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ALFRED GREENFIELD, Provincial Secretary.

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Superintendent's Office,  
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**H**IS HONOR the Superintendent directs the publication of the following Report for general information.

ALFRED GREENFIELD,  
Provincial Secretary.

REPORT ON NELSON HARBOUR, WITH  
SUGGESTIONS FOR INCREASING ITS  
ACCOMMODATION.

By JAMES MELVILLE BALFOUR, Esq., M. Inst. C.E.,  
Colonial Marine Engineer.

TO HIS HONOR THE SUPERINTENDENT.

SIR,—Having been requested by your Honor to report on the capabilities of Nelson Harbour, and to prepare a plan for its improvement and increasing its accommodation for shipping, I made arrangements with the Provincial Engineer to procure certain information (the greater part of which is embodied in the accompanying plan), as I was already sufficiently acquainted with the general character of the Port, and as my other duties rendered any long stay in the district impossible.

The tracings furnished by the Provincial Engineer, and the information accompanying them, have very

completely met my wishes, and have furnished ample data for a report of the general nature at present required, though, of course, a considerable number of borings and other observations of a more minute and detailed character would be required preparatory to making out any detailed design for proposed works.

The designs shown on the plan are of an alternative character; thus, an extension of the wharfage along Haven-road and a Patent Slip on Haul-ashore Island may be considered one design, and a Shipping Basin and Graving Dock above Green Point another

REMOVAL OF ROCKS.

Two small but awkwardly situated rocks exist in the fairway of the entrance, and these—the "Fairway" and the "Buoy" Rocks—should be removed as a preliminary to any other work. This could be done with great ease but for the rapidity of the tides, which renders it impossible to steady any floating stage over them sufficiently to allow of their being drilled, and even more impossible to work at them by diving bell or dress. The best way to remove them would be to drill a sufficient number of good sized deep holes in them from a stage supported on stout iron rods (as these would give much less hold to the current than any timber framing), and, when the bores have been charged, to fire the whole simultaneously at high water by the aid of electricity. If the rocks be sufficiently shattered by the discharge, the tidal currents will probably sweep away the debris; but, if necessary, the stage can be re-erected, and any remaining lumps either lifted by jointed claws or again drilled and blasted.

If the charges are all fired at high water, no fear need be entertained of any damage to adjacent property, as the head of water above the rock is amply sufficient to confine the explosive action.

#### ENTRANCE CHANNEL.

Beyond the removal of the Channel Rock, I am not prepared to recommend any attempt to improve the channel at the entrance.

Though the sharp turn in it calls for great watchfulness and skill on the part of pilots, experience proves that with good pilots, accidents of any kind are exceedingly rare; and the unchanging depth of water on the bar appears to indicate that the action of the various currents of ebb and flood in the Harbour and the Waimea River has attained a permanent balance which might not unlikely be disturbed by any change. A rubble causeway could certainly easily be constructed from the shore to the Arrow Rock, and the mere facility of access to the rock itself would often be in many respects a great convenience, while the causeway would confine the tidal currents and probably cause the inner end of Haul-ashore Island to be scoured away, to the improvement of the channel. As, however, the effect on the bar of any such change in the direction of the currents cannot be predicted with any certainty, and as no pressing need for such a causeway exists, it had better not be attempted, at least until it be more really necessary than at present.

#### WHARFAGE.

The simplest and most expeditious method of increasing the wharf accommodation of the Harbour, would certainly be to extend the present Government Wharf towards the entrance as shown; and as sufficient depth of water for vessels of any size could be obtained alongside such a wharf without dredging, it would also be, at least in the first instance, the most economical.

The plan shows an extension of the outer T or head of the present wharf, of about 25 chains in length, with approaches every 7 chains apart, and a certain amount of reclamation (to low water mark) alongside the Haven Road; but any smaller lengths could of course be constructed. The spaces between the approaches could be leased for stores and goods sheds, on condition that all such works should be constructed on piles at not less than a stipulated minimum distance apart so as not to contract the water way unduly.

Another method of obtaining increased accommodation would be by works above the present wharf. The plan shews a shipping basin with 94 chains of wharf frontage and a water area of about 31 acres; the basin is proposed to be comparatively narrow at the entrance and at the upper end, but wide enough in the middle to allow of the longest vessel being "canted" without difficulty, even if two tiers of vessels were moored on each side. But for the necessity for dredging, this wharfage could be constructed considerably more cheaply than that below the present jetty, and, even allowing for dredging, it should not be much more expensive yard for yard; while the more perfect shelter afforded to shipping, and the much greater susceptibility of expansion which any wharfage above Green Point must possess, are strong arguments in its favour. Moreover, as all warehouse sites would be on reclaimed land, thus admitting of the erection of more solid and permanent structures, they ought to fetch a correspondingly high price, if not placed in the market more rapidly than required. The shipping basin is designed to be dredged to a depth of 22 feet at low water alongside the wharves throughout, and to a depth of 22 feet at high water

over the wider space in the centre, as it is not necessary that vessels should be able to be canted at all times of tide. Further information as to the nature of the bottom and the depth at which rock is met with would be necessary before any plan for such a shipping basin could be finally matured, and many other arrangements, perhaps equally good as that shown, might be proposed; but the general principles must be the same in all, and so long as the Maitai River is diverted and the basin laid out nearly in the proportions of water space and wharfage shown, any alteration in detail is comparatively immaterial. Should, however, the bottom be proved to be such that the necessary depth may be easily obtained by dredging, the design on the plan will probably be found to be at least as convenient as any other which can be laid out.

All the wharfage, whether along Haven road or above Green Point, is proposed to be of squared timber, framed somewhat as shown on figs. 1 and 2, and of sufficiently massive construction to adapt it for berthing heavy vessels; the piles and other timber in water to be of West Australian mahogany, as that wood has the property of resisting the attacks of the marine worm more perfectly than any other known, and in some works is still sound after about 35 years' exposure in seas in which other timbers have been rapidly destroyed.

#### RIVER DEFLECTION.

As an essential part of any scheme for constructing a deep still-water basin for shipping, it is proposed to exclude the Maitai River, so as to prevent any tendency to damage to shipping from the velocity of flood currents, and, which is of much greater importance, to free the basin from the deposits of shingle which would otherwise of necessity take place. The line in which the river is proposed to be trained is a gentle curve from its present principal outlet, and it is laid out, so far as practicable, so as to take advantage of one of the existing channels, and reduce the amount of excavation required to a minimum.

#### RECLAMATION.

Between the proposed basin and the new course for the river, the whole area would be reclaimed as shown, and the land thus obtained ought to fetch a very high price for business purposes.

As a general principle, it is not advisable to reclaim any very considerable portion of the area of a Harbor in such a manner as to exclude tidal water, as it is established that the tidal flow is of vital importance in maintaining the depth on the Bar; and consequently the theoretically most correct method of proceeding is to reclaim only to half-tide level, and to excavate from thence at least to the level of low water, thus maintaining the tidal capacity of the Harbour unimpaired, though diminishing its superficial area; and it must be remembered that excavation below low water of spring tides has no more effect in admitting an increased amount of tidal water than any amount of filling above high water has in excluding it. There are, however, localities where a very large tidal basin has a contracted entrance, and in such a judicious reduction of the tidal area has had a beneficial effect; the reason being that under such circumstances, though the current is very rapid in the entrance, the basin has not time either to fill or empty completely during a tide, and thus, while the high water is lower, the low water level is higher, inside than outside. Reclamation up to a certain point in such a harbor will not at all diminish the amount of water passing in and out every day, but will only allow the tidal levels inside and out to assimilate; if carried beyond that point, reclamation will probably be injurious.

From calculations based on sections of Nelson Harbour, I find that fully 37½ millions of tons of water ought to flow in and out every spring tide (rising 15 feet), in order to make the levels inside and outside agree, but the cross section at the entrance is such that, even allowing a current of five knots to run for six hours, only some 31 millions of tons can pass in and out through the channel; and though no doubt the "overflow channels" will allow the high-water level at the lower part of the Harbour to be raised to sensibly the same height as it is outside, I should consequently expect that such is not the case over the upper portions of the mudflat, and thence would infer that a considerable amount of reclamation may be undertaken without excluding any tidal water.

Even should this not be the case, however, as the whole of the reclamation shown on the plan, both along Haven-road and on either side of the proposed basin, will exclude very little more than one and a-half millions of tons of water, or one-twenty-fifth of the whole tidal flow, there seems no reason to fear that such a moderate change should have any seriously injurious action, either at the entrance or on the bar, and that in consequence any special measures to counteract such action will be required.

The whole of the reclamation, shown along Haven-road and on either side of the proposed basin, would amount to about 126 acres, and would require in all, over three millions of cubic yards of filling, or, deducting the earthwork measured with and included in the estimate for the wharfage, training-wall, and dock, over three-quarters of a million of cubic yards. Of course it is not contemplated that such an extensive work should be undertaken at once, as a very modified amount of accommodation would amply suffice for the requirements of the port for a long time to come; the design is merely shown on so extensive a scale to enable an opinion to be formed as to its convenience when completed, and to facilitate the adoption of some general plan, of which all works undertaken from time to time, as required, would form an integral part.

#### PATENT SLIP.

It is much to be regretted that the land at Green-point has been leased, as otherwise an excellent site for a Patent Slip could have been erected there; but, without interfering with the leased sections, it would now be almost impossible to select a good place on the main land for such a work, which would not entail considerable expenditure either in excavating at the outer end of the ways, or in reclamation at the landward end; and on any such site the slip would be very liable to interfere with future works, and ought not to be constructed without very careful consideration of all the bearings of the case—at least should the general idea of a basin for shipping, either present or future, be entertained. To avoid these difficulties I have drawn a slip on Haul-ashore Island. At the same time, that site is in some respects very inconvenient—workmen, for instance, and all work, unless large workshops were erected on the island, would require to be carried backwards and forwards in boats at considerable cost and great loss of time. Moreover, it seems probable that so considerable a swell must cross the low parts of the Boulder-bank during certain winds, as to render it at times impossible either to raise or lower vessels with safety. The absence of fresh water on the island is also an objection to the site. On the other hand, a slip could be constructed on Haul-ashore Island more economically than anywhere else in the harbour.

#### HYDROSTATIC GRAVING DOCK.

As many people object to the use of patent slips, especially for large vessels, I have examined several other systems of docking vessels for repair, and on the outer end of the proposed reclamation, and also on a large scale in figures 4, 5, and 6, have shown a modification of the graving dock which seems to possess qualities which should recommend it for very general adoption in the colonies, and to be well adapted for Nelson.

In the patent slip a vessel is grounded on a cradle, which is then hauled up an inclined railway till it is above high water; in the ordinary graving dock a vessel is floated into a chamber, grounded on blocks, and either left dry by the ebbing tide or the water pumped out by power—in either case the water being excluded by gates till the repairs are completed; but in this system the vessel is lifted by the flotation of water until it is above high-water level, and then grounded on proper blocks; the general principle is well established, and was carried out on a very magnificent scale at Sebastopol.

This arrangement has many qualities which recommend it for adoption in this country, as simple earthwork may, to a very great extent, be substituted for fine masonry, and as the dock gates and other works which are required do not need to be so absolutely watertight as in an ordinary graving dock, in which the whole work is exposed to the searching test of a constant pressure from without, due to a head of water varying from perhaps eight feet at low water, to twenty feet or more at high water; while the hydrostatic graving dock is only required to retain the water until the vessel has been floated over the graving blocks, and, if there be a good supply of water, a very considerable amount of leakage would be of trifling consequence. As soon as the vessel is in position in such a dock the water is run off, and as the vessel is above the influence of the tides, no annoyance from leakage can be experienced, and no steam pumping gear is required.

The best site for such a dock is shown in close proximity to deep water, and it is pointed so that vessels hauling in or out will not be athwart the stream of tide. To save expenses, the floor of the upper chamber is proposed to be six feet below high water of spring tides, a very light second pair of gates being fitted to exclude the water, and the flotation power is proposed to be obtained by fluming from the Maitai.

#### ESTIMATES.

In the absence of more detailed information, and working drawings, of course only roughly approximate estimates can be submitted, but I have little doubt that the works could be completed for the several sums mentioned below, if not for a smaller amount:—

1. A Patent Slip complete, capable of taking up vessels of 1,200 tons register, should cost complete not more than . . . . .	£28,000	0	0
2. Hydrostatic Graving Dock.—Entrance gates with masonry . . . . .	£8,000		
Inner gates . . . . .	1,000		
Ten shoring stages, at £300 . . . . .	3,000		
Dock floor, graving blocks, &c. . . . .	5,000		
200,000 cubic yards earthworks at 2s. 6d. . . . .	25,000		
Flume, &c. &c. . . . .	3,000		
		45,000	0 0

(This, however, is for a Dock 350 feet long, and with twenty-two feet water on the sill; were it made 280 feet long, with eighteen feet water on the sill, the cost would be reduced to about £36,000.)

- 3. The cost of extending the present Government wharf in the most substantial manner, including the amount of reclamation thereon, and a proportion of the cost of the necessary approaches, will not exceed £77 per lineal yard, or per chain . . . . . 1,700 0 0
- 4. The proposed basin facing above Green Point, with an average breadth of about three chains of reclamation, and including dredging, will be about the same amount, or per chain . . . . . 1,700 0 0  
(On an average of the whole, though at first, and if but a small length be undertaken, the cost of the dredging plant would seem to swell the cost considerably.)

The complete schemes as shown on ten plans, may then fairly be estimated as under:—

[A.] Twenty-five chains wharfage along Haven-road, including reclamation, &c., at £1,700 . . . . .			£42,000	0	0
A patent slip . . . . .			28,000	0	0
			<hr/>		
			£70,000	0	0
[B.] Ninety-four chains basin-facing with earthwork, and dredging, at £1,700 . . . . .			£159,800	0	0
Extra reclamation . . . . .			53,000	0	0
River training wall . . . . .			19,000	0	0
Hydrostatic graving dock . . . . .			36,000	0	0
			<hr/>		
			£267,000	0	0

A comparatively small portion of even the smaller scheme would, however, amply suffice for present purposes; and the following estimates would fully

cover all works which will probably be required for a considerable period.

[C.] Extension of the present Government Wharf, ten chains long, at £1,700 . . . . .			£17,000	0	0
A patent slip . . . . .			28,000	0	0
			<hr/>		
			£45,000	0	0
[D.] Ten chains of basin-facing, with reclamation and dredging, at £1,500 . . . . .			£15,000	0	0
Dredging plant . . . . .			10,000	0	0
Thirty chains river training wall, at £320 . . . . .			9,600	0	0
Thirty chains road to dock from lower end of training wall, at £300 . . . . .			9,000	0	0
Dock . . . . .			36,000	0	0
			<hr/>		
			£79,600	0	0

I am not sufficiently acquainted with the tenure of property, and the right of water-way and frontage of the several owners of property, to be able to advise definitely whether the scheme represented by Estimate C., or that represented by Estimate D., should be adopted. Economy is certainly in favour of the former; but convenience and great susceptibility of after-extension is a strong argument in favour of the latter; and local interests or the rights and claims of local proprietors, may easily turn the scale either way. On the whole, I should prefer to increase the wharfage by extending the present works, and to construct the dock in preference to the slip.

I shall not attempt to estimate the cost of removing the channel and buoy rocks, as it depends very greatly on the method adopted; but I would very strongly recommend that their removal be at once authorized; and have no doubt that the Provincial Engineer will do the work most successfully, and at a very moderate cost.

I have the honor to be, Sir,  
Your most obedient servant,  
JAMES M. BALFOUR.

Wellington, March 23, 1868.