposed to the influence of a tropical sun will have much less effect on the people than lying where it is as a breeding ground for all these organisms which are now produced in the Cooum waters. This, however, is a matter on which some persons may hold one opinion and some another; it may be, however, noted that during the famine the bed of the Cooum was greatly exposed, that a large number of famine coolies were set to work to clear it; the exposure of such emaciated creatures to the imminent risk of disease was not an act which would have been sanctioned, and I do not think that there is any recorded outbreak because of the famine coolies being placed on such work, hence we may conclude that the proposals now made will not affect the health of the town.

95. The manner of removing and locating the removed material now claims attention.

96. I have given the matter serious consideration and I have come to the conclusion that the only satisfactory way of removing the Cooum deposits and of forming the bed into proper section is by means of a specially designed dredger and by a light tramway of about 1 mile in length which will be laid along the banks of the Cooum where required, and moved and relaid from time to time.

97. The railway would be used for the following works :—

(1) To carry the earth for filling in the north arm.
(2) To convey the stone for the sea groin from the South Indian Railway across the Island.
(3) To carry earth along the bank of the Cooum from the place of excavation to the place of deposit.
(4) And finally the railway might be handed over to the Municipality who require some such appliance for the removal of rubbish from the heart of the town to some distance from it. One mile would perhaps not be enough and $1\frac{1}{2}$ to 2 miles might be required.

98. The dredger may also require to be used for clearing the channel which is to be kept open to the sea, and for this purpose it will be necessary that the dredger pass the Napier bridge. It cannot pass under it as the bridge is too low at present. This bridge, however, is in such a decayed state that I have for some years been endeavouring to effect its removal, and only a few years ago its bracings were almost entirely renewed, but the top and bottom booms are now almost entirely gone. The bridge, in fact, is in a dangerous state, and will immediately require at least new girders for its whole length, if not new piers.

99. My present reason for referring to it, however, is in regard to the dredger ; should the proposal to open the bar be accepted, arrangements should be made to allow of its passing under the bridge, and my proposition is that, whatever way the bridge is renewed or restored, the spans over the new outlet channel be made in the form of a lifting girder bridge. In this class of bridge by means of balance weights, the spans are bodily raised to any required height above the ordinary floor level so that vessels can pass underneath. The cost of my proposal as regards two spans of 50 feet each would be about Rs. 20,000. By the adoption of this proposal the dredger would be able to pass in and out, and so also, I believe, could other boats and vessels, and I do not see any reason why a constant communication may not by this means be maintained between the harbour, the Cooum and the canals.

100. Whichever plan of keeping the lower portion of the river tidal is adopted, it will have to be dredged, and the proposed method of dredging would be somewhat similar to what is to be seen on the Suez Canal and also to what is adopted in Holland, viz., the stuff raised by

the dredger, in some cases mixed with water, will be sent on to the bank through pipes or by means of an endless belt. The earth will when dry be loaded into wagons in the light railway and deposited where required; in cases where the river is to be narrowed, the earth will be deposited by similar means on to the slopes and allowed to fall on the face thereof until the proper section of the river has been obtained.

101. The plan of the improved course of the river shows where such narrowing is proposed. The dredger would be used only in the tidal portion of the river; the upper portion would be excavated by ordinary manual labor.

102. A sketch of the class, but not the size, of dredger proposed will be found attached. The gearing must be capable of being lowered to pass the low bridges on the river.

103. As before explained I propose to form two wharves—one above Law's bridge on the left bank of the river where there is now a considerable traffic, the income from which is at present derived by the Municipality though the ground on which goods are landed is within the river boundary, and another at Harris' bridge. On the right bank below the weir, there is a landing place at present just below the bridge, the depth of the river at present is insufficient but it will be increased even at low tide. The present landing place below St. Andrew's bridge will also be improved.

104. I propose to increase St. Andrew's bridge (which has at present only 3 spans and 2 extra small arches) by another span on the left bank where there is room for it. The approach of this bridge encroaches considerably on the river area.

105. The new level of the bed at this bridge will be 14·75, and if the waterway of the bridge be extended from 144 feet to 192 feet, the depth required to pass 10,986 cubic feet of water per second will then be the same as at Harris' bridge, viz., with an area of 2,197 square feet, say, $\frac{2197}{192} = 11{\cdot}4$ feet or slightly more than at Commander-in-Chief's bridge; with its present length of waterway it requires $\frac{2197}{144} = 15{\cdot}2$ feet, which is 3·8 feet higher; the reduction will decrease the recurring flooding of the district of Lang's Garden just above the bridge.

106. I have already alluded to the banking of the left bank between St. Andrew's bridge and Law's bridge, and provision for it will be found in the estimates.

107. The following are the groins I propose to construct to ensure deep water in the centre of the bed of the river:—

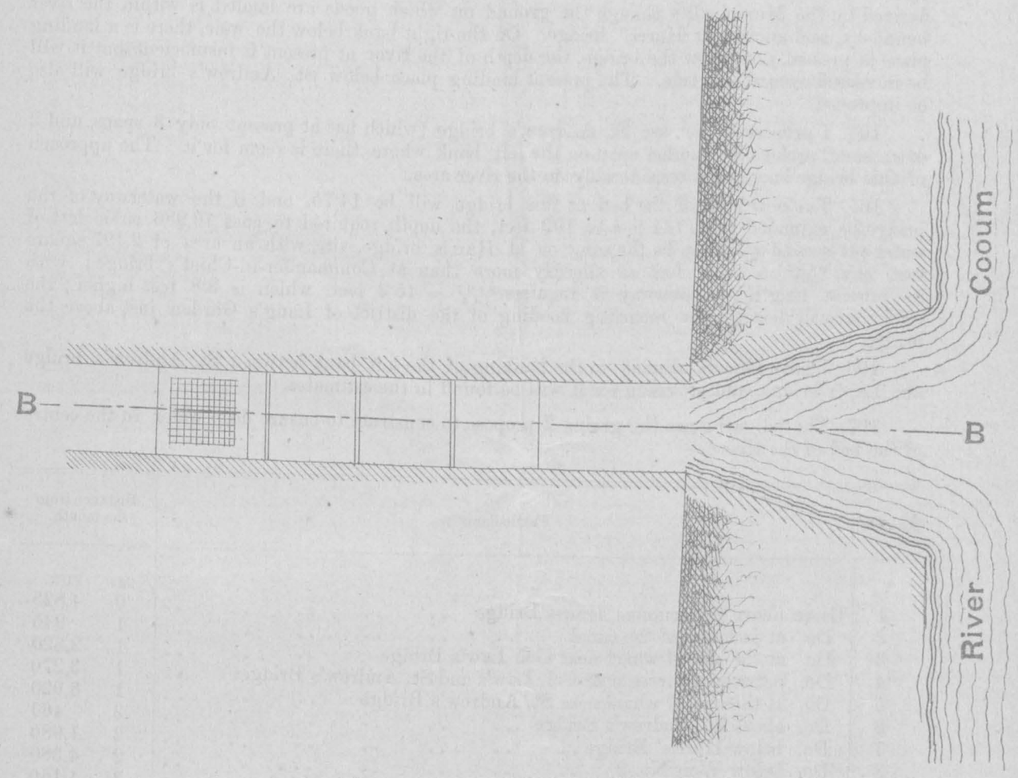
Number.	Particulars.	Distance from the mouth. M.	FUR.
1	Groin above Government House Bridge	0	4,825
2	Do at junction of the canal	1	945
3	Do. at the end of wharf near Col. Law's Bridge	1	2,820
4	Do. between wharves near Col. Law's and St. Andrew's Bridges	1	3,270
5	Do. at the end of wharf near St. Andrew's Bridge	1	3,920
6	Do. above St. Andrew's Bridge	2	460
7	Do. below Harris' Bridge	2	1,980
8	Do. below Weir No. 2	2	4,380
9	Do. between Commander-in-Chief's Bridge and Weir No. 3	3	1,150
10	Do. between do. do. do.	3	1,710
11	Do. below Anderson's Bridge	3	4,490
12	Do. above Weir No. 4	4	2,110
13	Do. above do.	4	2,740

108. While in the foregoing due provision has been made for the discharge of all the water of the Cooum and canal by its main branch, the cut between the canal and the main branch must be improved to procure a sufficient area for all the discharge which comes *viâ* the canal; this amounts to the drainage of 8 square miles and the amount to be discharged 1,241 feet per second. I propose to give a sectional area to this cut of 800 square feet, and, while constructing the lock already referred to, to improve St. Mary's bridge—which at any rate in a very short time would in any case have required renewal—and to give it two spans of 40 feet, the same as the bridge of the South Indian Railway. The depth of water will be about 10 feet, so that the amount capable of being discharged through the cut with a velocity of 5 feet per second will be 4,000 cubic feet a second, which is much more than required.

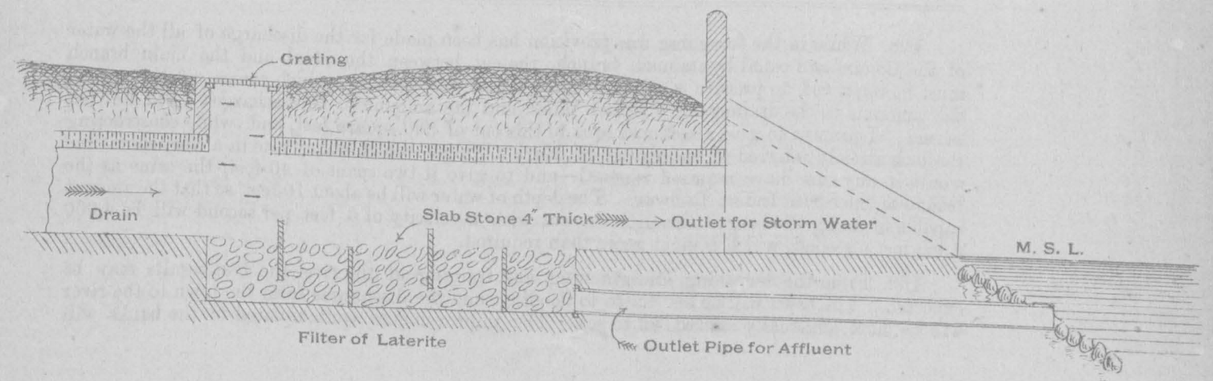
109. From the deepening, straightening and training of the river the best results may be expected. The town will be less liable to flooding, and the discharges from the town to the river will be more effectually carried off to sea. The improvements contemplated to the banks will

SCHEME FOR IMPROVEMENT OF RIVER COOUM

Sketch of Proposed Sewage Filters at the Mouth of Drain



SECTION ON B. B.



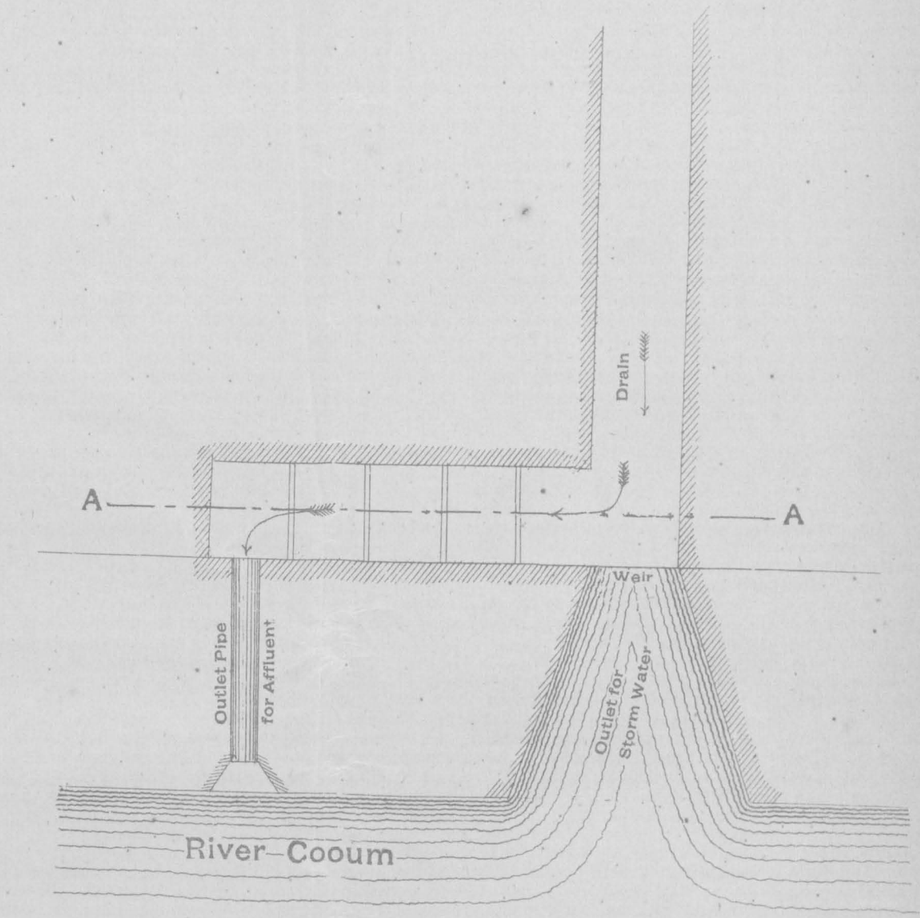
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1891

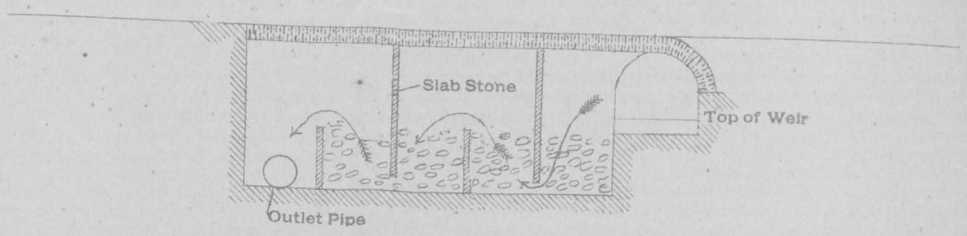
SCHEME FOR IMPROVEMENT OF RIVER COOUM

Sketch of Proposed Alternative Sewage Drain

AT THE MOUTH OF DRAIN



SECTION ON A. A.



Lithographed in Central Survey Office Madras

1891

make a marked improvement to the city. In very few cases has it been found necessary to encroach on adjoining lands, the most prominent instance of encroachment is in Napier Park, but I have less hesitation in recommending this knowing that a large portion of the river was taken and added to the Park some years ago and Government will only be resuming or taking little more than what belonged to it; and that for the public good. There is no doubt that more sectional area is required at this point. Deficient sectional area can result only in flooding the portions above the point of reduction of area.

110 One important proposed measure yet remains to be described, viz., the manner of preventing the deposit of the solid portion of the sewage in the river and the purifying of the effluent.

111. As the purification of the sewage does not require to be so efficient as if it were to pass into a stream the waters of which may afterwards be used for dietetic purposes, it will not be necessary to adopt the ordinary slow rate of filtration of 6″ in depth per hour. What is chiefly required is the arrestment of solid matters, actual contact of every particle of the water with the filtration medium is therefore not necessary. I propose that at the outlet of each drain a set of settling tanks or filter such as are used in the Gorbals water-works system of filtration be placed at or above the mouth of each drain, where the level will permit, and that when these are constructed the Municipal Commissioners be required to keep a proper staff to regularly attend to them and remove the solid matter; the design of these filters or tanks is shown in the sketch accompanying.

112. The best material for use in the filters will be ordinary laterite, small and large, as used for metalling roads. The iron in it will have considerable effect in the way of purifying the sewage as well as arresting the solid matter.

113. These filters may be placed either in the river at the mouth of the drain or as high as possible. Flood water will pass over them; at such times it will be impracticable, as it will also be unnecessary, to filter the contents of the drains.

114. The three drains marked as follow require special treatment. No. 3-R.B. is the main drain of Triplicane, it has a discharge of 525,000 gallons daily, an average of 22,500 gallons per hour or a maximum of 45,000 gallons or 7,200 cubic feet per hour. The sewage during the day is pumped up on to a portion of Napier Park in which there has been formed a sewage farm, but during the night and a portion of the day and on Sundays and Holidays the sewage flows into the Cooum. Arrangements should be made by the Municipality to pump night and day; there is not available sufficient land to use up all the sewage coming down this drain and therefore filters must be used as at other drains, but as this drain enters the Cooum at the low level of 18·98, filters cannot be placed below the level of the floor of the drain. I propose therefore that, on the line of the drain and above it, a set of filters be erected — there is plenty of space for this away from the Park — and that, when the sewage cannot be pumped on to the sewage farm, pumping be continued by running all the sewage through the filters, which may be somewhat differently arranged to those at most of the other drains. No alteration would be necessary to the present pumping station in the Park; an additional pipe would have to be laid or channel made from the pumps to the filters. This drain, probably more than any other, causes the filthy state of the Cooum near or below Government House bridge, and some special measures are therefore very necessary in regard to it.

115. On the left bank of the Cooum are two other large drains which must be similarly treated. One is the drain which receives all the sewage of New Town, Vepery No. 1-L.B., and which discharges just below Law's bridge close to the Penitentiary; who knows but that this drain may not be responsible for the outbreaks of disease among the prisoners, for they do garden work in close proximity to the outfall of the drain? A portion of the contents of the drain during the day is raised from a well in, and distributed over a portion of, the People's Park. The lifting is done by picottahs, and the raising and stirring up of the sewage is a nuisance to those who live in proximity to the well and is also a nuisance to those who frequent the Park. His Excellency the Governor has once or twice publicly remarked on this nuisance, and I propose to deal with this drain very similarly as regards filtration to the Triplicane drain outlet at the Napier Park. Here, instead of the picottahs, should be placed a small steam or hydraulic motor. Such motors run for hours without attention, the latter motor can sometimes be arranged to run for days. The well should be covered in and properly ventilated high above adjacent buildings. A system of covered filters would be placed over this drain also. There would then be no nuisance. The discharge of the sewage on to the grass would not be noticed, and during damp weather and at nights, instead of the sewage finding its way into the Cooum as it does now, it would be sent through the filters. A very great sanitary improvement would result by this method.

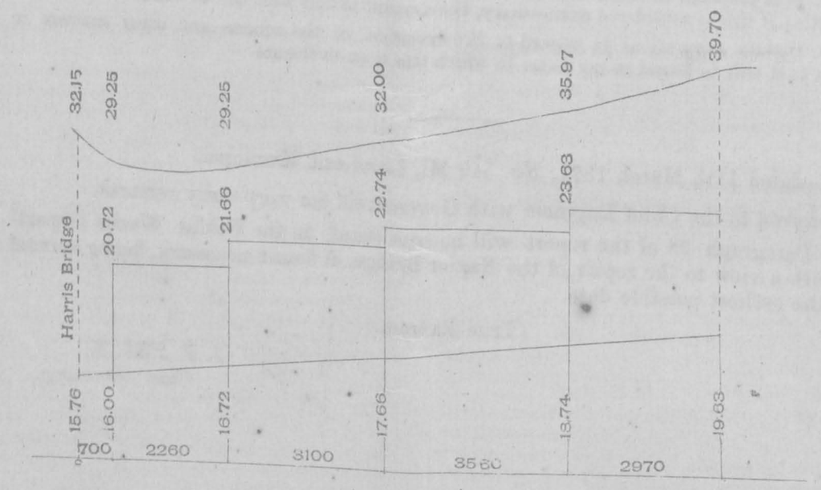
116. At Lang's Garden Road near the Egmore Police Court is another drain No. 8 L.B. of similar character. There is a sewage farm and a well, but the area of land is insufficient to take all the sewage, none of which is lifted after sunset. A large proportion, therefore, goes into the Cooum. Similar arrangements to what are proposed for the People's Park drain are necessary.

117. Should the drainage of Triplicane be early taken in hand, as it ought to be, all the sewage on the right bank will be diverted, and it will be very easy by the Shone system to join to it those sewers which run in on the left bank. This, no doubt, is the proper and most perfect way of diverting sewage from the Cooum. The proposals I have advocated are proposals which, in event of improved drainage not being carried out, may be accepted as tentative improvements. It will take some years to effect the drainage of Triplicane and Vepery, and until then the improvements suggested would be of benefit. The motors, which cost from £100 to £200, could then be moved elsewhere.

118. I now pass to consider the manner in which the upper reaches of the river should be dealt with.

119. What is desirable is to secure a depth of water in the river which will at all times under ordinary circumstances cover the bed.

120. The months during which there is ordinarily no rainfall which would to any extent affect the river are January to June, or, say, six months. The evaporation and percolation during these months may be taken as amounting to 4 feet, and this is the least depth that ought to be retained in that portion of the river not in connection with the sea, that is to say, we must have a series of tanks at least 4 feet deep at the upper end and varying at the other according to the fall of the river bed; the rise of the river from the permanent weir already proposed to Munro bridge is from 16·00 to 19·63, in all 3·63 feet, so that to cover the bed 4 feet deep at Munro bridge, if no other weirs were used, the permanent weir proposed would have to be 7·63 feet high. The permanent weir near Harris' bridge, however, from engineering consideration, viz, the necessity for keeping it as low as possible to pass floods, &c., cannot rise to a greater height above the bed than 4 or 5 feet, so that it will be necessary to place another weir a comparatively short distance above it. It is desirable to keep the weirs as low as possible, in order not to back up the subsoil water to too great a height under the adjoining lands; the banks of the river, however, are very much higher along its upper than its lower reaches and three weirs above the permanent weir are found to be sufficient and practicable.



121. The banks are fairly high at all the places where these weirs are proposed to be erected, and a calculation shows that if permanent weirs be put in, they would not raise the flood waters to an extent greater than the banks will allow, that is, they will not raise the river so as to cause flooding of adjacent lands. They will probably be much less expensive in the end than earthen weirs, which must be protected in some way or other and which would require restoration from year to year.

122. The design of the weirs will be similar to that of the permanent weir already described, and each weir will have self-opening sluices of considerable capacity for discharge.

123. The river would, of course, be first sectioned in the upper reaches before the weirs are built.

124. I propose to turf the banks and protect the same with fascines; sea turf should be used and a staff must be kept on to protect the turf until it is in a growing state. At some portions of the river retaining walls and stone pitching are required to avoid encroaching on roadways, &c., and to permit of the river retaining its necessary width.

124A. Such generally are my proposals for the improvement of the River Cooum.

125. In the present state of matters it was, I thought, not desirable to go very deeply into estimate details; the figures I have given are, therefore, to be accepted only as approximate but sufficiently close probably to allow Government to consider whether the benefits to be obtained are sufficiently commensurate with the expenditure to be incurred.

126. I desire, however, to call attention to certain portions of the estimate which seem to require explanation.

127. *Item No.* 3 *in Estimate No.* 1 is not an essential one to the scheme unless it be found that the funnel-shaped mouth gets unduly silted and cannot be kept open even with the plan of tidal gates maintaining high tidal level in the river until low tide. If the dredger must be used, then the alteration in the bridge must be effected, but the bridge will have to be soon renewed at any rate, and the whole cost of the alteration of the two spans is not fairly debitable to this estimate.

128. *Item No.* 5 *in Estimate No.* 1 does not appear in Estimate No. 2, as the scoop-drain is a storm drain and may enter the proposed canal at the same place that it now does the river.

129. *Item No.* 7 *in Estimate No.* 1 *or Item No.* 4 *in Estimate No.* 2.—Provision is made in the former estimate for a double lock to suit its position near bridges of double 40 feet spans. The sea canal enters the river *via* St. Mary's bridge, it may be better to put the lock up near Elephant Gate bridge, where probably a single lock will be sufficient.

130. *Item No.* 9 *in Estimate No.* 1 *and Item No.* 6 *in Estimate No.* 2.—This item will not be required if the drainage of Madras is carried out as proposed. The proposals are of a tentative nature.

131. *Item No.* 10 *in Estimate No.* 1 *and Item No.* 7 *in Estimate No.* 2.—A portion of this item is for three wharves to accommodate traffic up the river, and they are much required. The wharves themselves will cost about Rs. 35,000, and an income of not less than Rs. 1,500 per annum may be expected from the three.

132. It is proposed to turf the banks and protect the toes of the slopes by piling filled in with wattle; if this is considered unnecessary, the amount of this item can be reduced.

133. Certain suggestions in regard to the execution of the scheme and other matters in reference to it will be found in my letter to which this is an enclosure.

Order—dated 11th March 1891, No. 349 M., Local and Municipal.

Referred to the Chief Engineer with Government for very early remarks.

2. Paragraph 98 of the report will be considered in the Public Works Department with a view to the repair of the Napier Bridge, if found necessary, being carried out at the earliest possible date.

(True Extract.)

J. F. PRICE,
Chief Secretary.

To the Chief Engineer to Government, Public Works Department,
with plans and estimates.
„ Public Works Department.

Exd. A. Raitt.

30/10/135

Govt. of {1891} Madras.

LOCAL AND MUNICIPAL.

Issued

Recd. *Encl.*

G.O., 11th March 1891, No. 349 M.

MARCH.

Cooum River.

Forwarding to the Chief Engineer with Government, for very early remarks, Mr. Jones' scheme for the improvement of the —, and stating that paragraph 98 of the report will be considered in the Public Works Department with a view to the repair of the Napier Bridge, if found necessary, being carried out at the earliest possible date.

With order

No 753 M dt 14th Issued

Communicated to the Consulting Architect who will as soon as possible submit an estimate for securing the Napier bridge.

The consideration of the scheme for the improvement of the Cooum will be taken up on receipt of the Chief Engineer's report called for in para 1.

Ref. J.P.W.

C. A. to bout

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

READ—again the following paper:—

G.O., dated 27th February 1890, Mis. No. 328 M., Local and Municipal.

Order—dated 27th February 1890, Mis. No. 328 M., Local and Municipal.

The Government desires that Mr. Jones will prepare and submit, with as little delay as possible, a detailed scheme for the improvement of the River Cooum with a view to preventing it in future from becoming a nuisance during the dry months of the year. Mr. Jones' previous proposals on the subject, which are printed in G.O., dated 2nd July 1877, No. 1811, are not sufficiently elaborated to be of value, and, moreover, appear to Government to be unsatisfactory in themselves.

(True Extract.)

(Signed) J. GROSE,
Ag. Chief Secretary.

To J. A. Jones, Esq.
„ the President, Municipal Commission, Madras.

READ—also the following paper:—

From J. A. JONES, Esq., M.I.C.E., F.R.S.E., Sanitary Engineer to Government, to the Chief Secretary to Government, dated Fort St. George, 9th December 1890, No. 649.

I have the honor, in compliance with G.O., dated 27th February 1890, Mis. No. 328 M., Local and Municipal, to forward a scheme for the improvement of the River Cooum.

2. The papers sent herewith consist of—

(1) The report.	(3) One large scale plan.
(2) Estimates.	(4) One book of plans.

3. These very fully show the works which I consider are necessary to put the Cooum, between Munro's bridge and the sea, into the state it ought to be.

4. It will be found that there are alternative estimates for the work, viz.:—

	RS,
No. 1, amounting to	12,25,000
„ 2 „	10,90,000

Both of these amounts, however, include Rs. 1,70,000 for plant—a railway line and a dredger—both of which will be useful for other purposes and may, after completion of work, be handed over to other departments.

5. The actual cost of the works proposed stands therefore—

	Rs.
No. 1 estimate	10,55,000
„ 2 „	9,20,000

6. The alternative estimates are based on two different designs for connecting the Cooum with the sea—No. 1 by the Cooum bar, No. 2 by a canal starting from St. Mary's bridge and passing round the west side of the Fort to the south arm of the harbour.

7. It has no doubt not escaped the notice of Government that statements have been made that, while Mr. Pogson's scheme (which, as far as is known, is still *in nubibus*, at least it is so far as I am concerned) for cleansing the Cooum is estimated to cost 1½ lakhs, Mr. Jones' scheme is to cost no less than 10 lakhs.

8. I cannot claim for my scheme even half the advantages claimed for Mr. Pogson's; my scheme will cost more than a lakh and a half; it cannot be carried out in three months, nor will it allow of the drains being flushed with sea-water as they run up hill from the sea.

9. But, while I do not claim these advantages by its execution, I must point out to Government that the estimates which I send forward are for vastly more extensive works than the mere junction of the Cooum with the sea—*that* is a very necessary portion of any scheme, but it is at the same time a portion of the scheme the cost of which does not exceed one-sixth of the whole amount. The actual cost of opening the Cooum bar, or of forming a canal in connection with the harbour, amounts to about 1½ lakhs, and while one can only surmise what Mr. Pogson's scheme is, I believe it must be of this nature. In any case there cannot be much difference of cost between one scheme and another in respect to the bare proposal for securing circulation in the Cooum.

10. While the estimates are to some extent approximate, they have been prepared in considerable detail, and the various items are not to a large extent dependent one on the other. Thus Government may propose to execute only the portion of the work up to Harris bridge, and even from this portion may omit, mean time, wharves, training walls, the extension of St. Andrew's bridge, &c., and merely execute the opening of the bar or formation of the canal, the dredging of the main and the filling of the north branch of the river. But while that is so, yet I would earnestly urge that the works in the lower portion of the scheme be sanctioned in their entirety if the scheme is sanctioned at all. The cost could be spread over three or more years, and even if the whole scheme is executed, the expenditure will not, I think, be out of proportion to the results which, I believe, will be attained.

11. Although I have advanced many arguments in my report to show that the north branch of the river ought to be filled up, there is a still stronger one, and that is, that there will be very great difficulty in disposing of the stuff excavated from the main branch, if that is not done, as the stuff would have in such case to be carried out to sea at a much greater cost.

12. In my report I have but lightly touched on the great advantages which would accrue to Madras by the closing of the north branch. An examination of the plans will show that, taking advantage of the extra ground added to the river, I have suggested a new race-course; this particular item naturally does not fall within purview of the scheme, but the improvement of the island does so, and I venture therefore to throw out the suggestion as to the race-course, because I believe that the Race Committee, in view of this improvement, might be inclined to move all their meetings to Madras, and might be able to make a handsome contribution to the

scheme as they could then get rid of Guindy. This question affects to some extent the proposal for raising the level of the island (as an island to be abolished), and hence my allusion to the subject.

13. The report, though comparatively short, is one which has for its preparation required considerable investigation on many points; but it does not, I fear, of itself justify the time taken in its preparation. It has had to be prepared at a time when many other pressing works had to be kept up to date, and the small staff at my command has been unable to get out the plans and estimates at an earlier date than that at which it is now presented.

14. I send the report forward with some diffidence, for I am aware that some of the measures proposed may lead to considerable discussion; and seeing the importance of the subject and that the amount of money involved is large, I would desire that Government will, before sanctioning or disapproving the scheme, consider the advisability of associating with me (I presume to suggest) the Chief Engineer and Captain Street, R.N.R., for a consideration of any point which to Government may seem to demand further investigation.

15. Except perhaps an improved water-supply—for drainage is very closely associated with the improvement of the Cooum—there is probably no other work which can be undertaken in the City of Madras which will, in a higher degree, tend to ensure not only better health but also greater comfort and enjoyment to its people. The river, a large portion of which is adjacent to one of the largest air spaces—Madras' most important play-ground, constantly reminds us in no uncertain tone of its filthy condition. It tells indeed that—

> "The sewage that should feed the land
> "Makes poison for the town;
> "The stream, a sewer for the strand,
> "To drink its ordure down."

That is what the river has been called upon to do for years past. Improved drainage will prevent its being called upon to do that work in future, and the works I have in this report recommended will, when carried out, wash away, I trust, all remembrance of the treatment the river has received during the greater part of a century.

16. The reproach lately cast at the river by a writer in the *Madras Mail*, viz.:—

> "Ignoring all that science proves
> "Or sanitation teaches,"

will, I hope, be not much longer applicable, and the river, I trust, will soon be able to possess in truth, and not in ridicule, as at present, that name to which it, though many years ago, must have been rightly entitled, viz., "The Silvery Cooum."

17. As the scheme is one of perhaps more than local interest owing to some of the professional details, I trust the report may be printed and the plans lithographed.

—

Enclosure.

The River Cooum.

Scheme for its improvement within the limits of the City of Madras.

The River Cooum takes its rise some 29 miles to the west of Madras. At the Coratoor anicut, which is about 9 miles from the sea, the river has attained a length of 20 miles, and it receives in that length the drainage of 200 square miles of country. The maximum observed discharge at the Coratoor anicut amounts to 10,614 cubic feet per second. The length of the river from the Coratoor anicut to the sea is about 9 miles and the drainage area below the anicut does not exceed 15 square miles. The area drained within the City of Madras amounts to 8 square miles, so that on the river entering the municipal limits it has a drainage area of 207 square miles. The course of the river within the municipal limits is extremely tortuous. Its course with windings extends to 6·3 miles, while the distance in a straight line from the place where it crosses the municipal limits to its mouth is only 3·9 miles. At about one mile from its mouth it

is connected by a narrow cut with the Buckingham canal which occupies the valley of what used to be known as the North river, which river skirted the south of Fort St. George and joined the Cooum river near its mouth. In the plans to be found in "Orme," the cut, already spoken of, appears to have been different in position from that it now occupies, but there has always been a connection somewhere near this point, and that portion of the north river which skirts Fort St. George is now designated as a portion of the River Cooum. The Buckingham canal is in free connection with both branches of the Cooum, and during floods sends a considerable body of water down the Cooum. There is a lock on the canal at Shadayankuppam, 7 miles from Madras. Its purpose is said to be to keep the water high in the canal when the Kortalayár bar is open to the sea. It also limits the area of the flood discharges which affect the Cooum.

2. It has been proposed—*vide* paragraph 61 of report on Buckingham canal (G.O., dated 14th March 1883, No. 841 W.), to divert the drainage flow south of Shadayankuppam lock by a drainage channel and drain into the canal north of the lock. This can, I think, refer only to that portion of the canal between Cotton's canal and the lock mentioned, because on the other portion of the canal between Cotton's canal and the Cooum such an arrangement does not seem feasible. I am doubtful, however, if any portion of the arrangement has been carried out, and for the purposes of this report, I have considered the whole of the drainage south of Shadayankuppam lock as still entering the canal and finding an exit to the sea *via* the Cooum. The additional drainage area which has to be included on this account is that of about 8 square miles.

3. It may be taken therefore that on entering municipal limits, the Cooum drains 207 square miles and that at Law's bridge, just above its junction with the canal, it drains 207+8 square miles and below this point 215+8 square miles. These figures are not strictly accurate, as 215 square miles is the area drained to the mouth, less that brought in by the Buckingham canal, while Law's bridge is one mile from the mouth; again it has not been shown that all the drainage from the canal will enter by the cut near the Penitentiary and does not pass down by the north branch of the Cooum to join it just above its mouth at Napier bridge; the figures, however, given above are in excess and may, for the purpose of this report, be accepted.

4. Until I again refer specially to the north branch of the Cooum, my observations in the following paragraphs must be considered to relate to the main branch alone.

5. As before stated, the Cooum within the municipal limits is of an exceedingly tortuous character.

6. This circumstance causes the formation of large banks which are formed of course on the convex side, while the concave side is scoured out to considerable depths. The formation of these banks and consequent scours above the bridges necessarily endanger these structures, and on the concave side of the river just below the bridges, the bed has been scoured to great depths—*vide* Cooum sections Nos. 3 to 3-B.

The river, though partly a tidal stream for a part of the year, and during that time filled with sea water, is for the greater portion a mere lagoon filled with a mixture of fresh and sea water with no outlet, but liable to sudden variation on each occasion of rainfall.

7. The Cooum is in connection with the sea usually only for portions of the months of October to January. The following table shows the date of cutting and closing the Cooum bar during the last ten years:—

Year.	Month and date.	Particulars.	Number of days open.	Remarks.
1880	November 4	Opened		
1881 ..	January 1	Closed	59	
	November 12	Opened		
	December 21	Closed		
1882	November 16	Opened	40	
1883 ..	January 16	Closed		
	October 16	Opened	62	
1884 ..	January 22	Closed		
	October 19	Opened	99	
1885 ..	January 21	Closed		
	November 16	Opened	95	
	December 16	Closed		
1886 ..	November 9	Opened	31	Closed of itself.
	December 8	Closed		
1887	October 28	Opened	30	Do.
1888 ..	January 21	Closed		
	October 30	Opened	86	
1889 ..	January 19	Closed		
	October 15	Opened	82	
	Do. 19	Closed		
	December 18	Opened		
	Do. 27	Closed	15	

The river has also usually during this period indirect connection with the sea *via* the Junction canal, the Adyar, the Buckingham canal and the Kortalayár bar, and during the hot season sometimes at high spring tides with the Adyar bar open that river may rise from ·50 to ·70 above mean sea level. When the Junction canal and the Cooum is lower than the Adyar, the gates of the lock which is placed at the junction of the Adyar and Junction canal are opened and a flow down the Junction canal to the Cooum takes place. The result, however, to the level of the Cooum is insignificant, as the water has to spread a considerable distance up the main branch of the Cooum itself, up the north branch and up the Buckingham canal for 7 miles. Similarly with the Ennore bar open and the Cooum and canal lower than the water to the north side of the Shadayankuppam lock with the lock open a similar action takes place. Looking to the infrequency of these supplies to the Cooum and the very slight result when the supplies do take place we may consider the Cooum for nine months of the year to be a mere tank or backwater without motion through it of any sort.

8. Throughout the summer months, though it seldom receives direct supplies of flood or sea-water, it is unfortunately continually receiving large supplies of polluted water; and the City of Madras, I calculate, passes into the Cooum (excepting the canal) through 21 sewers on the right bank and 13 sewers on the left bank—no less than 1,000,000 gallons of sewage daily. The Cooum is not, however, during the months its bar and the bars of the Adyar and the Kortalayar at Ennore are closed totally unaffected by the sea, for I have observed a very distinct rise and fall in the Cooum during the hot season; this I believe is caused by the sea-water finding its way inland through the substratum at high tides, and this water, when the tide falls, escapes into the Cooum from the adjacent surrounding land instead of returning to the sea.

9. The constant delivery of sewage into the river naturally renders it the breeding ground for all kinds of organisms, and the want of circulation in its waters and the consequent small exposure of the organisms to the air are circumstances eminently favorable to their production. As soon, however, as any very slight circulation takes place, such as may be caused by a shower of rain, the organisms are at once exposed in large numbers to the atmosphere and their oxygenation and consequent destruction which the late Dr. McNally described as "of the nature of fermentation and analogous to the conversion of sugar into alcohol by the action of microphytes in the presence of oxygen," results in the production of offensive and poisonous substances of the nature of ammonia. When such results are produced, the inconvenience and nuisance to those who live in, or may come to the vicinity of, the Cooum is very great. Several of the most prominent of the Madras buildings, such as the "Senate House," "Government House," the Penitentiary, the "General Hospital," the "Women and Children's Hospital" and a large number of buildings on the Mount road are adjacent to the Cooum; it is evident, therefore, that the existing state of matters is a question of no small importance.

10. The state of the Cooum has for many years been a source of constant complaint, and during these years as many suggestions have been made for its remedy.

11. In the year 1882, owing to the Cooum being in the state which has been previously described, the then Senior Medical officer of the General Hospital proposed the admission of sea-water at high tides. Dr. Cornish, who was then Surgeon-General, in his order on that suggestion said: "The remedy suggested was tried on one occasion within the Surgeon-General's recollection, but instead of abating the nuisance only increased it. On this occasion (1870) the sea-water was let in at a time when the sea was full of a species of oscillatoria producing the phenomenon of phosphorescence. These minute creatures died by myriads under the changed conditions of their existence, and produced so fearful a stench that many persons having to pass near the river on any portion of its tidal length were attacked by sickness. Fortunately, heavy rain fell early in June of that year sufficient to force open the bar and remove the offensive matter."

12. It will have been noticed that the cause for the ordinary recurring offensive smells described by Dr. McNally and on the special occasion noticed by Dr. Cornish is the want of circulation in the river. In the ordinary case the animalculæ breed undisturbed until some rainfall or other cause brings them into contact with the atmosphere and oxygenation occurs; in the special case the oxillatoria were unable to live because their condition of life was changed by their being thrown into water comparatively fresh. There is therefore but one remedy and one alone which can prevent this recurring nuisance, and that remedy is circulation; if the water in the river is in constant circulation, the animalculæ if they die will die in average numbers throughout the year unnoticed and at the same time their productiveness will be exceedingly decreased and the nuisance will in fact disappear. The cause of the increased nuisance in the case referred by Dr. Cornish was not the letting in the sea-water alone, but the want of more water and a constant influx of sea-water so that the conditions of life in the Cooum and the sea would not have been very materially different; the remedy therefore recommended is the constant admission of sea-water to the Cooum and a corresponding daily rise and fall of the tide. How I propose to effect this I reserve until I come to discuss the engineering details of my scheme.

To change the water in the Cooum daily is the object to be effected and it is necessary to attain this as quickly as possible and to limit the flow to as small an area as possible. For this purpose it will be necessary to place a lock across the Buckingham canal near St. Mary's bridge and a

weir must also be placed somewhere in the river, because it is impracticable to keep the whole river within municipal limits as a tidal river; the upper portion of the river therefore must be treated in a different method from the lower. In the upper I propose to retain the water in tanks gradually ascending one above the other, the lower portion will be continually tidal.

13. The point where the dividing line should be has been of course a matter for much consideration, and my reason for fixing the site for the dividing line a short distance above Harris bridge, where a weir will be constructed, is that the ordinary tides when freely admitted will flow up to this point, and this weir will be above any of the points of entrance of sewage drains into the river.

14. In para. No. 8 I have already stated that 21 drains enter on the right bank and 13 on the left bank of the river. All these drains enter the river below the site I propose for the permanent weir.

15. That these drains are the most predominant cause of the production of organisms and animalculæ of all sorts need hardly be stated, and until these drains are wholly diverted from the river, the river will never be in the condition it ought to be. These drains in floods bring down large quantities of silt into the river; at other times they bring down sewage much of which is deposited at or near their mouths. It will be many years before the municipality are able to divert all the sewage from the river, but as the villages of Triplicane and Chintadrepet are most flagrant in respect to their steady discharge of sewage into the river, it seems to me that these villages might well first, before any other parts of the city, receive attention at municipal hands; pending such measures, it is my duty to suggest certain arrangements which will, without diverting the drainage from the river, tend to filter it before entering the river and also allow of the removal by the municipality from time to time of the solid sludge which I propose to arrest. These measures I shall refer to later on in this report.

16. When the measures I have suggested are carried out, they will prevent the pollution of the river in the future, but the deposits of many past years and the consequent present state of the river have yet to be dealt with.

17. To a certain extent no doubt the river gets cleared by annual floods; but it is just as certain that large deposits in the river never get cleared at all and also that a large amount of silt deposit is merely annually moved from its original site and re-deposited on the convex curves of the river, where large banks are formed which go on increasing, thus narrowing the river and causing an increased scour and encroachment in the concave banks at the bends and also cause the flooding of the lands adjacent to its banks.

18. Further radical improvements necessary therefore are these:—

(1) The removal of the banks referred to.
(2) The restoration of the banks where eroded.
(3) Deepening and re-sectioning of the river.
(4) The proper training of the river so that at ordinary seasons it will be confined to the centre of its bed and during floods will cease to deposit the silt it carries down on the convex side and scour away the concave side, and for this purpose the erection of groynes, &c., is necessary.
(5) The formation at certain places of wharves which would, to some extent, serve as groynes or training walls and afford facilities for the landing of goods at present effected in the muddy foreshore.
(6) The restoration, improvement and re-sectioning and turfing of existing banks and their future protection.

19. The acceptance of proposal No. (3) will allow of cargo boats proceeding up the river much further than at present and of No. (5) will ensure an income to Government probably in excess of the expenditure on the construction of wharves which would, I believe, be productive works. An instance in the point is the wharf erected by the municipality at Trevelyan basin, Black Town, where the cost of the wharf was covered by the profits from two or three years' income.

20. These recommendations do not, at first glance, seem to demand any great expenditure, but it will be seen, when engineering details are discussed, that they absorb a large proportion of the total amount of the estimate.

21. The Cooum when in floods at times rises higher at certain points than its banks; this, as regards that part of Madras called Lang's Garden, in the village of Chintadrepet, and on the left bank of the Cooum, is due to the very small waterway afforded by St. Andrew's bridge; a reference to paragraph No. 71, where the waterways of the various bridges are compared, will at one show how limited the waterway is at that bridge.

22. Below St. Andrew's bridge and still on the left, the bank, the roadways, &c., are also flooded; the floods affect the site of the Women and Children's Hospital; this, it is believed, will shortly be removed, but the roadway along the river between St. Andrew's bridge and Law's bridge is very often submerged much to the inconvenience of, and danger to, the public and on this account and for the proper training of the river the road ought to be raised.

23. Above the point where I propose to place the weir the river assumes a different aspect to that which it has in the lower reaches. It is very broad with a sandy bottom, and practically no sewage enters it. It is extremely shallow, and in the hot season is, in fact, a series of shallow pools. Its appearance is decidedly ugly; its banks are very ragged, and large expanses of sand encourage the growth of noxious vegetation and the commission of nuisance. Dhobies wash in these pools containing only small bodies of water, and as they are seldom replenished, the state of water in which the clothes are washed is not uncertain. The iron weir sluices which have been erected at the Commander-in-Chief's and Andrew's bridges are much too low to dam up the water for any distance back so as to completely cover the bed, and it has been remarked that these sluices probably let out more water than they retain. However that may be the principle on which their erection was based, viz., the retention of bodies of water so as to keep the bed of the river covered throughout the hot season is a good one and it is the principle I still propose to adopt, but as to the means of attaining that end my proposals will be slightly different. A greater depth of water is necessary to be of any use, and the manner in which I propose to secure their object will be found among engineering details.

24. When the river has been dealt with according to my scheme it will be found that—

(1) There will be a gradually increasing depth below the proposed Harris bridge weir with a constant circulation of the waters and the river will become a tidal one.
(2) The river will be trained and flow in the centre of its bed whether in flood or otherwise.
(3) The banks will be improved and will have proper slopes, and the present exposure of silted sewage banks will disappear.
(4) The river will be navigable to traffic from its mouth to Harris bridge and greater facilities will be placed at the disposal of the public for the import of firewood and other commodities.
(5) The periodical smells which arise from the river will, I believe, disappear.
(6) The upper reaches will be a series of lakes suitable for boating, and bathing might be allowed at certain places. The washing of cattle should, however, be prohibited.

25. I have now to consider what steps should be taken in regard to the north arm of the Cooum.

The points for consideration are these—

(1) What is the necessity for this branch of the Cooum at all?
(2) If there is no necessity, is there any advantage?
(3) Whether there would be greater advantages where this branch closed?
(4) If the branch cannot be closed, can any steps be taken to improve it?

26. What is the necessity? It serves at present to discharge or to partially discharge the flood waters brought down by the Buckingham canal. In para. 3 I stated that the figures I gave were not strictly accurate, because I based them on the supposition that all the drainage of the canal passed down the main branch of the Cooum. If the drainage can so pass, then one necessity for the north arm or branch of the Cooum disappears. While this may be so, there are circumstances which may call for the retention of the north branch, viz., that it may receive the storm drainage from certain portions of Madras. It in fact at present does do so for the "Scoop-drain" which drains the esplanades and which is also a storm overflow for part of the Black Town drainage scheme, discharges into the Cooum (north branch) between the Wallajah bridge and the Medical College. This branch of the Cooum also during floods brings down a supply to the Fort ditches.

27. As to the Scoop-drain, if the north arm of the Cooum were filled up the drain can be carried to the other branch at St. Mary's bridge, but I have no plan to suggest for the filling* the Fort ditches with water unless from the sea if the north arm ceases to fill them; perhaps as a sanitary measure it might be suggested that they would be better filled up altogether with earth. Whether military exigencies will allow of that I cannot determine; this, however, is a small matter, and I think it may be taken for granted that no necessity exists for the north arm if the main branch of the Cooum is sufficient to carry off all flood waters, and that is so because—

* They can be filled from the proposed canal if scheme No. (2) is adopted.

(1) Both branches discharge through the Napier bridge.
(2) Because the proposed improved section at Government House bridge will allow of a similar discharge.
(3) Because the improved sectional area of the river above Government bridges will be also sufficient.

28. What then is the advantage of the north branch? The only advantage that I can see is that it affords a course for boating, but if it be done away with, the improvement of the main branch will compensate for the loss of the north. It will perhaps be necessary to supply a small open channel to carry off to the sea the drainage from the slope of the south glacis and a portion of the island and this is provided for in the estimate.

29. What would be the advantages if the north arm were filled up? They are, namely:—

(1) There would be a more direct connection between Black Town and Mount road.

(2) A much-wanted communication from Body-guard road would be afforded.

(3) A large piece of land would be added to the island, making it much more valuable for military purposes and for public amusements.

(4) A much-wanted addition to the grounds of the General Hospital and College would be obtained, though by the present position of the South Indian Railway the access would require to be across that line.

(5) The summer odours, now thrown out by this branch of the Cooum, which in proportion to its length has a considerable area, would cease to pollute the air to the inconvenience of the Fort, the Medical College, the General Hospital and the general public.

(6) The flow of the tide up the main branch of the Cooum would be at a much greater speed and the circulation obtained much greater. This object might also be effected by a weir where the north and main branches of the Cooum join.

30. The filling of the branch would be effected by depositing, by means of a light railway, the excavated earth from the northern branch; to cover this, sufficient soil could be dug from the banks before filling up the river.

31. If the closing of the branch is objected to, this branch can, of course, be dealt by measures similar to those proposed for the main branch, but I strongly advocate its complete closure. The full benefits to be attained by the adoption of that measure will be more readily appreciated by a study of the plan of the present island with the branch closed.

32. The Buckingham canal extends from the north branch of the Cooum for a distance of 7 miles before the Shadayankuppam lock is reached. If the tide is to be allowed to flow up the canal, the Cooum will never obtain the full effects of the tide, and as this, I venture to think, is a necessity, as I have already indicated, I am strongly of opinion that lock gates ought to be erected near St. Mary's bridge. A design has been prepared for the site at St. Mary's bridge, which bridge requires renewal and widening. The design effects both these objects.

33. This is not the first proposal to place a lock near the Central station. His Grace the Duke of Buckingham, when Governor of Madras, had a temporary bund erected at the Central station. The main objection to this lock, which would be most useful as regards the Cooum and probably also in keeping the canal at a high level during a part of the year, is that the canal for half a mile above this point is much polluted with sewage. No doubt a large number of drains flow into the canal, but these shortly will be diverted from it, and as there is practically at present (except in flood times during which time the gates would be open) no circulation, it does not appear that the erection of a lock at the point indicated will, from a sanitary point of view, tend to aggravate the present condition of the canal.

34. For reasons similar to those already stated, a lock should also be placed at the north end of the Junction canal. The lock at the Adyar is no doubt a double lock and, while flood-waters of the Adyar can be sent to the Cooum, at the same time the Cooum can be prevented from flowing to the Adyar; but the question is how best to obtain the full benefit of the tide in the Cooum, and there can be no doubt that in proportion to the less area to be filled, will depend our success in keeping up more or less perfect circulation by the in and out flow of the tide.

35. With these remarks I may conclude what I may call the preliminary portion of my report, which embodies generally my proposals; the latter portion details with the engineering features of the scheme and details regarding the manner in which it is proposed to carry out the work.

Engineering Details, &c.

36. This report has been prefaced by a small scale plan of the Cooum within Municipal limits.

37. It is accompanied by—

Particulars.	Number of sheets.
1. Large scale-plan showing the river at present and as proposed	1
2. Longitudinal section of river showing present and proposed levels of bed, &c.	1
3. Cross sections of the river showing the proposed new sections of the river	7
4. Plan and sections of the proposed arrangement at the mouth of river	1
5. Sketch-plan and elevation of the lifting bridge at the Napier's bridge	1
6. Plan and sections of the weir at Harris bridge and cross section of wharf wall	1

Particulars.	Number of sheets.
7. Plan and sections of lock gates at and improvement at St. Mary's bridge	1
8. Plan showing the extension of St. Andrew's bridge	1
9. Plan of the place now called island as proposed to be improved	1
10. Sections across the island showing relative levels, high and low water mark, and the flood level as proposed	

38. The first question to be considered is the method of opening and keeping open the Cooum bar and this is a question which must be considered at some length.

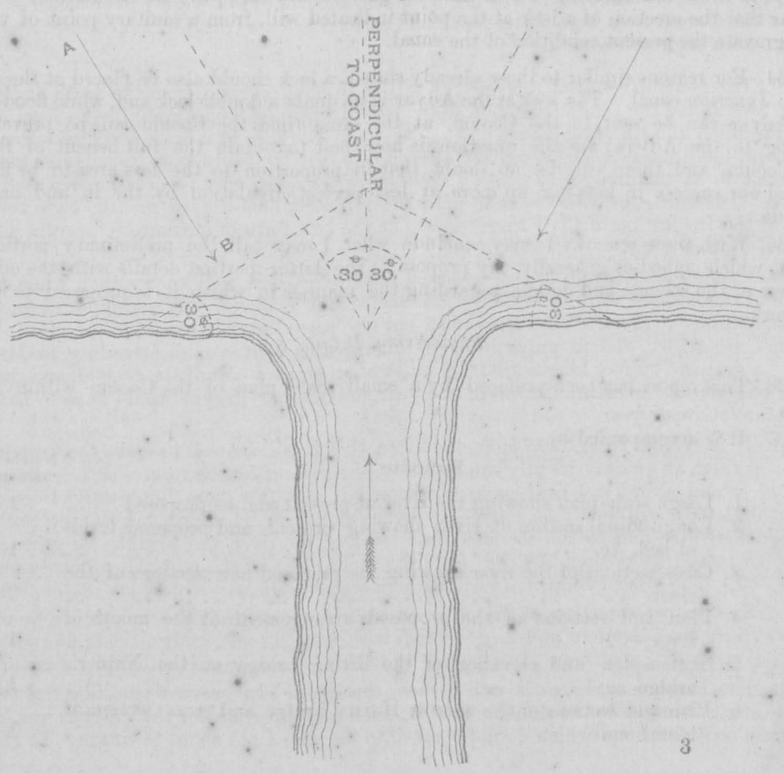
39. The experience gained in the construction of the Madras Harbour has shown that, as a rule, a groyne projecting from the coast will have the effect of accumulating sand to the south of it, while causing a scour to the north of it, because we may consider that the two groynes of the harbour as one groyne of great breadth.

40. Undoubtedly a groyne at the mouth of the Cooum would have had a similar effect before the construction of the harbour; the first question to be considered is, will it have it now?

41. We have first to consider to what, at the accumulation of sand and scour, are respectively due.

42. In evidence (55—p. 4) before the committee appointed to inquire into the question of the position of the entrance to the Madras Harbour, the late Mr. Parkes said, in reply to a question as to the general direction of the sea: "It seems to be quite independent of the wind so far as I can see" and (56—p. 4) "It varies a little to the north of a line perpendicular to the coast and a little south of that line;" but if paragraph 104 (p. 6) is referred to, we find the Chairman, with reference to a letter by Captain Taylor, saying: "This all rather seems to me to point to the sea accompanying the wind and not to the independent swell that is always setting on the entrance." Mr. Parkes: "There is no doubt that the seas do come from the south of east during the south-west monsoons and from north of east during the north-east monsoon" and in paragraph 108 (p. 6) we have the Chairman saying: "In no case," he says here, "is it believed that the angle exceeds 30° to the general line of the coast.?"

43. This is an important point The Cooum, when its mouth is open and when discharging into the sea with any great velocity, discharges at right-angles, or almost at right-angles, to the coast, and in the following sketch is shown the maximum limits of the direction of the sea and accordingly the line of the waves breaking on the coast:—



44. Now the bar of the Cooum within the last ten years was open during portions of the months of November and December usually, but sometimes from October and sometimes as late as 21st of January. During these periods the direction of the sea breaking on the coast, has been that from the north of east or as indicated by the arrow A B, and accordingly, the waves it has been observed that, before the bar is closed, the river flows more and more away to the south side of the channel which the river in the high floods scours out.

45. There is also a series of currents passing up and down the coast parallel to it, which are calculated to run at a velocity of from 1 to 3 miles per hour. These are not necessarily always in the direction of the wind, but generally when the wind is from north of east the current runs south and when the wind is south of east the current runs north.

46. We have at the mouth of the Cooum, therefore, two facts to deal with—the currents which convey the sand up and down the coast which, owing to their reversed direction, lodge at one time sand on one side of any projection from the coast while removing it on the other, and, at another time, reversing the operation. The southerly current, however, acting for the longer period, is the cause of the deposit of a larger quantity of sand than the northern current.

47. Having seen how the sand is lodged, I now return to the original questions—Will the harbour have any effect on the lodgement of sand at the mouth of the Cooum? As the harbour is north of the Cooum it is not likely to affect in any degree the action of the southerly currents, and, from what follows, I do not think that it will much affect the northerly currents. The outermost point of the harbour bears from the Cooum mouth 33° east of north, so that the mouth is unprotected from the north-eastern winds and as 33° is only 3° more than the maximum angle at which the waves may approach the shore, there will be little or no change in their direction. I am of opinion, therefore, that the harbour will not cause any difference in the result which would occur from the placing of a groyne at the Cooum than if such groyne were elsewhere. The small increase to the general shore line, caused by the harbour, of course, will continue, but harbour groynes will not prevent the scouring action which will take place to the north of a groyne erected near the mouth of the Cooum similar to the action which takes place and has taken place to the north of the north harbour groyne.

48. My proposals, therefore, for keeping open the mouth of the Cooum are—

(1) The improvement and extension to high water mark of the groyne now existing on the south bank at the Cooum mouth.

(2) A groyne 100 feet north of this (thus taking up two spans of the existing bridge) and widening out to 200 feet at high water mark and extending no further than that point.

(3) A breakwater groyne starting from near the end of No. 1 groyne on south of the south bank of the Cooum from high water mark and extending to a length of 650 feet at a point some 530 feet from high water mark.

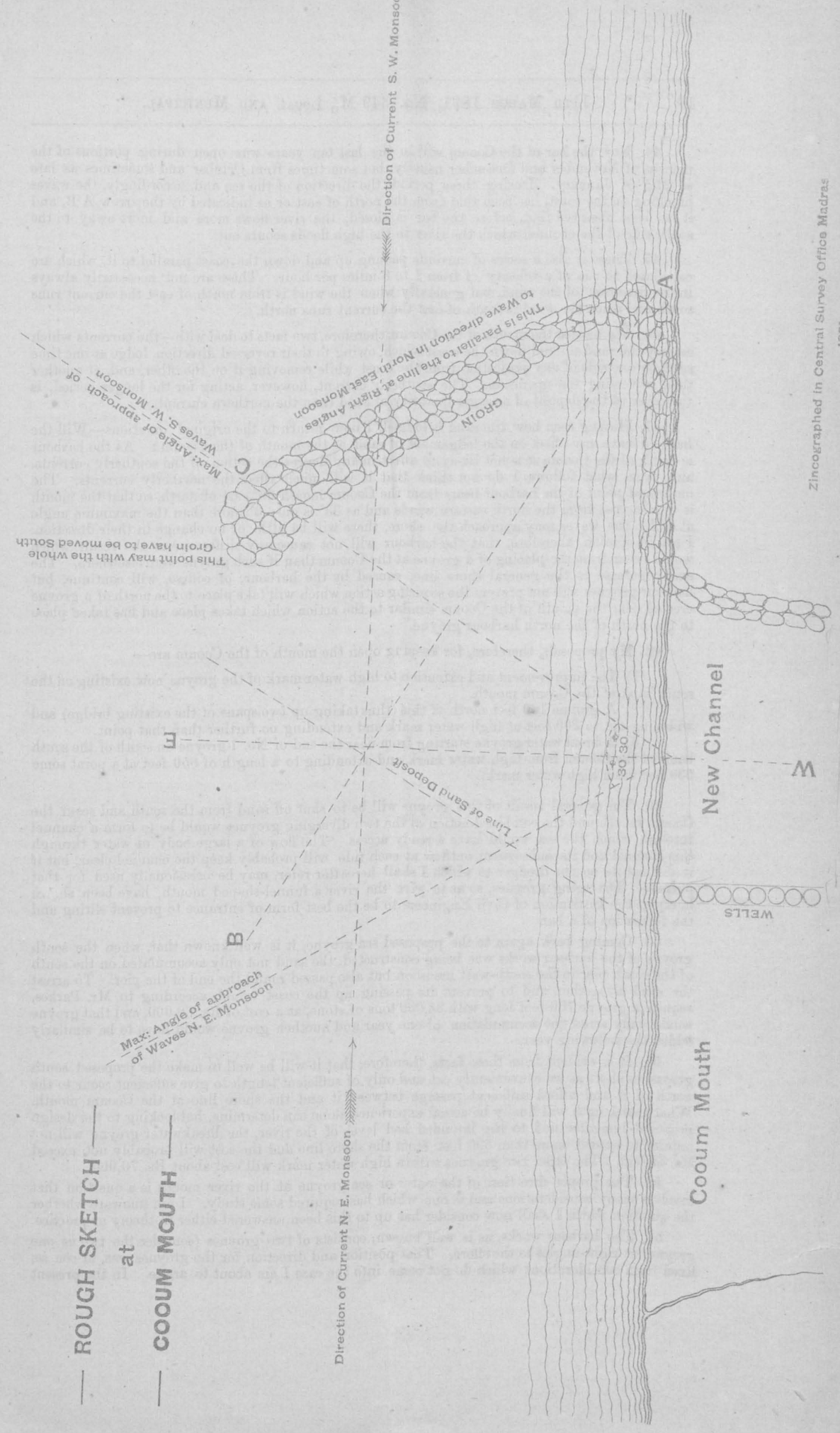
49. The general result of this groyne will be to shut off sand from the south and scour the Cooum mouth and the combined action of the two diverging groynes would be to form a channel through which the sea would have a ready access. The flow of a large body of water through this channel and its subsequent outflow at each tide will probably keep the channel clear, but if it did not do so the dredger to which I shall hereafter refer, may be occasionally used for that purpose. Diverging groynes, so as to give the river a funnel-shaped mouth, have been shown lately at the Institution of Civil Engineers to be the best form of entrance to prevent silting and the formation of a bar.

50. Coming back again to the proposed sea groyne, it is well known that, when the south groyne of the harbour works was being constructed, the sand not only accumulated on the south of the south pier in the south-west monsoon but also passed round the end of the pier. To arrest the sand altogether, and to prevent its passing up the coast would, according to Mr. Parkes, require a groyne 700 feet long with 33,000 tons of stone, at a cost of Rs. 66,000, and that groyne would only arrest the accumulation of one year and another groyne would have to be similarly added the following year.

51. It is evident from these facts, therefore, that it will be well to make the proposed south groyne as short as we conveniently can and only of sufficient length to give sufficient scour to the north of it and afford sufficient passage between it and the shore line at the Cooum mouth. What that length will finally be actual experience alone can determine, but looking to the design proposed hereafter and to the intended bed level of the river, the breakwater groyne will not require to extend more than 530 feet from the shore line and the cost will probably not exceed Rs. 69,000. The other two groynes within high water mark will cost about Rs. 70,000.

52. The proper direction of the outer or sea groyne at the river mouth is a question that involves many considerations and is one which has required some study. I am unaware whether the question which I shall now consider has up to this been answered either in theory or practice.

53. The harbour works, as is well known, consists of two groynes (consider the two as one groyne) at right-angles to the shore. That position and direction for the groynes was, of course, fixed from considerations which do not come into the case I am about to argue. In the present



Zincographed in Central Survey Office Madras 1891

case the real question is—What direction should the breakwater groyne take with reference to the shore line? Now it is well known that a groyne at right-angles to the shore, arrests the sand on one side and scours it away in the other, the action being reversed from time to time according to the season of the year. We may, however, leave the north-east monsoon out of the question and consider it in relation only to the south-west monsoon. Then the current is from the south and the waves strike the shore from the south-east more or less. Will a groyne at right-angles to the shore give the greatest scour to the north of it? The greatest scour can only be achieved if there is no lodgement of sand to the north of the groyne. Now the sand which would be lodged to the north of the groyne must come from the south and it would be sand washed round the end of the groyne.

54. The groyne then ought to be in such a position and have such a direction that the sand from the south will be arrested as slightly as possible and in such a position that the current carrying the sand will be diverted from the shore as much as possible and be also in a direction which would secure the mouth of the river from sand which has passed north of the groyne being carried towards it by the waves. Now these objects, during the south-west monsoon, would be secured to the greatest extent by placing the groyne at angle not less than the angle at which the line of the waves meet the shore during the south-west monsoon or in sketch accompanying the line A B.

55. There are, however, objections to the groyne in that position: firstly, it would have to be a long groyne; secondly, during the north-east monsoon its position is likely to cause a larger deposit of sand than if the groyne were inclined at a less angle to the shore. The north-east monsoon, it must, however, be remembered, is not so important a consideration as that of the south-west, because during a long period of the former, the river is ordinarily in flood and keeps its mouth open by its own action.

56. Taking all these considerations into account, I believe that the best position for the groyne is that shown as A C. The line of it is such that the southerly current will be diverted without being arrested or causing the sand to deposit at the back of groyne to the same extent as it would do if the groyne were at right-angles to the course of the current. The scour inside the groyne, owing to the greater area of slack water which will exist, will probably be greater. The position of the end of the groyne has been fixed with reference to the new level of the Cooum bed, the depth at the end being slightly greater than the depth at the mouth of the Cooum. The point is also fixed with regard to the necessity for ensuring that a scour will take place at the mouth and not only north as might be the case were the end of the groyne too far north, for, as is known, the scour at the north arm of the harbour works has not so much affected the line of shore close into the breakwater.

57. The funnel mouth of the groyne in shore will produce the greatest possible scouring effect through the channel and keep the channel clear, the bottom of it being laid with boulders. The effect of the outgoing tide can, if necessary, be improved by the use of scouring shutters which would be shut at high, and opened only at low, tide and the aid of the dredger still to be referred to can also be called in when necessary. I am therefore of opinion that the bar can be kept open and, such being so, circulation in the lower reaches of the Cooum will be secured.

58. The two in-shore groynes, as I have already stated, will be 100 feet apart at the Napier bridge and widen out to 200 feet at the sea margin. The south groyne may be formed by large boulders cemented with cement concrete but the north groyne must be of different construction. When the mouth of the river, except the narrow entrance to be maintained, is shut, that is, except when the river is in high flood, the north groyne must form a retaining wall to keep back the sand. When the river is in flood and the full breadth of the mouth is required for the discharge, that groyne will be in the centre of the flood waterway and must be such as not to take up more or little more than the breadth of the bridge piers, and, for this reason, I propose to form it of cement concrete cylinders sunk well down below a depth affected by scour. Between these two groynes at ordinary times the tide would run in at the rate of about two feet per second, calculated thus:—Under the new condition of the river yet to be described the area to be affected by the tide will be about $4\frac{1}{4}$ millions square feet. This would be filled in six hours, and, taking the average rise of the tide as 3 feet, and the sectional area of the channel as $100 \times 3 = 300$ feet, the rate of flow would average—

$$\frac{4,250,000 \times 3}{300 \times 6 \times 60 \times 60} = \frac{12,750,000}{648,000} = 2 \text{ feet per second.}$$

59. The rate would be less than this at the beginning of the flow and the ebb, but much greater during a large portion of the 6 hours, and the velocity will be quite sufficient, I believe, to keep the channel clear. If not, it will be easy to put up gates at the Napier bridge and dam up the tide in the river until low tide when the gates would be opened and a very high scouring action would occur.

60. The scour from the sea groyne proposed is not likely to affect the coast line to the north very much, but there is plenty of land to come and go on, and it is not likely that there will be more removed by the Cooum groyne than will be filled up again beyond the area of action of that groyne by the action of harbour South pier, probably indeed not so much.

61. That portions of the proposals just detailed are not new will probably not discount but increase their value and I would refer Government to a similar proposal by the late Mr. Clark—*vide* Memorandum on the Cooum (Drainage of Madras, 1872) and to the evidence of late Mr. Parkes and Captain Taylor before the Madras Harbour Committee.

Mr. Clark says: "As the quantity (of flood water in the Cooum) diminishes at the cessation of the rains, the water of the flood tide gradually finds its way in, and it becomes a contest between the loose sand thrown up by the surf at the mouth of the river, and the entering and issuing tidal water; as this process goes on during the north-eastern monsoon current, the river is forced towards the southern end of the bridge, where there is a short groyne, and the drift sand occupies four-fifths of the waterway of the bridge, leaving a narrow channel only; this channel is kept open for several months by the scouring action of the tidal water in passing to and from the *reservoir* of the Cooum.

"As the river succeeds in forcing for itself a channel through the enormous quantity of loose shifting sand for several months, it may, I think, be expected that, if some comparatively small means of assistance were afforded, it would remain permanently open.

"Those who have known the river before the rough groyne of granite boulders, above alluded to, was placed on the sea side of the bridge at its southern end, will be able to say how far, or for what period, the closing of the 'bar' has been protracted.

"My observations during the past two months have shown that the outlet of the channel into the sea shifts towards the north. A quantity of sand accumulates on the 'bar' side at the head of the groyne, and gradually increases in extent, causing the opposite or north side of the channel to scour away the sand by the action of the waves which break on its face during flood tide, and carrying the sand nearer to the bridge, where a very considerable eddy is formed, and a quantity of sand is piled up at the back of the shoal first formed as above; as this action proceeds, the northern side of the channel becomes more and more rapid, until the time when the projecting shoal on the south side will overlap the northern side of the channel completely (it now extends to a point opposite the seventh arch from the southern end of the bridge) and will soon completely everlap the channel; in this condition of things the waves (which break nearly parallel to the shore) will commence to cut the point of the shoal itself and drive it bodily in towards the bridge, and the 'bar' will then at once be closed.

"I am of opinion that, if a channel of suitable width be formed by the construction of groynes on both sides, and the entering and issuing water be confined to this channel during the dry season, a quantity of water, moving at sufficient velocity, will be obtained to keep the channel open throughout the year, by the scouring action of the tidal water alone.

"I have roughly estimated the quantity of water which the river Cooum will contain between the South beach and Harris bridge.

"The ordinary rise of the tide, I learn, is about 3 feet; for purposes of calculation I have taken 2 feet 6 inches as spread over the area of the Cooum between the above points, and I find the quantity to be about 16¼ millions of cubic feet which must enter through the channel at the 'bar' in 6 hours; this quantity in a channel having a sectional area of 300 square feet would give an average velocity of 2½ feet per second. Of course this velocity is not uniform; it is greatest about half tide of both flood and ebb; and at extreme high or low water the velocity will be much higher—such as I have mentioned open, if the loose sand at the mouth be so far confined and controlled as to admit of the scouring action of the water being concentrated on its sectional area only, and in a direction at right-angles to the general shore line.

"I have repeatedly observed the water entering with a velocity at the surface of 4 feet per second (and the channel I take to be about the size I have indicated) under the present condition of things, but the mass of sand it has to contend with, on both sides, along its whole length, is too great to be overcome by the small stream opposed to it."

Mr. Parkes said, in reply to Sir George Nare's question No. 2923*—What groynes are being constructed south of the harbour now?"—"I saw that Captain Taylor mentioned that one groyne had been made at the mouth of the Cooum, but the Cooum is a river I do not think that he quite explained the state of affairs at the Cooum, which comes round at the back of Madras and discharges itself some little distance to the south of Fort St. George, and, during the south-west monsoon, the mouth of the Cooum is completely closed by the drift of sand across it. Generally with the rains of the north-east monsoon, and the consequent floods in the Cooum, that bank is burst open; sometimes the floods are not sufficient to do that. The first time I was at Madras in 1873 it never opened; sometimes it is nearly open, and then they help it by casting out the sand. But lately, since I have been at Madras, I imagine, from what Captain Taylor said, they have attempted to keep this opening permanent by a groyne on the south side of it, which he seemed to say was 150 feet long. If so, I feel pretty certain that it is insufficient. He seems to think that it is on the wrong side, but I do not know what are his grounds for thinking so."

* Minutes of evidence taken before the Harbour Committee.

Captain Taylor said, in reply to Sir George Nare's No. 3090—"The southerly current passing the east face of the harbour must strike the land somewhere to the north to scour out the sand on the north side and carry it northward, do you think that it would strike anywhere south of the railway works?"—"It comes right into the corner."

No. 3091.—"It runs at present along the north pier, and curls right round there?"—"Yes, it curls round on to the revetment and the Railway Company's beach."

No. 3092.—"But with strength sufficient to carry the sand along?"—"With strength enough in stormy weather to displace the stone of the revetment. It is almost impossible to give you a clear idea of the thing without seeing it. On this particular occasion the revetment was washed away in many places; in the case of the Sailors' Home all the wall was gone, and the sea came up within a few feet of the house itself."

No. 3093.—"There is no doubt whatever of the movement of the shore; but what I cannot understand is, how that small amount of sand that is lodged in the corner between the north side of the north pier and the railway jetty can possibly be carried northward by the southerly monsoon current striking round there."—"This is matter of experience; I am certain it is so; I do not know how I can convey my opinion in any other language than that I am certain it is so. The tendency of the groynes on this coast is that, after the sand is deposited on the one side of the groyne, the waves cut close round, *so much so that you could keep the mouth of the Cooum open there*, and you could keep the canal open, thereby choosing a proper position for the groynes."

62. The proposal, therefore, is one which has the approval of no mean authorities, but I think it advisable to recommend that the construction of the sea groynes should be undertaken only after some experience has been gained of the results of the two in-shore groynes, the sea groyne it is just possible may not be found necessary.

63. Many years ago I made a proposal, I think at the time of the famine, to construct a canal *via* Ráyapuram from the Harbour works to the Canal basin; that certainly would have been a better means of communication with the harbour than *via* the Cooum bar and the sea. The Collector of Madras lately called for a copy of that plan showing the line of the canal proposed. Many buildings have sprung up in the intervening 13 years and the line then proposed would now involve the destruction of much property.

64. Seeing, however, that circulation in the canal and Cooum would have been secured by that proposal and looking to the fact that the proposed method of keeping open the Cooum bar may be the cause of controversy, and that, however, much discussion may take place, it is not likely that the matter can ever be decidedly settled until the experiment (if it be so called notwithstanding the strong arguments I have used and the proofs of its probable success which I have put forward) is ventured upon. I have, therefore, an alternative to suggest to Government which, perhaps, from the fewer undetermined factors in probable results, will more favorably commend itself to Government. An alternative estimate has been worked for this scheme now about to be detailed, taking the cost of the canal as proportionate to the cost of the Junction canal (I do not think that the cost will be more) and it will be seen that the total cost of this scheme is less than that for opening the bar.

65. The alternative scheme is this, also a canal from the harbour, but in a different direction. I propose to start this canal 50 to 60 feet wide (perhaps 100 feet would be better) from the south arm of the harbour and continue it along the coast through the newly-formed foreshore as far as the north-east angle of the Fort. The canal would then pass along the Fort and to the west thereof *viâ* the Fort ditches until it joined the north arm of the Cooum near the Medical College, thence it would pass on at the back of the General Hospital taking up only 100 feet breadth of the north arm until it joined first the Buckingham canal and then the Cooum near St. Mary's bridge and the Penitentiary. The route taken is an economical one. No property, except Government property, would be interfered with and by passing through the Fort ditch a great deal of excavation is avoided. The following special works would have to be executed:—

(1) The harbour would require dredging on its eastern side.

(2) An intercepting sewer for storm water should be constructed or arrangements made to pass storm water under the canal by means of syphons.

(3) The Fort engine, which lifts the sewage from the main drain, would require to be moved to a new site.

(4) The line of the intercepting sewer at or near this point might have to be slightly altered.

(5) A syphon to carry the storm waters of the main drain would be required.

(6) Bridges to carry the Beach and Benfield roads over the canal would be necessary.

(7) A lock near St. Mary's bridge would be required to shut off the Cooum when in floods from the sea canal.

66. While the elements of uncertainty are less in this scheme than in the one of opening the Cooum bar, the benefits to be derived from it will probably not be so great as it brings some compensating evils in its train. It may silt up to some extent and its mouth in the harbour may silt up. When the boats are passing to and fro, some of the draw-bridges in the Fort would have to be opened. The substitution of the canal for the river near the hospital would not be so advantageous as the complete abandonment of the whole north arm, &c.

67. The plan has, however, much to commend it.

68. I have in paragraph 49 spoken of having the assistance of a dredger to keep open the mouth of the Cooum, and for the improvement, and for the maintenance of that improvement in the lowest parts of the river, I consider a dredger will be the most economical method.

69. Before dealing with the mode of dredging, sectioning the river, &c., it is convenient to consider first what sectional area is required in the river, for on that area depends the amount of material which has to be removed.

70. As the river is bridged at many points, it is evident that the dimensions of the sectional area to be adopted must be, to a great extent, dependent on the waterway now existing at the various bridges.

71. Taking the bridges in order (I do not propose to deal with the river above Munro's bridge), we find them as follows with the lineal feet of waterways as noted :—

	Lineal feet.
Munro's bridge	170
Anderson's bridge	160
Commander-in-Chief's bridge	200
Harris bridge	192
St. Andrew's bridge	144
Law's bridge	220
Government House bridge	318
Napier bridge	450

72. To pass the same quantity of water in the same time through each of these bridges, requires a varying depth and a varying velocity, and the quantity of water to be dealt with naturally increases as the mouth is approached, but unfortunately the waterways of the bridges are not so arranged.

73. As before stated, St. Andrew's bridge is the most flagrant example of this anomaly ; for, while it has fully four more square miles of drainage area to serve than Munro bridge, it has 26 feet less waterway, while the river banks are not so high ; it has 56 less lineal feet of waterway than Commander-in-Chief's bridge which has 2 to 3 square miles less area to drain ; and Law's bridge just below St. Andrew's bridge has 78 more lineal feet of waterway.

74. That St. Andrew's bridge has quite insufficient waterway is further proved by the cross section of the river immediately below it which has been scoured out so deep as to be a danger to the bridge, and we have also the fact of the extreme flooding of Lang's Garden village above the bridge on the left bank.

75. In considering, then, what ought to be the proposed sectional area of the Cooum, this bridge, as it at present stands, may be omitted from consideration, for its extension is evidently a matter of great necessity and this has been provided for in the rough estimate.

76. Accepting the figures given in paragraph No. 1 of this report, we have at Coratoor anicut 200 square miles drainage and a maximum discharge of 10,614 cubic feet per second. Deducing the co-efficient for the formulæ $D = C M^{\frac{2}{3}}$, we find that it comes to 310·35, and applying this co-efficient for the other areas, we have to provide for the discharge as follows :—

Names of bridges.	Drainage area.	Discharge = 310·35 $M^{\frac{2}{3}}$.
Munro bridge	207 sq. miles.	10,831 c. ft. per second.
Commander-in Chief's bridge	211 ,,	10,986 ,, ,,
Law's bridge	215 ,,	11,161 ,, ,,
Government House bridge	223 ,,	11,420 ,, ,, if canal drainage is included.
Napier bridge	223 ,,	11,420 ,, per second if canal drainage is included.

77. From the cross sectional maximum flood level areas and fall of the river, the velocity of the discharge in the river is found to vary from 5 to 6½ feet per second. It is advisable to keep the velocity at the lower figure, if possible ; and in the calculations which follow, a velocity of 5 feet per second has been adopted. Taking the discharge at the bridges as above, the sectional area required at these points will be :—

Munro bridge	$\frac{10,831}{5}$	= 2,166 sq. ft.
Commander-in-Chief's bridge	$\frac{10,986}{5}$	= 2,197 ,,
Law's bridge	$\frac{11,161}{5}$	= 2,232 ,,
Government House and Napier bridges	$\frac{11,420}{5}$	= 2,284 ,,

and dividing these latter amounts by the waterways, we get the depths during floods as follows :—

		Flood depth..	Hydraulic mean depths.
Munro bridge	$\frac{2,166}{170}$ =	12·7 ft.	11·0 ft.
Commander-in-Chief's bridge	$\frac{2,197}{200}$ =	10·9 ,,	9·9 ,,
Law's bridge	$\frac{2,232}{220}$ =	10·1 ,,	9·2 ,,
Government House bridge	$\frac{2,284}{318}$ =	7·1 ,,	6·8 ,,
Napier bridge	$\frac{2,284}{450}$ =	5·1 ,,	4·9 ,,

78. The next point to be considered is the level at which the bed of the river ought to be fixed and the gradient of the various portions of that bed.

79. The depths and hydraulic mean depths and velocity at certain of the bridges having been fixed from the formulæ—

$$F = \frac{\left(\frac{V}{\cdot 9}\right)^2}{2 \text{ H.M.D.}}$$

when F is the fall in feet per mile and V the velocity in feet per second, it is found that the fall of the river above the bridges, as undernoted, must be as detailed ; the total falls are calculated and noted in the last column :—

Names of bridges.	Distance from sea.	Intermediate distance.	Fall required above bridges feet per mile.	Total fall between each bridge.	Increasing total.
Napier	650	3,570	3·1	2·08	2·08
Government House	4,220	3,210	2·3	1·38	3·46
Law's	7,430	9,320	1·7	3·00	6·46
Commander-in-Chief	16,750	8,870	1·6	2·67	9·13
Munro	25,620		1·4		

80. It is curious to observe that the Cooum has a less slope in the upper reaches than in the lower, the reverse of what is usually the case ; but this is to be accounted for by the fact that, in the upper reaches, the Cooum flows more in the direction of a line parallel to the coast, while below Law's bridge it is flowing almost eastwards in the line of natural slope of the country.

81. In the above table it will be observed that the waterways of the bridges between Munro's and Commander-in-Chief's bridges and between the latter bridge and Law's bridge have been omitted from consideration and they have been so because, while the discharge must naturally be an increasing quantity, some of the waterways of these bridges are less than those higher up, while the river banks are lower, and to introduce them for the purpose of calculation would only tend to vitiate, or at least complex, the calculations above made, while no satisfactory result would be obtained by their inclusion.

82. Indeed, the figures obtained in the above cases can only be approximated to as there are many additional considerations which, to a great extent, determine the depth and breadth especially through the city, other than those just referred to.

83. It is not intended (except in regard to St. Andrew's and St. Mary's bridges, which require consideration by themselves) to make any proposal for the increase of the waterways of the bridges.

84. It is desirable that the gradients, as above calculated, should be fixed with reference to the levels of the bed of the river at the bridges, omitting the scour depths ; that is to say, to fix the new bed level as nearly as possible at the level at which the top of the floors would have been placed in the bridges when originally designed and it is found that to do so it will be necessary to start from the Napier bridge with the bed of the river at a level of 10·50, which is 6 feet above the lowest point of scour at present.

85. It should be here observed that all the levels in this report have reference to DeHavilland's datum, and not to the Trigonometrical Survey datum, and, for this reason, that some of the survey work was done so long ago as 1883-84 and the bench marks in Madras City are on the DeHavilland datum ; and it was therefore more convenient to work out the scheme on that datum

91. The determination of the gradients allow of the proposed cross section of the river being fixed and these will be found in sheets No. 3 to No. 3/6, where the area of earth to be removed from the river bed and to be embanked is shown. The amount of earth to be excavated between the proposed weir and the sea is estimated at 808,770 yards and above that point at 333,000 yards. This is a very large quantity and the question which naturally presents itself is — What is to be done with it ?

92. It must be remembered that all the foregoing calculations are based on the idea of the acceptance of the proposals for closing the north arm, for, if the north arm be not closed, there will be less water coming down the main branch below Law's bridge and less provision for it will be required to be made.

93. Assuming, however, that the north arm is to be closed, we have to fill into that arm 723,040 cubic yards of earth, and for banking the sides of the Cooum we require 47,319 cubic yards, a total of 770,359, which is less than what will be removed from the main branch below Harris' bridge, viz., 808,770. But there is one improvement that I think very desirable, and that is the improvement of the Island itself. Sections sheet No. 10 show that it lies extremely low and it is very liable to floods; by stripping the low portions 12″ deep and burying the stuff to be removed from the Cooum, a great improvement will be effected, and that improvement will be for the benefit of the Military and the general public.

94. There may be some fear that the stuff to be removed from the Cooum will be deleterious when exposed and may cause an outbreak of disease. I do not anticipate any such result, and I feel certain that the stuff when removed and exposed to the influence of a tropical sun will have much less effect on the people than lying where it is as a breeding ground for all these organisms which are now produced in the Cooum waters. This, however, is a matter on which some persons may hold one opinion and some another; it may be, however, noted that during the famine the bed of the Cooum was greatly exposed, that a large number of famine coolies were set to work to clear it; the exposure of such emaciated creatures to the imminent risk of disease was not an act which would have been sanctioned, and I do not think that there is any recorded outbreak because of the famine coolies being placed on such work, hence we may conclude that the proposals now made will not affect the health of the town.

95. The manner of removing and locating the removed material now claims attention.

96. I have given the matter serious consideration and I have come to the conclusion that the only satisfactory way of removing the Cooum deposits and of forming the bed into proper section is by means of a specially designed dredger and by a light tramway of about 1 mile in length which will be laid along the banks of the Cooum where required, and moved and relaid from time to time.

97. The railway would be used for the following works :—

(1) To carry the earth for filling in the north arm.
(2) To convey the stone for the sea groin from the South Indian Railway across the Island.
(3) To carry earth along the bank of the Cooum from the place of excavation to the place of deposit.
(4) And finally the railway might be handed over to the Municipality who require some such appliance for the removal of rubbish from the heart of the town to some distance from it. One mile would perhaps not be enough and 1½ to 2 miles might be required.

98. The dredger may also require to be used for clearing the channel which is to be kept open to the sea, and for this purpose it will be necessary that the dredger pass the Napier bridge. It cannot pass under it as the bridge is too low at present. This bridge, however, is in such a decayed state that I have for some years been endeavouring to effect its removal, and only a few years ago its bracings were almost entirely renewed, but the top and bottom booms are now almost entirely gone. The bridge, in fact, is in a dangerous state, and will immediately require at least new girders for its whole length, if not new piers.

99. My present reason for referring to it, however, is in regard to the dredger; should the proposal to open the bar be accepted, arrangements should be made to allow of its passing under the bridge, and my proposition is that, whatever way the bridge is renewed or restored, the spans over the new outlet channel be made in the form of a lifting girder bridge. In this class of bridge by means of balance weights, the spans are bodily raised to any required height above the ordinary floor level so that vessels can pass underneath. The cost of my proposal as regards two spans of 50 feet each would be about Rs. 20,000. By the adoption of this proposal the dredger would be able to pass in and out, and so also, I believe, could other boats and vessels, and I do not see any reason why a constant communication may not by this means be maintained between the harbour, the Cooum and the canals.

100. Whichever plan of keeping the lower portion of the river tidal is adopted, it will have to be dredged, and the proposed method of dredging would be somewhat similar to what is to be seen on the Suez Canal and also to what is adopted in Holland, viz., the stuff raised by

the dredger, in some cases mixed with water, will be sent on to the bank through pipes or by means of an endless belt. The earth will when dry be loaded into wagons in the light railway and deposited where required; in cases where the river is to be narrowed, the earth will be deposited by similar means on to the slopes and allowed to fall on the face thereof until the proper section of the river has been obtained.

101. The plan of the improved course of the river shows where such narrowing is proposed. The dredger would be used only in the tidal portion of the river; the upper portion would be excavated by ordinary manual labor.

102. A sketch of the class, but not the size, of dredger proposed will be found attached. The gearing must be capable of being lowered to pass the low bridges on the river.

103. As before explained I propose to form two wharves—one above Law's bridge on the left bank of the river where there is now a considerable traffic, the income from which is at present derived by the Municipality though the ground on which goods are landed is within the river boundary, and another at Harris' bridge. On the right bank below the weir, there is a landing place at present just below the bridge, the depth of the river at present is insufficient but it will be increased even at low tide. The present landing place below St. Andrew's bridge will also be improved.

104. I propose to increase St. Andrew's bridge (which has at present only 3 spans and 2 extra small arches) by another span on the left bank where there is room for it. The approach of this bridge encroaches considerably on the river area.

105. The new level of the bed at this bridge will be 14·75, and if the waterway of the bridge be extended from 144 feet to 192 feet, the depth required to pass 10,986 cubic feet of water per second will then be the same as at Harris' bridge, viz., with an area of 2,197 square feet, say, $\frac{2197}{192} = 11{\cdot}4$ feet or slightly more than at Commander-in-Chief's bridge; with its present length of waterway it requires $\frac{2197}{144} = 15{\cdot}2$ feet, which is 3·8 feet higher; the reduction will decrease the recurring flooding of the district of Lang's Garden just above the bridge.

106. I have already alluded to the banking of the left bank between St. Andrew's bridge and Law's bridge, and provision for it will be found in the estimates.

107. The following are the groins I propose to construct to ensure deep water in the centre of the bed of the river:—

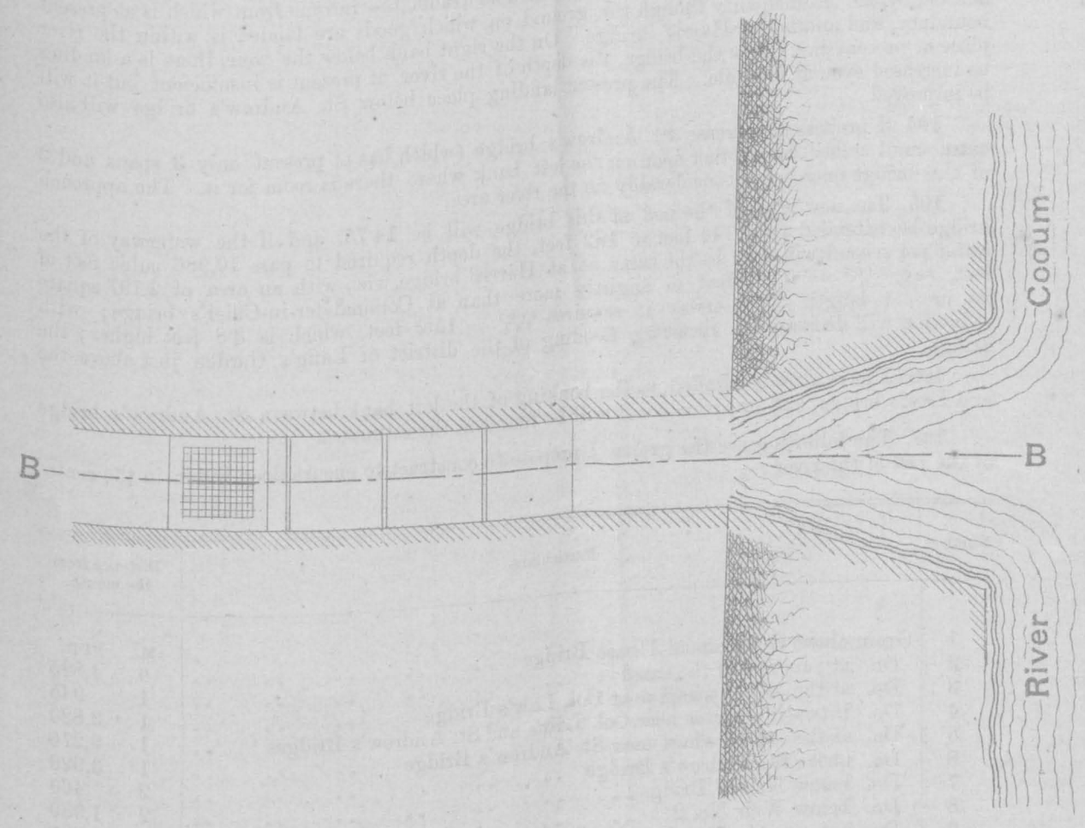
Number.	Particulars.	Distance from the mouth. M.	FUR.
1	Groin above Government House Bridge	0	4,825
2	Do. at junction of the canal	1	945
3	Do. at the end of wharf near Col. Law's Bridge	1	2,820
4	Do. between wharves near Col. Law's and St. Andrew's Bridges	1	3,270
5	Do. at the end of wharf near St. Andrew's Bridge	1	3,920
6	Do. above St. Andrew's Bridge	2	460
7	Do. below Harris' Bridge	2	1,980
8	Do. below Weir No. 2	2	4,380
9	Do. between Commander-in-Chief's Bridge and Weir No. 3	3	1,150
10	Do. between do. do. do.	3	1,710
11	Do. below Anderson's Bridge	3	4,490
12	Do. above Weir No. 4	4	2,110
13	Do. above do.	4	2,740

108. While in the foregoing due provision has been made for the discharge of all the water of the Cooum and canal by its main branch, the cut between the canal and the main branch must be improved to procure a sufficient area for all the discharge which comes *viâ* the canal; this amounts to the drainage of 8 square miles and the amount to be discharged 1,241 feet per second. I propose to give a sectional area to this cut of 800 square feet, and, while constructing the lock already referred to, to improve St. Mary's bridge—which at any rate in a very short time would in any case have required renewal—and to give it two spans of 40 feet, the same as the bridge of the South Indian Railway. The depth of water will be about 10 feet, so that the amount capable of being discharged through the cut with a velocity of 5 feet per second will be 4,000 cubic feet a second, which is much more than required.

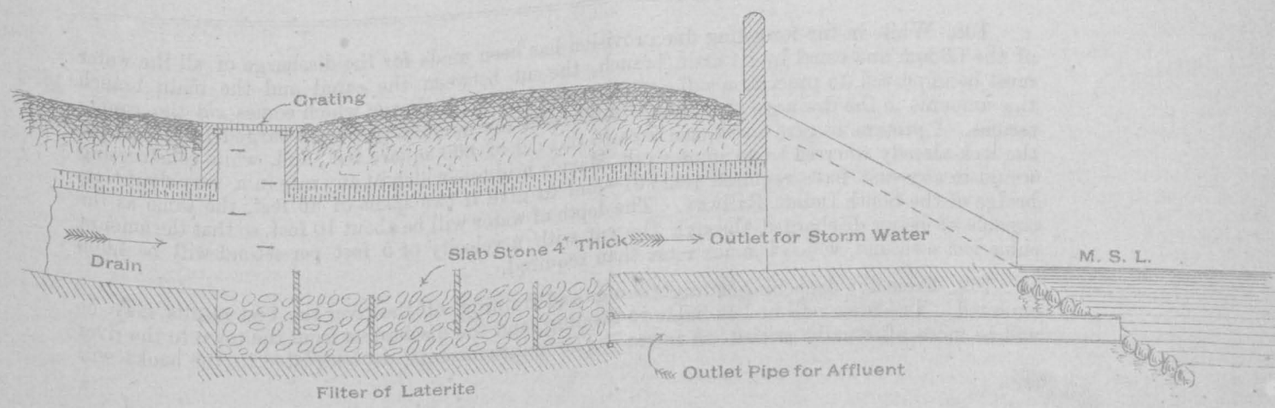
109. From the deepening, straightening and training of the river the best results may be expected. The town will be less liable to flooding, and the discharges from the town to the river will be more effectually carried off to sea. The improvements contemplated to the banks will

SCHEME FOR IMPROVEMENT OF RIVER COOUM

Sketch of Proposed Sewage Filters at the Mouth of Drain



SECTION ON B. B.



Zincographed in Central Survey Office Madras

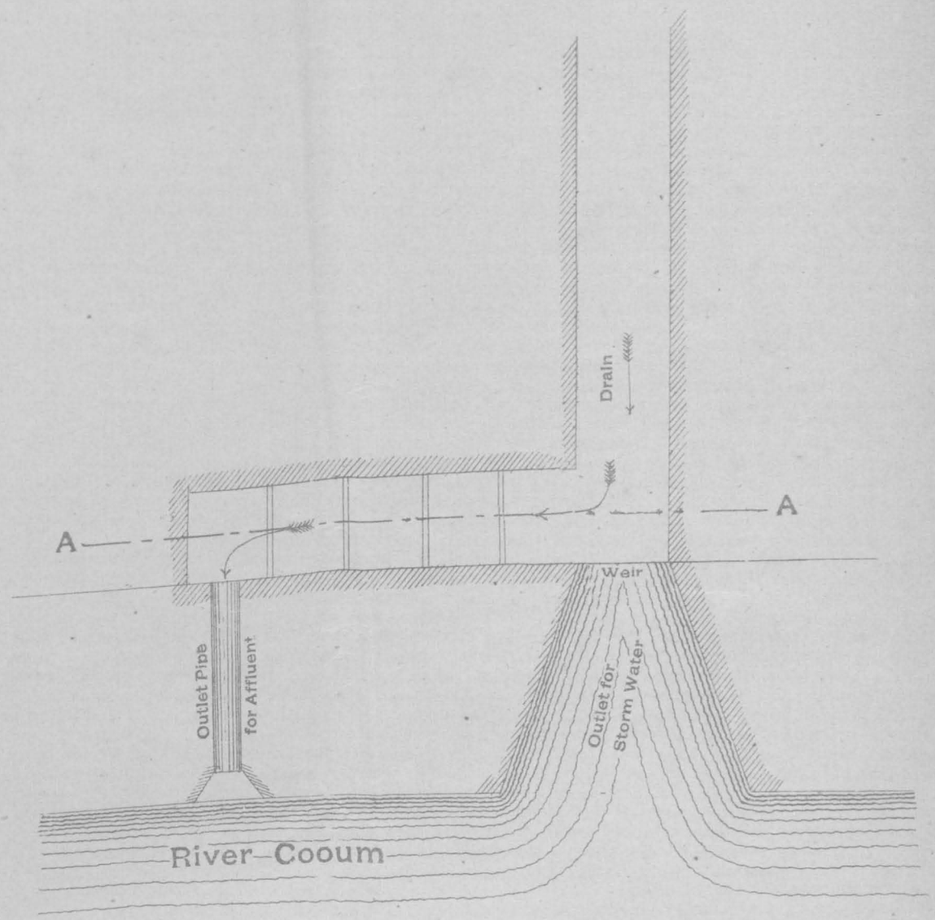
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RECORD OFFICE

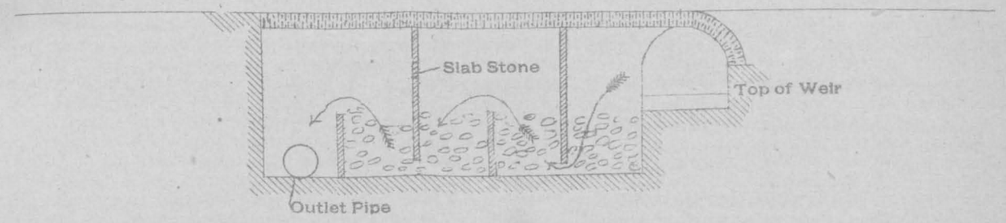
SCHEME FOR IMPROVEMENT OF RIVER COOUM

Sketch of Proposed Alternative Sewage Drain

AT THE MOUTH OF DRAIN



SECTION ON A. A.



Lithographed in Central Survey Office Madras

1891

MADRAS RECORD OFFICE

make a marked improvement to the city. In very few cases has it been found necessary to encroach on adjoining lands, the most prominent instance of encroachment is in Napier Park, but I have less hesitation in recommending this knowing that a large portion of the river was taken and added to the Park some years ago and Government will only be resuming or taking little more than what belonged to it, and that for the public good. There is no doubt that more sectional area is required at this point. Deficient sectional area can result only in flooding the portions above the point of reduction of area.

110 One important proposed measure yet remains to be described, viz., the manner of preventing the deposit of the solid portion of the sewage in the river and the purifying of the effluent.

111. As the purification of the sewage does not require to be so efficient as if it were to pass into a stream the waters of which may afterwards be used for dietetic purposes, it will not be necessary to adopt the ordinary slow rate of filtration of 6″ in depth per hour. What is chiefly required is the arrestment of solid matters, actual contact of every particle of the water with the filtration medium is therefore not necessary. I propose that at the outlet of each drain a set of settling tanks or filter such as are used in the Gorbals water-works system of filtration be placed at or above the mouth of each drain, where the level will permit, and that when these are constructed the Municipal Commissioners be required to keep a proper staff to regularly attend to them and remove the solid matter; the design of these filters or tanks is shown in the sketch accompanying.

112. The best material for use in the filters will be ordinary laterite, small and large, as used for metalling roads. The iron in it will have considerable effect in the way of purifying the sewage as well as arresting the solid matter.

113. These filters may be placed either in the river at the mouth of the drain or as high as possible. Flood water will pass over them; at such times it will be impracticable, as it will also be unnecessary, to filter the contents of the drains.

114. The three drains marked as follow require special treatment. No. 3-R.B. is the main drain of Triplicane, it has a discharge of 525,000 gallons daily, an average of 22,500 gallons per hour or a maximum of 45,000 gallons or 7,200 cubic feet per hour. The sewage during the day is pumped up on to a portion of Napier Park in which there has been formed a sewage farm, but during the night and a portion of the day and on Sundays and Holidays the sewage flows into the Cooum. Arrangements should be made by the Municipality to pump night and day; there is not available sufficient land to use up all the sewage coming down this drain and therefore filters must be used as at other drains, but as this drain enters the Cooum at the low level of 18·98, filters cannot be placed below the level of the floor of the drain. I propose therefore that, on the line of the drain and above it, a set of filters be erected — there is plenty of space for this away from the Park — and that, when the sewage cannot be pumped on to the sewage farm, pumping be continued by running all the sewage through the filters, which may be somewhat differently arranged to those at most of the other drains. No alteration would be necessary to the present pumping station in the Park; an additional pipe would have to be laid or channel made from the pumps to the filters. This drain, probably more than any other, causes the filthy state of the Cooum near or below Government House bridge, and some special measures are therefore very necessary in regard to it.

115. On the left bank of the Cooum are two other large drains which must be similarly treated. One is the drain which receives all the sewage of New Town, Vepery No. 1-L.B., and which discharges just below Law's bridge close to the Penitentiary; who knows but that this drain may not be responsible for the outbreaks of disease among the prisoners, for they do garden work in close proximity to the outfall of the drain? A portion of the contents of the drain during the day is raised from a well in, and distributed over a portion of, the People's Park. The lifting is done by picottahs, and the raising and stirring up of the sewage is a nuisance to those who live in proximity to the well and is also a nuisance to those who frequent the Park. His Excellency the Governor has once or twice publicly remarked on this nuisance, and I propose to deal with this drain very similarly as regards filtration to the Triplicane drain outlet at the Napier Park. Here, instead of the picottahs, should be placed a small steam or hydraulic motor. Such motors run for hours without attention, the latter motor can sometimes be arranged to run for days. The well should be covered in and properly ventilated high above adjacent buildings. A system of covered filters would be placed over this drain also. There would then be no nuisance. The discharge of the sewage on to the grass would not be noticed, and during damp weather and at nights, instead of the sewage finding its way into the Cooum as it does now, it would be sent through the filters. A very great sanitary improvement would result by this method.

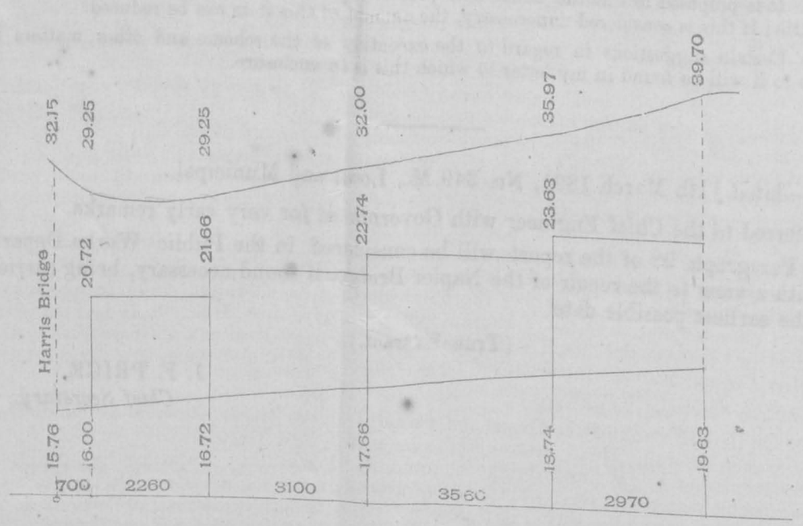
116. At Lang's Garden Road near the Egmore Police Court is another drain No. 8 L.B. of similar character. There is a sewage farm and a well, but the area of land is insufficient to take all the sewage none of which is lifted after sunset. A large proportion, therefore, goes into the Cooum. Similar arrangements to what are proposed for the People's Park drain are necessary.

117. Should the drainage of Triplicane be early taken in hand, as it ought to be, all the sewage on the right bank will be diverted, and it will be very easy by the Shone system to join to it those sewers which run in on the left bank. This, no doubt, is the proper and most perfect way of diverting sewage from the Cooum. The proposals I have advocated are proposals which, in event of improved drainage not being carried out, may be accepted as tentative improvements. It will take some years to effect the drainage of Triplicane and Vepery, and until then the improvements suggested would be of benefit. The motors, which cost from £100 to £200, could then be moved elsewhere.

118. I now pass to consider the manner in which the upper reaches of the river should be dealt with.

119. What is desirable is to secure a depth of water in the river which will at all times under ordinary circumstances cover the bed.

120. The months during which there is ordinarily no rainfall which would to any extent affect the river are January to June, or, say, six months. The evaporation and percolation during these months may be taken as amounting to 4 feet, and this is the least depth that ought to be retained in that portion of the river not in connection with the sea, that is to say, we must have a series of tanks at least 4 feet deep at the upper end and varying at the other according to the fall of the river bed; the rise of the river from the permanent weir already proposed to Munro bridge is from 16·00 to 19·63, in all 3·63 feet, so that to cover the bed 4 feet deep at Munro bridge, if no other weirs were used, the permanent weir proposed would have to be 7·63 feet high. The permanent weir near Harris' bridge, however, from engineering consideration, viz, the necessity for keeping it as low as possible to pass floods, &c., cannot rise to a greater height above the bed than 4 or 5 feet, so that it will be necessary to place another weir a comparatively short distance above it. It is desirable to keep the weirs as low as possible, in order not to back up the subsoil water to too great a height under the adjoining lands; the banks of the river, however, are very much higher along its upper than its lower reaches and three weirs above the permanent weir are found to be sufficient and practicable.



121. The banks are fairly high at all the places where these weirs are proposed to be erected, and a calculation shows that if permanent weirs be put in, they would not raise the flood waters to an extent greater than the banks will allow, that is, they will not raise the river so as to cause flooding of adjacent lands. They will probably be much less expensive in the end than earthen weirs, which must be protected in some way or other and which would require restoration from year to year.

122. The design of the weirs will be similar to that of the permanent weir already described, and each weir will have self-opening sluices of considerable capacity for discharge.

123. The river would, of course, be first sectioned in the upper reaches before the weirs are built.

124. I propose to turf the banks and protect the same with fascines; sea turf should be used and a staff must be kept on to protect the turf until it is in a growing state. At some portions of the river retaining walls and stone pitching are required to avoid encroaching on roadways, &c., and to permit of the river retaining its necessary width.

124A. Such generally are my proposals for the improvement of the River Cooum.

MADRAS RECORD OFFICE

125. In the present state of matters it was, I thought, not desirable to go very deeply into estimate details; the figures I have given are, therefore, to be accepted only as approximate but sufficiently close probably to allow Government to consider whether the benefits to be obtained are sufficiently commensurate with the expenditure to be incurred.

126. I desire, however, to call attention to certain portions of the estimate which seem to require explanation.

127. *Item No.* 3 *in Estimate No.* 1 is not an essential one to the scheme unless it be found that the funnel-shaped mouth gets unduly silted and cannot be kept open even with the plan of tidal gates maintaining high tidal level in the river until low tide. If the dredger must be used, then the alteration in the bridge must be effected, but the bridge will have to be soon renewed at any rate, and the whole cost of the alteration of the two spans is not fairly debitable to this estimate.

128. *Item No.* 5 *in Estimate No.* 1 does not appear in Estimate No. 2, as the scoop-drain is a storm drain and may enter the proposed canal at the same place that it now does the river.

129. *Item No.* 7 *in Estimate No.* 1 *or Item No.* 4 *in Estimate No.* 2.—Provision is made in the former estimate for a double lock to suit its position near bridges of double 40 feet spans. The sea canal enters the river *via* St. Mary's bridge, it may be better to put the lock up near Elephant Gate bridge, where probably a single lock will be sufficient.

130. *Item No.* 9 *in Estimate No.* 1 *and Item No.* 6 *in Estimate No.* 2.—This item will not be required if the drainage of Madras is carried out as proposed. The proposals are of a tentative nature.

131. *Item No.* 10 *in Estimate No.* 1 *and Item No.* 7 *in Estimate No.* 2.—A portion of this item is for three wharves to accommodate traffic up the river, and they are much required. The wharves themselves will cost about Rs. 35,000, and an income of not less than Rs. 1,500 per annum may be expected from the three.

132. It is proposed to turf the banks and protect the toes of the slopes by piling filled in with wattle; if this is considered unnecessary, the amount of this item can be reduced.

133. Certain suggestions in regard to the execution of the scheme and other matters in reference to it will be found in my letter to which this is an enclosure.

Order—dated 11th March 1891, No. 349 M., Local and Municipal.

Referred to the Chief Engineer with Government for very early remarks.

2. Paragraph 98 of the report will be considered in the Public Works Department with a view to the repair of the Napier Bridge, if found necessary, being carried out at the earliest possible date.

(True Extract.)

J. F. PRICE,
Chief Secretary.

To the Chief Engineer to Government, Public Works Department, with plans and estimates.

„ Public Works Department.

Exd. A. Raitt.

Govt. of {1891} Madras.

LOCAL AND MUNICIPAL.

Returns to Endorsement
Cadjan —

Issued

Recd. *Encl.*

G.O., 11th March 1891, No. 349 M.

MARCH.

Cooum River.

Forwarding to the Chief Engineer with Government, for very early remarks, Mr. Jones' scheme for the improvement of the —, and stating that paragraph 98 of the report will be considered in the Public Works Department with a view to the repair of the Napier Bridge, if found necessary, being carried out at the earliest possible date.

86. The mean sea level as fixed by De Haviland would be at a level of 20·00; it has, however, been shewn by the erection of a tide guage at Madras that the correct level of mean sea according to De Haviland's datum is 18·97 or 1·03 feet lower than De Haviland calculated it. The proposed level of 10·50 for the bed of the river at Napier bridge is therefore 8·47 feet below mean sea level, and taking the range of tides as 3 feet, the lowest spring tide would fall to a level of 18·97—1·50 = 17·47, so that a level of 10·50 gives the bed at the Napier bridge about 7 feet below the lowest spring tide.

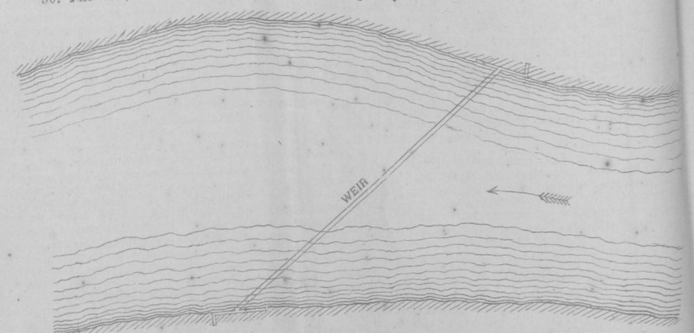
87. From the table in paragraph 79 it will be seen that the total proposed rise in the river is 9·13 up to Munro bridge, so that the spring tides starting with a level of 18·97 + 1·50 = 20·47 would reach that bridge; the bed there having a level of 19·63, this would cover it by about 20·47—19·63 = 0·84 feet, that is if the necessary minimum gradients are not exceeded. The calculated gradients and levels proposed to be adopted are shown below:—

—	Calculated rise.	Mean level of sea.	Calculated level of bed.	Depth below H. S. tide 20·47.	Depth below L. S. tide 17·47.
Tidal.					
Napier	0	18·97	10·50	9·97	6·97
Government House	1·38	18·97	12·58	7 89	4·89
Law's	·79	18·97	13·96	6·51	3·51
St. Andrew's	1·17	18·97	14·75	5·72	2·72
Harris'	1·01	18·97	15·76	4·71	1·71
Not Tidal.					
Commander-in-Chief's	1·20	18·97	16·96	3·51	0·51
Anderson's	1·21	18·97	18·17	2·30	— 0·70
Munro Bridge	1·46	18·97	19·63	0·84	— 2·16

88. In paragraph 13 I have given certain reasons for selecting a point above Harris' bridge for a dividing weir, and that the point selected is the proper one is shown by the fact that, in addition to the reasons given in the paragraph referred to, there is the fact that the river bed at this point will have a level of 16·00, so that with a L. S. T. (17·47) we will have about 1·5 feet of water in depth at the foot of the weir. The exact point is 700 feet above Harris' bridge, cross section No. 16. The plans of this weir will be found in sheet No. 6 and training walls will have to be built below the weir as far as Harris' bridge, one of these training walls will be the front wall of the wharf which it is proposed to form at this point.

89. The floods will not cause a rise over this weir of more than 2 feet in depth, but in case the rise in the river over this weir is greater than this, I propose to have self-acting sluice doors in the weir, as in all other weirs, so that the area of obstruction will be reduced and the maximum overflow limited. The river, at the place where I propose to place the weir, has a cross sectional flood area of 2,935 square feet against 2,163 square feet at Harris' bridge just below and 2,163 square feet higher up.

90. The weir, as other weirs, I propose to place diagonally thus:—



so that the greatest scour will be on the side where the banks are highest and this will also cause less scour on the concave side of the river at the bridge.

Note.—To face Para 100

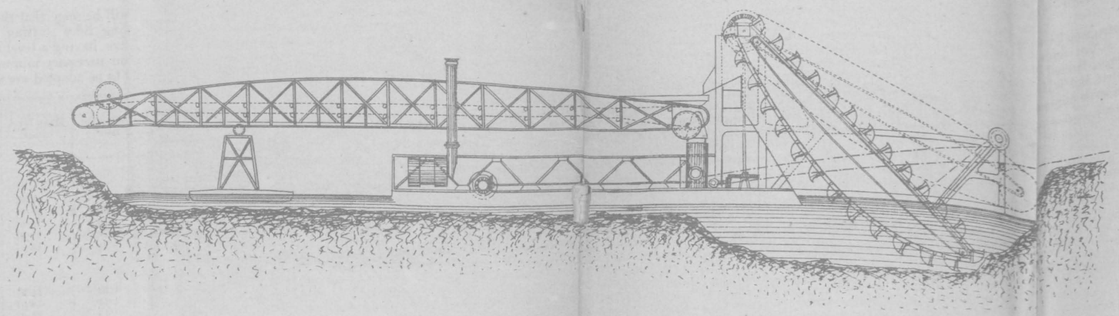
IMPROVEMENT OF RIVER COOUM

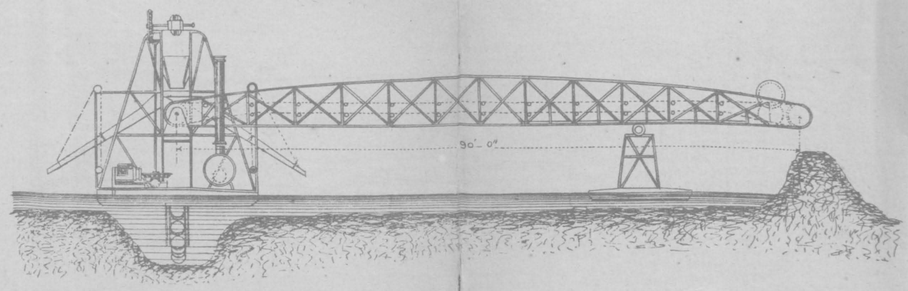
SKETCH PLAN

SHEWING CLASS OF

DREDGER

PROPOSED TO BE USED





OFFICE OF THE SANITARY ENGINEER TO GOVT:
FORT ST. GEORGE DECR 1890

MEM: INST: C.E.
SANARY ENGINEER TO GOVT.

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