

KURRACHEE HARBOUR

By
WILLIAM PARKES, ESQ., C.E.



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Sani H. Panhwar

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**SECOND REPORT
ON THE
STATE OF THE HARBOUR.**

**BY
WILLIAM PARKES, ESQ., C.E.**

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**KURRACHEE HARBOUR.
MR. PARKES' REPORT.
TO THE SECRETARY TO GOVERNMENT,
PUBLIC WORKS DEPARTMENT, BOMBAY.**

BOMBAY, 15th March 1864.

SIR,

In compliance with your instructions to me, dated 8th January last, I proceeded at once to Kurrachee, where I landed on the 15th of the same month.

I immediately put myself in communication with Captain Giles, the Master Attendant of the Port, and with Mr. Price, the Superintendent of the Harbour Works. The latter gentleman left for England a few days afterwards on medical certificate; but on all matters of fact the information which he would have given me was equally well afforded by Lieutenant Merewether, R.E., who acts as Superintendent during Mr. Price's absence, and with whom I was in constant communication, He is thoroughly acquainted with all the details of the work, and freely communicated to me- the results of his experience.

In compliance with the request of Government, Colonel Tremenheere, Chief Engineer in Sind, arrived at Kurrachee on the 28th, and remained a week, during which time I had opportunities of fully discussing with him the whole question of the probable effects of the Harbour Works. I believe that each explained to the other his views quite unreservedly, but we were unable to decide upon any course which we could each recommend the Government to adopt. I have informed Colonel Tremenheere of the general nature of the proposals I am about to make, and he will make his own report, which will be, I believe, unfavorable to them. In the absence of a written statement of his views, I should do injustice both to him and to myself if I were to attempt any detailed examination of them; but it may tend to save time and future correspondence if I now shortly repeat, with especial reference to those points on which I expect that Colonel Tremenheere will differ from me, the main principles on which I rely for the ultimate improvement of the Harbour. I think it will be found that in some important points the main difference between us is, that he regards as permanent 'evils what I look upon as merely temporary inconveniences incidental to a change, which will be ultimately beneficial.

Principles of the Original Design.—If we suppose a given quantity of running water, which originally flowed in a channel a mile wide, to be confined to one of half that width, the first effect will be to double the velocity of the stream in the contracted channel. Then this double velocity, acting upon the bottom of the channel, will remove the material of

which it is composed, until it is deepened and consequently enlarged, and the velocity proportionally reduced. When the reduction has been carried to a certain point, the water will be no longer able to cut away more material, and the channel will again become as permanent as it was before it was contracted. If the material of the bed be of an uniform character, and if the dimensions of the original channel were such as the stream had formed for itself, then the velocity will have been reduced to what it was originally. If, however, in deepening the bed a harder material be met with, then the velocity will continue permanently greater than it was in the original channel, and the new channel will be proportionally smaller. The above seems almost self-evident, so far as the portion of the channel actually within the new bounds is concerned; but the question next arises, what is to become of the material which the increased current scours away from the confined channel? Colonel Tremenheere, in a report to the Commissioner in Sind, dated 2nd March 1868, replies to this question in terms with which I quite agree. He says, "*it will be deposited at a greater or less distance from the mouth of the Harbour, varying with the gravity of the particles.*" "What we have to do, therefore, is, if possible, to fix the position of the "mouth of the Harbour" (the end of the Groyne or East Pier), so that, at the distance to which the heaviest particles are carried, there will be such deep water that the shoaling caused by their deposit shall not be obstructive to navigation. What that distance may be, can only be determined by experience; and it is possible that it may be such, that from other causes it is impracticable or undesirable to carry out the "mouth of the Harbour" So far. In this case we have another alternative. The whole quantity of sand to be removed out of the contracted channel is limited, and of this limited quantity a portion, and probably only a very small portion, cannot be carried by natural scour clear of navigation. It may then be dredged away. This operation would have no analogy to the proposal to remove the existing Bar by dredging alone, without removing the means by which the material would be replenished as fast as it could be dredged away.

I see no reason to doubt, however, that the natural scour alone, when the right position for the "mouth, of the Harbour" has been found, will be sufficient; but, at any rate, we have the artificial means to fall back upon, if we cannot apply the natural. It has been already proved that at the present distance of the "mouth of the Harbour," the original light material of the Bar is amenable to natural scour. Let the mouth be brought so much nearer that the present heavier material shall be equally amenable to the scour, and it seems evident that it, too, must go away.

It is true that the whole quantity of material likely to be removed from the Harbour is so large, that if it were all deposited in the immediate neighbourhood of the entrance, it would cause such a shoaling as would materially injure the navigation. That some will be deposited in the entrance is certain, and that some will be carried away so far as to be harmless is equally certain; what the relative proportions may be, is at present merely matter of conjecture. From what I have seen, I think the injurious part of the deposit will be small,— probably insignificant. If, however, it should be greater than I expect, it will still be limited in quantity. There will be no constantly recurring supply of it, as in the case of the mouth of a large river like the Indus, the Nile, or the Danube; and the same agencies which have removed it from the interior of the Harbour, applied on a smaller scale to the new deposit, cannot fail to remove the latter also.

Such are the main principles on which I rely for the ultimate success of the process of removing the Bar, or at least of forming and maintaining a larger channel over it. I cannot discover any fallacy in the principles, although I readily admit the existence of complications caused by other natural agencies which tend to counteract, and for a time almost to nullify, the benefit of the natural scour; but I look upon these as difficulties to be conquered in detail, and I feel sure that none will prove insuperable. Some, of which I shall have to speak in this Report, have been foreseen and provided for in the design; others will arise as the undertaking progresses, and must be met as they arise. No doubt this is a more than ordinarily difficult work; but I think the difficulties will show themselves to be rather of detail than of principle, if we keep in view the axiom, that a greater quantity of water is the first essential of a larger channel.

I cannot dismiss this part of my subject without recording the satisfaction I had in conferring with Colonel Tremenheere. He conveyed his views to me in the most friendly and cordial manner, and though neither has succeeded in persuading the other, we understand each other better; and, though I differ from his conclusions, many of his observations and suggestions were very valuable to me, and a consideration of them has much aided me in preparing my present proposals.

Want of Surveys.— In the pursuit of my Investigations at Kurrachee I met with some difficulties and delays which I did not anticipate, and to the causes of which, in order that future proceedings may be put upon a proper footing, it is desirable that I should allude.

Mr. Price was appointed Superintendent of Harbour Works with the view of carrying out certain definite works, of which drawings and specifications, signed by Messrs. Walker, Burges, and Cooper, were furnished to him. He appears to have carried out his duties in a very complete manner. If his staff were not always efficient, he made up for the defaults of others by his own personal energy and that of Lieutenant Merewether and some of the subordinates. Nothing can be more satisfactory than the records of the work, so far as I have had occasion to ask for their production, and the work itself is highly creditable to all concerned. But it is in no way to Mr. Price's discredit that the arrangements for duties, which were not directly within his province, were less complete. On the contrary, he deserves praise for what he has done in preparing surveys, to show the action of the works; and that earlier and more efficient provision for this important department was not made, is probably to be accounted for by the successive transfers of the chief responsibility of the whole undertaking from Mr. Walker to Colonel Turner, and from Colonel Turner to Colonel Tremenheere. Mr. Price did his best, and in December 1862 directed an intelligent serjeant of sappers to survey the Harbour. This was a most fortunate appointment. Serjeant Humby turned out to be a very good self-taught marine surveyor, and made one complete survey in December 1862 and January 1863, a partial one in April 1868, and another complete one in September and October following. Common justice then demanded promotion for Humby, but unfortunately routine stepped in, and a necessary condition of his promotion was his removal from duties, for which he showed such unexpected aptitude, to a situation which carried more pay. He was succeeded by another serjeant, who had no more notion of the principles of marine

surveying than might naturally be expected from his class; and the consequence was; that but for my arrival at Kurrachee in the middle of there would have been little chance of any definite information as to the state of the Harbour being obtained before the next monsoon. I lost no time in commencing the survey my and at my urgent representation Serjeant Humby was, after many delays, brought back to complete it. I trust that provision will be made for the future for keeping the post of “Harbour Surveyor” filled by a competent person. Humby has certainly earned the right to continue to perform the duties, but the post is one which should have been filled by an experienced marine surveyor of suitable rank, and not by an unusually clever subordinate.

Inefficiency of Office Staff.— The peculiar requirements of the surveys, however, are not confined to the out-door work. When sent in, they have to be reduced to other forms by very careful draughtsmanship in the office, and unfortunately there was no competent draughtsman on the office staff The Tough unworkmanlike manner in which the sections were prepared, have led to much useless labour in the attempt to found nice calculations upon them; and I am at last obliged to satisfy myself with general results, until Lieutenant Merewether has established a system of reliable draughtsman ship. I am sure the details of the matter are safe in his hands, but it is right I should urge upon the Government the necessity of some two or three first rate responsible office assistants being permanent on the establishment. The work is of so special a character that every new person brought to it will have to learn much before he can be made useful.

In my Report to the Under Secretary of State, dated 28th October last, ‘I described the changes which had taken place in the Harbour as shown by the Surveys of January and April 1863, which were forwarded to me. I have repeated the calculations, which I founded upon the copies sent home, upon the sections to a larger scale, which had been made in the Harbour Works Office. Although the general result was the same, yet there were large discrepancies in the figures, due to imperfect draftsmanship in both sets of drawings; and before precise results can be obtained, new sets of drawings must be made.

This, especially with the present inexperienced staff, will take some time; and therefore as a safe conclusion may be founded on more general results, I shall con myself to the latter.

Changes in the Harbour.— The space over which the increased scour and other agencies are now producing their effects may, for the purposes of consideration, be conveniently divided into three portions :—

1st. The *Keamari* Channel, so far as it is con fined by the Groyne, comprising Sections 1 to 16.

2nd. The portion between the end of the Groyne and the Bar comprising Sections 16A to 25, with the N.E. portions of some of the remaining sections.

3rd. The Bar itself.

KEAMARI Channel.— Of the first portion, the Channel, we possess the following records

- 1st. Captain Grieve's Survey in 1854.
- 2nd. My own Survey in January 1858.
- 3rd. A Survey by Serjeant Humby in January 1863.
- 4th. A Survey by the same in October 1863.
- 5th. A Survey by myself (completed by Serjeant Humby) in January 1864.

Although the first of these (Captain Grieve's, in 1854) was not so detailed as the succeeding ones, yet a comparison between it and the next, made four years afterwards, shows that the sides and bed of the channel, and its sectional area, were subject to considerable changes from natural agencies alone.

In November 1861, nearly four years after the date of the Survey of 1858, the Groyne was commenced, but we have no record whatever of the natural changes which had taken place in the channel during those four years. The next survey was made upwards of twelve months after the commencement of the Groyne, when it had advanced more than two-thirds of its intended length, and consequently we do not know how far the changes shown by a comparison of the Surveys of January 1858 and January 1863 were due to natural action previous to November 1861, and how far to the action produced by the Groyne.. They showed a very considerable enlargement of the channel, an effect which was naturally to be expected from the Groyne, and one which, indeed, must in the end necessarily be caused by it. They, however, showed considerable changes in other respects, which may have been due either to previously existing agencies, or to agencies incidentally caused by the Groyne. For example, the upper part of the channel from Sections 1 to 6 showed a movement to the eastward of from 150 to 300 feet, the eastern shore having been washed away, and the western shore having accumulated, to that extent. In the lower part of the, channel the effect was reversed, and the whole had moved westward. Whether moved eastward, or westward, however, the channel in every part, so far as the Groyne extended, showed an increased sectional area. No doubt agencies, some caused by the Groyne and some natural, may be pointed out as tending to produce these results; but in attempting to do so, one insensibly falls into the region of conjecture. There can be no doubt that the evidence of the actual effect of the Groyne during the first year of its existence is very incomplete. We are justified in attributing the deepening of the channel to it, at least in great measure, but subsequent effects show that other changes required study.

Nine months now elapsed before this channel was again surveyed, and during this interval two important agencies had been at work. The Groyne was completed to its full authorized length, and terminated at a most critical place; just opposite Deep-Water point. Subsequently came the south west monsoon with its high tides, heavy surf, and disturbance of sandy bottoms, and the Survey of October 1863 shows the joint result of these two agencies. The separation of the results is again left to conjecture.

The principal result is one for which, I confess, I was not prepared. Instead of the increased scour caused by the monsoon tides, still further enlarging the *Keamari* Channel, there is found, from Section 2 as far as Section 12 an uninterrupted decrease of area, leaving the channel in some cases little different from what it was in 1858. Had an effect so unexpected and apparently anomalous taken place in any other part, it would have been more discouraging; but the natural effect of the increased scour in increasing the area of the confined channel is so certain a thing, that I imagine no one can doubt that a contrary effect is due to some cause either independent of the Groyne, or at most incidentally connected with it. It is not the less to be regretted, however, that the absence of surveys prevents our fixing the time when the effect took place. No doubt future surveys will throw more light upon the matter, and suggest some mode of preventing or remedying the evil. The survey lately completed, shows a return to the natural effect of the scour. The channel had in, the three months, between October 1868 and January 1864, considerably increased on the whole, though a portion of the material moved by the flood tide appears to have been deposited (not injuriously to navigation) in its upper part—Sections 2, 3, and 4. The lower part of the channel (Sections 13—16 A) shows a progressive increase in each survey.

I think I have shown sufficient reason to justify me in suspending my conclusion as to the causes of the apparently anomalous decrease of the sectional area of the upper part of the channel. In the mean time I am sure it may be safely concluded that the effect is merely incidental, and probably temporary, and will disappear as the principles of the design are more fully carried out. I may also state, that while I suspend my conclusions as to all the causes that may have produced this evil, I see defects in the present state of the entrance which are certainly calculated to tend towards it, and which are susceptible of remedy.

I will here state that there is one theory on which this result might be supposed to follow directly from the confinement of the entrance by the Groyne. That confinement might be carried to such an extent as to prevent the full flow of tide into the Harbour. In other words, that the tidal space within the Harbour would not fill with water, and consequently as much or more scour might be lost by a diminution of quantity of water than would be gained by its concentration into one channel. This supposition is susceptible of test by direct experiment; and it is found by careful observation that the tide rises as high at *Keamari*, as compared with *Manora* now, as it did in 1858, so that its flow has not been sensibly choaked by the narrowing of the entrance. What is lost in width is made up for, first, in velocity, and subsequently, in depth. This supposition therefore falls to the ground.

Channel between end of Groyne and Bar.— I now pass to the second portion of the space influenced by the increased scour, that between the end of the Groyne and the Bar, Sections 16 A to 25.

It may be remembered that in my Report of 28th October 1863, I pointed out that while the Groyne was incomplete there was a tendency to some deposit in this portion of the Harbour. It was to this distance, probably, that the heavier particles were brought from the channel above, and could not be carried further, although the lighter particles, which

formed the original bed ,were scoured away even at a greater distance from the Harbour mouth. Fortunately we possess an additional survey of this portion, made in April 1868, just after the completion of the Groyne, and before the monsoon. We then found this partial accumulation in course of removal, and a similar accumulation taking place at a further distance to seaward equal to that which the Groyne had in the interval been advanced. This last position of deposit unfortunately happened to coincide with the Bar itself, and so it remains to the present time.

Whatever may have been the causes which tended to silt up the channel above, they certainly did not act here, for the action of the high monsoon tides, covering a great area of marsh and greatly increasing the scour, was to widen and deepen the channel in this portion of the Harbour very considerably. This was shown to the greatest extent by the October 1863 Survey: and by that of January 1864, it appears that there is little, if any, tendency under the diminished Scour since the monsoon to any silting, and the channel remains little changed. The action in this second portion is so far altogether satisfactory.

The Bar— We now come to the third and practically most important division including the Bar, and the shallow channels over and through it.

The Survey of January 1868 showed a promising action in progress. The crest or ridge of the Bar had been cut away; indeed that appeared to be the case with a large portion of the mass of the Bar which had been removed by scouring from the sea face, though that advantage was balanced by an accumulation on the landward side of material brought from above, which the scour could not lift over the Bar.

These changes were accompanied, as was natural, by some silting up of the channel through which the ebb-tide current did not run (the East Channel) but, on the other hand, a new channel was cut through the Bar, nearly at the point which had formerly been the highest, and which became deeper than the original West Channel ever was, though it was never so deep as the East Channel had been.

Between this survey and the next in April the Groyne was finished, and the position of deposit being moved out to a corresponding extent was fixed upon the Bar. Some of the light material which had been deposited previously to January was again removed, but heavier material was deposited a little further out. On the whole the Bar was increased in size, though it was evidently undergoing daily changes, the scour searching out the soft places, and leaving patches of harder matter elsewhere.

Effect of Monsoon.— Then came the monsoon, and with it art action which had not hitherto been seen in combination with the effect of the Groyne, that of continued breakers.

For eight months the increased scour had been acting directly upon the Bar, had materially changed its form, and to a great extent had changed the material of which it was composed. The breakers fell upon it, and in a few weeks the Bar was, so far as could then be discovered, very much what it was before the Groyne was made.

The crest which the scour had cut away was replaced to the same height as before—the East Channel round the tail of the Bar which had been closed up was reopened, and the whole presented a remarkable likeness in general form to the original Bar.

This is clearly exemplified in the three accompanying sketches which show the state of the Bar in 1858, in April 1863, and in October 1863.

There was, indeed, one important difference between the Bar in previous monsoons and in the late one. Formerly the West Channel was always maintained open, so that vessels of light draught could sail into port through it. This channel was filled up before the late monsoon, and a new channel, nearly in the site of what was formerly the highest part of the Bar, was formed. This new channel was, filled up immediately upon the breakers falling on it, and it became again the site of a high ridge. After the monsoon ceased, however, a very few tides served to re-open it, though it has never quite regained its former depth, nor has the East Channel silted up to the same extent as it did last year. The action of the scour is the same; but the material of the new deposit upon the Bar being coarser, the effect is slower than it was upon the original fine sand. It is evident that the channels over the Bar, whether the old or the new, have been caused entirely by the scour, but that in the equilibrium which formerly existed, the old' channel had settled itself into a place where the breakers had less effect, and under the increased scour a slight change of direction having been established for the current, a new channel was formed where the breakers have their greatest force, and for the time they last completely overpower the effect of the scour.

In your instructions to me, you raise the question whether the accumulation on the Bar during the monsoon is due to material brought down from the Harbour or from the sea. My reply is, that it is *neither*, but simply a redistribution of the material already existing in the Bar itself. For a considerable portion of the length of the Bar, the sections taken in October show less sectional area of the solid matter of the Bar than those taken in April. A low, flat, wide bank had been simply changed into a high, steep, narrow one. On other parts of the Bar, and especially near the eastern extremity, there had been accumulation, and of this no doubt the larger portion was due to material brought by the ebb-tide current, which during the monsoon did not run over the Bar as usual, but was diverted by the breakers into the old Eastern Channel, as it had been no doubt during previous monsoons. Captain Cues, in a report made soon after the monsoon, had suggested that this diversion was caused by the increased force of the sea current which sets constantly from West to East in the offing, but in calm weather is overpowered near the entrance of the Harbour by the greater momentum of the ebb-tide stream. There is no corroborative evidence of there' being any such increase of this current near the shore as would divert the ebb tide. Such increase would be certainly manifested by its effect on vessels entering and leaving the port, and they do not feel it. The appearances observed by Captain Giles are, I think, quite accounted for by the breakers, and the obstruction caused by them. It is by their agency that the powerful scour during the monsoon is diverted from the direct entrance to the Harbour, and so long as they are permitted to play upon the Bar, I feel sure that the effects of the scour will be more or less counteracted. It is possible that in a number of

years the Bar and Channels might return to a state of equilibrium as they were before the Groyne was made, and one of the conditions of such equilibrium would no doubt be rather better channels than the original ones, as they would have to pass more water over what would ultimately be the same kind of bed. But considering that this would be the result, not of a continued action of the scour, but of one interrupted during four months out of the twelve by a vastly overpowering force, I do not think it would be possible to form any idea of the time which would be required to complete it.

Manora Breakwater.— If, however, one of these contending natural agencies be removed, the other will have uninterrupted play. Let the seas on the Bar be calmed, if only so far as to prevent their breaking, and the whole ebb tide will pass through out the year in a straight west channel. This may be accomplished by constructing the Manora Breakwater as laid down by Mr. Walker. My recommendation of this, is not made solely on Mr. Walker's authority, though I know the importance which he attached to its effect will have weight with the Government, nor even upon the further grounds suggested by my Survey of 1857-58, but I have reconsidered the whole subject with reference to later observations, and also to the critical remarks made by others. The result has been a strong confirmation of my original opinion.

It is quite true that the ground upon which I believe the idea first presented itself to Mr. Walker is not tenable, viz, the existence of a shore movement of sand round the end of Manora Point, for subsequent observations show that there is little, if any, such movement; nor is there, as I anticipated in 1858, any probability of such movement being established at any future time on a larger scale. But the necessity of carrying the western shelter of the Harbour entrance fairly out of the breakers, upon which Mr. Walker and myself both insisted from the first, has been abundantly confirmed.

Extension of Groyne.— It must not be supposed, however, that this is all that is needed to make the entrance perfect or even permanent. The course of the flood tide on entering the Harbour is a difficulty. Instead of coming straight from sea as the ebb sets straight out to sea, it comes *from* the westward with some force round the end of Manora Point, and thence makes a circuit to the eastward before entering the Harbour.

In doing so it necessarily passes over a considerable extent of shallow water with a sandy bottom, where, during the monsoon, a heavy surf prevails, and the inflowing water enters from the eastward at an angle with 'the direction of the main channel and charged with much sand. This, no doubt, is one of the causes of the silting of the channel between January and October, and is an effect of the monsoon. I doubt whether it is sufficient to account for the whole; but so far as it goes, it will be remedied in proportion as the area of shallow water open to the eastward of the main channel is reduced; and hence, I hope, that a prolongation of the Groyne may have a good effect. It is mainly on other grounds, however, that I recommend this to be done.

The Groyne now terminates just below the most projecting part of Deep-water Point, and the channel, which half a mile further up is 2,000 feet wide, and has an extreme depth of 24 feet, at Deep water point, has a width of only 1,100 feet, and is 47 feet deep. Moreover,

this difference of width is made entirely by the concavity of the western shore, so that the ebb tide coming fair down the Harbour has a tendency to be deflected to the eastward, while the flood shoots across the line of the channel with great velocity to the westward, causing eddy tides just above Manora Jetty. Such great inequalities of width, depth, and velocity, and such abrupt diversions of the current, cannot but obstruct the natural formation of a regular uniform channel. Some assistance must, therefore, be given towards such a formation. On the east side I would recommend that the Groyne be extended so far that the flood tide shall be led into a straight course up the Harbour, before it passes Deep-water Point.

On the west side some assistance must be given to the removal of Deep-water Point. The material of which this point is composed, though mainly sand, which will easily scour away, contains a number of pebbles washed in by the light surf, which runs along the eastern shore of Manora Point in the monsoon. As the sand has washed away by the increased scour, the pebbles have remained until they have formed hard shingle beaches. These beaches require to be removed by hand at low water, and then the scour of the tide will carry away the sand which they had protected. This has been done during the last two springs at a trifling expense, and with good effect; and it will be continued. I hope it will accelerate the removal of the point; but if more decided measures are required, they should be adopted rather than allow such an obstruction to remain. It may be remembered that in Mr. Walker's first report, he proposed the artificial removal of this point, and the idea was only abandoned in consequence of my opinion, that it would be scoured away by natural action. It appears, however, to want a little help.

The end of the Groyne, as it now stands, has had another bad effect. Presenting, as it does, an abrupt obstruction to the course of the flood tide, the latter rushes round it with great violence, and has scooped out deep holes in the sand. But for the precaution taken of throwing in a foreshore of stone in advance of the end of the Groyne, the latter would probably have been undermined. The sand scooped out from the holes has, of course, been carried into the Harbour and added to the accumulation. In prolonging the Groyne, I would propose to carry it for 1,000 feet, at its present level, four feet above high water; then let it drop to high water level, and thence gradually slope downwards to low water level at a further distance of 500 feet. Thus as the tide rises it will spread further over the sloping Groyne, and the scour will not be confined throughout the flood tide to one spot as at present.

Possible future Works.— These two works, the prolongation of the Groyne and some assistance to the scouring away of Deep-water Point, will, I think, do much to mitigate the evils caused by the present irregular form of entrance; but I cannot pledge myself to their being all that is required. When their effects are seen, it may be desirable either to prolong the Groyne still further, or to carry another Groyne on the western side of the channel northward from near Manors. Jetty for a sufficient distance to deflect the flood tide from the western shore, and lead it into the same channel as the ebb. This, again, would be only a return to an original suggestion of Mr. Walker, dropped on account of its not being supposed necessary.

The extension of the Groyne would also, I hope, for reasons given in my former Report, and in an earlier part of the present, prevent any further tendency to temporary deposit upon the Bar, and enable the scour to act more effectually upon the Bar itself in calm weather, and upon the Eastern Channel during the monsoon.

Chinna Creek Diversion.- In the present state of the channels I do not think it would be desirable to admit the Chinna Creek waters through the Harbour. The increased velocity of the currents should first be permitted to effect, at least to a greater degree than at present, the equalizing of the channels; after this a gradual increase of water will, I hope, effect a gradual improvement without causing temporary damage. At present the channel up to the new jetty has been dredged, so that the facilities for native craft and lighters approaching the wharfs has been much improved. This has been accomplished at comparatively small expense, owing to the material having been deposited so as to raise the level of certain low lands at Kurrachee and Keamari, and thus materially enhance their value. Thus, though the diversion of the Chinna Creek water into the new channel will undoubtedly be a further great improvement for the upper Harbour navigation, the present state is so great an advance upon the past that the next step is not urgent.

Works recommended. - The works I would recommend for immediate sanction, then, are:—

- 1st. The Manora Breakwater, to the extent and in the line laid down by Mr. Walker.
- 2nd. The prolongation of the Groyne, to its full height for 1000 feet, and thence for a further 500 feet with its top sloping from high water to low water levels.
- 3rd. The removal of hard material from Deep-water Point at the discretion of the Superintendent.

I have consulted Lieutenant Merewether upon all these propositions, and he entirely agrees in them. We have also conferred together on the best means of carrying them out, and I have furnished him for his consideration with a statement of my views upon this in detail. He will adopt them to such an extent as he may find consistent with the local circumstances, of which he is so much better a judge than myself. Captain Giles is also strongly in favour of these proposals, and had, indeed, himself recommended them all before my arrival at Kurrachee. I would beg to state, however, that they do not pretend to be final. The works are of an essentially tentative kind. I have confidence in their being right in direction, but their final extent must depend on observation of their effects. This remark applies obviously to the two latter recommendations. With regard to the first, the Breakwater, I recommend the whole length, because I do not think any less length will give the requisite amount of shelter. Indeed, if I were making a new design with my present knowledge of the respective actions of scour and breakers, I should probably show a greater length of break water, and I think it possible such greater length may be found desirable. This, however, will be tested by experience of the length now proposed.

Section of Breakwater.— Estimates.— In the detail of construction, I would propose to depart work and of the precautions necessary to secure it against damage by sea, I would not advise calculating upon the expenditure of any sum less than Mr. Walker's estimate,

£110,000. This expenditure would probably have to be spread over four years, though, if in execution it should be found possible to carry on the work faster, I would strongly recommend that the funds be not withheld, considering that the improvement of the Harbour entrance is in great measure dependent upon this work.

The extension of the Groyne, taking as a basis the amount expended on the portion already finished, would cost £15,500. The time of execution should, I think, be spread over eight or nine months to avoid the evil effects of too rapid a change in the channel.

Of the cost of removing the shingle from Deep water Point no total estimate can be made, but it will be comparatively small. At present the current expense does not exceed £20 per month.

To carry on the breakwater works in a satisfactory manner, it is desirable that a first class superintendent, or foreman experienced in rough sea should be engaged in England; also an experienced diver mason. The latter would, I think, be able gradually to introduce native masons in the diving work. Two diving dresses are already in the Harbour Works stores; I think a third should be provided. Very good stone for the more exposed parts of the work, the western wall and the top, is to be found at Joongshai, fifty-three miles from Kurrachee on the Scinde Railway, and an arrangement should be made with the Railway Company for its conveyance. For the interior work under water, large blocks of concrete may be made from Manora conglomerate. The remainder of the work would be built of stone from the excellent quarries now open at Hand's Hill.

New Wharfage.— The constantly increasing trade of the Port of Kurraehee seemed to make it desirable that I should reconsider the principles of the design, made by Mr. Walker six years ago, for a system of basins and docks. It was his expectation that increasing use would be made of Keamari for trading purposes. Hitherto, however, the tendency has been rather the other way, and godowns which were erected a few years ago at Keamari are now abandoned in favour of those nearer the native town. There can be little doubt that this result is caused by the want of facilities for landing and loading cargoes at Keamari, and will be reversed when these are provided upon a large scale. In the meantime, however, pressure is rather felt for more space at the wharfs upon the mole and the new jetty than at Keamari. It becomes a question, when, as must soon be the case, more accommodation is required, whether the Government may not do well to have regard to the wants of the more perfect and economical future system, and encourage its development, rather than merely supply existing demands by means which may in a few years become obsolete. Probably the leading merchants of Kurrachee may see their interest in taking the same view; and, if so, I would submit that when the Government shall feel that the time is come for giving further wharfage, the best site would be the wall which is placed in Mr. Walker's plan between the Commissariat jetty at Keamari and the entrance to the proposed basin. Here ships might come alongside, and load and discharge cargoes directly into railway trucks, which might convey the goods without transshipment to and from the merchants godowns at Kurrachee. This system would be a great economy over the present one of lightering to the mole, or new jetty, and then carting to the godowns; and the system might be gradually extended as required, by continuing the

wharf into the basin according to Mr. Walker's lines. Such a deep water wharf at Keamari, combined with a system of frequent local trains between it and Kurrachee, with private branches from the Railway to the different godowns, would reduce the actual cost of conveyance between the ship and the godowns fully one half, while the indirect advantage in expediting business would probably be also great. Whether the time is come when the expenditure necessary to obtain this advantage is justifiable, is rather a commercial than an engineering question. The cost of such a wharf, 1,200 feet in length, including dredging, and consequently capable of receiving five ships alongside at one time, would be probably £60,000.

I attended by request a meeting of the Committee of the Kurrachee Chamber of Commerce at which this subject and another, which I am about to mention, were discussed. The Chamber will, I believe, communicate with the Government on both subjects.

Graving Dock.— The other subject was that of providing a graving dock.

An application on the subject was made by the Chamber sixteen months ago to the Commissioner in Sind. The Commissioner then declined to take any further steps in the matter, on the ground of the uncertain state of the Bar. I would submit, however, that the necessity for the means of repairing ships is not dependent upon the existence of a good entrance to the Harbour, but rather upon the number of ships requiring examination and repair. Indeed, unless we are to suppose that the result of the Harbour works will be to close the Port entirely to European trade, it would seem that a difficult entrance, on which a ship may "bump," rather increases such a necessity. If ship owners in England know that their vessels may repair any damage they may sustain at the entrance before putting to sea again, they will the more willingly accept freights and employ larger ships for Kurrachee, and thus the establishment of a graving dock would, to some extent, compensate for the evils of the Bar.

The representatives of the mercantile interests of Kurrachee will urge, with more force than I can, the special reasons which have led them (and I may say myself also) to the conclusion, that the time is arrived for the construction of a dock; and should the Government take the same view, I think the most suitable form would be Mr. Edwin Clark's hydraulic lift. One of these has been in action with success for five years in the Victoria (London) Docks, and several are in course of construction for the British Government and others. The total cost of the lift with pontoons¹ for two ships of 1,000 tons each, would be about £85,000, exclusive of dredging, which, however, would pay itself, or nearly so, in the formation of ground in the neighbourhood. The best site would be that shown for graving docks within the tidal basin in Mr. Walker's plan. The cost of an ordinary graving dock would be nearly double that of a lift, and the accommodation afforded inferior, particularly in the special circumstances of Kurrachee.

Engineering Control.- In my letter to the Under Secretary of State, dated 14th November last, I suggested the possibility of its being desirable to make some change in the

¹ The number of pontoons may be indefinitely increased as required, all being raised by the same lift.

engineering responsibility of this undertaking. My further investigation of the subject on the spot, has led me to the conviction that for the successful accomplishment of the objects of the Government, it is absolutely necessary that the progress of the undertaking should be constantly watched, and in important matters controlled, by some engineer who not only possesses the confidence of Government, but who is also favorable to the principles on which the design has been formed.

The superintendence which Colonel Tremenheere has exercised over the works has been hitherto, I am sure, impartial, and the advice he may have given in matters of organization or construction, of great value; but these are not the most important of the duties of a Chief or Consulting Engineer. From the exercise of discretion as to modifying the designs, or accommodating original instructions to circumstances as they may arise, it seems to me that Colonel Tremenheere's generally unfavorable opinion of the design completely excludes him, and I am quite sure he would feel it his duty to abstain from exercising any such discretion; yet that some one should do so, in the present state and future prosecution of the works, is most essential.

I formerly suggested that it might be desirable that the Superintendent should be put into direct communication with myself with this view. I am well aware of the objection which the distance of London from the scene of operations offers to this plan, and would willingly make over my responsibility in the matter to some engineer in India who may be willing to accept it; but I think even from London I could perform the necessary duties in such a way as would be better than their not being performed at all, as has hitherto been virtually the case. I am satisfied that the interests of the undertaking have already materially suffered from the absence of a, proper discretionary power exercised in harmony with the principles of the design, and I think the want of such a power is more than ever likely to be felt for the future.

I have the honour to be,

Sir,

Your most obedient Servant,

W. PARKES.