

*Order of Procedure.*—The structural works should be proceeded with in the following order: The training mound and breakwater on the south side will be first undertaken, and carried on uninterruptedly until arriving at a point abreast of the low-water line of the sea-beach on the north side of the entrance; thereafter, the north and south breakwaters should proceed simultaneously, the latter being always kept somewhat in advance of the former. Concurrently with the commencement of the north breakwater, the north training wall should be begun at its eastern end, the tip-head being kept well in the rear of the outer works, in order to economize material.

*Dredging.*—The northern side of the channel, from opposite the lagoon entrance to abreast of Johnstone Street, should be dredged, so as to give a depth of not less than 9 feet at low water of spring tides over the area crossed by red lines, in so far as the same may not be scoured by the action of the tidal currents and flood waters. In the estimate hereinafter given, it is assumed that all the materials down to a depth of 9 feet below low water may have to be dredged, although it is very probable that no inconsiderable portion will be removed by the improved scour derived from the action of the two training banks.

The entire area to be filled in with dredgings at the back of the south training bank, eastward of the lagoon entrance, should be reserved as standage ground for railway wagons. I apprehend the time is not far distant when the whole of it will be required for that purpose.

When the development of the coal mines of the Grey Valley shall have increased to such an extent as to call for further accommodation of this kind, the area (indicated by red sprinkling on Drawings Nos. 1 and 2) southward of the inner end or root of the south breakwater, and seaward of the blocks marked as "Packers' Quay," should be used for the same purpose. This area will be filled up by accretion as the breakwater advances, and should be scrupulously reserved for standage ground. This appropriation will of course necessitate the construction of a permanent swing-bridge across the lagoon channel, but the structure need only be of a simple and inexpensive character.

*Principles of Design Recommended.*—With regard to the principles by which I have been guided in designing the works now recommended, I may say that, in dealing with a case such as that now under consideration, the amount of protection to be afforded against the heaviest seas is not the only point to be considered; a matter of at least equal importance is the direction best adapted for creating and maintaining the greatest depth of water in the entrance. Experience has satisfied me (and theory supports the conclusion) that this latter object can be best accomplished by so training and guiding the passage of the currents of tidal and fresh waters, and more especially the outgoing streams, as to cause them to impinge as directly as possible upon the seas which act most effectively, and therefore most injuriously, in heaping up sand upon the coast. It does not necessarily follow, as is frequently assumed—indeed, it may be regarded as the exception rather than the rule—that the direction of the breakers or surf falling in any part of the coast will be absolutely identical with that of the heaviest seas in the offing. It is only by carefully considering the circumstances and conditions of each particular case in all its bearings, and with all its local surroundings, that a safe conclusion can be arrived at.

Feeling assured, as I do, that the direction of the entrance works, as proposed both by Mr. Moriarty and Mr. Carruthers, would not secure the best results, I have adopted a more southerly direction as the best for securing the object in view. I should here remark that whatever may happen to be the position of the entrance channel, or the form of the sand-banks at the time when the lines for the new works are marked out for execution—and it may almost be said that both the position of the channel and form and extent of the banks are about "as uncertain as the winds that blow"—I would, nevertheless, advise that the lines I have laid down be virtually adhered to, for the new channel will inevitably follow the line of the works as they proceed.

It would be well, when the breakwaters advance beyond the shore-line, that frequent and careful observations be made therefrom by the officer in charge of the works on those occasions when the sea may be breaking in depths of from 2 to 3 fathoms at low water, so that a full record may be kept, and registered in such a manner as to be available for reference in determining, when the proper time arrives, whether any slight modification can advantageously be made in the direction of the outermost part of the breakwaters, and the precise extent of their overlap. I feel well assured, however, that such change, if any, will not be material. It is also possible that the width of 400 feet at low water may, in some small degree, be varied with advantage. Experience alone can determine with precision this, as well as the other points just named, but the width laid down on the drawing has been arrived at after calculation and careful consideration based upon the data available for the purpose.

It will be seen that I have projected the outer end of the north training bank somewhat beyond the shore-line, and that the breakwater on the northern side of the entrance is laid off at a different angle to that on the southern side. This has been done advisedly, and with the special object of forming a wave-trap, in which the greater part of any undulation that may pass in between the breakwaters will be expended upon the slope of the beach between the seaward termination of the north training wall and the root of the north breakwater.

Moreover, the north breakwater being kept down to the level of high water of neap tides, as hereinbefore described—the south breakwater it must be remembered being well above high water of the highest tides—the seas in heavy gales from about west south-west will overtop the work, and thus expend their force without causing an inconvenient amount of disturbance within. The comparatively low level of the top of the north training bank will act in the same manner, if in extreme cases any undulation should pass in beyond its outer end. I would further remark that the lines of the new works near the lagoon entrance have been so arranged that they will not only give the best results as regards the easy confluence of the outgoing currents from the lagoons with those of the main channel, but their form is such that they will serve as an additional wave-trap on the south side, and that at the same time their effect will be such that the submerged shoal, previously adverted to as prejudicial and sometimes dangerous to the navigation, will be removed by the additional scour that will be created under the new conditions; more especially when the channel leading into the lagoon shall have been dredged to the extent hereinbefore recommended.