Public Works (1896) Department.

G.O., No. 397

Dated 31-1-96

[Despatch Abstract]

Mangalore Harbour: Letter from C.J. Walsh submitting his final report and proposals for improving the Mangalore "Lower" harbour and its entrance, Comd with remarks by Supdg: Engineer, IV Circle, for submission of detailed estimates.

BACK PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

FURTHER PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

No. 397 W., 31st January 1896.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Civil Works.

Read—the following paper :—

From G. T. WALCH, Esq., Mem. Inst. c.e., to the Chief Secretary to Government, dated Ootacamund, 14th November 1895.

With reference to paragraph 1 of G.O. No. 377, Marine, dated 21st September 1894, G.O. No. 419, Marine, dated 1st November 1894, and paragraph 4 of G.O. No. 159, Marine, dated 5th June 1895, I have now the honour to submit my final report and proposals in connection with the Mangalore "Inner* harbour and its entrance."

* See paragraph 7 of Preliminary Report.

I would have sent this report sooner, but I have for some time been hoping to get the Proceedings of Madras Government with the Arsikere-Mangalore Railway survey, which I was informed would be accompanied by a "note" on the Mangalore harbour, by Mr. Gilchrist, the Engineer-in-Chief of the Railway Survey, and that note I thought it would be advisable to deal with in my report.

This was specially the case as Mr. Gilchrist was good enough to let me know a good deal that there would be in his "note," and there was evidently much that I could not agree with. However, so much time has passed that I cannot any longer delay my report.

Besides plan A, which accompanies the "report," I send herewith the undermentioned charts specially prepared for me, whilst studying the subject, by Mr. Simpson, the Port Officer, with the help of a Surveyor, and of Mr. Vas, Sub-Division Officer, Public Works Department. To Mr. Simpson I am much indebted for his earnest endeavours during seven months to do what I wanted as far as was possible with the somewhat limited time, and rough appliances at his disposal.

The difficulty of dealing with the subject owing to the absence of such charts and records for previous years is noted in paragraph 5 of my letter, dated 24th May 1895, printed with Proceedings of Madras Government, No. 159, Marine, dated 5th June 1895.

Enclosures.

List of charts referred to in letter above.

1	Chart (tracing)	Mangalore backwater and entrance (scale 1″ = 660′)		do.	for Nov. and Dec. 1894.
1	Do.	do.	do.	do.	for January 1895.
1	Do.	do.	do.	do.	for February 1895.
1	Do.	do.	do.	do.	for March 1895.
1	Do.	do.	do.	do.	for April 1895.
1	Do.	do.	do.	do.	for May 1895.
1	Chart (tracing), Entrance to backwater (scale 1″ = 100′)				
1	Combined tracing of charts for November and December 1894, and April 1895 (scale 1″ = 660′)				

Mangalore Harbour.

Final Report and Proposals.

(Referred to in Proceedings of Madras Government No. 377, Marine, dated 21st September 1894, and No. 419, dated 1st November 1894.)

Before proceeding with this report, it will be convenient to re-read the "Preliminary Report" which will have to be frequently referred to.

Preliminary Report called for in G.O. No. 296, *Marine, dated 25th July* 1894.

Mangalore port consists of an open roadstead where large vessels anchor from one to two miles from the shore, and a "backwater" forming an inner harbour used by the smaller sea-going craft ("pattimars"); access to this inner harbour is through the channel by which the waters of two rivers (the "Nétrávati" and the "Gurrupúr" river) find their way to the sea, the channel being kept open, even when no fresh water is coming down the rivers, by the tidal scour due to the extensive natural basin affected by the tides.

2. *Mangalore town* lies for about 3 miles along the eastern side of the "backwater," which there varies from 1,800 to 2,800 feet in breadth, and is separated from the sea by a low strip of sand, nowhere more than 1,000 feet wide and in parts but little more than 100 feet.

3. Into the "backwater" at its northern end near "Sultan's Battery" flows the "Gurrupúr river" draining some 320 square miles, and across the southern end of the backwater near the "Marine yard" flows the Nétrávati draining about 1,220 square miles. For some 3 or 4 miles before it enters the backwater proper near Sultan's Battery, the course of the "Gurrupúr river" is nearly north and south and roughly parallel to the coast, but the course of the Nétrávati for its last few miles is almost east and west, nearly at right angles to the coast line.

4. The sandy barrier between the backwater and the sea is so narrow, low, and unstable that it is easily breached through when the level of the backwater is raised by river floods; the consequence is that new openings to the sea are frequently formed; sometimes each river has a separate mouth; at other times, as now, there is but one mouth common to both rivers, and these openings or "mouths" shift about along the whole length of the backwater between "Tannirbhavi" opposite Sultan's Battery on the north, and the village of Ullal on the south.

5. This ever-changing position of the harbour entrance and the resulting variations of the state of the bar and of the "backwater," which cause uncertainty as to what from year to year will be the difficulties in the way of shipping, are great drawbacks to the port. Its history is by no means one of continuous deterioration as is sometimes supposed, but one of constant change; a bad state of affairs having been followed by a better one, which has again deteriorated to be followed by improvement, *e.g.*, one of the great complaints as to the present state of the inner harbour is that whereas it used to be deep enough along its eastern side for "pattimars" and large laden cargo boats, to approach the quay (locally known as the "bunder"), the place is now so shallow there that those crafts have to lie some distance from the quay and cargo has to be taken to and from them in small boats; in November 1843, however, the then District Engineer, Captain (now General) F. C. Cotton, R.E., says in his diary . . . . "*no boats* can approach the landing place except near the time of high water and the larger vessels which communicate with the pattimars in the offing make in consequence but one trip a day." . . . "the distance from deep water to the custom-house is about 900 feet;" he therefore proposed dredging a channel for the boats to pass to and from the larger craft; the state of affairs would thus appear to have then been considerably worse than now; and again, the channel from the harbour entrance to the pattimar anchorage opposite the custom-house is now much complained about and is certainly very bad, but in 1837 it was apparently even worse, for in a letter from the "Civil Engineer" to the "Principal Collector, Mangalore," dated 30th May 1837, he says that as the result of there being two mouths to the rivers . . . . "the backwater has become considerably shallow and when the tide is out greatly diminished in breadth, the consequence of which is that whereas formerly pattimars used to lie on the backwater opposite the custom-house, they are now obliged to remain lower down and immediately inside the mouth of the southern river."

6. Records also show that the "bar," though it has sometimes been better than it now is, has not infrequently been worse.

7. There does not appear to have been, in recent times at all events, any deterioration of the open sea anchorage for large vessels, and improvement of it could only be effected by an artificial harbour on the general lines of the one at Madras, at an altogether prohibitory cost. It is not, it is understood, to be now dealt with, the present investigations being confined to the means of making the best of the inner harbour and its entrance.

8. The first step in this direction has been taken by an inspection of the port during the south-west monsoon when the rivers were in fresh, and a general consideration under those conditions of the various proposals which have from time to time been made for improvement of the harbour. All the European merchants and most of the native ones were good enough to state their views and to give all information in their power.

9. But before it can be determined what detail proposals shall be made, it is necessary * that the port should be studied also under the different aspects which it will present when no river waters are affecting it and shipping operations are in full swing; certain surveys and soundings also are required; in the meantime, however, some of the general conclusions already arrived at may be thus stated—

* See covering letter, paragraphs 4 and 5.

(*a*) When, as often has been the case, there have been two openings to the sea, the entrances to the harbour and their "*bars*" have been worse than when the river waters and the tidal scour have been concentrated on one opening.

(*b*) When the "Nétrávati" has had its mouth towards the north of the backwater, its flood waters have scoured out the backwater along the town face to deeper than is the case when that river passes in the most natural course direct to the sea, near the south end of the backwater; but on the other hand the latter position is the best for the harbour entrance and the bar.

(*c*) It is of *primary* importance to secure a good permanent "bar" and entrance to the inner harbour; the difficulties *in it* could always be dealt with by dredging which could be carried on in smooth water at all times.

(*d*) Though it is impossible to divert from the backwater much of the drainage which brings a considerable quantity of silt into it between the "Sultan's Battery" and the "Marine yard," the minor town drains which now form shoals in most inconvenient places along the face of the quay might be so dealt with by silt traps (to be kept constantly cleared by manual labour) that they would cease to be the annoyances and hindrances to traffic that they now are.

(*e*) The tidal scour is the chief, if not the only, factor in keeping the "bar" practicable during the dry season which is also the shipping season, and therefore no appreciable curtailment of the tidal basin should be allowed.

10. From these premises may be deduced the general lines which the proposals to be made will probably have to follow; they are—

(*a*) The protection of the barrier between the sea and the backwater so that it may be possible to carry out,

(*b*) the *fixing* of the entrance and bar and keeping them approximately uniform in size and depth instead of allowing them to vary in those particulars year by year.

(*c*) The provision of means of dredging in the inner harbour whenever and wherever required.

11. It may be at once stated that there is no probability of the "Port funds," now considered as belonging exclusively to Mangalore, being able to meet the cost of the works which will be necessary, but the railway from Mysore will raise the port to a position of such general public importance as would seem to warrant its being dealt with liberally from "Provincial," if not "Imperial" funds.

12. Though perhaps not strictly within the intended scope of this report, it seems right to call attention to the necessity for, *as soon as possible*, dredging out the channel from the harbour entrance to the pattimar anchorage opposite the custom-house; the state of this channel has for some time past seriously hampered the port, and will, if not improved, again this year seriously hamper it. This work is one which may well be met from the local "Port funds" and "dues."

See appendices 1 and 2 with this report for correspondence with the Marine Department about this.

13. There is another subject connected with improvements to the port which it may be as well to notice here, and that is, the proposed reclamation of the ragged foreshore between the present "Bunder" and the "Marine yard" referred to in paragraphs 3 and 5 of letter from the Presidency Port officer, No. 695—276 G., dated 20th July 1894, with Proceedings of the Madras Government No. 297-A, dated 26th July 1894.

The project was worked out in detail by Colonel A. T. Frazer, R.E., then Executive Engineer, West Coast Division, in September 1889. His estimate came to Rs. 45,520 and was doubtless approximately correct. The work appears a most advisable one on its own merits even irrespective of the general improvement of the harbour, especially if the railway runs into Mangalore at, or near, the "Marine yard" as will most probably be the case. This reclamation would not, of course, be recommended if it would appreciably reduce the tidal area [see (*e*) of paragraph 9 *supra*], but this would not be the case, for though it would provide some 11 acres of ground for a road, for wharves, for warehouses, and perhaps for railway sidings, &c., the area is so shoal that the quantity of tidal water which at times covers it forms but an insignificant percentage of that which passes in and out of the harbour mouth. Most certainly no private rights in connection with the foreshore in question should be allowed to spring up.

14. For reference there are sent with this report (1) "Marine chart sheet IX" *borrowed* from the Presidency Port officer, and (2) a copy on tracing linen of a "plan of Mangalore harbour taken in January 1885" *borrowed* from the office of the Superintending Engineer, IV Circle.

(Signed) G. T. WALCH, M. INST. C.E.

OOTACAMUND,
13th September 1894.

Since that preliminary report was written I have paid two more visits to Mangalore—one in February, the other in May. From personal observations then made and from the surveys and soundings taken for me at various times between November and May, I am enabled to submit the following recommendations which, if followed, will, I have no doubt, much improve the inner harbour and its entrance, and will also improve to some extent the *sea bar*, though to have much effect on *it* would require sea walls of upwards of ¾ mile long, extending beyond it into deep water, of so massive a character, to withstand the heavy seas of the south-west monsoon, that the work would assume the general character of the Madras harbour walls, and would be so costly a work that it is useless now to consider it.

Confining myself, therefore, to the inner harbour and its entrance, I recommend—

FIRST.—The protection of the sand-spit, or barrier, between the sea and the backwater, from "Tannirbhavi," nearly opposite Sultan's Battery, to Ullal, so that the formation of any second opening to the sea may be prevented, and the entrance to the inner harbour may be fixed to *one* definite place.

It will be useless to attempt the execution of any of the subsequent proposals, if this first and most essential one be not efficiently carried out to start with.

This part of the work will be easy and comparatively inexpensive. From what I have seen and read, I am convinced that what have to be guarded against are not breaches caused by the sea, but breaches caused by currents and eddies on the backwater side of the barrier; when such breaches occur just before, or whilst the rivers, especially the Gurrupúr river, are in high flood, they give trouble, perhaps for years, though sooner or later the sea closes them and nature reverts to the one opening to the sea somewhere about opposite the end of the Nétrávati river.

The effect of protection put up by private persons along the margins of the backwater, at Ullal and elsewhere, shows that a comparatively slight edging of stone, carried up to near high tide level, will effectually protect the inner margin of the sand-spit from erosion, and it is such protection that I propose should be used, except near and at the Entrance, which will be dealt with separately.

The general disposition for this sand-spit protection is shown on plan No. A herewith; but this, it will be understood, is only an indication of what is proposed, and changes in configuration, depths, &c., which are constantly taking place, may render it necessary to depart considerably from what is now shown; as long as the protection to the sand-spit is effective, the lines in which it is arranged are of minor moment.

SECOND.—The training of the northern, or Gurrupúr, branch of the backwater between Sultan's Battery and the "Marine yard," so that the energy of the freshwater and tidal currents may not, as now, be dissipated over a wide shallow basin, forming in it tortuous channels of little depth, but be more concentrated on the eastern side of the backwater, where depth and comparative straightness of channel are required for navigation.

The best final width for this portion of the backwater cannot, of course, be now laid down with absolute certainty, the conditions to be dealt with are too complex for this, but an average width of about 1,600 feet will not be too narrow, and even this could be worked up to tentatively.

The reclamation which would be required to secure this, is shown on plan No. A by a green wash, and it would be gradually secured by the construction of training groynes, the ends of which, when they had fulfilled their object, and the width for the backwater was finally decided on, might be connected by training walls.

On the plan are shown some suggested positions for the groynes, but it must be understood that here, as elsewhere in dealing with this subject, it is not possible for me on the data at my disposal to lay down absolute sites, &c., for the works recommended, that must be left to whoever has to work out the scheme in detail, and even when that has been done much must still be left to the judgment of the Engineer who carries out the works.

A word of warning must be here given against even commencing these groynes before the protection of the sand-spit has been carried out. Without that protection the groynes would almost certainly cause breaches in the sand-spit.

It is believed that the greater depth which will result from narrowing the backwater will fully compensate, even in tidal volume, for the reduction in the area of the basin, and will provide a more efficient outlet than now for the Gurrupúr river; it is however possible, that here, as in so many somewhat similar cases, assistance from dredging may be required at first to remove shoals and establish the channel which will facilitate the tidal scour.

THIRD.—The training of the course of the Nétrávati river near its mouth, so as to lead the fluvial and tidal discharges more directly on to the harbour entrance than is now the case.

At present much of the discharge, especially of that of the ebb-tide when there is no fresh water coming down the river, runs round the deep bay on the south side of the river, and then northwards along the narrow sand-spit from Ullal to the entrance, where it has to turn at about right angles to its former course in order to pass out to sea. At the same place also it meets the discharge from the Gurrupúr backwater in almost direct opposition, the result being of course a shoal just inside the harbour mouth, which gives much trouble to navigation.

The two branches of the backwater so lie with reference to one another that the waters issuing from them cannot be made to join at a really favorable angle, but at all events the present state of affairs may be much improved by the training suggested, which will also help to guide the flood waters of the Nétrávati on to the entrance and the bar, in the most advantageous direction.

The general arrangement suggested for the training works is shown on plan No. A.

FOURTH.—The fixing of the harbour entrance.

The necessity for this is stated in the Preliminary report; and in his report of 1871, Mr. George Robertson, the harbour expert employed by the Government of India, says: "Perhaps the most important thing that can be done for the improvement of Mangalore is to fix the harbour mouth and prevent its shifting. So long as the mouth wanders about, the bar will never have the full water on it that is due to the available scour." . . . . "The effect of fixing the harbour mouth will very soon be felt at the bar."

As said in the "preliminary report," 9 (*b*), it is believed that the present position of the harbour entrance is about the best, and there it is proposed to fix it.

But before considering how this is to be accomplished, it is necessary to settle what width of entrance should be provided.

In deciding this, the chief element to be considered is that of the flood discharges which have to be passed, and passed without such restriction as will unduly raise the levels of floods along the lower courses of the rivers.

In the preliminary report the drainage areas of the Nétrávati and Gurrupúr rivers were taken, on the best information then available, as 1,220 and 320 square miles, respectively, but the railway authorities now take them, I am informed, as 1,410 and 352 square miles. Adopting these areas and also the formula and co-efficient used by the railway, viz., "Dicken's" * with 825, the flood discharges of the two rivers are 190,000 cubic feet a second, and 67,000 cubic feet per second, respectively, or in all 257,000 cubic feet per second, to pass out to sea through the entrance.

$$* D = 825 M^{\frac{3}{4}}$$

Allowing a velocity through it of 6 miles per hour or, say, 9 feet per second, this large body of water would require 28,555 square feet of sectional area of water-way, and assuming an effective depth of 20 feet, the width required would be slightly over 1,400 feet. This calculation is necessarily largely made up of assumptions, but the width arrived at is about what nature has provided, and to appreciably reduce it would, I believe, be to run serious risk of flooding the margins of the lower reaches of the rivers.

This being the case it is useless to go into any theoretical considerations of whether a narrower entrance would not be better for the simple tidal discharge which has to pass to and fro through it, but I may say that, from what I saw during the spring tides of May, I would not, even if it was the discharge due to them which alone had to be considered, make the width of the entrance much less than now advocated.

To prevent the shifting of the entrance it is necessary to protect the ends of the sand-spits at the place. The simple and inexpensive method which will answer in the backwaters, where the water is still and the scour but slight, will obviously not do here, where the swell and the waves are often considerable, and the scour deep. Nor will it do to try merely a modification of the same method making the protective walls larger, for any such walls would most certainly be undermined and their materials scattered about where they would be constant sources of danger to every craft using the inner harbour. Whatever kind of work is used must go down so deep that it will not be undermined, and it must be composed of materials which cannot be moved and dropped about to form hidden dangers to the shipping; no work practicable at the place meets these requirements except "piling."

In the report already quoted from, Mr. Robertson proposed to fix part of the then harbour mouth, not the present one, by "a row of sheet piling . . . . the piles to come up to high water level, to have a waling on the outside, and to be tied back at intervals to others driven into the bank behind. Stone pitching, or a thick layer of stones, should be brought up from the pile heads in a gentle slope for some distance back so as to form an artificial beach for the sea to break upon." . . . . Mr. Robertson's suggestions as to the kind of work seems generally most suitable and is adopted, except that, for the reasons given above, it is not advisable to form the "artificial beach" at back of the piles, of loose stone, and instead of it, brushwood "mattresses" or "fascine work" should be used.

The construction of these "heads" to protect the ends of the sand-spits at the entrance will necessarily be costly, for the piling along a considerable part of them will have to average some 25 feet long and be driven some 20 feet into sand.

The suggested positions and forms for these "heads" are shown on Plan A, but they are merely approximations, modifications of which will be rendered necessary by alterations in conditions before they are taken in hand.

There accompanies this report an "abstract approximate estimate" for the work recommended, which amounts to Rs. 2,40,000. This is possibly more than Government anticipated, but if the harbour is to be dealt with at all, it should be so in a systematic and fairly complete manner; to merely put, for instance, a groyne here, and another there, and expect any really beneficial result would be futile; better let the place alone than deal with it in a desultory way which would probably prove not only useless but mischievous.

It will be noticed that, except by a remark in the concluding paragraph of the second recommendation, I have not in this report dealt with the question of *Dredging*, because even without it the works proposed would be complete in themselves and efficacious to a considerable extent; but I am still of opinion that the Mangalore inner harbour will never, no matter what works are carried out, be kept in continuously first-rate order without "the means † of dredging whenever and wherever required."

† Preliminary Report, 10 (*e*).

This final report also does not deal with the suggestions made in the "Preliminary" one as to the town drains; and the reclamation between the "Bunder" and the "Marine yard," because the former is a Municipal affair, and the latter, though advisable on its own merits and in connection with the proposed railway, is not a necessity as regards the special object dealt with in this report.

Ootacamund,
14th November 1895. (Signed) G. T. WALCH, M. Inst. C.E.

Abstract approximate estimate for work recommended in final report on Mangalore Harbour.

Dimensions. Length.	Dimensions. Breadth.	Dimensions. Depth.	Quantities.	Description.	Rate.	Per.	Totals.	Remarks.
Ft.	Ft.	Ft.		Recommendation No. 1. *Protection of Sand-spit.*	Rs. A. P.		Rs.	
21,780	3	6	392,040 c. ft.	Stone facing	7 8 0	100 c. ft.	29,400	Assuming average height 6 ft., and breadth 3 ft. Rate, from estimate for similar work supplied by Public Works Department.
				Contingencies	..	..	2,900	
				Total ..	..	..	32,300	
				Recommendation No. 2. *Training Northern, or Gurrupúr backwater.*				
			5,300 Rg. ft.	Groynes	4 0 0	Rg. foot.	21,200	Assuming to be made of stone.
				Planting accretions ..	..	Say.	300	Average height 8 feet. Slopes ½ to 1.
				Contingencies	..	..	2,100	(*Note.*—Various kinds of groynes, *e.g.*, Stone—Earthen banks faced with stone or fascine work—Piles with watt-ling and filled with brushwood—could be tried and the cheapest effective style adopted).
				Total ..	..	..	23,600	
				Recommendation No. 3. *Training Nétrávati backwater.*				
			10,000 Rg. ft.	Training groynes	3 8 0	Rg. foot.	35,000	Made of earth or sand, with stone facing 1 foot 6 inches thick.
				Planting accretions ..	..	Say.	600	Average height 9 feet. Slopes 1 to 1.
				Contingencies	..	..	3,500	
				Total ..	..	..	39,100	
				Recommendation No. 4. *"Heads" to protect ends of sand-spits at entrance.*				
			1,900 Rg. ft.	Sheet piles averaging 25 feet long.	50 0 0	Rg. foot.	95,000	Piles Rs. 1-8-0 per foot. Driving Rs 12-8-0.
			500 ,,	Sheet piles averaging 15 feet long.	30 0 0	Do.	15,000	Piles Rs. 1-8-0 per foot. Driving Rs. 7-8-0.
			4,800 ,,	Waling pieces (2), good jungle wood.	2 0 0	Do.	9,600	Size 12" × 12".
			240 No.	Rear piles, at 10' apart, jungle wood.	15 0 0	Each.	3,600	
			3,600 Rg. ft.	Ties from front to rear piles, jungle wood.	2 0 0	Rg. foot.	7,200	Size 12" × 12".
2,400	15	..	36,000 sq. ft.	Mattress or fascine work for "artificial beach."	2 0 0	100 sq. ft.	720	Rate—rough approximation—no such work yet done.
				Contingencies	..	..	13,880	
				Total ..	..	..	1,45,000	
				Grand Total (exclusive of superintendence).	..	..	2,40,000	

14th November 1895. (Signed) G. T. WALCH, M. Inst. C.E.

Order—No. 397 W., dated 31st January 1896.

Communicated to the Superintending Engineer, IV Circle, who will submit detailed estimates for carrying out the works proposed by Mr. Walch. On receipt of these estimates, the Government will consider the question of the provision of funds.

(True Extract.)

Under Secy. to Govt., P.W.D.

To G. T. Walch, Esq., M.I.C.E.
,, the Superintending Engineer, IV Circle, with enclosures.
,, the Marine Department.

Ezd. T. K. Narayana Aiyangar.
Spare Copies

BUILDINGS AND ROADS.
CIVIL WORKS.

Govt. of {1896} Madras.

PUBLIC WORKS.

Dated January, 31*st.*

Recd. *Encl.*

G.O. No. 397 W., 31st Jan. 1896.

JANUARY.

Mangalore Harbour

Letter from Mr. G. T. Walch submitting his final report and proposals for improving the Mangalore "Inner" harbour and its entrance, communicated with remarks to Superintending Engineer, IV Circle, for submission of detailed estimates.

Please note number & date

No. ~~44, Marine, 23rd January 1896.~~

GOVERNMENT OF MADRAS.

MARINE DEPARTMENT.

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* See paragraph 7 of Preliminary Report.

I would have sent this report sooner, but I have for some time been hoping to get the Proceedings of Madras Government with the Arsikere-Mangalore Railway survey, which I was informed would be accompanied by a "note" on the Mangalore harbour, by Mr. Gilchrist, the Engineer-in-Chief of the Railway Survey, and that note I thought it would be advisable to deal with in my report.

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The difficulty of dealing with the subject owing to the absence of such charts and records for previous years is noted in paragraph 5 of my letter, dated 24th May 1895, printed with Proceedings of Madras Government, No. 159, Marine, dated 5th June 1895.

ENCLOSURES.

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1 Combined tracing of charts for November and December 1894, and April 1895 (scale 1″ = 660′)

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Preliminary Report called for in G.O. No. 296, *Marine, dated* 25*th July* 1894.

Mangalore port consists of an open roadstead where large vessels anchor from one to two miles from the shore, and a "backwater" forming an inner harbour used by the smaller seagoing craft ("pattimars"); access to this inner harbour is through the channel by which the waters of two rivers (the "Nétrávati" and the "Gurrupúr" river) find their way to the sea, the channel being kept open, even when no fresh water is coming down the rivers, by the tidal scour due to the extensive natural basin affected by the tides.

2. *Mangalore town* lies for about 3 miles along the eastern side of the "backwater," which there varies from 1,800 to 2,800 feet in breadth, and is separated from the sea by a low strip of sand, nowhere more than 1,000 feet wide and in parts but little more than 100 feet.

3. Into the "backwater" at its northern end near "Sultan's Battery" flows the "Gurrupúr river" draining some 320 square miles, and across the southern end of the backwater near the "Marine yard" flows the Nétrávati draining about 1,220 square miles. For some 3 or 4 miles before it enters the backwater proper near Sultan's Battery, the course of the "Gurrupúr river" is nearly north and south and roughly parallel to the coast, but the course of the Nétrávati for its last few miles is almost east and west, nearly at right angles to the coast line.

4. The sandy barrier between the backwater and the sea is so narrow, low, and unstable that it is easily breached through when the level of the backwater is raised by river floods; the consequence is that new openings to the sea are frequently formed; sometimes each river has a separate mouth; at other times, as now, there is but one mouth common to both rivers, and these openings or "mouths" shift about along the whole length of the backwater between "Tannirbhavi" opposite Sultan's Battery on the north, and the village of Ullal on the south.

5. This ever-changing position of the harbour entrance and the resulting variations of the state of the bar and of the "backwater," which cause uncertainty as to what from year to year will be the difficulties in the way of shipping, are great drawbacks to the port. Its history is by no means one of continuous deterioration as is sometimes supposed, but one of constant change; a bad state of affairs having been followed by a better one, which has again deteriorated to be followed by improvement, *e.g.*, one of the great complaints as to the present state of the inner harbour is that whereas it used to be deep enough along its eastern side for "pattimars" and large laden cargo boats, to approach the quay (locally known as the "bunder"), the place is now so shallow there that those crafts have to lie some distance from the quay and cargo has to be taken to and from them in small boats; in November 1843, however, the then District Engineer, Captain (now General) F. C. Cotton, R.E., says in his diary . . . . "*no boats* can approach the landing place except near the time of high water and the larger vessels which communicate with the pattimars in the offing make in consequence but one trip a day." . . . "the distance from deep water to the custom-house is about 900 feet;" he therefore proposed dredging a channel for the boats to pass to and from the larger craft; the state of affairs would thus appear to have then been considerably worse than now; and again, the channel from the harbour entrance to the pattimar anchorage opposite the custom-house is now much complained about and is certainly very bad, but in 1837 it was apparently even worse, for in a letter from the "Civil Engineer" to the "Principal Collector, Mangalore," dated 30th May 1837, he says that as the result of there being two mouths to the rivers . . . . "the backwater has become considerably shallow and when the tide is out greatly diminished in breadth, the consequence of which is that whereas formerly pattimars used to lie on the backwater opposite the custom-house, they are now obliged to remain lower down and immediately inside the mouth of the southern river."

6. Records also show that the "bar," though it has sometimes been better than it now is, has not infrequently been worse.

7. There does not appear to have been, in recent times at all events, any deterioration of the open sea anchorage for large vessels, and improvement of it could only be effected by an artificial harbour on the general lines of the one at Madras, at an altogether prohibitory cost. It is not, it is understood, to be now dealt with, the present investigations being confined to the means of making the best of the inner harbour and its entrance.

8. The first step in this direction has been taken by an inspection of the port during the south-west monsoon when the rivers were in fresh, and a general consideration under those conditions of the various proposals which have from time to time been made for improvement of the harbour. All the European merchants and most of the native ones were good enough to state their views and to give all information in their power.

9. But before it can be determined what detail proposals shall be made, it is necessary * that the port should be studied also under the different aspects which it will present when no river waters are affecting it and shipping operations are in full swing; certain surveys and soundings also are required; in the meantime, however, some of the general conclusions already arrived at may be thus stated—

* See covering letter, paragraphs 4 and 5.

(*a*) When, as often has been the case, there have been two openings to the sea, the entrances to the harbour and their "*bars*" have been worse than when the river waters and the tidal scour have been concentrated on one opening.

(*b*) When the "Nétrávati" has had its mouth towards the north of the backwater, its flood waters have scoured out the backwater along the town face to deeper than is the case when that river passes in the most natural course direct to the sea, near the south end of the backwater; but on the other hand the latter position is the best for the harbour entrance and the bar.

(*c*) It is of *primary* importance to secure a good permanent "bar" and entrance to the inner harbour; the difficulties *in it* could always be dealt with by dredging which could be carried on in smooth water at all times.

(*d*) Though it is impossible to divert from the backwater much of the drainage which brings a considerable quantity of silt into it between the "Sultan's Battery" and the "Marine yard," the minor town drains which now form shoals in most inconvenient places along the face of the quay might be so dealt with by silt traps (to be kept constantly cleared by manual labour) that they would cease to be the annoyances and hindrances to traffic that they now are.

(*e*) The tidal scour is the chief, if not the only, factor in keeping the "bar" practicable during the dry season which is also the shipping season, and therefore no appreciable curtailment of the tidal basin should be allowed.

10. From these premises may be deduced the general lines which the proposals to be made will probably have to follow; they are—

(*a*) The protection of the barrier between the sea and the backwater so that it may be possible to carry out,

(*b*) the *fixing* of the entrance and bar and keeping them approximately uniform in size and depth instead of allowing them to vary in those particulars year by year.

(*c*) The provision of means of dredging in the inner harbour whenever and wherever required.

11. It may be at once stated that there is no probability of the "Port funds," now considered as belonging exclusively to Mangalore, being able to meet the cost of the works which will be necessary, but the railway from Mysore will raise the port to a position of such general public importance as would seem to warrant its being dealt with liberally from "Provincial," if not "Imperial" funds.

12. Though perhaps not strictly within the intended scope of this report, it seems right to call attention to the necessity for, *as soon as possible*, dredging out the channel from the harbour entrance to the pattimar anchorage opposite the custom-house; the state of this channel has for some time past seriously hampered the port, and will, if not improved, again this year seriously hamper it. This work is one which may well be met from the local "Port funds" and "dues."

See appendices 1 and 2 with this report for correspondence with the Marine Department about this.

13. There is another subject connected with improvements to the port which it may be as well to notice here, and that is, the proposed reclamation of the ragged foreshore between the present "Bunder" and the "Marine yard" referred to in paragraphs 3 and 5 of letter from the Presidency Port officer, No. 695—276 G., dated 20th July 1894, with Proceedings of the Madras Government No. 297-A, dated 26th July 1894.

The project was worked out in detail by Colonel A. T. Frazer, R.E., then Executive Engineer, West Coast Division, in September 1889. His estimate came to Rs. 45,520 and was doubtless approximately correct. The work appears a most advisable one on its own merits even irrespective of the general improvement of the harbour, especially if the railway runs into Mangalore at, or near, the "Marine yard" as will most probably be the case. This reclamation would not, of course, be recommended if it would appreciably reduce the tidal area [see (*e*) of paragraph 9 *supra*], but this would not be the case, for though it would provide some 11 acres of ground for a road, for wharves, for warehouses, and perhaps for railway sidings, &c., the area is so shoal that the quantity of tidal water which at times covers it forms but an insignificant percentage of that which passes in and out of the harbour mouth. Most certainly no private rights in connection with the foreshore in question should be allowed to spring up.

14. For reference there are sent with this report (1) "Marine chart sheet IX" *borrowed* from the Presidency Port officer, and (2) a copy on tracing linen of a "plan of Mangalore harbour taken in January 1885" *borrowed* from the office of the Superintending Engineer, IV Circle.

(Signed) G. T. WALCH, M. Inst. C.E.

Ootacamund,
13th September 1894.

Since that preliminary report was written I have paid two more visits to Mangalore—one in February, the other in May. From personal observations then made and from the surveys and soundings taken for me at various times between November and May, I am enabled to submit the following recommendations which, if followed, will, I have no doubt, much improve the inner harbour and its entrance, and will also improve to some extent the *sea bar*, though to have much effect on *it* would require sea walls of upwards of $\frac{3}{4}$ mile long, extending beyond it into deep water, of so massive a character, to withstand the heavy seas of the south-west monsoon, that the work would assume the general character of the Madras harbour walls, and would be so costly a work that it is useless now to consider it.

Confining myself, therefore, to the inner harbour and its entrance, I recommend—

FIRST.—The protection of the sand-spit, or barrier, between the sea and the backwater, from "Tannirbhavi," nearly opposite Sultan's Battery, to Ullal, so that the formation of any second opening to the sea may be prevented, and the entrance to the inner harbour may be fixed to *one* definite place.

It will be useless to attempt the execution of any of the subsequent proposals, if this first and most essential one be not efficiently carried out to start with.

This part of the work will be easy and comparatively inexpensive. From what I have seen and read, I am convinced that what have to be guarded against are not breaches caused by the sea, but breaches caused by currents and eddies on the backwater side of the barrier; when such breaches occur just before, or whilst the rivers, especially the Gurrupúr river, are in high flood, they give trouble, perhaps for years, though sooner or later the sea closes them and nature reverts to the one opening to the sea somewhere about opposite the end of the Nétrávati river.

The effect of protection put up by private persons along the margins of the backwater, at Ullal and elsewhere, shows that a comparatively slight edging of stone, carried up to near high tide level, will effectually protect the inner margin of the sand-spit from erosion, and it is such protection that I propose should be used, except near and at the Entrance, which will be dealt with separately.

The general disposition for this sand-spit protection is shown on plan No. A herewith; but this, it will be understood, is only an indication of what is proposed, and changes in configuration, depths, &c., which are constantly taking place, may render it necessary to depart considerably from what is now shown; as long as the protection to the sand-spit is effective, the lines in which it is arranged are of minor moment.

SECOND.—The training of the northern, or Gurrupúr, branch of the backwater between Sultan's Battery and the "Marine yard," so that the energy of the freshwater and tidal currents may not, as now, be dissipated over a wide shallow basin, forming in it tortuous channels of little depth, but be more concentrated on the eastern side of the backwater, where depth and comparative straightness of channel are required for navigation.

The best final width for this portion of the backwater cannot, of course, be now laid down with absolute certainty, the conditions to be dealt with are too complex for this, but an average width of about 1,600 feet will not be too narrow, and even this could be worked up to tentatively.

The reclamation which would be required to secure this, is shown on plan No. A by a green wash, and it would be gradually secured by the construction of training groynes, the ends of which, when they had fulfilled their object, and the width for the backwater was finally decided on, might be connected by training walls.

On the plan are shown some suggested positions for the groynes, but it must be understood that here, as elsewhere in dealing with this subject, it is not possible for me on the data at my disposal to lay down absolute sites, &c., for the works recommended, that must be left to whoever has to work out the scheme in detail, and even when that has been done much must still be left to the judgment of the Engineer who carries out the works.

A word of warning must be here given against even commencing these groynes before the protection of the sand-spit has been carried out. Without that protection the groynes would almost certainly cause breaches in the sand-spit.

It is believed that the greater depth which will result from narrowing the backwater will fully compensate, even in tidal volume, for the reduction in the area of the basin, and will provide a more efficient outlet than now for the Gurrupúr river; it is however possible, that here, as in so many somewhat similar cases, assistance from dredging may be required at first to remove shoals and establish the channel which will facilitate the tidal scour.

THIRD.—The training of the course of the Nétrávati river near its mouth, so as to lead the fluvial and tidal discharges more directly on to the harbour entrance than is now the case.

At present much of the discharge, especially of that of the ebb-tide when there is no fresh water coming down the river, runs round the deep bay on the south side of the river, and then northwards along the narrow sand-spit from Ullal to the entrance, where it has to turn at about right angles to its former course in order to pass out to sea. At the same place also it meets the discharge from the Gurrupúr backwater in almost direct opposition, the result being of course a shoal just inside the harbour mouth, which gives much trouble to navigation.

The two branches of the backwater so lie with reference to one another that the waters issuing from them cannot be made to join at a really favorable angle, but at all events the present state of affairs may be much improved by the training suggested, which will also help to guide the flood waters of the Nétrávati on to the entrance and the bar, in the most advantageous direction.

The general arrangement suggested for the training works is shown on plan No. A.

FOURTH.—The fixing of the harbour entrance.

The necessity for this is stated in the Preliminary report; and in his report of 1871, Mr. George Robertson, the harbour expert employed by the Government of India, says: "Perhaps the most important thing that can be done for the improvement of Mangalore is to fix the harbour mouth and prevent its shifting. So long as the mouth wanders about, the bar will never have the full water on it that is due to the available scour." . . . . "The effect of fixing the harbour mouth will very soon be felt at the bar."

As said in the "preliminary report," 9 (*b*), it is believed that the present position of the harbour entrance is about the best, and there it is proposed to fix it.

But before considering how this is to be accomplished, it is necessary to settle what width of entrance should be provided.

In deciding this, the chief element to be considered is that of the flood discharges which have to be passed, and passed without such restriction as will unduly raise the levels of floods along the lower courses of the rivers.

In the preliminary report the drainage areas of the Nétrávati and Gurrupúr rivers were taken, on the best information then available, as 1,220 and 320 square miles, respectively, but the railway authorities now take them, I am informed, as 1,410 and 352 square miles. Adopting these areas and also the formula and co-efficient used by the railway, viz., "Dicken's" * with 825, the flood discharges of the two rivers are 190,000 cubic feet a second, and 67,000 cubic feet per second, respectively, or in all 257,000 cubic feet per second, to pass out to sea through the entrance.

* $D = 825\ M^{\frac{3}{4}}$

Allowing a velocity through it of 6 miles per hour or, say, 9 feet per second, this large body of water would require 28,555 square feet of sectional area of water-way, and assuming an effective depth of 20 feet, the width required would be slightly over 1,400 feet. This calculation is necessarily largely made up of assumptions, but the width arrived at is about what nature has provided, and to appreciably reduce it would, I believe, be to run serious risk of flooding the margins of the lower reaches of the rivers.

This being the case it is useless to go into any theoretical considerations of whether a narrower entrance would not be better for the simple tidal discharge which has to pass to and fro through it, but I may say that, from what I saw during the spring tides of May, I would not, even if it was the discharge due to them which alone had to be considered, make the width of the entrance much less than now advocated.

To prevent the shifting of the entrance it is necessary to protect the ends of the sand-spits at the place. The simple and inexpensive method which will answer in the backwaters, where the water is still and the scour but slight, will obviously not do here, where the swell and the waves are often considerable, and the scour deep. Nor will it do to try merely a modification of the same method making the protective walls larger, for any such walls would most certainly be undermined and their materials scattered about where they would be constant sources of danger to every craft using the inner harbour. Whatever kind of work is used must go down so deep that it will not be undermined, and it must be composed of materials which cannot be moved and dropped about to form hidden dangers to the shipping; no work practicable at the place meets these requirements except "piling."

In the report already quoted from, Mr. Robertson proposed to fix part of the then harbour mouth, not the present one, by "a row of sheet piling . . . . the piles to come up to high water level, to have a waling on the outside, and to be tied back at intervals to others driven into the bank behind. Stone pitching, or a thick layer of stones, should be brought up from the pile heads in a gentle slope for some distance back so as to form an artificial beach for the sea to break upon." . . . . Mr. Robertson's suggestions as to the kind of work seems generally most suitable and is adopted, except that, for the reasons given above, it is not advisable to form the "artificial beach" at back of the piles, of loose stone, and instead of it, brushwood "mattresses" or "fascine work" should be used.

The construction of these "heads" to protect the ends of the sand-spits at the entrance will necessarily be costly, for the piling along a considerable part of them will have to average some 25 feet long and be driven some 20 feet into sand.

The suggested positions and forms for these "heads" are shown on Plan A, but they are merely approximations, modifications of which will be rendered necessary by alterations in conditions before they are taken in hand.

There accompanies this report an "abstract approximate estimate" for the work recommended, which amounts to Rs. 2,40,000. This is possibly more than Government anticipated, but if the harbour is to be dealt with at all, it should be so in a systematic and fairly complete manner; to merely put, for instance, a groyne here, and another there, and expect any really beneficial result would be futile; better let the place alone than deal with it in a desultory way which would probably prove not only useless but mischievous.

It will be noticed that, except by a remark in the concluding paragraph of the second recommendation, I have not in this report dealt with the question of *Dredging*, because even without it the works proposed would be complete in themselves and efficacious to a considerable extent; but I am still of opinion that the Mangalore inner harbour will never, no matter what works are carried out, be kept in continuously first-rate order without "the means † of dredging whenever and wherever required."

† Preliminary Report, 10 (*c*).

This final report also does not deal with the suggestions made in the "Preliminary" one as to the town drains; and the reclamation between the "Bunder" and the "Marine yard," because the former is a Municipal affair, and the latter, though advisable on its own merits and in connection with the proposed railway, is not a necessity as regards the special object dealt with in this report.

Ootacamund,
14th November 1895.

(Signed) G. T. WALCH, M. Inst. C.E.

Abstract approximate estimate for work recommended in final report on Mangalore Harbour.

Dimensions. Length.	Breadth.	Depth.	Quantities.	Description.	Rate.	Per.	Totals.	Remarks.
Ft.	Ft.	Ft.		Recommendation No. 1. *Protection of Sand-spit.*	Rs. A. P.		Rs.	
21,780	3	6	392,040 c. ft.	Stone facing	7 8 0	100 c. ft.	29,400	Assuming average height 6 ft., and breadth 3 ft. Rate, from estimate for similar work supplied by Public Works Department.
				Contingencies	..	..	2,900	
				Total ..	..	..	32,300	
				Recommendation No. 2. *Training Northern, or Gutty-pûr backwater.*				
			5,300 Rg. ft.	Groynes	4 0 0	Rg. foot.	21,200	Assuming to be made of stone.
				Planting accretions ..	..	Say.	300	Average height 8 feet. Slopes $\frac{1}{2}$ to 1.
				Contingencies	..	..	2,100	(*Note.*—Various kinds of groynes, *e.g.*, Stone—Earthen banks faced with stone or fascine work—Piles with wattling and filled with brushwood—could be tried and the cheapest effective style adopted).
				Total ..	..	..	23,600	
				Recommendation No. 3. *Training Nitrâvati backwater.*				
			10,000 Rg. ft.	Training groynes	3 8 0	Rg. foot.	35,000	Made of earth or sand, with stone facing 1 foot 6 inches thick.
				Planting accretions ..	..	Say.	600	Average height 9 feet. Slopes 1 to 1.
				Contingencies	..	..	3,500	
				Total ..	..	..	39,100	
				Recommendation No. 4. *"Heads" to protect ends of sand-spits at entrance.*				
			1,900 Rg. ft.	Sheet piles averaging 25 feet long.	50 0 0	Rg. foot.	95,000	Piles Rs. 1-8-0 per foot. Driving Rs 12-8-0.
			500 ,,	Sheet piles averaging 15 feet long.	30 0 0	Do.	15,000	Piles Rs. 1-8-0 per foot. Driving Rs. 7-8-0.
			4,800 ,,	Waling pieces (2), good jungle wood.	2 0 0	Do.	9,600	Size 12" × 12".
			240 No.	Rear piles, at 10' apart, jungle wood.	15 0 0	Each.	3,600	
			3,600 Rg. ft.	Ties from front to rear piles, jungle wood.	2 0 0	Rg. foot.	7,200	Size 12" × 12".
2,400	15	..	36,000 sq. ft.	Mattress or fascine work for "artificial beach."	2 0 6	100 sq. ft.	720	Rate—rough approximation—no such work yet done.
				Contingencies	..	..	13,880	
				Total ..	..	..	1,45,000	
				Grand Total (exclusive of superintendence).	..	..	2,40,000	

14th November 1895.

(Signed) G. T. WALCH, M. Inst. C.E.

397 W. 31 Jany 1896

Order—No. 44, Marine, dated 23rd January 1896.

Communicated to the Superintending Engineer, IV Circle, who will submit detailed estimates for carrying out the works proposed by Mr. Walch. On receipt of these estimates, the Government will consider the question of the provision of funds.

(True Extract.)

Under Secy. to Government.

To G. T. Walch, Esq., M.I.C.E.
" the Superintending Engineer, IV Circle, with enclosures.
" the Marine Department.

Is this necessary?
Yes, the order should issue in P.W.D.
Rue 31/1

Exd. T. K. Narayana Aiyangar.
Spare Copies

Please answer the query in page 4

see communication?

Govt. of {1896} Madras.

MARINE.

Dated January, 23rd.

Recd. *Encl.*

G.O. No. 44, 23rd Jan. 1896.

JANUARY.

Mangalore Harbour

Letter from Mr. G. T. Walch submitting his final report and proposals for improving the Mangalore "Inner" harbour and its entrance, communicated with remarks to Superintending Engineer, IV Circle, for submission of detailed estimates.

No. 44 / 23 / Jany 96

No. MARINE, DECEMBER 1895.

GOVERNMENT OF MADRAS.

MARINE DEPARTMENT.

READ—the following paper:—

From G. T. WALCH, Esq., M.M. INST. C.E., to the Chief Secretary to Government, dated Ootacamund, 14th November 1895.

With reference to paragraph 1 of G.O. No. 377, Marine, dated 21st September 1894, G.O. No. 419, Marine, dated 1st November 1894, and paragraph 4 of G.O. No. 159, Marine, dated 5th June 1895, I have now the honour to submit my final report and proposals in connection with the Mangalore "Inner* harbour and its Entrance."

* See paragraph 7 of Preliminary Report.

I would have sent this report sooner, but I have for some time been hoping to get the Proceedings of Madras Government with the Arsikere-Mangalore Railway survey, which I was informed would be accompanied by a "note" on the Mangalore harbour, by Mr. Gilchrist, the Engineer-in-Chief of the Railway Survey, and that note I thought it would be advisable to deal with in my report.

This was specially the case as Mr. Gilchrist was good enough to let me know a good deal that there would be in his "note," and there was evidently much that I could not agree with. However, so much time has passed that I cannot any longer delay my report.

Besides plan A, which accompanies the "report," I send herewith the undermentioned charts specially prepared for me, whilst studying the subject, by Mr. Simpson, the Port Officer, with the help of a Surveyor, and of Mr. Vas, Sub-Division Officer, Public Works Department. To Mr. Simpson I am much indebted for his earnest endeavours during seven months to do what I wanted as far as was possible with the somewhat limited time, and rough appliances at his disposal.

The difficulty of dealing with the subject owing to the absence of such charts and records for previous years is noted in paragraph 5 of my letter, dated 24th May 1895, printed with Proceedings of Madras Government, No. 159, Marine, dated 5th June 1895.

ENCLOSURES.

List of charts referred to in letter above.

1 Chart (tracing)	Mangalore backwater and Entrance (scale 1″ = 660′)		do.	for Nov. and Dec. 1894.
1	Do.	do.	do.	for January 1895.
1	Do.	do.	do.	for February 1895.
1	Do.	do.	do.	for March 1895.
1	Do.	do.	do.	for April 1895.

1 Chart (tracing), Entrance to backwater (scale 1″ = 100′) for May 1895.
1 Combined tracing of charts for November and December 1894, and April 1895 (scale 1″ = 660′)

MANGALORE HARBOUR.

Final Report and Proposals.

(Referred to in Proceedings of Madras Government No. 377, Marine, dated 21st September 1894, and No. 419, dated 1st November 1894.)

Before proceeding with this report, it will be convenient to re-read the "Preliminary Report" which will have to be frequently referred to.

Preliminary Report called for in G.O. No. 296, Marine, dated 25th July 1894.

Mangalore port consists of an open roadstead where large vessels anchor from one to two miles from the shore, and a "backwater" forming an inner harbour used by the smaller seagoing craft ("pattimars"); access to this inner harbour is through the channel by which the waters of two rivers (the "Nétrávati" and the "Gurrupúr" river) find their way to the sea, the channel being kept open, even when no fresh water is coming down the rivers, by the tidal scour due to the extensive natural basin affected by the tides.

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6. Records also show that the "bar," though it has sometimes been better than it now is, has not infrequently been worse.

7. There does not appear to have been, in recent times at all events, any deterioration of the open sea anchorage for large vessels, and improvement of it could only be effected by an artificial harbour on the general lines of the one at Madras, at an altogether prohibitory cost. It is not, it is understood, to be now dealt with, the present investigations being confined to the means of making the best of the inner harbour and its entrance.

8. The first step in this direction has been taken by an inspection of the port during the south-west monsoon when the rivers were in fresh, and a general consideration under those conditions of the various proposals which have from time to time been made for improvement of the harbour. All the European merchants and most of the native ones were good enough to state their views and to give all information in their power.

9. But before it can be determined what detail proposals shall be made, it is necessary * that the port should be studied also under the different aspects which it will present when no river waters are affecting it and shipping operations are in full swing; certain surveys and soundings also are required; in the meantime, however, some of the general conclusions already arrived at may be thus stated—

* See covering letter, paragraphs 4 and 5.

(*a*) When, as often has been the case, there have been two openings to the sea, the entrances to the harbour and their "*bars*" have been worse than when the river waters and the tidal scour have been concentrated on one opening.

(*b*) When the "Nétrávati" has had its mouth towards the north of the backwater, its flood waters have scoured out the backwater along the town face to deeper than is the case when that river passes in the most natural course direct to the sea, near the south end of the backwater; but on the other hand the latter position is the best for the harbour entrance and the bar.

(*c*) It is of *primary* importance to secure a good permanent "bar" and entrance to the inner harbour; the difficulties *in it* could always be dealt with by dredging which could be carried on in smooth water at all times.

(*d*) Though it is impossible to divert from the backwater much of the drainage which brings a considerable quantity of silt into it between the "Sultan's Battery" and the "Marine yard," the minor town drains which now form shoals in most inconvenient places along the face of the quay might be so dealt with by silt traps (to be kept constantly cleared by manual labour) that they would cease to be the annoyances and hindrances to traffic that they now are.

(*e*) The tidal scour is the chief, if not the only, factor in keeping the "bar" practicable during the dry season which is also the shipping season, and therefore no appreciable curtailment of the tidal basin should be allowed.

10. From these premises may be deduced the general lines which the proposals to be made will probably have to follow; they are—

(*a*) The protection of the barrier between the sea and the backwater so that it may be possible to carry out,

(*b*) the *fixing* of the entrance and bar and keeping them approximately uniform in size and depth instead of allowing them to vary in those particulars year by year.

(*c*) The provision of means of dredging in the inner harbour whenever and wherever required.

11. It may be at once stated that there is no probability of the "Port funds," now considered as belonging exclusively to Mangalore, being able to meet the cost of the works which will be necessary, but the railway from Mysore will raise the port to a position of such general public importance as would seem to warrant its being dealt with liberally from "Provincial," if not "Imperial" funds.

12. Though perhaps not strictly within the intended scope of this report, it seems right to call attention to the necessity for, *as soon as possible*, dredging out the channel from the harbour entrance to the pattimar anchorage opposite the custom-house; the state of this channel has for some time past seriously hampered the port, and will, if not improved, again this year seriously hamper it. This work is one which may well be met from the local "Port funds" and "dues."

See appendices 1 and 2 with this report for correspondence with the Marine Department about this.

13. There is another subject connected with improvements to the port which it may be as well to notice here, and that is, the proposed reclamation of the ragged foreshore between the present "Bunder" and the "Marine yard" referred to in paragraphs 3 and 5 of letter from the Presidency Port officer, No. 695—276 G., dated 20th July 1894, with Proceedings of the Madras Government No. 297-A, dated 26th July 1894.

The project was worked out in detail by Colonel A. T. Frazer, R.E., then Executive Engineer, West Coast Division, in September 1889. His estimate came to Rs. 45,520 and was doubtless approximately correct. The work appears a most advisable one on its own merits even irrespective of the general improvement of the harbour, especially if the railway runs into Mangalore at, or near, the "Marine yard" as will most probably be the case. This reclamation would not, of course, be recommended if it would appreciably reduce the tidal area [see (*e*) of paragraph 9 *supra*], but this would not be the case, for though it would provide some 11 acres of ground for a road, for wharves, for warehouses, and perhaps for railway sidings, &c., the area is so shoal that the quantity of tidal water which at times covers it forms but an insignificant percentage of that which passes in and out of the harbour mouth. Most certainly no private rights in connection with the foreshore in question should be allowed to spring up.

14. For reference there are sent with this report (1) "Marine chart sheet IX" *borrowed* from the Presidency Port officer, and (2) a copy on tracing linen of a "plan of Mangalore harbour taken in January 1885" *borrowed* from the office of the Superintending Engineer, IV Circle.

(Signed) G. T. WALCH, M. INST. C.E.

OOTACAMUND,
13th September 1895.

Since that preliminary report was written I have paid two more visits to Mangalore—one in February, the other in May. From personal observations then made and from the surveys and soundings taken for me at various times between November and May, I am enabled to submit the following recommendations which, if followed, will, I have no doubt, much improve the inner harbour and its entrance, and will also improve to some extent the *sea bar*, though to have much effect on *it* would require sea walls of upwards of ¾ mile long, extending beyond it into deep water, of so massive a character, to withstand the heavy seas of the south-west monsoon, that the work would assume the general character of the Madras harbour walls, and would be so costly a work that it is useless now to consider it.

Confining myself, therefore, to the inner harbour and its entrance, I recommend—

FIRST.—The protection of the sand-spit, or barrier, between the sea and the backwater, from "Tannirbhavi," nearly opposite Sultan's Battery, to Ullal, so that the formation of any second opening to the sea may be prevented, and the entrance to the inner harbour may be fixed to *one* definite place.

It will be useless to attempt the execution of any of the subsequent proposals, if this first and most essential one be not efficiently carried out to start with.

This part of the work will be easy and comparatively inexpensive. From what I have seen and read, I am convinced that what have to be guarded against are not breaches caused by the sea, but breaches caused by currents and eddies on the backwater side of the barrier; when such breaches occur just before, or whilst the rivers, especially the Gurrupúr river, are in high flood, they give trouble, perhaps for years, though sooner or later the sea closes them and nature reverts to the one opening to the sea somewhere about opposite the end of the Nétrávati river.

The effect of protection put up by private persons along the margins of the backwater, at Ullal and elsewhere, shows that a comparatively slight edging of stone, carried up to near high tide level, will effectually protect the inner margin of the sand-spit from erosion, and it is such protection that I propose should be used, except near and at the Entrance, which will be dealt with separately.

The general disposition for this sand-spit protection is shown on plan No. A herewith; but this, it will be understood, is only an indication of what is proposed, and changes in configuration, depths, &c., which are constantly taking place, may render it necessary to depart considerably from what is now shown; as long as the protection to the sand-spit is effective, the lines in which it is arranged are of minor moment.

SECOND.—The training of the northern, or Gurrupúr, branch of the backwater between Sultan's Battery and the "Marine yard," so that the energy of the freshwater and tidal currents may not, as now, be dissipated over a wide shallow basin, forming in it tortuous channels of little depth, but be more concentrated on the eastern side of the backwater, where depth and comparative straightness of channel are required for navigation.

The best final width for this portion of the backwater cannot, of course, be now laid down with absolute certainty, the conditions to be dealt with are too complex for this, but an average width of about 1,600 feet will not be too narrow, and even this could be worked up to tentatively.

The reclamation which would be required to secure this, is shown on plan No. A by a green wash, and it would be gradually secured by the construction of training groynes, the ends of which, when they had fulfilled their object, and the width for the backwater was finally decided on, might be connected by training walls.

On the plan are shown some suggested positions for the groynes, but it must be understood that here, as elsewhere in dealing with this subject, it is not possible for me on the data at my disposal to lay down absolute sites, &c., for the works recommended, that must be left to whoever has to work out the scheme in detail, and even when that has been done much must still be left to the judgment of the Engineer who carries out the works.

A word of warning must be here given against even commencing these groynes before the protection of the sand-spit has been carried out. Without that protection the groynes would almost certainly cause breaches in the sand-spit.

It is believed that the greater depth which will result from narrowing the backwater will fully compensate, even in tidal volume, for the reduction in the area of the basin, and will provide a more efficient outlet than now for the Gurrupúr river; it is however, possible, that here, as in so many somewhat similar cases, assistance from dredging may be required at first to remove shoals and establish the channel which will facilitate the tidal scour.

THIRD.—The training of the course of the Nétrávati river near its mouth, so as to lead the fluvial and tidal discharges more directly on to the harbour entrance than is now the case.

At present much of the discharge, especially of that of the ebb-tide when there is no fresh water coming down the river, runs round the deep bay on the south side of the river, and then northwards along the narrow sand-spit from Ullal to the entrance, where it has to turn at about right angles to its former course in order to pass out to sea. At the same place also it meets the discharge from the Gurrupúr backwater in almost direct opposition, the result being of course a shoal just inside the harbour mouth, which gives much trouble to navigation.

The two branches of the backwater so lie with reference to one another that the waters issuing from them cannot be made to join at a really favorable angle, but at all events the present state of affairs may be much improved by the training suggested, which will also help to guide the flood waters of the Nétrávati on to the entrance and the bar, in the most advantageous direction.

The general arrangement suggested for the training works is shown on plan No. A.

FOURTH.—The fixing of the harbour entrance.

The necessity for this is stated in the Preliminary report; and in his report of 1871, Mr. George Robertson, the harbour expert employed by the Government of India, says: "Perhaps the most important thing that can be done for the improvement of Mangalore is to fix the harbour mouth and prevent its shifting. So long as the mouth wanders about, the bar will never have the full water on it that is due to the available scour." . . . . "The effect of fixing the harbour mouth will very soon be felt at the bar."

As said in the "preliminary report," 9 (*b*), it is believed that the present position of the harbour entrance is about the best, and there it is proposed to fix it.

But before considering how this is to be accomplished, it is necessary to settle what width of entrance should be provided.

In deciding this, the chief element to be considered is that of the flood discharges which have to be passed, and passed without such restriction as will unduly raise the levels of floods along the lower courses of the rivers.

In the preliminary report the drainage areas of the Nétrávati and Gurrupúr rivers were taken, on the best information then available, as 1,220 and 320 square miles, respectively, but the railway authorities now take them, I am informed, as 1,410 and 352 square miles. Adopting these areas and also the formula and co-efficient used by the railway, viz., "Dicken's" * with 825, the flood discharges of the two rivers are 190,000 cubic feet a second, and 67,000 cubic feet per second, respectively, or in all 257,000 cubic feet per second, to pass out to sea through the Entrance.

* $D = 825\ M^{\frac{3}{4}}$.

Allowing a velocity through it of 6 miles per hour or, say, 9 feet per second, this large body of water would require 28,555 square feet of sectional area of water-way, and assuming an effective depth of 20 feet, the width required would be slightly over 1,400 feet. This calculation is necessarily largely made up of assumptions, but the width arrived at is about what nature has provided, and to appreciably reduce it would, I believe, be to run serious risk of flooding the margins of the lower reaches of the rivers.

This being the case it is useless to go into any theoretical considerations of whether a narrower entrance would not be better for the simple tidal discharge which has to pass to and fro through it, but I may say that, from what I saw during the spring tides of May, I would not, even if it was the discharge due to them which alone had to be considered, make the width of the entrance much less than now advocated.

To prevent the shifting of the entrance it is necessary to protect the ends of the sand-spits at the place. The simple and inexpensive method which will answer in the backwaters, where the water is still and the scour but slight, will obviously not do here, where the swell and the waves are often considerable, and the scour deep. Nor will it do to try merely a modification of the same method making the protective walls larger, for any such walls would most certainly be undermined and their materials scattered about where they would be constant sources of danger to every craft using the inner harbour. Whatever kind of work is used must go down so deep that it will not be undermined, and it must be composed of materials which cannot be moved and dropped about to form hidden dangers to the shipping; no work practicable at the place meets these requirements except "piling."

In the report already quoted from, Mr. Robertson proposed to fix part of the then harbour mouth, not the present one, by "a row of sheet piling . . . . the piles to come up to high water level, to have a waling on the outside, and to be tied back at intervals to others driven into the bank behind. Stone pitching, or a thick layer of stones, should be brought up from the pile heads in a gentle slope for some distance back so as to form an artificial beach for the sea to break upon." . . . . Mr. Robertson's suggestions as to the kind of work seems generally most suitable and is adopted, except that, for the reasons given above, it is not advisable to form the "artificial beach" at back of the piles, of loose stone, and instead of it, brushwood "mattresses" or "fascine work" should be used.

The construction of these "heads" to protect the ends of the sand-spits at the Entrance will necessarily be costly, for the piling along a considerable part of them will have to average some 25 feet long and be driven some 20 feet into sand.

The suggested positions and forms for these "heads" are shown on Plan A, but they are merely approximations, modifications of which will be rendered necessary by alterations in conditions before they are taken in hand.

There accompanies this report an "abstract approximate estimate" for the work recommended, which amounts to Rs. 2,40,000. This is possibly more than Government anticipated, but if the harbour is to be dealt with at all, it should be so in a systematic and fairly complete manner; to merely put, for instance, a groyne here, and another there, and expect any really beneficial result would be futile; better let the place alone than deal with it in a desultory way which would probably prove not only useless but mischievous.

It will be noticed that, except by a remark in the concluding paragraph of the second recommendation, I have not in this report dealt with the question of *Dredging*, because even without it the works proposed would be complete in themselves and efficacious to a considerable extent; but I am still of opinion that the Mangalore inner harbour will never, no matter what works are carried out, be kept in continuously first-rate order without "the means † of dredging whenever and wherever required."

† Preliminary Report, 10 (*e*).

Mangalore Harbour.
Revised "proof" of W. Walch's Report.

This final report also does not deal with the suggestions made in the "Preliminary" one as to the town drains; and the reclamation between the "Bunder" and the "Marine yard," because the former is a Municipal affair, and the latter, though advisable on its own merits and in connection with the proposed railway, is not a necessity as regards the special object dealt with in this report.

OOTACAMUND,
14th November 1895.

(Signed) G. T. WALCH, M. INST. C.E.

ABSTRACT approximate estimate for work recommended in final report on Mangalore Harbour.

Dimensions. Length.	Breadth.	Depth.	Quantities.	Description.	Rate.	Per.	Totals.	Remarks.
FT.	FT.	FT.		RECOMMENDATION No. 1. *Protection of Sand-spit.*	RS. A. P.		RS.	
21,780	3	6	392,040 c. ft.	Stone facing	7 8 0	100 c. ft.	29,400	Assuming average height 6 ft., and breadth 3 ft.
				Contingencies	..	..	2,900	Rate, from estimate for similar work supplied by Public Works Department.
				Total ..	..	..	32,300	
				RECOMMENDATION No. 2. *Training Northern, or Gurrupúr backwater.*				
			5,300 Rg. ft.	Groynes	4 0 0	Rg. foot.	21,200	Assuming to be made of stone.
				Planting accretions ..	..	Say.	300	Average height 8 feet. Slopes ½ to 1.
				Contingencies	..	..	2,100	(*Note.*—Various kinds of groynes, *e.g.*, Stone—Earthen banks faced with stone or fascine work—Piles with wattling and filled with brushwood—could be tried and the cheapest effective style adopted).
				Total ..	..	..	23,600	
				RECOMMENDATION No. 3. *Training Nétrávati backwater.*				
			10,000 Rg. ft.	Training groynes	3 8 0	Rg. foot.	35,000	Made of earth or sand, with stone facing 1 foot 6 inches thick.
				Planting accretions ..	..	Say.	600	Average height 9 feet. Slopes 1 to 1.
				Contingencies	..	..	3,500	
				Total ..	..	..	39,100	
				RECOMMENDATION No. 4. *"Heads" to protect ends of sand-spits at Entrances.*				
			1,900 Rg. ft.	Sheet piles averaging 25 feet long.	50 0 0	Rg. foot.	95,000	Piles Rs. 1-8-0 per foot. Driving Rs 12-8-0.
			500 ,,	Sheet piles averaging 15 feet long.	30 0 0	Do.	15,000	Piles Rs. 1-8-0 per foot. Driving Rs. 7-8-0.
			4,800 ,,	Waling pieces (2), good jungle wood.	2 0 0	Do.	9,600	Size 12" × 12".
			240 No.	Rear piles, at 10' apart, jungle wood.	15 0 0	Each.	3,600	
			3,600 Rg. ft.	Ties from front to rear piles, jungle wood.	2 0 0	Rg. foot.	7,200	Size 12" × 12".
2,400	15	..	36,000 sq. ft.	Mattress or fascine work for "artificial beach."	2 0 0	100 sq. ft.	720	Rate—rough approximation—no such work yet done.
				Contingencies	..	..	13,880	
				Total ..	..	..	1,45,000	
				Grand Total (exclusive of superintendence).	..	..	2,40,000	

14th November 1895.

(Signed) G. T. WALCH, M. INST. C.E.

Cancel the Marine number & remember it in P.W.D.

Public Works ~~PUBLIC WORKS~~ DEPARTMENT.

~~Abstract of 23rd January 1896.~~
No. 397 W. dated 31st January 1896.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

READ the following

Letter from G. T. Walch Esqre. M. Inst C.E. dated 14th November 1895.

Communicated to the Supdg Engineer IV Circle who will submit detailed estimates for carrying out the works proposed by Mr Walch. On receipt of these estimates, the Government will consider the question of the provision of funds.

20 Jan

21/1/96

DESPATCHED 7 FEB 96

21/1/96

16/1/96

G. T. Walch Esqre. M.I.C.E.
S.E. IV Circle with enclos.
Marine Dept.

Note. It is proposed to obtain exact financial details before according final approval to the scheme. It is by no means certain that funds will be immediately available and the source from which they are to come has not yet been considered, i.e. whether Port, Imperial or Provincial is to find the money.

(40—4,000—2-11-95.)

CH 20/1 16/96

C/o

Mr. Walch's report on the Mangalore Harbour

I/B

I/B

circ 17/1 R22/1.

Mar. Cl. 947

From M: G. T. Walch
& 1 tracings

Mangalore Harbour

Forwarding certain proofs duly corrected in connection with the

on his table. D.O. 1812-95.

are not these papers wanted with your Rep. 30/12

HC 391

3/1

5.5.96.

C.a.W. The papers are now with T who is scrutinizing the estimates. Rep 3/5

RR Circ. File may be completed

The papers required for the disposal of this current can be removed from the file with the I. They are not required by him. He has simply to examine the estimate. RS 9 Jan 96

Public Works Department.

Current No. 10356.

Letter No.

Dated

From the Marine Dept.

TECHNICAL NOTE.

Name of work Improvements in the Mangalore inner harbour.

Amount of Estimate Rs 240,000

Mr. Walch submits his final scheme for improving the inner harbour & its entrance at Mangalore with plans & approximate estimate amounting to Rs 240,000 & recommends the following works:

(a) The protection of the land strip between the sea & the backwater from Tannirbhavi in the north to Ullal in the south, in order to prevent a second opening of the inner harbour to the sea.

(b) The training of the northern portion of the backwater or Gurpur branch by narrowing the bulk water between Sultans Battery & the marine yard in order to provide, as far as possible, a uniform average width of about 1600 ft for navigation by reclaiming the western portion of the backwater as shown in green on survey

Public Works Department.

Current No. 10356.

Letter No.

Dated

From the Harbour Engr.

TECHNICAL NOTE.

Name of work Improvements to the Galle inner harbour.

Amount of estimate Rs 240,000

Mr. Walsh submits his final scheme for improving the inner harbour & its entrance at Mangalore with plans & approximate estimate amounting to Rs 240,000 & recommends the following work

(a) The protection of the land strip between the sea & the backwater from Tannirbhavi in the north to Ullal in the south, in order to prevent a second opening of the inner harbour to the sea.

(b) The training of the northern portion of the backwater or Gurpur branch by narrowing the bulk of water between Sultans Battery & the marine yard in order to provide, as far as possible, a uniform average width of about 1600 ft for navigation by reclaiming the western portion of the backwater as shown in green on survey

Mr Walsh's report on the Mangalore Harbour

Papers retained in office as I said the C.Rs and other papers were with D.W.

P.K.

The papers requisitioned for the despatch of the cheques for the moneys from the Pilot at Tellicherry are still lying in the Secretariat

circ 17/5

of 21780 feet from average width of 3 feet & 6 feet in height & by construction of training groynes as shewn on plan. The reduction in the area of the northern basin, it is stated, will provide a more efficient outlet than now existing for the Gurrupem river.

(c) The training of the northern basin near the mouth of the Netravati river by constructing training groynes in order to lead the tidal discharges more directly on to the harbour entrance.

(d) The entrance to the harbour is proposed to be fixed in its existing position, viz, opposite the mouth of the Netravati river & the width of the entrance is proposed to be made 1400 feet. This has been fixed with reference to the flood discharges of both the Netravati & Gurrupem rivers, whose drainage areas as taken by the railway authorities are 1410 sq miles for the Netravati & 352 sq miles for the Gurrupem river, the flood discharges from both these areas viz 1762 sq miles, calculated by Dickens formula $M^{3/4}$ with a coefficient of 825, will be 259,000 cft per second to pass through the proposed entrance of 1400 feet with a depth of 9 feet with a velocity of 9 feet per second.

The harbour entrance is proposed to be protected by a row of sheet piling 25 feet long, driven 20 feet into sand at either ends or heads of the harbour entrance, with the tops of piles below mean level of high water level & with single wood waling pieces 12" x 12" fixed outside & tied to single wood piles fixed in rows 10 feet apart & filled with brushwood at back.

The estimate is only approximate & is made up as follows:-

Protection of sand spit — Rs	32,300
Training Gurrupem backwater	23,600
Do Netravati backwater	39,100
Harbour entrance	145,000
Total Rs	240,000

Drawing of the ratio cannot be checked.

8.1.96

W. The only thing to be done is to approve of Mr Walch's scheme & to call on the Supdg Engineer VI circle for a detailed estimate presuming that there will be no financial difficulty in the matter. cost 1/96

C.I. Marine.

Richford
Estacement
2/12/95

The Secretary Chief Engr
P.W.D.

Sir I have the honour to return herewith the papers received with your Memorandum 33 Enquiries of 29th ult. regarding Canara. I noted the proposed entrances should be carefully attended to & without them parts of the Report and Estimate would be unintelligible

I have the honour to be
Sir
Your most obed't Servant
C. Walch

No. 84 Marine.

Government of Madras.

Marine
~~PUBLIC WORKS~~ DEPARTMENT.

MEMORANDUM.

Dated Madras, 23rd December 1895.

Letter from G.T.Walch Esq-M.I.C.E. dated 14th November 1895-submitting final report and proposals in connection with the Mangalore Inner Harbour and its Entrance.

Transferred to the Public Works Department for examination of the project.

C.A.B. Bourchier.

Under Secretary to Government.

To,

The Public Works Department,

with papers in original.

41 -2,000—11-3-95.

Marine Current No: 94

Encls 5

Recd: 3.12.95

No 296 dy 25-7-94 Marine
" 297A " 26-7-94 "
" 377 " 21-9-94 "
" 406 " 18-10-94 "
" 419 " 1-11-94 "
" 294-5 " 7-10-95 "
" 300 " 10-10-95 "
" 317 " 6-11-95 "
Memo " 33 " 29-11-95 "
" " 84 " 23-12-95 "

M. E. CURRENT No. 10356

Recd. 23.12.45 (original ptc)

44 marzii