

With the compliments Secretary Lyttelton Harbour Board.

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Lyttelton Harbour Extensions

NEW ZEALAND.

REPORT

- BY -----

Messrs. COODE, SON & MATTHEWS,

16th APRIL, 1908.

Accompanied by Eight Drawings.

Also Memorandum by CYRUS J. R. WILLIAMS,

Engineer Lyttelton Harbour Board, dated 12th June, 1908.

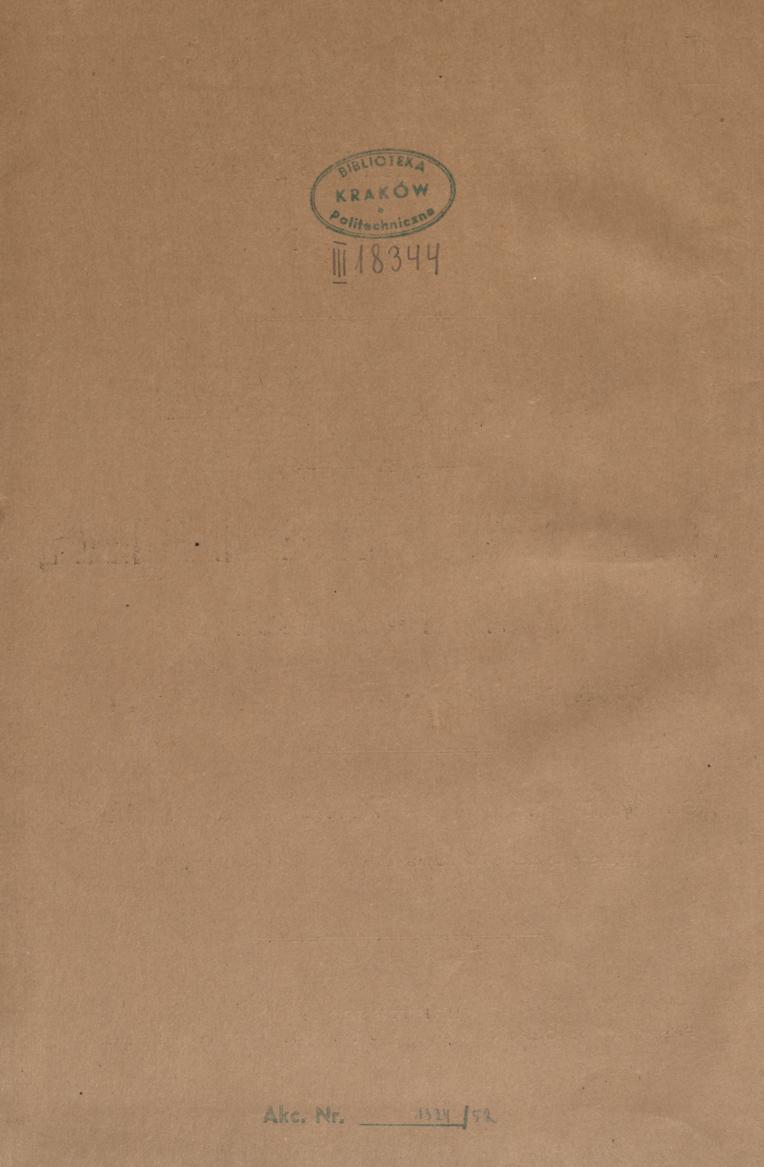
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LYTTELTON HARBOUR EXTENSIONS,

NEW ZEALAND.

THE CHAIRMAN

LYTTELTON HARBOUR BOARD, New Zealand. WESTMINSTER CHAMBERS 9 VICTORIA STREET, LONDON, S.W. 16TH APRIL, 1908

SIR -

In June 1906 we received a letter from the High Commissioner of New Zealand informing us that he had been desired by his Government to obtain for the Lyttelton Harbour Board expert advice as to the practicability of certain schemes set out in a report of the Engineer to the Board (copy of which was forwarded to us) "for the provision of further Harbour Extensions and of a Canal from the sea towards "Christchurch and also upon any other scheme for connecting Christchurch with the sea that may "commend itself to the expert after inspection of the surrounding country." The High Commissioner further desired to know if we would be willing to undertake to advise the Board in the sense desired.

2. On the 16th July following we replied expressing our willingness to undertake the duties required, proposing that our partner, Mr. M. F. G Wilson, should visit Christchurch for the purpose of making the necessary investigation upon the spot and of arranging for the preparation of such data and particulars as might be necessary for the proper consideration of the subject after his return home and for the preparation of such report, plans and estimates as might be required. We further made our proposals with regard to the payment to be made to us for our services and expenses in connection therewith.

3. On the 10th November 1906, the High Commissioner wrote to inform us that he had received the following cable message from New Zealand :---

"Lyttelton Harbour Board authorise you to accept Coode, Son and Matthews' offer as

- "mentioned in their letter of 16th July last to investigate and report on Harbour questions at
- "Lyttelton and Christchurch, including Ship Canal, and would like visiting Engineer to come to

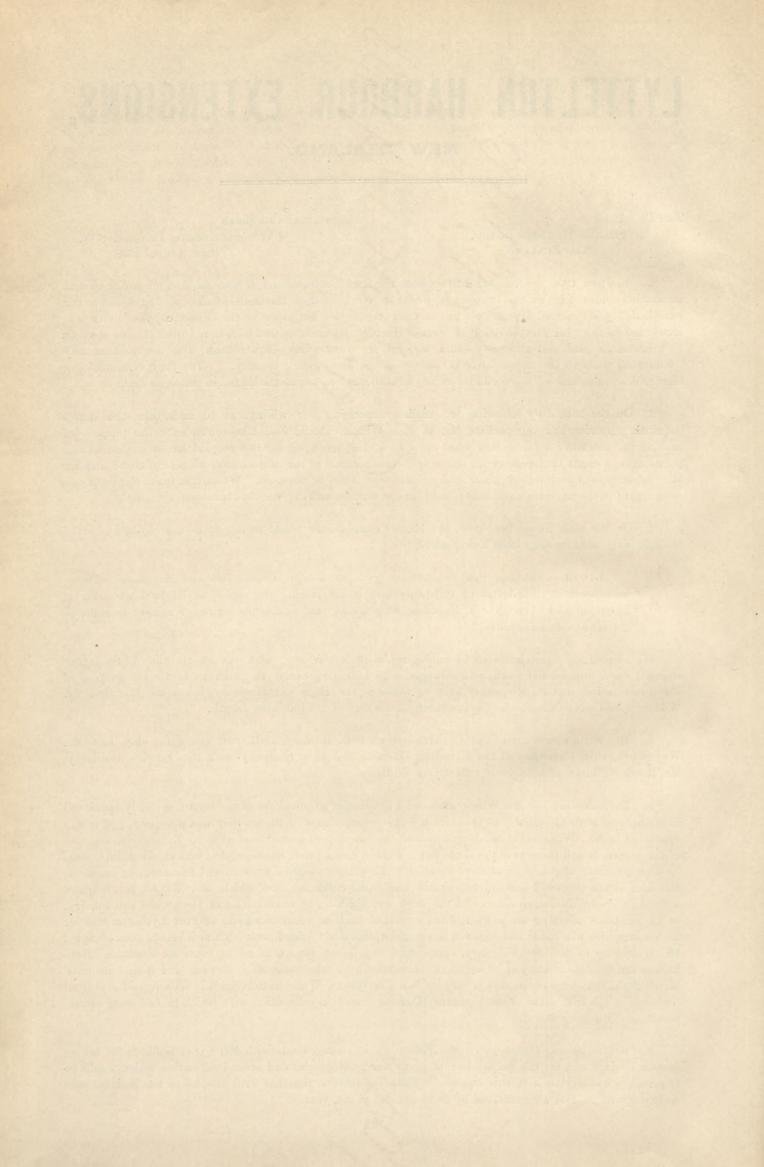
" Colony as soon as possible."

We accordingly communicated by cablegram with Mr. Wilson, who was at the time in Singapore engaged upon professional work, and arranged with him to proceed to Christchurch for the purpose of the investigation, and on November 21st we wrote to the High Commissioner, informing him that Mr. Wilson would leave Colombo for Christchurch on the 29th of the following month.

4. Mr. Wilson duly arrived at Christchurch on 25th January, 1907, and the same day met Mr. Waymouth, then Chairman of the Lyttelton Harbour Board, in company with the Board's Secretary, Mr. Hood Williams, and Engineer, Mr. Cyrus Williams.

5. The following day Mr. Wilson attended a meeting of a Committee of the Board, specially appointed in connection with his visit. At this meeting the general scope of the enquiry was discussed, and it was explained to Mr. Wilson that the Board desired that our report should deal with the Engineering features of the proposals and the cost of the same, but it was not desired that we should deal with the financial aspect, or with questions of policy as affected thereby. They then visited Lyttelton and Sumner, and inspected the sites of the proposed harbour extensions and canal entrance, after which Mr. Wilson, in company with Mr. Cyrus Williams, commenced a thorough investigation, by examination on the ground and enquiry, of all questions affecting the proposals for increased harbour accommodation at Port Lyttelton and for the construction of a canal and docks in the neighbourhood of Christchurch. These investigations occupied Mr. Wilson up to the 18th February, upon which day he left for Auckland, en route for England. Here he was unfortunately delayed owing to the breakdown of the steamship service, and it was not until March 24th, that he was enabled to sail for San Francisco. While so delayed Mr. Wilson paid a visit to Gisborne at the invitation of the Gisborne Harbour Board, in connection with which he had some correspondence with your Board.

6. Before leaving Christchurch Mr. Wilson made arrangements with Mr. Cyrus Williams for taking certain borings and for the preparation of plans and photographs and other information which would be required in connection with this report. These documents, together with samples of the borings, were duly despatched, and were received by us in October of last year.



7. We desire here to express our regret at the somewhat long interval which has elapsed since the receipt of these documents and the completion of this report. The delay has been quite unavoidable, and is due to a great press of work in connection with the starting of some large works at Singapore, and also in connection with some extensive works in progress on the West Coast of Africa. We sincerely trust that the Board will have experienced no inconvenience on account of this delay which, as above stated, has been quite unavoidable.

8. Having now had an opportunity of fully studying the whole question, we are in a position to present this report.

9. Mr. Williams has submitted in his report two main propositions, whereby the harbour or dock Mr. Williams accommodation necessary for the increasing trade of Christchurch and the surrounding district may be obtained, as follows :--

- (1) To increase the present harbour accommodation in the Port of Lyttelton.
- (2) To form a large wet dock, provided with the necessary quays and jetties, in the neighbourhood of Christchurch, and to give access thereto by means of a canal from the sea at Sumner, the entrance to the canal being protected by rubble stone moles.

10. We are requested in our instructions already referred to, to report upon any other scheme for Alternative schemes.

11. The City of Christchurch is situated upon Canterbury Plain, at the foot of the high, mountainous ground of volcanic origin known as Banks Peninsula. To the east of Christchurch the plain extends continuously to the sea, the coast being from 3 to 4 miles distant. The general surface level in the neighbourhood of the city is about 14 feet above high water, dropping to about 2 feet above high water at the estuary of the Avon and Heathcote Rivers. The material in the neighbourhood of the city consists almost entirely of hard, grey shingle and gravel intermixed with varying proportions of sand and silt, and is in general quite permeable to water. This formation extends to a great depth below the surface, as has been proved by numerous borings which have been made for water supply by means of artesian wells. A little to the eastward of Christchurch, the gravel is gradually replaced by fine sand, and it is through this latter material that the canal, as proposed by Mr. Cyrus Williams, would for the most part be formed. Southward of Christchurch, the nearest point at which the Canterbury Plain reaches to the coast is at the northern end of "Ninety Mile" Beach, just to the southward of the high ground of Banks Peninsula. The distance from Christchurch to the sea is here upwards of 20 miles, which would render the cost of constructing a canal in this direction prohibitive. In addition to this, such a canal would open upon a beach exposed to the full force of the S.E. gales which at times blow with great violence, whereas Sumner beach is much protected from the S.E. by Banks Peninsula. Moreover, there is a great travel of shingle along "Ninety Mile" Beach, as already experienced at Timaru, which would render it impracticable to maintain the necessary depth of water at the canal entrance. We have, therefore, no hesitation in saying that if Christchurch is to be connected with the sea by a canal, the only feasible method of accomplishing this end must be, speaking generally, somewhat upon the lines proposed by Mr. Williams.

12. We purpose, therefore in the following remarks, to discuss the harbour and canal schemes as proposed by Mr. Williams, making suggestions as to such modifications in the same as may appear to us to be desirable.

13. In order that the various questions discussed, and the accommodation set forth, may clearly be **Drawings**. understood we have prepared the following drawings :

Drawing No. 1 is a general plan of the district showing the relative positions of the various places referred to in this report.

Drawing No. 2 is a similar plan whereon are shown the schemes proposed by Mr. Cyrus Williams.

Drawing No. 3 shows in a similar manner our own proposals.

Drawing No. 4 is an enlarged plan of Port Lyttelton showing Mr. Williams' proposal for a harbour at Gollan's Bay.

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Deaving No. 4 is an enlarged plus of Pers furtision sharing Mr. Willisine' property form hathour Gullen's Bar

Drawing No. 5 is a similar plan showing our own proposal for a harbour at Gollan's Bay.

Drawing No. 6 is an enlarged plan of the estuary of the Rivers Avon and Heathcote, and including Sumner Head. On this plan is shown Mr. Williams' scheme for a dock at Heathcote connected with the sea by a canal.

Drawing No. 7 is a similar plan showing our own proposal for a canal and dock.

Drawing No. 8 gives typical cross sections in connection with our proposals.

14. It will be observed from the notes upon the plans that they have been prepared from the Admiralty Chart, from maps of the New Zealand Survey Department, and from drawings supplied by Mr. Cyrus Williams. In compiling these plans several discrepancies were discovered between the different plans and the Chart, but wherever available the ground line as shown upon the drawings furnished by Mr. Cyrus Williams has been adopted. Should it ultimately be decided to carry out any of the works now proposed, we would point out the extreme desirability of having a complete and correct survey of the whole site of the works prepared before the detail drawings are proceeded with.

LYTTELTON. HARBOUR EXTENSION AT PORT

15. We propose in the first instance to deal with the proposed Harbour Extension in Port Lyttelton.

16. The present harbour at Lyttelton is formed by two rubble stone moles, the western mole extending Present from Naval Point for a length of about 1,480 feet, the eastern mole commencing at Officer's Point and Harbour. extending for a length of about 2,000 feet. The area enclosed is about 107 acres, with a clear width of entrance of about 550 feet. Within the harbour, jetties and breastworks (or wharves) have been constructed for the accommodation of vessels, the total length of these works, reckoning both sides of the jetties, being given as 12,847 lineal feet, of which 5,841 lineal feet is available for ocean steamers. At present the middle section of the harbour, wherein are placed the jetties is maintained by dredging to a depth of 25 feet below low water of ordinary spring tides, and we understand that the eastern portion of the harbour is now being dredged to that depth preparatory to the erection of two new jetties for the accommodation of ocean steamers. The harbour is approached by means of a channel about 7,000 feet in length and 400 feet in width, dredged to a depth of 24 feet, but now being deepened to a depth of 28 feet at low water of spring tides.

17. Although from a comparison of recent soundings taken by Mr. Cyrus Williams, with those given Deposit of upon the Admiralty Chart of 1849, it appeared that no general diminution of depth was apparent within Port Lyttelton, nevertheless, within the harbour and the dredged channel considerable deposit takes place, necessitating a large amount of dredging for maintenance purposes, which will now doubtless be augmented due to the increased area of deep water to be maintained within the harbour itself and to the increased depth of channel to which allusion has been made above.

18. Mr Williams, in his report, quotes figures to show that the trade of the Port has maintained for some Necessity for years a large and steady increase, and he gives a table and diagram indicating the probable trade in future Extension. years. It is not desirable to place entire reliance upon the rate of increase shown by such tables being continued for many years, but it may be stated that the returns up to the end of 1906 showed the rate of increase to be fully maintained, and there is apparently no reason to anticipate any falling off in the near future.

19. We understand, as above referred to, that owing to this increase of trade the Board are about to proceed with the construction of two new jetties within the existing harbour which will no doubt provide for immediate requirements. Meantime it becomes desirable to consider how still further accommodation, which it is reasonable to expect will in the course of some years show itself to be necessary, can best be afforded.

20. One of the first points to be considered in connection with harbour extension is the draught, together with the general dimensions of the vessels likely to use the Port.

21. With regard to the draught of vessels, Mr. Wilson was informed by the Committee that the Draught and Dimensions Harbour Board had decided that a depth of at least 30 feet below low water ordinary spring tides should of Vessels. be provided, and the matter was further considered in New Zealand and valuable information kindly

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HARBOUR EXTENSION AT PORT LYTTELTON

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afforded by Mr. Bennett (Manager of the New Zealand Shipping Company), Captain Bone (Marine Superintendent of that Company), Captain McDougall (of the Shaw, Savill and Albion Company), and others, from which it appeared that they considered the maximum draught of vessels would be from 27 feet to 28 feet. We have since been in communication with the London offices of the New Zealand Shipping Company and Messrs. Shaw Savill and Albion Company with regard to this matter and to the dimensions generally of their vessels trading with New Zealand, from which it appears that the deepest draught vessels visiting New Zealand are those of the "Corinthic" type belonging to Messrs. Shaw Savill and Albion and in writing to us they quote the following dimensions as applying to these vessels, viz. :--Length, 500 ft. 3 in.; breadth, 63 ft. 3 in.; depth 45 ft.; maximum mean loaded draught, 32 ft. 3 in. The New Zealand Shipping Company give 29 feet as the present maximum draught of their vessels. We have also had the advantage of interviews with Captain Kempson, of the "Athenic," and Captain McKellar, of the "Kaikoura." Captain Kempson informed us that they frequently left Wellington drawing upwards of 31 feet. We consider, therefore, having regard to the general tendency to increase the draught of vessels, that although a depth of 30 feet at low water alongside the jetties and wharves might in the first instance prove generally sufficient, they should be so constructed as to admit of future dredging to a depth of say 35 feet alongside.

22. Another important point to be kept in mind in designing the harbour is to so arrange it that the amount of dredging required to properly maintain the necessary depth of water within the harbour and its approaches may be reduced to a minimum.

Physical 23. Before proceeding further it is necessary to refer to the physical conditions with regard to wind and sea which are met with in Port Lyttelton, and for which provision must be made.

24. In 1863 a Commission was appointed to consider the whole question of harbour and wharfage 1863 Comaccommodation at Lyttelton, and the existing harbour was the outcome of the recommendation of that Commission. They enquired very minutely into the question of the prevailing winds and sea and it may be of interest here to refer to their report. Referring to the Port it is stated, "The anchorage does not lie within a land-locked harbour but is open to the ocean swell which sweeps round Banks Peninsula and "sets up the bay from E. and N.E.-at times with great violence and in very long undulations." It was further stated in evidence that "South-easterly gales which do not blow home send a heavy "swell round Banks Peninsula which penetrates the Port of Lyttelton in a long, blind roll." Again: "The anchorage is also exposed to S.W. gales which blow with great force over a low saddle of lofty hills "surrounding the harbour, and raise in only two or three fathoms water a short, chopping sea, for which "the sailor is at a loss to account as there is but a short 'fetch' of only two miles. Each of these two " dangers spring from a quarter of the compass at right angles to that from which the other comes. The "violent S.W. gales prevail mostly in winter, last generally for three days, and almost invariably begin at "N.W. veering round gradually by W. to S.W. At W. and W.S.W. it often blows with " greatest violence but more steadily, and raising much less sea than when it has settled down from S.W."

25. We may say that the above description was entirely corroborated in the course of the enquiries Weather and made during our recent investigation, and are further borne out by the abstract of weather reports with. wind diagrams since the year 1879, so kindly prepared by Mr. Williams. It was abundantly proved that the heaviest seas experienced are those due to S.E. gales, which send in a long ground swell round Banks Peninsula and up the Port of Lyttelton. It is a curious fact, however, that the S.E. gales which create this swell never blow "home" at Lyttelton. It was stated that when S.E. gales were experienced at Timaru, or elsewhere along the coast, the wind at Lyttelton was almost invariably S.W. This absence of S.E. winds is shown in a striking manner in Mr. Williams' abstract of weather reports above referred to.

26. As already mentioned, the strongest winds experienced in Port Lyttelton are from a southwesterly direction. These winds blow at times with great violence, and it is considered essential that jetties and wharves should be built approximately in that direction, so that vessels may lie head or stern to the wind.

27. With regard to the height of waves experienced, the general local opinion appeared to be that Height of Waves. these seldom exceed four feet in height from trough to crest as far up as Lyttelton Harbour, though they have occasionally, on an ebb tide, been known to break opposite the harbour entrance. Mr. Williams, in his memorandum accompanying the documents forwarded to us and referring to the sea outside the "Heads," says :---" The direction of the heaviest sea has been observed and measured by looking along the wave " crests and then measuring the height of the observer's eye above the water level. The result of these "observations gave a height of 9 feet from trough to crest, which is put down as 10 feet on plan to allow

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28. It appears, therefore, that any harbour constructed in Port Lyttelton must be protected to the Shelter eastward from the long ocean swell caused by S.E. gales, and to the southward and westward from the short, choppy sea which is raised within the Port itself by the exceedingly violent gales which are experienced from that direction.

STICKING POINT HARBOUR.

29. Mr. Williams, in his report, proposes two alternative schemes. The first proposal is for the con- General struction of a comparatively small harbour to the eastward of and adjoining the present harbour. It would be formed by two moles, the Western mole springing from the outer bend of the existing "Officers' Point" mole, the Eastern mole starting from "Sticking Point." Within the area enclosed (about 90 acres) four jetties would be erected, breastworks to form wharves at which vessels could lie, being constructed as required along the inner faces of the moles themselves. This harbour is shown by brown colour on Drawing No. 2. There is no doubt that a very material addition to the present accommodation could thus be afforded, but in connection with this scheme there are certain considerations to be borne in mind.

30. In the first place, owing to the steep and mountainous nature of the land surrounding the whole Difficulties of of Port Lyttelton it is not possible, once the area of the harbour has been fixed by its enclosing arms, to Extension. extend that area. Consequently, when further extension is found to be necessary, an entirely new harbour must be formed. It is, therefore, extremely desirable that ample area should be provided when carrying out any further extension, and in this connection the increasing draught and dimensions of vessels, and the space required for manœuvring, must be taken into consideration.

31. The natural depth of water in the neighbourhood of the proposed harbour at "Sticking Point" is about 22 feet. Consequently, in order to obtain a minimum depth of 30 feet within the harbour and approach channel, a large amount of dredging would be necessary, and, moreover, judging from the experience gained at Lyttelton, there can be no doubt that constant dredging would be required to maintain this depth. Added to this, the harbour, as designed, is cramped in area and less commodious for the purpose of handling large vessels than is the existing harbour.

32. For these reasons we are unable to recommend the construction of a harbour at "Sticking Point," and we believe that this is also Mr. Williams' opinion.

HARBOUR. GOLLAN'S BAY

33. Mr. Williams' alternative scheme for a harbour in Port Lyttelton is that proposed to be con- General. structed at Gollan's Bay, and is indicated by red colour on Drawings Nos. 2 and 4. This appears to be in every way a well-thought-out and carefully considered scheme. Speaking generally, and subject to certain remarks which we have to make thereon, we are of opinion that a harbour, very much on the lines and in the position of that shown by Mr. Williams, would fully meet the requirements of the Port and the special local conditions. The entrance is placed practically at the 30 feet contour line, so that in the first instance no dredged approach channel would be required, and seeing that as already mentioned it has been found that no appreciable silting is taking place generally within the Port, the full depth at the entrance should be readily maintained. Within the harbour, owing to the considerable natural depth of water already existing, the amount of dredging which would be necessary in order to give the required depth of 30 feet below low water is not excessive.

34. Looking first at the ground plan of the Harbour, as proposed by Mr. Williams, we consider that Plan of some slight improvement might be made in the entrance. The Eastern mole does not appear to us to Harbour sufficiently overlap the head of the Western mole so as to shut out the swell coming up the Port, and we would, therefore, propose to slightly lengthen this arm.

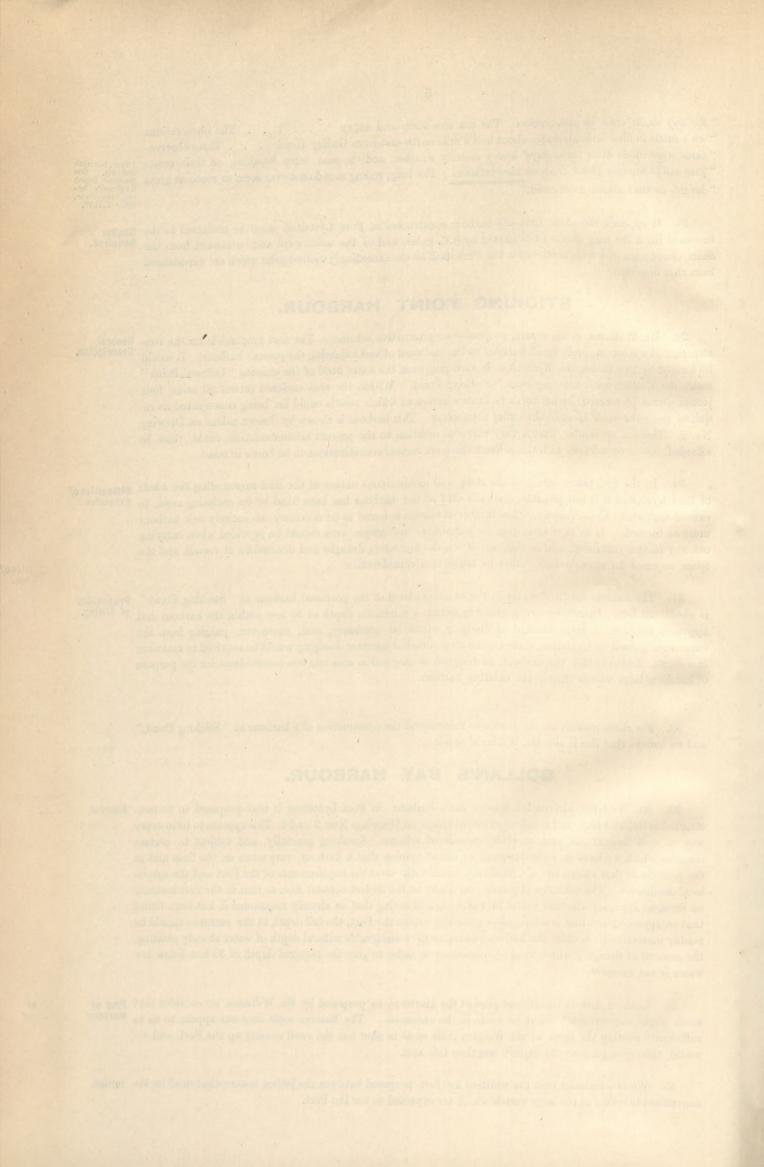
35. We also consider that the width of 250 feet proposed between the jetties is somewhat small for the Jetties. convenient berthing of the large vessels which are expected to use the Port.

Required.

? Four, not nine fathoms. See Harbour Board Engineer's let-ter, 14th June, 1907.--C.H.W.

Description,

Probability of Silting.



36. Furthermore, as the trade increases it is extremely probable that the need of warehouse accommodation in the neighbourhood of the harbour may become felt. In connection with the western mole and jetties, the space available for such accommodation and also for railway sidings appears to be very limited in extent. It is assumed that the first jetties to be constructed would be those projecting from the Western mole, and that the jetties and reclamation works shown upon the northern side of the harbour would not be undertaken until rendered necessary by the future requirements of the Port.

37. With regard to the sheltering breakwater on the eastern side of the harbour, it is proposed that this Breakwater. should be constructed of rubble stone, quarried from the cliffs adjoining the site of the works. Seeing that there is an unlimited supply of hard stone, mostly of basaltic formation, in the surrounding hills, this will clearly be the most expeditious and economical method of constructing the work.

38. Mr. Williams proposes that the section of the mound should be generally similar to that of the Mr. Williams' existing "Officers Point" mole, with the exception that the stones should be of somewhat larger size, and the slope slightly flatter. We understand that the outer slope of this work stands at from $1\frac{1}{2}$ to 2 to 1, and has required practically no maintenance during the four years that Mr. Williams has been in Lyttelton.

39. From the cross sections which have been supplied to us, it appears that the heart of the breakwater would be constructed of stones from 1 cwt. upwards, with an outer coating of 5-ton stones and a slope of 2 to 1, the inner face being coated with 2-ton stones at a slope of 1 to 1. The top of the mound to be 10 feet wide and placed at 6 feet above high water of ordinary spring tides.

40. It is, no doubt, the fact that the heaviest swells which are experienced in Port Lyttelton are of Eastern Mole no great height and are unaccompained by wind at the back; nevertheless, in the case of a long ocean swell of that nature, the weight of blow received by any obstruction would be severe. The breakwater, as proposed by Mr. Williams, is placed practically at right angles to the direction of the swell, and would, therefore, experience its force to the full, whereas the existing mole at "Officers Point," forms but a slight angle with the direction of the waves, thus materially diminishing their effect. Moreover, a harbour at Gollan's Bay would be some 2 miles nearer the mouth of the Port and in much deeper water than the harbour at Lyttelton, which would increase the weight of sea to be encountered at the former place as compared with the latter. In the report of the 1863 Commission, to which reference has already been made, it is stated that "the swell receives no serious check in sweeping up the northern shore of Port Lyttelton until it has " passed about one mile and a-quarter above Gollan's Bay."

41. For these reasons, and from our own experience of the effect of the sea upon rubble mounds, we are of opinion that the proposed section of the breakwater mound should be increased to the extent hereinafter referred to.

42. With regard to the Western mole, this work not being directly exposed to heavy seas, we consider Western Mole that the slope as provided by Mr. Williams should prove satisfactory. We should propose, however, to make the top width somewhat greater than that shown by Mr. Williams, and to use somewhat heavier material.

43. A careful examination of these structures, as constructed and in use in Lyttelton, has shown letties and them to be well adapted for the work required of them and we, therefore, do not propose any alteration in the general design, which has been adopted for many years with success. In the proposed new jetties and breastworks Mr. Williams contemplates the use of Australian Ironbark timber for piles, beams and bracing, Jarrah or Red Mahogany being used for decking. In connection with the use of timber for these structures, we may mention that the Teredo Navalis, which elsewhere in New Zealand is exceedingly destructive of timber work, is not active in Port Lyttelton, Ironbark being specially free from its attacks. In this connection also we may say that piles of that material were pointed out which had been in the water thirtyseven years and, with the exception of some slight worm action near the surface, were in perfectly sound and good condition. We therefore consider that under these circumstances the use of the timber would be justified.

RECOMMENDATIONS.

44. We have given careful consideration to the whole question, and upon Drawing No. 5 have shown a design for a harbour at Gollan's Bay which, we consider, will best meet the more immediate requirements of the Port and give ample space for future extension. As will be observed, it is upon the general lines of that proposed by Mr. Williams, but embodies some modifications which we consider desirable.

Section for Moles.

Breastworks

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RECOMMENDATIONS

22. We have grown careful contribution to the whole quantities, and upon the star (or, if have shown) a define for a barbour of the second star of the second star

45. The head of the East breakwater by projecting somewhat beyond the head of the Western mole as shown will afford better protection to the harbour in the matter of shutting out the swell coming up the harbour.

46. It will be observed from the drawing that we propose a width of entrance of 700 feet clear waterway, which, we believe, will meet all requirements of navigation, while at the same time giving ample protection When the moles are drawing together to form the entrance it will, however, to the harbour from the sea. be possible to modify if desired either the aspect of the entrance or its width or the amount of overlap of the East breakwater to such an extent as experience may show to be necessary. We have already alluded to the interviews which, through the courtesy of Messrs. the Shaw, Savill and Albion Steamship Company and the New Zealand Shipping Company, we have been afforded with the Captains of the "Athenic" and "Kaikoura." We may here add that those officers have expressed themselves as entirely saitsfied with the general design of the harbour and the position and aspect of the entrance.

We propose to commence the Western mole at Sticking Point in lieu of at Battery Point, as in General 47. Mr. Williams' design. The outer end will be canted inwards so as to afford protection to the jetties from the easterly swell. By commencing the mole at Sticking Point railway access to the jetties will be quicker and more direct than in the case of the mole starting from Battery Point; this should prove of great advantage in the working of the traffic. At the inner end of the mole and extending across to Battery Point a reclamation of about 36 acres in extent would be formed as shown upon the drawing, affording valuable space suitable for offices, sheds, warehouses, railway sidings, &c., which would be required as the trade of of the Port developed.

48. We have provided for jetties 1,200 feet long in lieu of 800 feet, as in Mr. Williams' scheme. The extra width of the harbour, as derived by commencing the western mole at Sticking Point instead of Battery Point enables this to be done while still affording ample space for manœuvring vessels entering or leaving the Port. These jetties, however, need only be constructed 800 feet long in the first instance, being extended hereafter as required. The large accommodation which would thus be afforded at the jettles projecting from the Western mole, where the railway access is direct and convenient, should prove of great value, inasmuch as the necessity for constructing jetties off the northern shore where, in addition to their remoteness, access thereto must be by the inconvenient method of back shunting, would be postponed for many years to come.

49. We have, however, shown by green colour on the drawing, an extension of the breastwork quay, about 2,900 feet in length, along the western shore of the harbour, and a reclamation with jetties along the northern shore, which could be constructed in the future, should such additional accommodation be found necessary.

50. It may possibly be urged that in thus commencing the Western mole at Sticking Point, the easterly swell might be led along the back of the arm and across the entrance of the present harbour at Lyttelton, to the inconvenience of vessels using the same. Having regard, however, to the information we received at Lyttelton with respect to the sea experienced at that place, and also to the large extent to which the sea will be cut off by the Eastern breakwater of the proposed harbour, we do not anticipate any difficulty on this account, and feeling confident of the advantages which would be obtained by means of the longer jetties permissible, and of the direct access thereto and of the valuable site which could be reclaimed at the root of the mole, we have no hesitation in recommending the adoption of our proposals as shown upon the drawing.

51. To the westward of Sticking Point an area has been shown crossed by red lines, which represents approximately the distance to which the hill would be cut back in order to provide material for the This would afford valuable space for railway sidings, and would allow a convenient Western mole. approach with easy curves to the proposed harbour.

52. The East breakwater, as proposed by us, is on the same line as that shown on Mr. Williams' design, but we have increased its length by 200 feet in order to give greater overlap at the entrance.

East Breakwater.

Description

of Proposed

Works.

53. We have already alluded in general terms to the breakwater as designed by Mr. Williams, and expressed the opinion that the section should be increased. A cross section of the breakwater which we would recommend is shown upon Drawing No. 8. From this it will be observed that we propose the mound should be constructed with a slope seaward of $2\frac{1}{2}$ to 1 to a depth of 10 feet below low water, the slope thence to the sea bed being taken at $1\frac{1}{2}$ to 1. The inner slopes would be $1\frac{1}{2}$ to 1 to 5 feet below low water, with the feature that or the first oreal water by projecting concerns, happend the hard of the Western mole as shown will afford better protection to the barbons in the matter of phinting out the swell couring up the rarbons.

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48. It will be obtained there is deviating that we propose a within all entrances of 700 free clear waterany, which we believe will need all requirements of narrowiting, a tile at the number time grains angle production for the harbour from the events of Mars the moles are deviating together to term the events of with harbour term is events of the moles are deviating together to term the events of with harbour term is event to the moles are deviating together to term the events of with harbour term in another the second of the moles are deviating together to term the events of with harbour term is another the second of the second of the term of the events of the indices of the formation of the formation of the term of term of the term of term of the term of term of term of the term of term of the term of term of term of the term of the term of term of the term of the term of term of the "term of term of term of term of the "term of term of the term of term of the term of the term of the "term of term of the "term of term of the term of ter

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35. We have however shown in press mount on the drawing an extension of the breatwark quart, anota to the breatwork quart, along the wettern shore, of the narbows, and a redunation with jettice along the unribero shore, which could be constructed in the future thanks with additional accommodation is found measure.

We lit may possibly be arged that in this bounseneing the Weners made at Sticking Point, the carriedy avail might be hed along the mark of the arm and armos the entrance of the present horbers at hytichten to the inconvenience of vessels using the same. Having regard however, to the information we received at hyritelton with respect to the we experienced at that place, and also to the base, estent to which the secwill be cut off by the Eastern brankwater of the proposed harbert, we do not surviving the conthis account, and beeing confident of the advantages of the variant, we do not surviving the large permandition and the define confident of the advantage of the variable is of which the thermal permandition and of the define access thereto and of the radiable is which the termination of the thermal of the under we have no hestration in thereing the adoption of one proposals as shown aport the drawing

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52. The East breakwater, as proposed by us, is on the same line as that shown on Mr. Williams' fait friends being her we have intreased its length by 200 ices in order to give intentor overlap at the entrance. water

Discription of Propased Works and 1 to 1 below that level. The top width of the mound will be 20 feet at a level of 7ft. 6in. above high water of ordinary spring tides. We further consider that the outer slopes should be formed of stones 8 tons and upwards in weight. It will be noticed that the section we recommend is considerably in excess of that proposed by Mr. Williams, but, taking into account the considerably heavier swell which it will encounter as compared with the existing breakwater at Lyttelton, we do not consider it to be excessive. A lighter section would, we fear, require a large amount of maintenance.

54. For the West mole we consider that the section as adopted by Mr. Williams with outer slope of West Mole 1½ to 1 should prove sufficient, but propose covering this slope with stones of say 5 tons in weight. We propose to construct the outer end, seaward of the jetties, with a top width of 15 feet in place of 10 feet. The cross section of this work is shown on Drawing No. 8 It will be noticed that from the commencement of the mole proper to the outer jetty we have provided for widening the mole on the inside to a width of 55 feet, measured from the inside of the small parapet also shown upon the cross section. Seeing that the whole of the traffic to and from the jetties will have to pass along this work, we consider that the above-named width should be allowed in order to provide space for four lines of rails. We also consider it desirable to provide a parapet along the seaward side of the mole in order to protect the railways and quay surface from damage during S.W. gales. This parapet would be constructed of concrete blocks laid dry in order that they might be taken up and re-set as settlement of the mound took place. When the mound had become thoroughly consolidated they could be finally re-set in cement, if so desired.

55. As already stated, we do not propose, seeing that the jetties now in existence have proved entirely **Jetties.** satisfactory, to suggest any alteration in their general design. Inasmuch, however, as the jetties in Gollan's Bay Harbour will be in considerably deeper water than those in Lyttelton Harbour, we are of opinion, in order to give sufficient lateral stiffness, that it will be necessary to provide either cross bracing below low water level or to deposit a mound of rubble stone along the centre of each jetty.

56. In view also of the information received as to draught of vessels to which reference has been made in a preceding paragraph, we consider that the piles of the jetties should be driven down to a sufficient distance to allow of dredging alongside to the depth of 35 feet, should this ever become necessary.

57. We should propose that in the first instance dredging to provide a depth of 30 feet below low **Dredging** water ordinary spring tides should be undertaken to the extent necessary to give access to the jetties projecting from the West mole as shown by red colour on the drawing. The extent of this dredging is shown by crossed red lines.

58. The dredgings would be deposited, as far as possible, within the bay to the westward of Battery **Reclamation**. Point. They would be retained by means of a rubble bank tipped from the root of the mole towards Battery **Point**, an opening being left to enable the hoppers to pass in and out for the purpose of depositing their loads. When dredgings had been deposited to the fullest extent practicable, the opening in the bank should be closed. The dredgings would then be dumped at a convenient spot and pumped by means of a suitable pontoon pump dredger provided with cutters into the reclamation area to the required level. By this means a valuable area could be reclaimed at a comparatively small cost.

59. We estimate the cost of the works, if carried out to the extent shown by red colour on Drawing No. 5, as follows :---

Eastern Mole, in general accordance with the cross section shown upon Drawing No. 8	£64,870
Western Mole, ditto, ditto, and including widening out on Harbour side for railway access	
to jetties and also concrete blockwork curtain wall	£133,015
Rubble protection banks from root of Western Mole to Sticking and Battery Point	£31,800
Dredging, to the extent shown upon the drawings, the dredged material being deposited	
in, or pumped into, reclamation	£36,455
Timber jetties, as shown upon Drawing No. 5, together with breastwork wharf along	
front of reclamation	£285,560
Shed accommodation	£21,945
Buoys	£660
Navigation lights	£1,650
Cranes, locomotives, trucks and miscellaneous plant in quarry, and for railway	£57,475
Pontoon Pump Dredger for pumping dredgings into reclamation, &c	£11,000
Laying railways on wharvesand connecting same with Government Railway	£11,000

£655,430

Say, £655,500.

The above estimate includes 10 per cent. for engineering and contingencies.

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57. We should propose that in the first instance dealging to provide a daph of 30 feet before for Oradgin water ordinary spring tides should be underraken to the extra necessary to give arcses to the jettica projecting from the West table as shown by red colour on the draving. The extend of this dradging in shown by coosed ted lines.

58. The deduces would be dependent as for an possible, within the bay to the vertured of Sattery Resize at Point. They would be retained by means of a rubble hart tipped from the motel the nucle forwards Pathery Point, and opposing her to enable the hoppers to pass in such out the parces of depariting their leads. When dredgings had been deparited to the follow rations possible, the vertual formards Pathery Const. and opposited to the follow rations possible, the vertual of the nucle formards Pathery Const. and opposited to the follow rations possible, the vertual of the basic should be constructed to the follow rations possible, the vertual of the basic should be constructed to the follow rations possible, the vertual opposited to the follow rations possible, the vertual block of a stitution opposited to the contract into the contract of the contract into the contract opposited with curtary into the contract into the contract on the vertual level. By this means a valuable area could be reducined at a comparative ration contract opposited with events into the contract opposited cont.

50. We estimate the cost of the works, if carded out to the extent above by red colour on Drawing No.

Wratern Mole dates, and instability widening out on Harbour side for rails or access
Navignion fights

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(N. 2655,501)

The above estimate includes 10 new cent. for engineering and continuencia

60. In framing this estimate we have, after very careful consideration, adopted generally the prices taken by Mr. Williams. The prices for rubble stone are based upon the actual cost of quarrying similar material at Timaru, allowing for the advantage in the present case of having the material actually at the spot, thus avoiding the long lead and special railway required at Timaru.

61. In view, however, of the section of the East breakwater having been increased and heavier stones having been adopted for the sea slope, it would be necessary, in order that these may be properly got into position, to provide for a 15-ton travelling crane with, say, 45 feet radius, and we have consequently allowed in our estimate for the provision of such a crane. Similarly with regard to the West mole, we have provided for a 10-ton travelling crane with 30 feet radius.

62. In connection with the use of these cranes, the stone would be loaded at the quarry into loose boxes or trays, which would be placed upon undercarriages and run to the moles. The cranes would then lift the boxes and deposit the stone in the moles and upon the slopes thereof where required.

63. The cost of jetties, breastworks and dredging are derived from those actually experienced in Lyttelton. We have, however, somewhat increased the price of the jetty work to cover the increased length of piles and the under water cross bracing or rubble mound to which we have already called attention. With these qualifications we see no reason to depart from the prices allowed by Mr. Williams.

64. We have provided in the estimate for sheds and railways, but not for dock equipment in the shape of cranes, electric lighting, &c. With these exceptions our estimate covers the cost of the whole of the work shown by red colour on Drawing No. 5, though in all probability it would not be necessary to construct more than two or three of the jetties in the first instance, and these only to a length of 800 feet. These could be lengthened and other jetties added as required. Similarly the dredging of the harbour to the necessary depth would be completed as required.

65. It will be seen that we have included in the estimate a sum of £68,475, to cover the provision of plant. Under this head we have provided for the following :-

- 13 Cranes in the quarry.
- 2 Cranes upon the moles.
- 3 Locomotives.
- 100 Underframes carrying tipping boxes.
- 30 Side and end tip muck waggons.
- 1 Pontoon pump dredger.

Which we consider will be required in order to complete the work within seven years, and is based upon our experience in the carrying out of similar works. We have adopted the prices for which such plant could be obtained in England, and have added thereto 50 per cent. to cover the cost of freight, Customs duty, and erection, which, we understood, was a fair allowance to make. It is, of course, possible that a considerable portion of the plant may be obtained in the Dominion, thereby effecting some saving in this respect.

66. In going into the question at Lyttelton, Mr. Williams expressed his belief that in the event of a harbour being constructed either at Sticking Point or Gollan's Bay, no additional dredging plant would be necessary, the existing plant being sufficient to undertake all that would be required. We have consequently not provided for any dredging plant in the above estimate, with the exception of the small pontoon pump dredger for reclamation purposes, to which reference has already been made.

67. One principal consideration always to be borne in mind in connection with harbour extension Railway to in Port Lyttelton, is that the whole of the goods shipped or unshipped have to be carried along a single line of railway through a tunnel 11 miles in length, penetrating the Port Hills There is no doubt that the railway could deal with a large increase upon the present traffic, especially if improved siding accommodation could be formed at the Lyttelton end of the tunnel, which, we understand, is in contemplation. But there is also no doubt that with a considerably increasing trade the time must come when the duplication of the tunnel will become necessary and have to be seriously entertained.

68. With a view of obviating this difficulty it has been proposed to form a dock in the vicinity of Christchurch itself, connected with the sea at Sumner Beach by a canal through which the largest vessels could pass.

Dredging Plant.

Lyttelton.

? The length of Lyttelton Tunnel is 1 mile 50 chains—C.H.W. and its in trading the compute to have after only such conditation, stopped generally the prices taken on the Williams. The prices for radius more are based upon the terraid cust of cramping similar material so Treases, advects for the advantage of the process case of inverse flat material actually at the spot, thus avoiding the long lead and special values received at Trans.

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65 The and di phine, heperatoris and declare we defined from these accessive experiences in Letterance. We have heavyour something inchessed the proof of the jairs which to ever the intersect longth of pairs and the order even event brachty or rabble-merged to which we have arready called artenian. We is then yield bracking we are no means to depute from the price alread by Mr. Wittens.

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64. We have provided in the connects to shoke and nowire, but per for lock equipment in the single of orages, showing he infinite parts of the single of the second contracts of the single of the second contracts of the

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68. With a roow of obviating this difference is has been proposed to from a dock in the righter of Christophych study connected with the sec or Subtrac Been h by a count changels which the largest vessels could now. 69. We purpose now to consider the proposals which have been put forward with this object.

CANAL AND DOCK SCHEME.

70. Mr. Williams, in his report, put forward two alternative schemes for providing dock accommodation Alternative in the vicinity of Christchurch. The first proposal is for the construction of a Port or Tidal Basin in the estuary near the mouth of the Heathcote River. As an alternative it is proposed to construct the Port or Basin at Linwood, some three miles nearer the city. In either case the connection with the sea would be by means of an open ship canal with an entrance at Sumner.

71. In the course of our investigation at Christchurch, it was in some quarters very strongly urged Difficulties that the construction of such a canal would be impracticable, chiefly for the following reasons :--

- (1) That quicks and sexist at the entrance of the proposed canal, which would render the construction of the northern mole impossible.
- (2) That the existence of quicksands generally along the line of canal would render its construction impracticable.
- (3) That the entrance to the canal would silt up owing to sand travel and could only be maintained in a navigable condition at prohibitive cost.

72. Instances were given of vessels sinking into the sand at Sumner Bar, also of a well near Heathcote, the sinking of which had to be abandoned owing to the quicksands which were encountered. Another instance given was the putting in of the foundations for a sewage tank at Christchurch, some 30 feet in diameter, where the work had to be discontinued owing to quicksands. During the course of our investigation at Christchurch, these points received careful attention, and the particular instances quoted were specially enquired into.

73. With regard to quicksands at Sumner Bar, a very careful examination was made upon the spot and nothing in the nature of quicksands could be discovered. A 2 cwt. anchor was dropped and buoyed on the line of the proposed north mole. After two days this was raised with the greatest ease, having scarcely penetrated into the sand. Careful enquiries were also made of Mr. Day, pilot at Sumner, who has known the place intimately for more than 50 years, covering the period before the construction of the railway to Lyttelton, when the lightering of goods from Lyttelton to the Heathcote River was carried on to a large extent. He had known many lighters to be lost on the bar. They would gradually break up and be carried away, but he was convinced that no boat had ever sunk into sand. The channel was constantly shifting to and fro, and a wrecked vessel might consequently become buried by the moving sand, which would possibly account for the suggestion that it had been swallowed up by a quicksand. Much bathing was carried on in the vicinity, persons swimming across the channel and about the bar. He was in charge of the bathers and had never heard of anyone ever getting into difficulties on account of quicksands.

74. Mr. Sowden, the foreman who had actual charge of the sinking of the well at Heathcote, to which reference has been made, stated that the well consisted of cast iron cylinders about 4ft. 6in. diameter, and that it had been intended to sink these by hand, the water being kept down by pumps. When about 18 ft. down the sand flowed in so rapidly that it was impossible to continue. Eventually the water was allowed to rise, and sinking was continued by a diver excavating inside the cylinder without any difficulty, and no further trouble was experienced on account of sand flowing in.

75. Mr. Cuthbert, Engineer to the Christchurch Drainage Board, kindly afforded particulars with regard to the trouble experienced in putting in the foundations for a sewage tank. The foundations were carried about 25 feet below the surface of the ground. It was attempted, in the first instance, to sink the excavation in the dry, the water being kept down by pumping, but it was soon found that the sand ran in so rapidly that the work had to be abandoned. A timber cylinder 30 feet in diameter was then constructed, and after being weighted, was sunk through the water by grabbing from the inside, all pumping being discontinued. This method of procedure was entirely successful, and the cylinder was sunk to the required depth of 25 feet without any further trouble. The bottom was then sealed with concrete deposited through the water, after which the water was pumped out and the tank completed.

76. Mr. Dobson, Borough Surveyor, of Christchurch, also gave valuable information upon this subject. He had a large experience in sinking wells and bores in the district, and had found no evidence of specially

Schemes.

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ne. We purpose now to consider the purposals which have been out forward which this end

AMAR AND DOOK SCHEME

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(A) Mr. Dobéan, Gorengh European at Palatabarda, also gave variable information upon the antipact; He had a large comprised in authing with and bone in the district, and had from a middanet of receivily. wet or running sand having been met with. Mr. Dobson had further been engaged upon what is known as the "Avon Cut," near New Brighton, which consists of a cut about 14 feet deep connecting two bends of the river Avon. This was carried out in the dry, and no difficulty was experienced from running sand.

77. There is no doubt that the whole district is saturated with water, the natural level of the subsoil Saturation water being about 4 feet below the surface at Christchurch, i.e., about 10 feet above the level of high water of Ground. ordinary spring tides, and whenever open excavations are attempted for the purpose of foundations for buildings, pipe laying and the like, trouble is experienced on account of water laden with sand flowing into the excavation, but the difficulty ceases upon allowing the water to rise and continuing the excavation within the water without pumping.

78. In the case of the canal and dock, it is proposed that the whole of the excavations shall be carried out by means of dredges working in the water, so that we do not anticipate that any difficulty would be encountered due to running sand, as has been found to be the case with open excavations executed in the dry.

79. With regard to the question of possible silting up of the Entrance, this is a matter to which we have Sand Travel. given the most careful attention, seeing that it is a danger which invariably attends the projection of a solid pier across a sandy beach. So far as we were able to ascertain, no appreciable alteration in the foreshore from New Brighton to Sumner has taken place since the date of the original survey some 50 years ago. Mr. Day, the Lyttelton Harbour Board pilot at Sumner, did not consider that Sumner Beach had appreciably altered within his recollection, i.e., upwards of 50 years, though it was possible that the low water line had somewhat receded, but he could not speak with certainty as to this.

80. Upon Plan No. 1, accompanying Mr. Williams' report, recent soundings taken by him are shown, Comparative a few soundings taken from the Admiralty Chart of 1849 being also given by the underlined figures. An inspection of the soundings shows that no material alteration has taken place since the date of the Admiralty survey. Mr. Williams forwarded with his notes and recommendations a plan of Sumner Entrance, showing comparative soundings taken in 1854 and 1904. With the exception of a single line of soundings in front of Sumner Beach, and generally parallel thereto, the two sets of soundings are practically identical. The same plan gives the present high water line on Sumner Beach as derived from actual levels and an "approximate' high water line as agreed some years ago (the date is not given) between the Lyttelton Harbour Bcard and the Sumner Borough Council, and it will be seen that the two lines agree very closely.

81. It appears, therefore, that there is no direct evidence of any appreciable alteration in the foreshore of Sumner and New Brighton beaches during the past fifty years, and upon careful examination on the spot no indications of sand travel could be detected.

82. It is, however, apparent that the mouth of the River Avon has in the course of time been pushed to the southward until the rocky ground prevented any further movement in that direction. This is evident from the sand spit extending southward from New Brighton to the river mouth. Further northward, near Kaiapoi, a similar spit extending to the southward of the Waimakariri River gives some indication of the same action.

83. Moreover, a closer comparison of the Admiralty soundings of 1849 with those recently taken by Mr. Williams appears to show some diminution of depth between the 3 and 5 fathom contour line, off Sumner Head. The Admiralty soundings are very few and far apart, and the scale of the chart so small that an entirely reliable comparison is not possible. It appears to us, however, that there is probably a slight movement of sand to the southward, but inasmuch as the indications of this movement are so slight and indeterminate over a period of more than fifty years, we see no reason to anticipate any special difficulty in maintaining the entrance to the required depth, though it is certain that dredging to some extent would be required for this purpose.

84. For the foregoing reasons, and upon careful consideration, of the whole question we are, therefore, of opinion that the construction of the canal and dock presents no insuperable engineering difficulties, and we are consequently in a position to discuss in detail the proposals put forward.

85. It appears to us that the proposal to form a dock at Linwood is open to objection on account of Alternate expense. In the first place, it would necessitate the construction of nearly three miles of additional canal, Proposals and secondly, the dock would be constructed upon ground already occupied and to a large extent built over, thus involving heavy expense in the purchase of land both for the immediate necessities of the case and for possible future extensions. A large expense would also be involved in the diversion of the existing light Heathcote.

Soundings.

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railway to Sumner so as to pass to the southward of the dock and canal. Failing this diversion, it would be necessary to construct a swing bridge with a large opening span across the canal, which would be exceedingly costly, besides being very inconvenient for traffic.

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86. At Heathcote, on the other hand, in addition to the saving effected by the shorter length of canal, the avoidance of the light railway diversion, etc., the dock would be constructed upon ground of little value and for the most part below present high water mark of the estuary. Valuable property in the immediate vicinity of the dock would be formed by reclamation with the material dredged from the site of the dock and canal, and would be the property of the Board and available for extensions or for letting purposes.

87. The principal objection to the formation of the dock at Heathcote is, of course, its greater distance from the city, involving extra cost in the conveyance of goods to and fro. We do not, however, apprehend that the inconvenience resulting therefrom would be very great. For all goods to be despatched by rail direct from the docks to the country districts, and for goods sent by rail from the country for shipment, a dock at Heathcote would be as convenient as if at Linwood. In the case of goods destined eventually for the country districts, but which would not be despatched direct by rail from the ship's side, warehouses would, without doubt, be constructed in the immediate neighbourhood of the docks, where ample space is available, in which the goods would remain until ready for despatch. The only goods, therefore, which would necessarily be affected by the extra haulage between Christchurch and the docks would be those intended for actual consumpton within the limits of the city, and would form a relatively small proportion of the total dealt with, and we are doubtful if this comparatively small advantage would be worth the large extra cost involved, estimated by Mr. Williams at upwards of £690,000 (being the difference between his estimates for the Canal Scheme with a port at Linwood, and for the same with a port at Heathcote.)

88. We propose, therefore, to confine our remarks to a consideration of Mr. Williams' scheme for a dock at Heathcote, with a canal opening into the sea at Sumner Beach, as shown in red colour upon Drawing No. 6. These remarks, however, would apply equally to the scheme in connection with the construction of a port at Linwood, the only difference being the length of the canal required.

89. The first point to be considered is the position of the entrance of the Canal. By making a direct Position and cut to the sea from the dock in a north-easterly direction, the length of the canal would have been considerably reduced, and a curved channel would have been avoided. On the other hand, by making the entrance at Sumner, the fullest advantage is taken of the protection afforded by the land to the southward, a consideration of great importance. The entrance as at present faces the long S.E. swell, as it bends round Banks Peninsula during S.E. gales, which we consider to be an advantage in case of vessels making the harbour; whereas in the case of the direct and shorter cut the entrance would have pointed considerably to the north-In the course of our enquiry whilst at Christchurch we had the advantage of an interview with several ward. captains of vessels belonging to the large shipping companies trading with the Port, and throughly discussed with them the position of the proposed entrance. They were generally of opinion that the aspect of the entrance as shown was good, and that it would be easy to make, and except in unusually heavy weather, would present no difficulties to vessels making the entrance. With regard to the width of entrance, it was considered that this should be at least 700 feet clear waterway. Opinions differed as to the minimum depth of water required, but varied from five to ten feet in excess of the draught of the vessel in order that the entrance might be taken during ordinary seas. These opinions were further corroborated by Captains Kempson and McKellar, of the "Athenic" and "Kaikoura" respectively, at the interviews to which we have already alluded. They were both, however, of opinion that during heavy storms it would probably be necessary to lie off until the weather moderated. This contingency was inherent to "making' a harbour with a comparatively narrow entrance in a heavy sea, and could not be obviated by any alteration in the position or aspect of the entrance, which they considered was correctly placed.

90. We have, therefore, to express our general concurrence with Mr. Williams' proposal to place the entrance at Sumner Beach, and also with the aspect of the same.

91. Having regard to the opinions expressed above, we consider that it would be advantageous to Width and increase the width of entrance of 700 feet between the centres of the mole heads to 800 feet, which would allow a clear waterway of 700 feet wide at the full depth. We are also of opinion that assuming a depth of 30 feet at low water is to be provided as the working depth of the canal, the entrance should be placed in a depth of at least 35 feet at low water ordinary spring tides.

Depth of Entrance.

Aspect of

Entrance.

92. The north mole is shown by Mr. Williams to run parallel with and close to the canal itself. This would tend to lead into the canal any swell from the east and south-eastward. We should prefer to commence

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the northern mole some little distance further to the northward in order to provide a spending beach for waves upon the north side of the canal proper, the existing Sumner Beach acting in a similar capacity on the south side of the canal.

93. With regard to the canal itself, keeping in view the fact that it will be constructed almost through- Canal out its entire length upon the curve, and that vessels navigating the same will be of the largest class, and will at times be subject to strong cross winds, we consider that a bottom width of at least 250ft. should be provided, the banks being so placed as to admit of the width being increased to 300 feet, should this be found necessary hereafter. We also think it would be well with a view to further facilitating navigation that the curves be formed of a radius of not less than 10,000 feet. There would appear to be no difficulty in providing for this. The slopes provided for by Mr. Williams, viz. :- 6 to 1 outside Sumner Bar and 5 to 1 inside the Bar should, in our opinion, prove to be adequate.

94. We notice that Mr. Williams, in his estimate, has made no provision for protecting the sides of Protection of Banks. the canal from the wash of steamers. Considering the sandy nature of the material through which the canal would be constructed, we are strongly of opinion that the canal sides from somewhat below low water upwards should be adequately protected with a coating of rubble stone.

95. With regard to the proposed dock or basin at Heathcote we consider it would be preferable that the Docks at Heathcote. discharge of the Heatchote River should be carried into the canal below the dock, rather than discharge into the corner of the dock opposite the jetties, as shown on Mr. Williams' drawing. We notice in the cross section of the breastworks as given by Mr. Williams, that the sand is shown standing at a slope of 13to 1, without any protection. We fear that the wash from steamers and the action of the propellers would render such a slope unstable, and that subsidence of the ground at the back of the wharfing would be liable to ensue. In our opinion the more preferable mode of construction would be by means of a rubble bank with a timber wharf or breastwork similar to that adopted in the harbour of Lyttelton. In this case the rubble bank would afford potection to the sand and prevent scouring.

96. With regard to the proposed jetties, we consider, as already remarked in connection with the letties. proposed harbour in Port Lyttelton, that it would be necessary to provide either cross bracing below low water or to deposit a mound of rubble stone along the centre of the jetty in order to give sufficient lateral stiffness.

RECOMMENDATIONS.

97. Drawing No. 7 shows by red colour our recommendations with regard to this scheme which embody such modifications of Mr. Williams' proposal as appear to us to be necessary.

98. We propose to maintain the aspect of the entrance the same as in Mr. Willliams' design, but Entrance. to place the heads of the moles at a depth of 35 feet at low water ordinary spring tides, which we consider is the minimum allowable. We have also somewhat increased the width of entrance so as to provide a clear 700 feet of waterway between the heads.

99. It will be observed that the northern mole, instead of running parallel to the line of the canal, has Wave Trap. been spread out at the landward end, thus providing a beach at the north side of the canal upon which waves entering the harbour may break and disperse. This beach, together with the existing Sumner Beach on the south, will materially assist in quieting the water at the entrance to the canal proper.

100. Drawing No. 8 gives cross sections of the north and south moles respectively. It will be noticed Sections of that the section of the mound which we propose is considerably heavier than that shown by Mr. Williams, which latter, we understand, is derived from the cross section of the breakwater recently constructed at Timaru. Having had large experience of rubble mound breakwaters, however, we consider that the cross section we have shown is the minimum which we could recommend with confidence, in which connection it must further be remembered that the moles at Sumner will be carried out into considerably deeper water than obtains in the case of the work at Timaru. The mounds should be constructed of as large angular stones as practicable, the top and sea slopes being protected by stones of 10 tons and upwards in weight.

101. At the re-entrant angle formed on the seaward side of the southern mole where it projects from Sumner Head, there will be a considerable concentration and rebound of the sea from the cliffs during south easterly weather. We would, therefore, propose to widen the mound by 5 feet for a distance of say 300 feet from its commencement, making it 25 feet wide at the top over that length.

Moles.

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RECOMMENDATIONS

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102. Mr. Williams proposes to construct a training bank on the south side only of the canal entrance. Owing to the modification in the line of the north mole which we propose, it will be necessary to construct a parallel training bank on the north side of the canal, commencing near the southern extremity of the tongue of land forming the present eastern boundary of the estuary. The level of the top of the training banks at their commencement would correspond with that of the retaining banks of the adjoining reclamation, and at their termination would be about low water level. They would be formed of stone obtained from the quarry and deposited from barges or flats.

103. With regard to the canal, it will be seen that we have adopted practically the same line as Mr. Canal. Williams, with the exception that we propose, as above referred to, to flatten the curves to not less than 10,000 feet. We have retained the slopes of 1 in 6 seaward of Sumner Bar, and 1 in 5 landwards of that point, as provided for by Mr. Williams. We propose to protect the banks of the canal from the wash of passing steamers by means of a coating of rubble stone extending from 4 feet above high water to the level of low water ordinary spring tides, as shown on Drawing No. 8.

104. We think it would be advisable for the safe and convenient navigation of the canal that a passing Proposed place for vessels should be provided somewhere near the middle of its length. We propose, accordingly, that **Passing** no dredgings should be pumped to form reclamation into the small bay opposite Moncks, but that this bay should be left open and the canal widened by 500 feet over a length of 1,200 feet, as shown upon the drawing. This would form a convenient "lay by "space, and would be provided with moorings, where vessels could tie up when required, in order to allow others to pass. By this arrangement, also the yachting station and fishing village at Moncks would be preserved intact, which would be a further advantage. At the eastern end of Moncks Bay the southern training bank of the canal would be commenced as shown.

105. It will be observed that we have shown the navigable channel marked by buoys placed about 800 feet apart. These will be essential for the safe working of the canal, the distance apart being parctically that found necessary in the Suez Canal in order that two pairs of buoys might always be in view.

106. Throughout the greater portion of the canal it would be necessary to form a rubble bank on each Retaining side to the proposed height of 4 feet above high water ordinary spring tides, in order to retain the reclamations. The stone facing above referred to would, of course, be combined with these retaining banks. This is clearly shown upon the section. The stone would be deposited from barges or flats as described in the case of the training banks. That portion of the retaining bank reaching from the commencement of the south training bank opposite the Cave Rock to the eastern side of the small bay opposite Moncks, might, with advantage, be tipped direct from waggons.

107. With regard to the dock, we propose to construct a basin about 3,500 feet in length by 1,750 Dock. feet in breadth. The north and south sides of the dock would be provided with breastwork quays 2,000 feet and 2,500 feet in length respectively. Within the dock would be constructed two large jetties 2,000 feet in length by 300 feet in breadth. Ample shed accommodation immediately alongside the quays would also be provided. We are strongly of opinion that such a system of quays and sheds would be much more convenient for the storing of goods awaiting shipment and the general handling of cargo, than narrow jetties, and as the site lends itself to the construction of wide jetties, we have no hesitation in recommending their adoption. The breastworks or wharves would be constructed upon the same principle as now adopted in Lyttelton Harbour, viz. : with a timber facing and rubble slope at the back. The wide jetties would consist of two such breastworks forming the quay faces, the space between being filled in with sand pumped from the dredging operations. The surface of the quays would be placed at a height of 6 feet above high water ordinary spring tides.

108. It is proposed that the whole of the excavations for the canal and the dock should be executed Dredging and by dredging. The material to be dealt with consists almost entirely of sand with, in places, an admixture Reclamations of clay, as is shown by the borings, and could in our opinion be satisfactorily raised by a pump dredger. The material so raised would be similarly pumped over the sides of the canal banks to form reclamations approximately to the extent tinted red upon the drawing. The exact extent of the reclamations would, of course, depend upon the amount of material raised and the level to which the surface is finished. We have assumed, except in the neighbourhood of the dock, a general surface level of 4 feet above high water ordinary spring tides, which is that shown upon Mr. Williams' cross sections. We will refer to this matter again in dealing with the plant required for the work.

109. We propose that the canal and dock should in the first instance be dredged so as to give a minimum depth of 30 feet at low water ordinary spring tides, the bottom width of the canal being 250 feet, to be

Place.

Banks.

Proposed Depth for Canal and Dock.

Training Banks.

Owing to the modification in the fibe of the conth code which we propose, it will be deniate to event compare. In a parallel training hash on the there of the contain code which we propose, it will be deniated to construct of tand intering the present autoen boundary of the senare commending equilibrium of the antiping hash their commencement would be advect boundary of the senary. The level of the containty tanks at their commencement would be already with that of the vehicing builts at the objected maining hash at at their commencement would be already for which of the vehicing builts at the objected interview the parts and deposited inter buyer of five when level. They would be families if acone of the interview the gausy, and deposited inter buyer of five.

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102. It is proposed that has whole of the entertations for the corol and the dock should be executed by configure. The material to be deals with contents almost entirely of card with in places an edmirther of elary, as is above by the benerge, and could in our epinion to mainterants mised by a pulp driftper. The material so cased would in similarly propod, over the older of the card builts to four redemations approximately to the extent thirds red upon the drawing. The effect of the card builts to four redemations apcourse, depend upon the anomine of upon the drawing. The effect of the material the material to the restaurations would, of assumed, except in the origination best the dock, a general ender to which the materia is invested. We have apring tides, which is that reduced of the dock, a general enders to which the materia power bigh wath continues apring tides, which is that required for the dock, a general enders to which the materia is to the materials of the place to the the theory of the dock append enders which the material to the material and the place of the book of the dock append enders which the theory of the material appendix with the plant required for the work.

109. We propose that the court and does should in the first instance be dred relied to a lo give a minimum first in the level of first at low water ordinary apping titles, the bottom width of the apping 200 feet to be first.

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Producend Depth for Canal and widened to 400 feet at the outer end of the training banks, the depth being gradually increased to 35 feet, as shown upon Drawing No. 7.

River Avon 110. In order to confine the River Avon to the new channel shown upon the drawing, it would be necess-**Diversion.** sary to form two low mounds of rubble stone, one on either side of the river. In any case, these banks would be required to retain the reclamation dredgings, and we have accordingly provided for them in the estimate.

111. The stone for the moles and retaining banks, &c., would be obtained from quarries, which it is Quarry and proposed to open for the purpose at Sumner Head, where an ample supply of suitable material is available.

112. The rubble in the moles would be deposited from stagings carrying three lines of railway. Mr. Williams proposes to adopt a type of staging exactly similar to that used in the construction of the breakwater at Timaru, and which has proved successful. The proposed moles would, however, be carried into much deeper water than at Timaru, and we consider that additional cross bracing, such as wire guys or chains with coupling screws, carried below low water to the ground level, or some other means for stiffening the structure laterally should be adopted. Owing to the increased width of mound a somewhat wider staging than that at Timaru would be necessary.

113. Material for the north mole would be conveyed along a temporary railway crossing the River Avon by means of a timber viaduct, at some convenient point above the Cave Rock. It would be necessary to provide an opening span of say 60 feet to enable dredging and other craft to pass up and down as required, and we have provided accordingly in our estimate.

114. We have very carefully looked into the question of quarry and railway plant required, and con- Quarry and **Other Plant** sider that in order to complete the works in ten years, the following plant would be required :----

20 Cranes in quarry.

9 Locomotives.

120 Side and end tip waggons.

115. As already stated it is proposed to utilize the material dredged from the site of the canal and Dredging dock to reclaim the area upon either side of the canal now forming the estuary of the rivers Avon and Heathcote, to a level of 4 feet above high water ordinary spring tides, and to the extent tinted red on the drawing, a channel 200 feet wide being provided for the discharge of the River Avon in the position shown. It is proposed to effect this reclamation by pumping the dredgings direct on to the site.

116. The area to be reclaimed is of large extent, and the extreme distance to which the dredgings would require to be pumped, viz. : to the northern corner of the estuary, is upwards of 9,000 feet, a distance, we believe, largely in excess of anything which has hitherto been attempted.

117. The problem, therefore, presents some difficulties, and it is one to which we have given very careful attention, and we have gone into the matter in considerable detail with Messrs. Simons & Co., of Renfrew, who have had great experience in the construction of every description of dredging plant.

118. It is considered that 5,000 feet is the limit to which it would be advisable to pump direct from the dredger. For distances beyond this limit, it would be desirable to provide an auxiliary pump with extra pipe line complete. The auxiliary pump would be coupled up direct to the end of the 5,000 feet of discharge pipe line from the dredger, the discharge pipe from the latter becoming, as it were, the suction pipe of the auxiliary pump. This last pump would be fitted with 3,000 feet of pipe line, making in all a length of 8,000 lineal feet from the dredger to the final discharge. This, we consider, would be sufficient pipe line to provide, seeing that the material would largely flow for the remaining distance required. In any case, the area to be filled beyond the 8,000 feet is too small to justify any large addition to the cost of the pipe line and pumping power.

119. In general we would propose to provide :--

(1) One pontoon pump dredger, capable of dredging to a depth of 40 feet and of delivering 1,000 cubic yards of sand per hour through 5,000 feet of pipe line.

(2) One auxiliary pump to be attached when required to the extremity of the 5,000 feet of pipe line leading from the first-named dredger, and capable of delivering the same quantity of material, viz. : 1,000 cubic yards per hour, through 3,000 lineal feet of pipe line.

and Reclamation

Temporary Works.

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provosed to open for the particle and measures theirs are world be strained from quarties which it is genery and provosed to open for his property as 8 source from \$7 becade include apply or missible material installable. Jesperary

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114 We have very excelsive looked into the entering of query and relevery plant required, and non- francy a bider that is order to complete the works to ten years, the following plant would be required :--- fine-inthe francy in many.

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116. The strate to be netritized in of large extents and the extreme distance to which the designer would require to be promod. via : to the corther's corner of the esthery, is movestic of 0.0% hat, a distance, we believe largely in vious of anythics which has hidden been pitumpied.

111. The problem, through a process come differences and is is one to which we have given very more fail attention, and we have give tuto the metric or considerative datall with Nation Summar & Co. of Annhow, who have been experience to construction of every discontance of foodering plant.

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2 One in-these minute structure expension of structuring to a vie of the of -10 over a sink of the structure 1, (eq.) endow yorkeeld a trial per iterative fuence. Name is in principle of pipe lines.

(2) One contine of paragraphic standard when required on traingerman (or the hOW loss of para line) and the control of paragraphic of control of the second of the sec

(3) One twin screw bucket hopper dredger of 1,100 tons hopper capacity, and capable of lifting 900 tons per hour.

120. Part of the discharge pipe line of dredger (1), say 500 feet in length, would be of flexible type carried on pontoons, so as allow of movement of the dredgers. All delivery pipes would be of the same character and interchangeable. All necessary branch pieces, ball and socket joints, &c., required to allow of ready adjustment in the line and direction of the pipes, would be provided.

121. The auxiliary pump (No. 2) would be driven either by steam or by electric power. Electric power would be the more advantageous, inasmuch as greater speed could be given to the engines and their weight correspondingly reduced, which would render them more portable in the event of it being necessary to move them from place to place.

122. We have provided for a bucket dredger because, although there does not appear from the borings to be any great likelihood of material unsuitable for pump dredging being met with, we consider that in a dredging work of this magnitude, it would be advisable to provide a dredger capable of dealing with such material in the event of it being found.

123. Our estimate for the above plant delivered in New Zealand is £200,000, including the cost of all work in connection with the auxiliary pumping station. This is considerably in excess of the sum provided by Mr. Williams for dredging plant, but, after considering the matter very carefully with Messrs. Simons, we are of opinion that it would not be prudent to reduce it.

124. The plant provided for should be capable of completing the work in ten years.

125. Should it be determined to carry out this scheme there is no doubt that an electrical equipment of lighting and cranes would be installed at the docks. The power station might be proceeded with in the first instance, and current taken therefrom for driving the auxiliary pump (No. 2) by which means some saving in cost would be affected.

126. We estimate the cost of the works as follows :---

North Mole, in general accordance with the cross sections shown upon Drawing No	o. 8,	
and including staging		£470,910
South Mole, ditto		£127,405
Training banks, retaining banks for dredgings and lining of canal banks, as indic	ated	
upon the drawings		£78,180
Rubble banks under breastwork wharves in dock		£150,220
Dredging of dock and canal to dimensions and depths shown upon the drawings	, in-	
cluding depositing material at sea or in reclamations		£233,010
Timber breastwork wharves in dock		£248,705
Shed accommodation, and surfacing roadways with broken stone, steam rolled		£262,305
Buoying channel		£5,060
Navigation Light		£2,420
Laying railways on wharves and connecting same to Government Railway		£14,300
Cranes, locomotives, trucks and miscellaneous plant in quarry and for railway		£77,715
Dredgers, miscellaneous floating plant and shore pumping station		£233,750
Temporary viaduct over canal entrance with rolling bridge and temporary railways		£17,380
in the second		

Say £1,925,000.

£1,921,360

The above estimate includes 10 per cent. for engineering and contingencies.

127. The above estimate contains 10 per cent. for engineering and contingencies, but does not provide for interest and depreciation of plant, nor does it take any credit for the value of the plant upon the completion of the works.

128. In framing the estimate we have, as in the case of the proposed harbour at Gollan's Bay, adopted Mr. Williams' prices for stone, seeing that they are based upon the actual cost of similar work as carried out at Timaru. For the reasons above explained, we have somewhat increased his estimate for the temporary staging for the moles in order to provide for additional bracing and extra width and increased depth of water.

10) the twin survey bucket upper dredger of 1,000 turis hopper capability and capable of litting

and the fart of the deviation pairs fore of deciger (1), are 500 feet to lengthe social he of straight type confied on performe, is as allow of merechant of the decigent. All delivers piper would be of the same character and interchangeable. All recensers bracely pices that and weight joints, the required to allow of ready adjustments in the line and direction of the pipes would be not the second by a line.

121. The autobary pump (No. 2) would in drive utility a seara or by seara or by secara power. Eleveric power, eleveri power, eleveric power, eleveric power

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20. We estimate for each of the north at follows :--

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The above estimate includes 10 per cash, for automorphy and continuencies.

137. The above estimate contains to per cost. In engineering and contingenties, and does not provide for interest and depreciation of plant, nor done in take new credit for the value of the plane upon the completion of the works.

128. In framing the seconds we have us in the case of the proposed technics at follow's day, around at finite or the proposed technics of the second technic of the carried and the orthon cost of aiming and an carried and at Timare. For the reasons above explained, we have second the second technics of the technics of tech

129. The remarks which we have made above in connection with the Gollan's Bay Harbour scheme with reference to the plant provided in the estimate apply generally in the present instance. We have provided plant which, in our opinion, would be sufficient to complete the works as shown by red colour in ten years, the price of the plant being estimated at its cost in England, plus 50 per cent. for freightage, Customs dues, and erection in the Dominion.

130. We presume that if the Canal scheme be adopted, the harbour at Lyttelton would be practically abandoned, so that it would probably be found necessary to provide in the first instance the full dock accommodation as indicated by red colour on the drawing. The length of quay there shown is practically the same as now exists at Lyttelton, the advantage in favour of the former being that it is all deep water berthage, whereas at Lyttelton a considerable proportion is suitable only for small vessels.

131. We have now considered in detail the whole project of providing a dock in the vicinity of Christ- General church with access to the sea for the largest vessels by means of a ship canal, and subject to certain modifications which we have recommended, have in general concurred in the main lines of the proposal put forward by Mr. Williams. In the event of it being ultimately decided to proceed with the works all details in connection with the carrying out thereof would, of course, require to be very carefully reconsidered, particularly with regard to the plant necessary for dredging and reclamation purposes, which will require to be of very special character.

Considera-

tions

132. It will be observed that our remarks as hereinbefore set forth have so far resolved themselves into two alternative recommendations, as follows :----

- I. In the event of the future requirements of the Port being met by harbour extension in Port Lyttelton, we recommend the execution of works at Gollan's Bay, to the extent shown by red colour on Drawing No. 5. The same drawing shows by green colour means by which still further accommodation could be provided when required.
- II. In the event of its being decided to construct a dock in the neighbourhood of Christchurch connected with the sea by a ship canal, we recommend that the dock be constructed at Heathcote with a canal to Sumner in general accordance with the design shown in red upon Drawing No. 7. Future possible extensions are indicated by green colour upon the drawing.

133. It now remains to consider the relative merits of the two main alternative proposals as above briefly set forth.

134. In the consideration of this question we have borne in mind the desire of the Board as referred to at the outset of this report, viz. : that we should not take into account questions of finance and general policy, leaving these to be decided by the Board hereafter. We have consequently confined our remarks more particularly to the engineering and navigation aspect of the question.

135. A dock as proposed within the estuary of the Avon and Heathcote Rivers, the basin being formed almost entirely by dredging, could be constructed comparatively cheaply. Most of the land required for wharves, warehouses, railways, &c., would be reclaimed by the Board with dredgings obtained from the forming of the dock itself, and the canal. Other land required could, no doubt, be obtained at small cost. Extensions to the dock could be made as required to practically an unlimited extent, and at a minimum cost by dredging, owing to the flat and sandy nature of the soil. There would be ample space adjoining the dock for all requirements in the way of sheds, warehouses, railway and tram accommodation, easy connections being possible with the existing Government Railways and the Municipal Tramway system.

'136. On the other hand at Port Lyttelton, owing to the steep and rocky nature of the shore, extensions of a harbour once constructed cannot readily be made. Space for sheds, warehouses, railway sidings. &c... can only be obtained or added to by means of rock excavation or reclamations. We are, however, of opinion, that should the harbour at Gollan's Bay be carried out to the extent already recommended and shown upon Drawing No. 5, ample accommodation for all future requirements, so far as can with reason be anticipated, would be provided.

137. The approach to the proposed dock at Heathcote would be through a narrow channel some 31 miles in length, measuring from the entrance near Sumner Head to the Basin This, in itself, would always to a certain extent be inconvenient to navigation, and in the case of strong winds blowing across the 120. The remarks which we have made above in connection with the Collean's flag Hachour solvene with reference to the plant provided in the estimate apply generally in the present instance. We have provided plant which, is our opinion, would be sufficient to charaker the works an shown hy red colour in bot years, this price of the plant being estimated as he con in Hagland, plat 50 per cent. for heightage. Caroons dues, and arcelion in the Domition.

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channel, navigation will be difficult. The passage of vessels up and down would necessarily be regulated by signal, and delays would be inevitable. The width of the entrance itself must of necessity be limited, in order as far as possible, to preclude heavy seas from entering the canal, and although captains of ships and pilots have generally expressed themselves satisfied with the proposed entrance, there can be no doubt that the entering of a comparatively narrow channel of this description in heavy weather would be attended by a certain amount of difficulty.

138. On the other hand, the proposed works at Gollan's Bay would be situated within the magnificent natural harbour of Port Lyttelton, which can be entered with perfect ease and safety in all weathers, the width between the "Heads" being upwards of a mile in extent, all in deep water; this deep and ample waterway moreover, extending practically to the entrance to the proposed harbour.

139. The depth of water to be provided has been fixed provisionally at 30 feet below low water of ordinary spring tides. Should it be required at any time to increase this to say 35 feet, a very large amount of dredging would be required in order to deepen the canal and dock by this amount.

140. On the other hand, in the case of the proposed harbour at Gollan's Bay, the natural depth of the water at the entrance is at present approximately 30 feet, and in the event of an ultimate depth of 35 feet being required, this could be obtained with comparatively little dredging.

141. The further very important consideration must also be borne in mind viz. : that in the case of harbour extension in Port Lyttelton, it may be said that practically all the conditions affecting the construction of the works and the future maintenance thereof are known, being merely a repetition on a somewhat larger scale of what has already been carried out at Lyttelton. The general depth of water in Port Lyttelton iftself has been proved unaltered during the past fifty years. The cost of dredging for the maintenance of the required depth in the present harbour at Lyttelton and approach channel is accurately known.

142. In the matter of the canal scheme, however, it is not possible to speak with the same certainty with regard to the dredging which would be required to maintain the entrance, together with the canal and basin.

143. With regard to the entrance, we have already expressed the opinion that the maintenance dredging which would be required in connection therewith would not prove excessive.

144. With respect to the canal and basin, however, the conditions are somewhat different. We have already alluded to the fact of the ground in the neighbourhood of Christchurch being saturated with water, the natural level at Christchurch being about 10 feet above high water level, falling to about high water level at the estuary. This water is, of course, constantly percolating through the ground on its way to the sea, and in the case of a deep cut being formed as by the proposed canal a proportion of the water would percolate through the sides of the cut, possibly carrying with it a small amount of sand into the canal, depending upon the rate of percolation and the fineness of the sand. The removal of sand thus brought into the canal would, we believe, be the chief item of maintenance, and it is impossible to forecast with certainty the extent to which this would be necessary.

FINAL RECOMMENDATION.

145. Knowing the importance which attaches to this question and the interests involved, we have given the most anxious and careful attention to the considerations above set forth, and after full deliberation are of opinion that, apart from questions of finance and general policy, the Board would on the whole be best advised in adhering to Port Lyttelton for future harbour extension, and we have therefore, finally to recommend for adoption the scheme for a harbour at Gollan's Bay in Port Lyttelton, as shown upon Drawing No. 5, accompanying this report, as being under all circumstances the most suitable.

In conclusion, we have to express our thanks to yourself and the members of the Lyttelton Harbour Board for their kindness and courtesy, and for the assistance rendered to us in connection with our inspection. Also to those gentlemen connected with the shipping interests and others who so kindly afforded us information. In particular, we desire to express our appreciation of the invaluable assistance which we received from the Board's Engineer, Mr. Cyrus Williams, throughout the whole of the enquiry, and of the admirable manner in which all the detailed information required for this report was prepared and tabulated.

We have the honour to be,

Sir, Your obedient servants,

COODE, SON & MATTHEWS.

channel, anvigation will be difficult. The pressage of versus up and down would necessarily be regulated by signal, and delays would be inevitable. The width of the estance itself must of processity be limited, in order as far as pressible, its predinde heavy sole from contribut the canal, and although captains of abipa and pilots have generally expressed them elves articuled with the proposed emerses, there can be notically that the satisfies of a compensively measure channel of this description in heavy weather would be attended, by a certain amount of difficulty.

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139. The depth of water to be provided has need axed provisionally at 20 feat before new water of ordinory opting tides. Should it be required at very time to intrease that in any 50 feet, a durt large emotion of declaring would be required in order to decreas the canal and deck by this around.

140. On the other hand, in the uses of the proposed barbour of following Bay, the natural depth of the bare of the bare of the principle of the barbour of the event of an ultimate depth of the barbar proposed the device of the event of an ultimate depth of 35 real baing required, this evold be anciented with comparatively fulle device of

191. The intribut very unperturb consideration must also behave in mind via : that in the case of harbour extension in Fort Lyterton, it may be rate that prachesky all the conditions effecting the construction of the works and the fattle maintenance thereof are harbour being mentry a repetition on a concernation harger wale of what has already there extend off at faytofrom. The period depth of water in Furtherina iffeeld has been proved makement during the sast fifty years. The cost of distribute fare maintenance of the requires depth in the present harbour as faytofrom and approach obtained to extra the maintenance of the requires depth in the present harbour as faytofrom and approach obtained to extra the maintenance

142. In the unthat of the optical whenes, however, it is not possibly to speak with the case costsinty with regard to the diadging which would be required to maintain the entrance, together with the cases and basis.

143. With regain (or the entrance: we have already expresses the opinion that the maintenance dealgeing which would be negatisfield in connection therewill would not pouve examine.

14. With respect to the small and basin, however, the conditions are somewhat different. We have already alloaded to the fact of the ground in the neighbourhood of Christenneth being seturated with water, the natural level at Christenation being seturated with water level the natural level at Christenation being statut to beet above high water terms, falling to about high water level the esturate. This water is, of comic, constantify percentating through the ground on its way to the zero at the estuary. This water is, of comic, constantify percentating through the ground on its way to the zero and in the case of a deep cut being fortulated as be the proposal event a proportier of the water would generalize upon the rate of percolation and the fineness of the same of the set of percolation and the fineness of the same. The removal of and in the stary the bind the fineness of the same data the rate of percolation and the fineness of the same. The removal of and in the stary the the rate of percolation and the fineness of the same of a single the observant of an interval to the same equal to the same term of term of the same term of the same term of term of the same term of term of the same term of the same term of term

FINAL RECOMMENDATION.

155. Buowing the importance which attaches to this quartion and the interests involved, we have given the most auximus and caroicit attaction to the considerations above set forth, and there full deliberation are of opinion that, apart from quarticus of funnee and general policy, the Board would on the whole be best advised in adhering to Port furtheres for future larbour extension, and we have rightfore, finally to recommend for adoption the solution for a barbour as Gollaria Heyr in Port Lyttelion, as shown upon Drawing No. 5, accompanying this report, as bong when all circulostances the most sainable.

In conclusion, we have to express our thanks to voirself and the members of the Lortelton Harbour Board for their kindness and contracy, and for the assistance rendered to us in connection with our inspection. Also to those geodermen connected with the slopping interests and others who to kindle afforded us information. In particular, we desire to express our appreciation of the lievainable assistance which we received four the Board's linguiers. Mr. (yrus Williams, throughout the whole of the caquing, and of the admirable manner in which all the defined information to this ways the sector of the admirable manner in which all the defined information we defined for this report was prepared and tabled to be admirable manner in which all the definited information to the the sector of the information.

ue obediente servanis.

Engineer's Office, Lyttelton Harbour Board, June 12th, 1908.

Memorandum on Report of the Consulting Engineers on Proposals for Harbour Extensions in Port Lyttelton.

In this memorandum it is not proposed to discuss the report of the Consulting Engineers, but merely to make some reference to the points on which their conclusions have differed from my own, and to give some reasons that led to my conclusions.

PROPOSALS FOR EXTENSIONS IN PORT LYTTELTON.

In the main, their conclusions and recommendations are very close to my own. The slight increases in the strength of the works proposed are all in favour of extra efficiency (though not in my opinion necessary). The commencement of the Western mole at Sticking Point, instead of Battery Point, is an improvement, though it adds considerably to the cost, against which, however, we would have a place of deposit for the dredgings. The small amount of overlap in my moles was deliberately arranged to make the entrance easier for vessels, but would, if found necessary, have been increased in carrying out the work. Their estimates of cost agree very closely with my own.

PROPOSAL FOR HARBOUR AT HEATHCOTE WITH ENTRANCE AT SUMNER HEAD.

The Consulting Engineers generally agree with me in the placing of the entrance and in the location of the canal, but propose to increase the entrance width by 100 feet, to which there can be no objection, and this alteration would not affect the cost.

The difference in cost of construction as estimated by the Consulting Engineers and by me arise from the following :--

- (A) North mole splayed out at the inner end to form a wave trap, and another training pier to be carried along parallel with the canal as on the south side, instead of the mole being carried out parallel with the canal.
- (B) Increase in bottom width of the canal from 200 feet to 250 feet.
- (c) Increasing the radius of the canal to 10,000 feet.
- (D) Coating the sides of the canal with rubble stone.
- (E) Discharging the Heathcote into the canal below the basin instead of into the basin.
- (F) Carrying the moles and entrance into 35 feet at low water instead of 30 feet.
- (G) Increasing the section of the moles.
- (H) Increasing the strength of the staging for the moles.
- (K) Increasing the shed accommodation.
- (L) Increase in cost of necessary plant.

(A) With regard to the North Mole being parallel to the Canal in my report.—The provision of a wave trap on the north side was not overlooked in my proposal, but owing to the action of the land in influencing the direction of the waves, the seas always come in at an angle of at least 29° with the line of the canal, so that I do not see how the seas could run up the canal. The entrance of the Suez Canal from the Mediterranean Sea has the weather side jetty or mole parallel and close to the canal, and no difficulty is experienced on that account. Moreover, at Westport it has been found that the weather side wave trap provided by Sir John Coode was unnecessary, only increasing the cost of the work, and it is being done away with.

Remorandum on Report of the Consulting Engineers on Proposals for Harbour Extensions in Part

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TROPOSAL FOR MARNOUR AT HEATHCOTE, WITH ENTHANCE AT SOUTHER MEAD.

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(a) With neuron (2) the down Monis being parallel to the Ganzi in my report. The province of a view trans an the institution and avera and reasoned is an impact. In the set of the action of the land in information is should be not see the average the set of a single of a single of at least 20 with the line of the case. In the first set is and see the max could run the the cault of the set part is a the first of the line of the case Madration with a time average in the max could run the the cault of the set and the set of the first of the first and the first set is a time the max could run the the cault of the set part is a the set of the max could run the the cault of the set of the s (B) With regard to increasing the bottom width of the Canal from 200' to 250'. Obviously the greater the width the better, and due provision for enlargement in this respect is desirable. The Suez Canal, however, had for many years a bottom width of only 72 feet, has now a bottom width of only 120 feet, and is ultimately to have a bottom width of only 213 feet. The Manchester Ship Canal has a bottom width of 120 feet only

(c) With regard to increasing the radius of the Curves. The very considerable practical advantage of being able to start the work inside the bar with the dredges afloat fixed for me the location of the canal at the Shag Rock and to a certain extent governed the radius of the curves, the smallest radius being about 8,000 feet, which, in view of the experience in the Suez Canal, would have proved quite workable. The proposed increase would, of course, make the navigation easier.

(D) Coating the sides of the Canal with rubble stone would obviously be an improvement, but I do not see how it could be carried out until the work had been in use for some time and had taken its final slopes and dimensions, by which time I expect it would be found not to be necessary, as there is considerable clayey earth among the sand and a growth of aquatic plants is a good protection for the banks, as was found in the Suez Canal, the banks of which were entirely unprotected for many years, and are only now, as the canal is being widened, being faced with stone pitching.

(E) Discharging the Heathcote River below the basin instead of into it. The flow of the river is so insignificant that I considered it could do no harm, while its tidal effect would help to keep sweet the water in the basin.

(F) With regard to the depth of water at the Entrance, I fixed upon 30 feet at low water as sufficient because at Fremantle, which is the last port of call for Australia, there is only 30 feet at low water, with a rise of tide of 2 feet 9 inches at ordinary high water, or a daily working depth of 32 feet 9 inches at high water, the entrance channel being cut through rock. My provision of 30 feet at low water spring tides with a daily rise of 5 feet would provide a working depth of 35 feet, against 32 feet 9 inches at Fremantle, and would be sufficient for a vessel drawing 30 feet. Moreover, the bottom is sand and easily dredgeable in view of further depths being required. The full depth is required in the canal to allow vessels to steer easily and to travel at a reasonable speed. Of course, the entrance would only be taken by the largest vessels at high water.

(c) With regard to the section of the moles which the Consulting Engineers propose to increase. The section I proposed was that which has proved sufficient at Timaru in the eastern extension, with slight flattening of the slopes as an extra precaution. The Timaru mole is founded in 26 feet at low water, and is placed square to the blow of the seas, which are heavier there than any which are experienced at Summer Head, in addition to which the Summer moles would meet the seas at an acute angle.

(K) The provision for shed accommodation is largely in excess of what I considered necessary.

(L) Increase in cost of necessary plant. I allowed for the plant which I considered necessary, the general increase of the magnitude of the work would naturally increase this item.

Generally, to look too far ahead is as bad policy as not to look far enough. Harbour works can be, and are every day throughout the world being, increased and enlarged to meet increments to trade : but if planned on too large a scale in the first instance, the excessive charges necessary simply drive trade away. I think the Consulting Engineers' Summer proposals are on an unnecessarily large scale. With this exception, I am very pleased with their report, which deals with the questions submitted to them in a most exhaustive manner.

I have the honour to be,

Sir,

Your obedient servant,

CYRUS J. R. WILLIAMS,

ENGINEER TO THE BOARD.

THE CHAIRMAN,

LYTTELTON HARBOUR BOARD.



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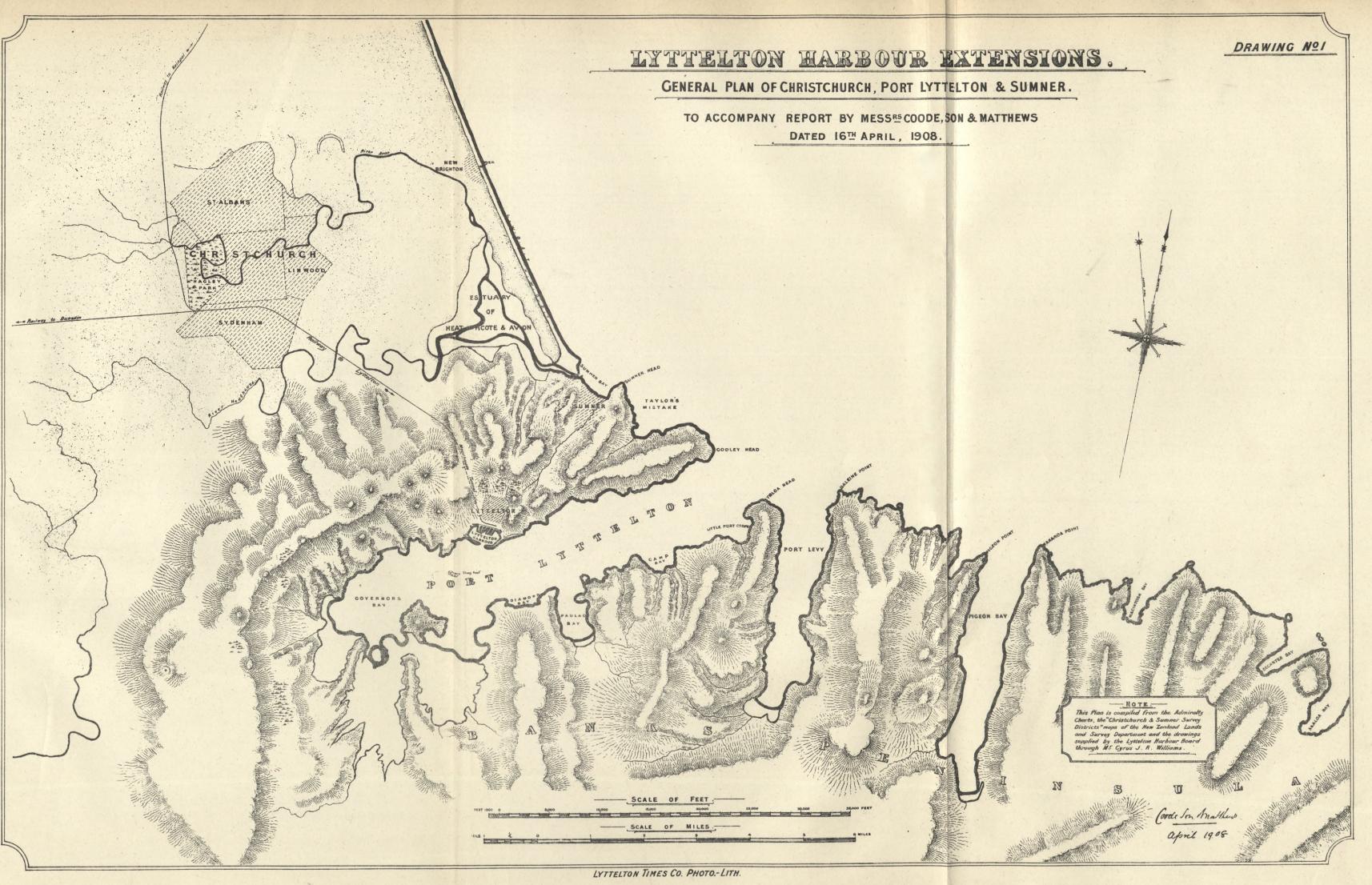
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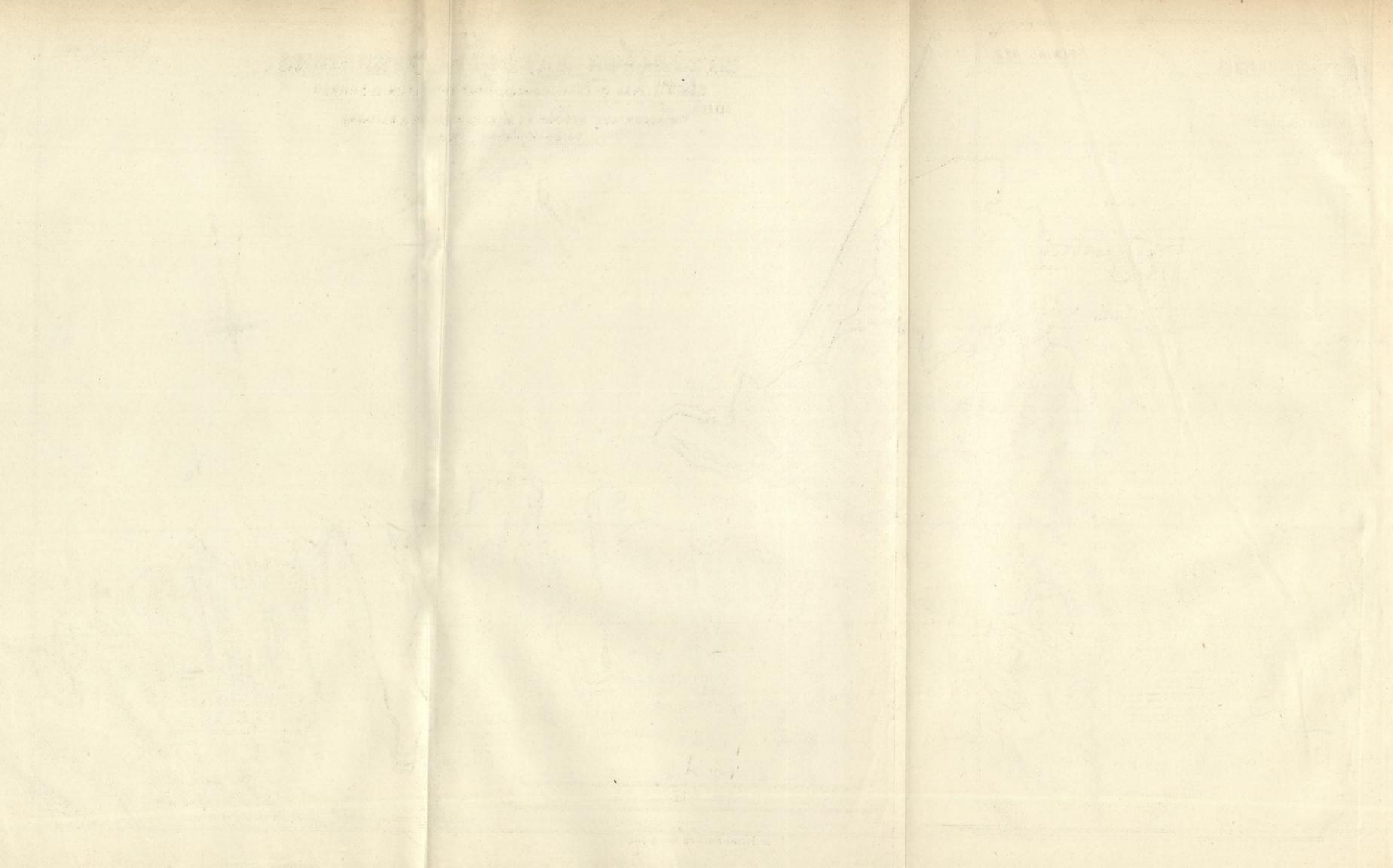
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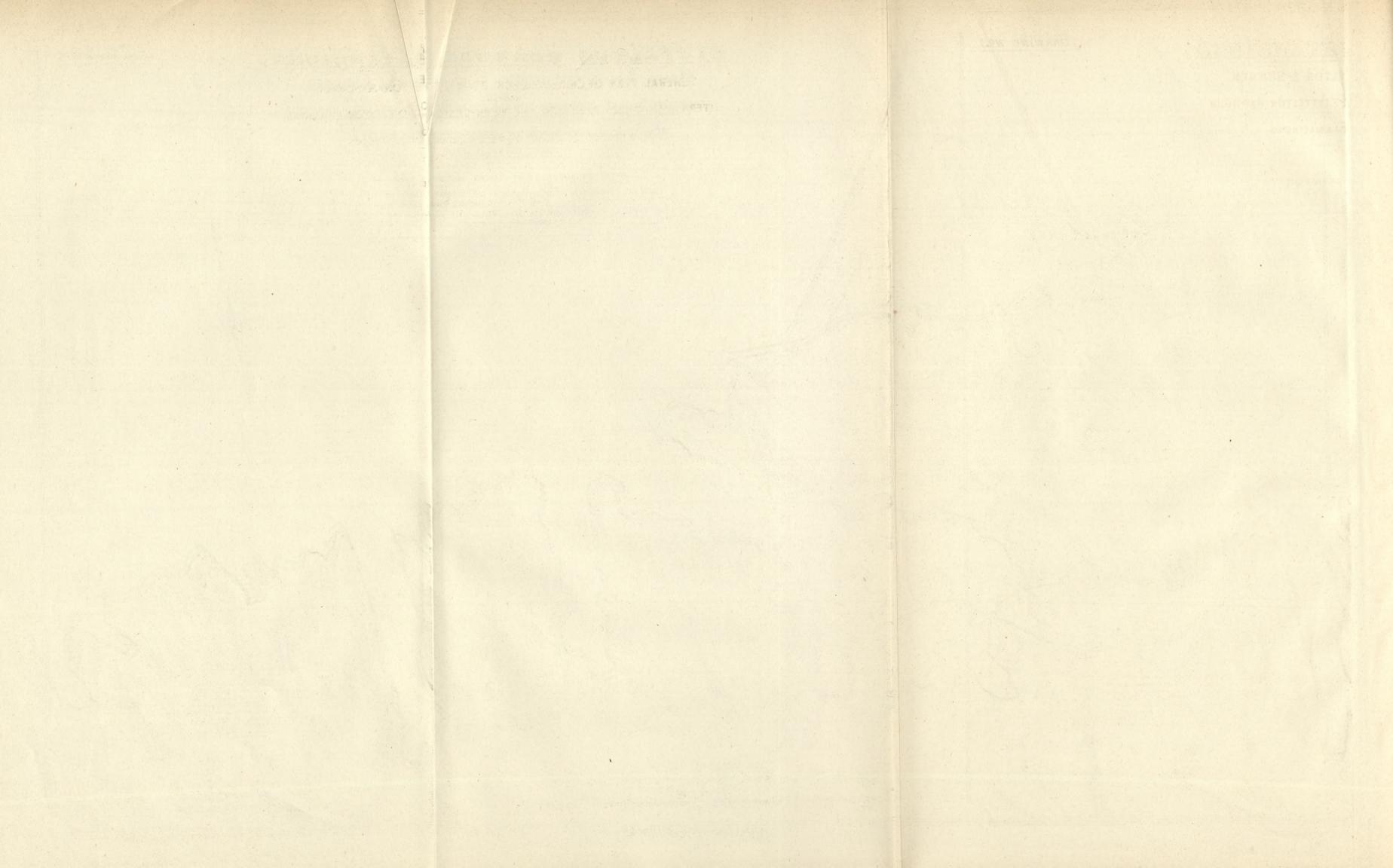
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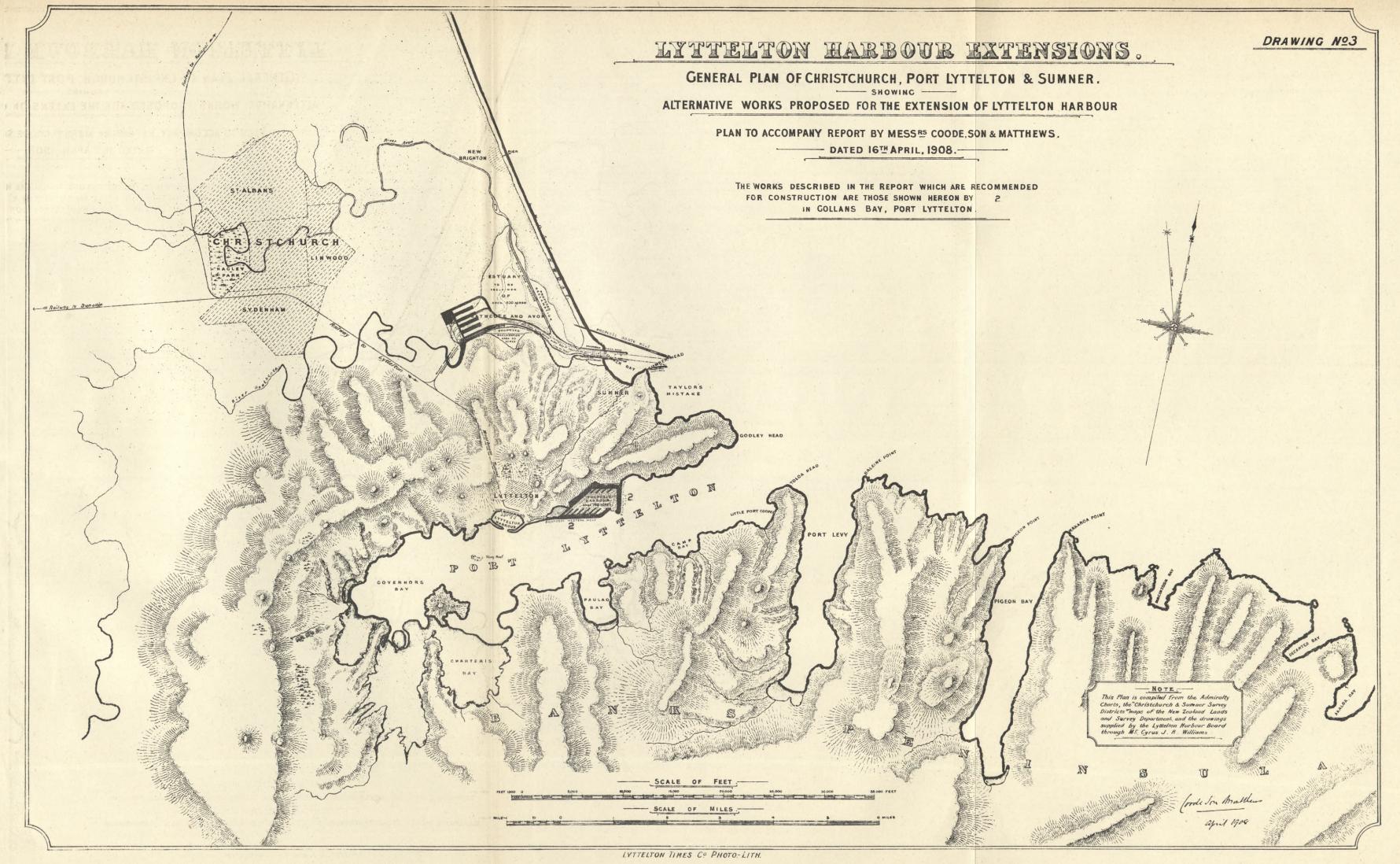


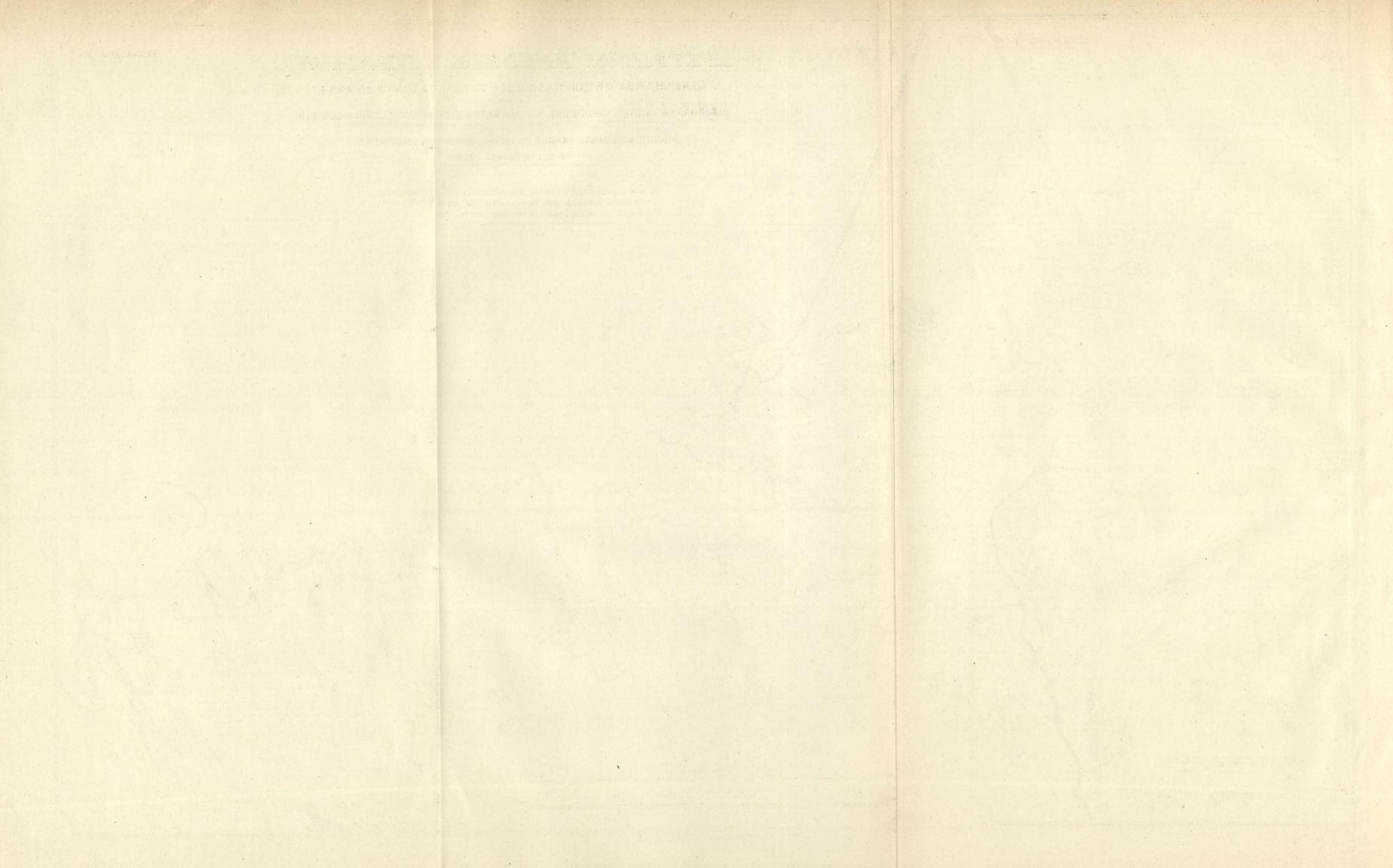


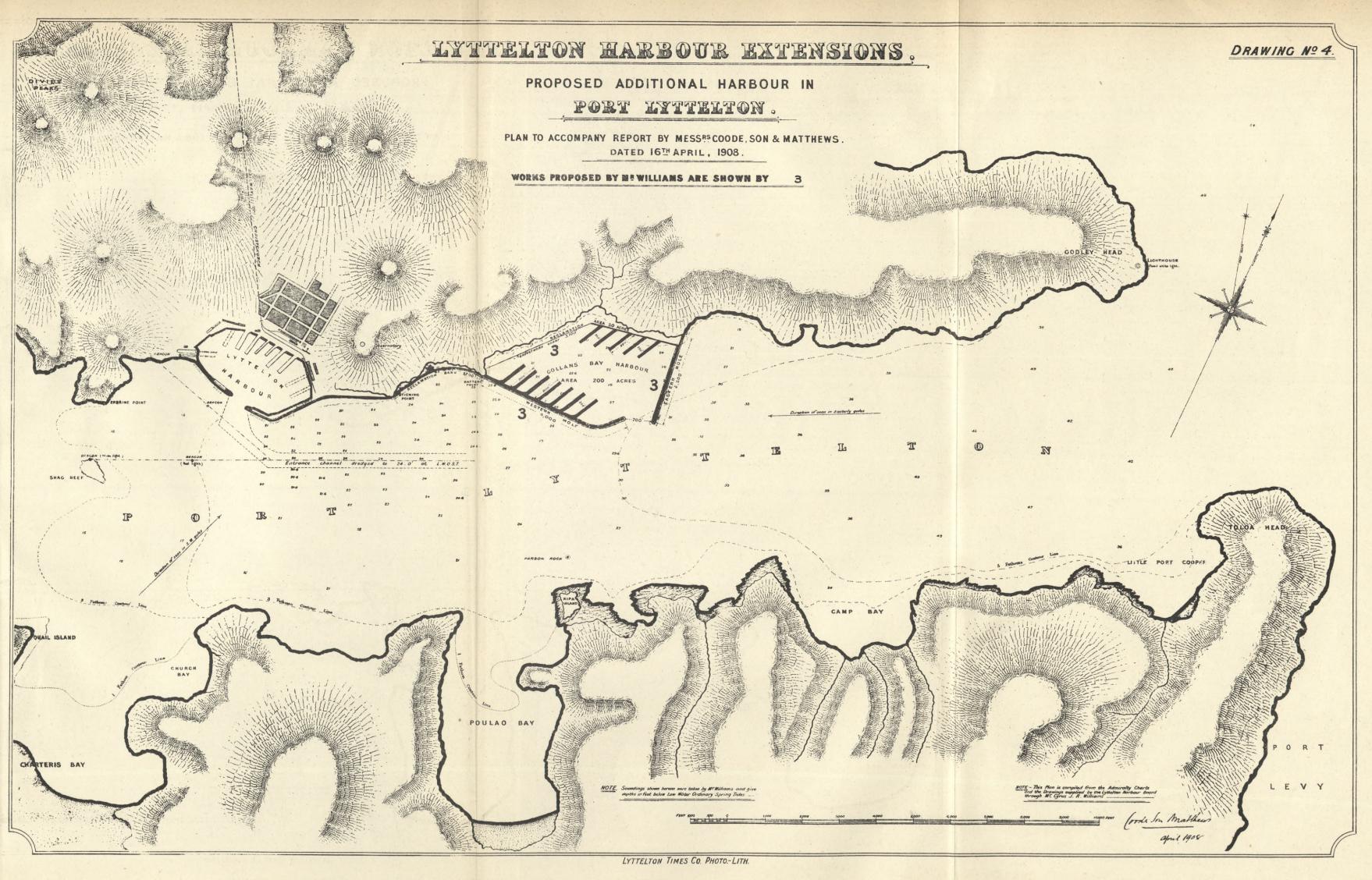


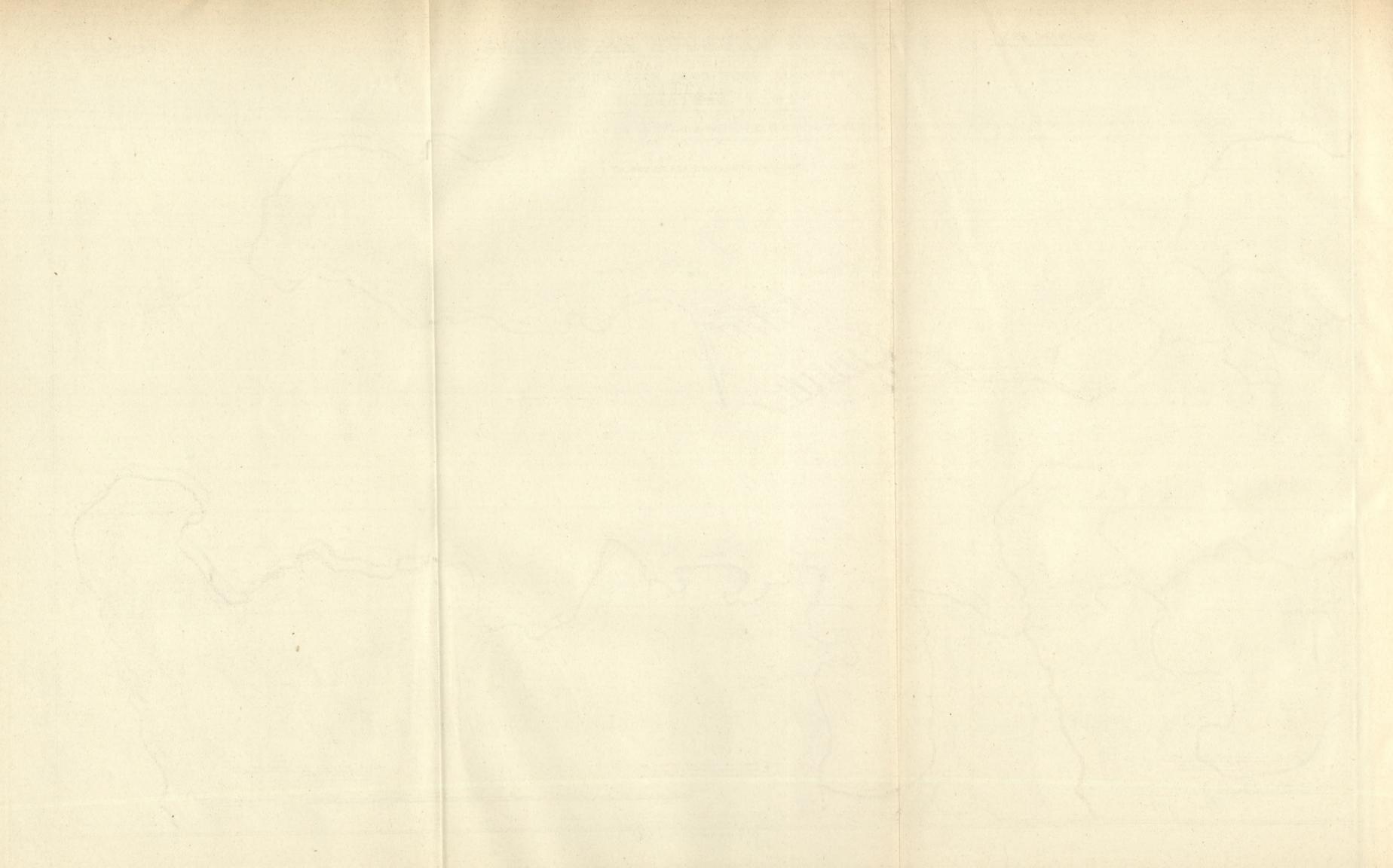


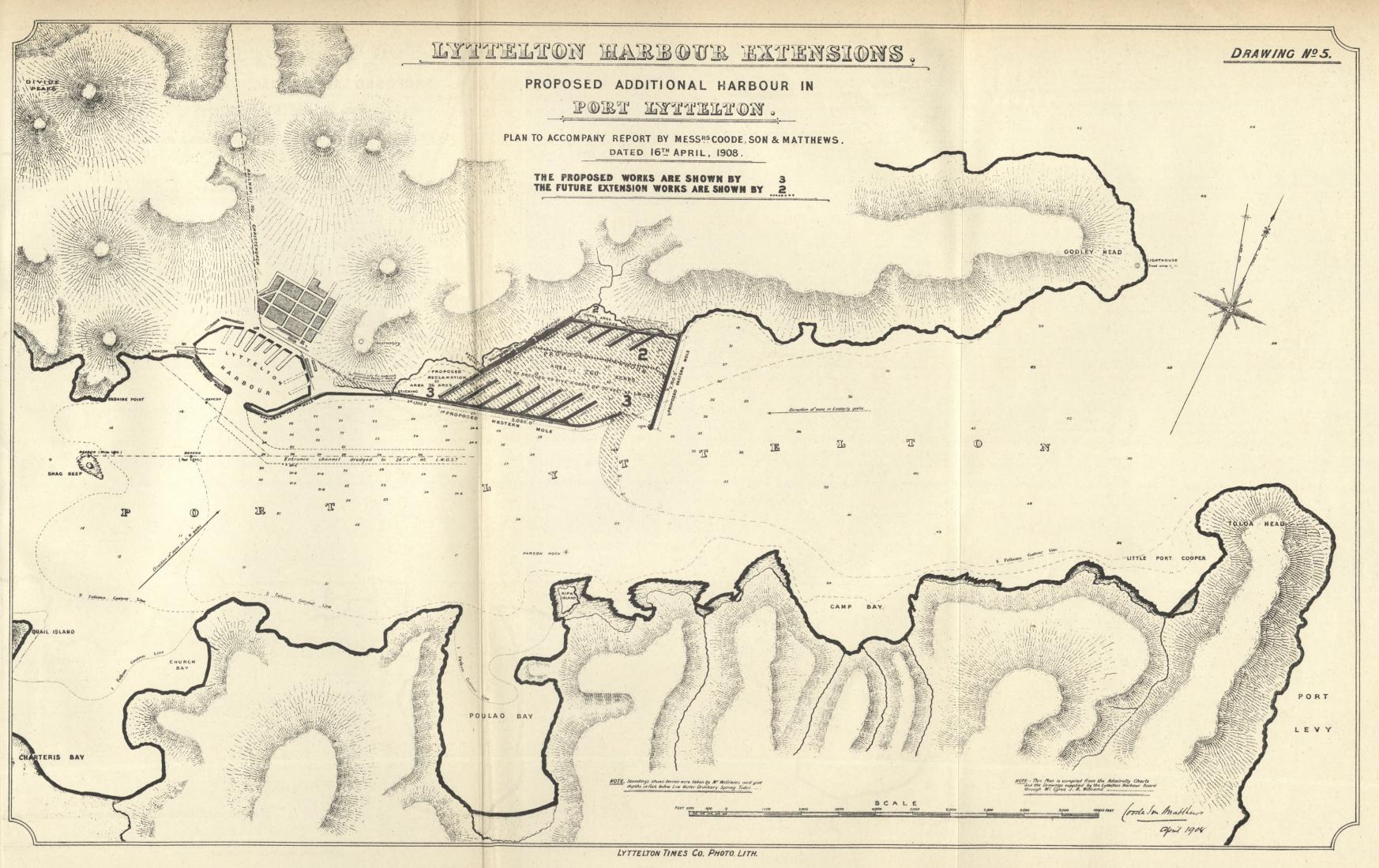


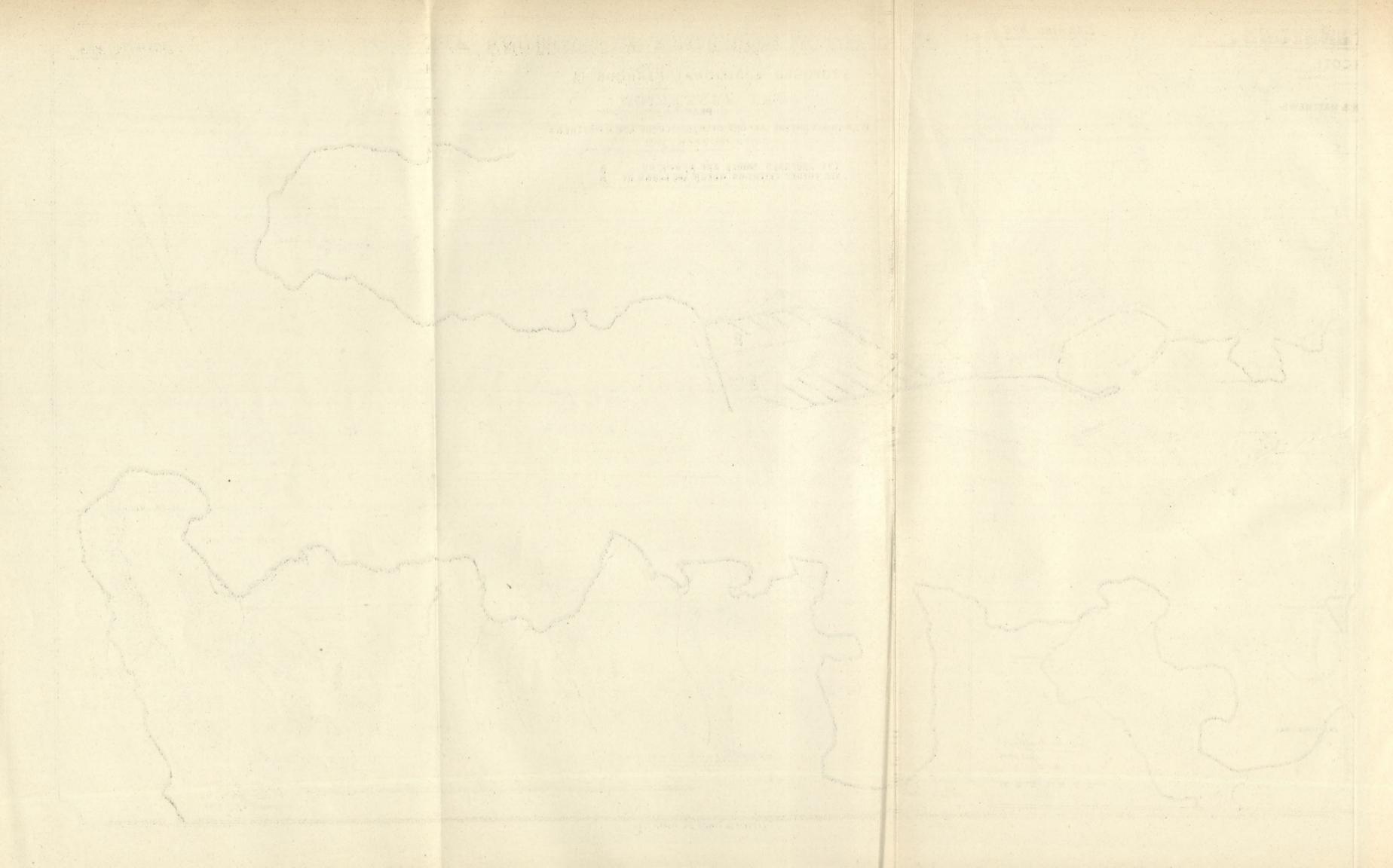


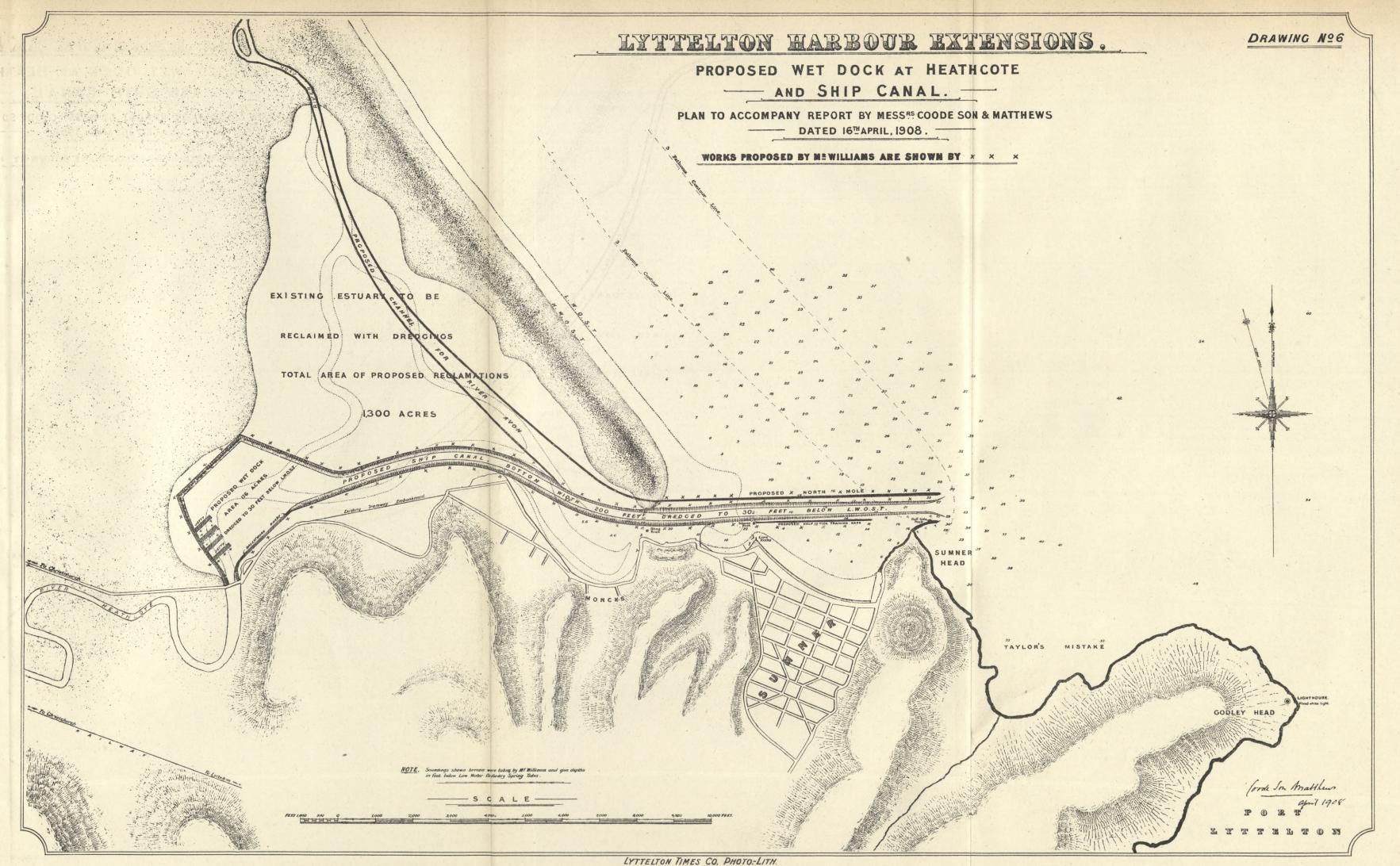


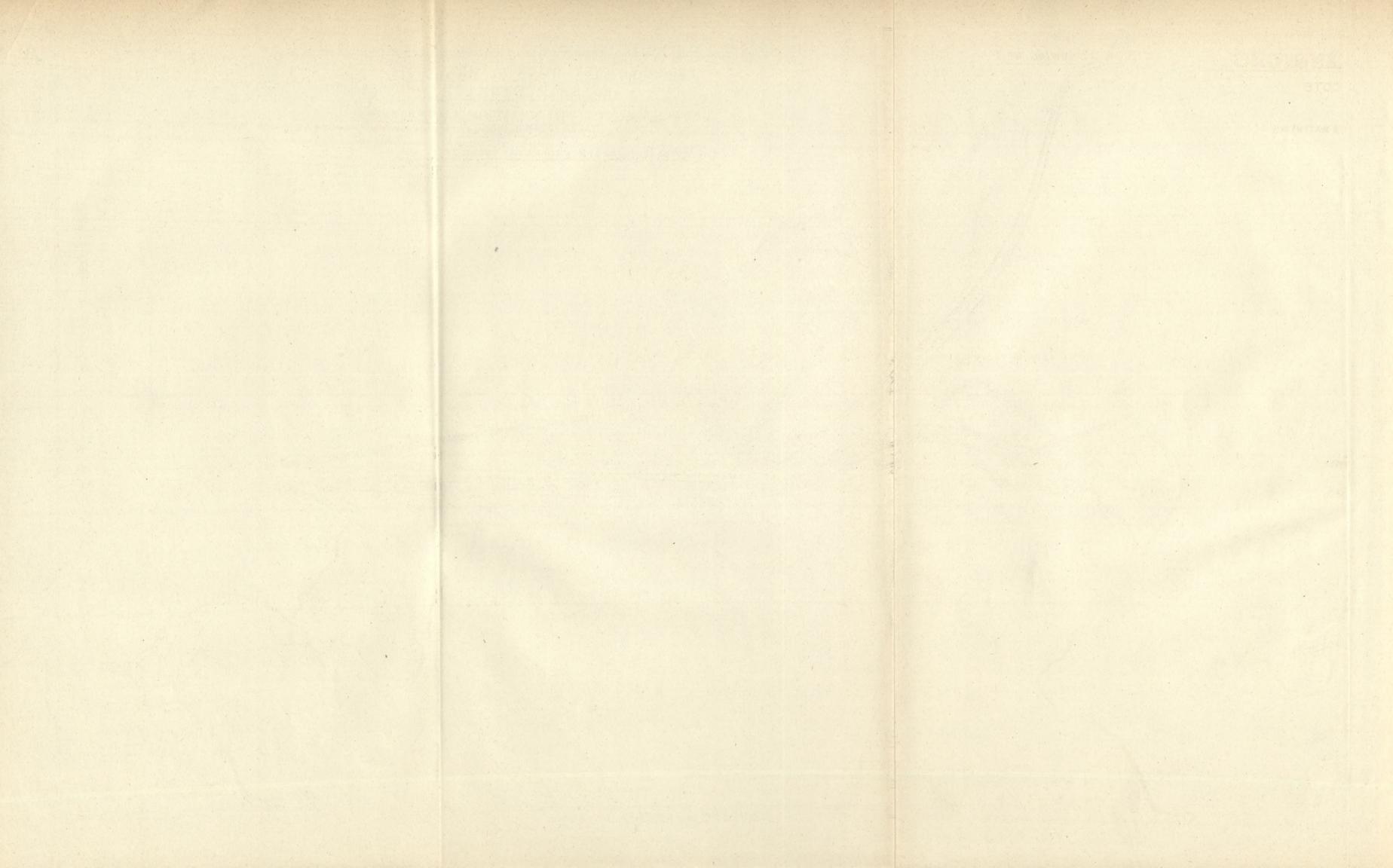


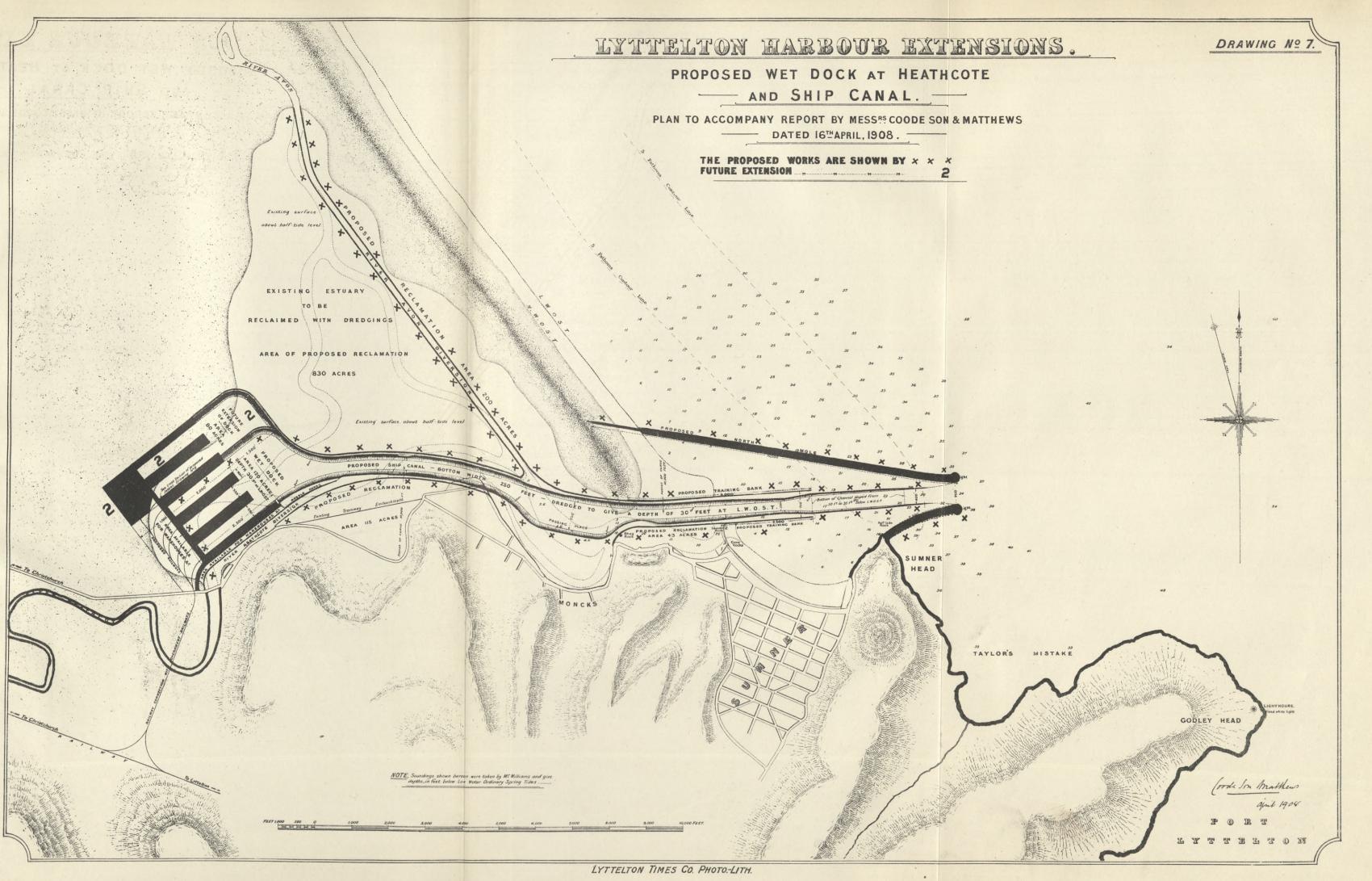


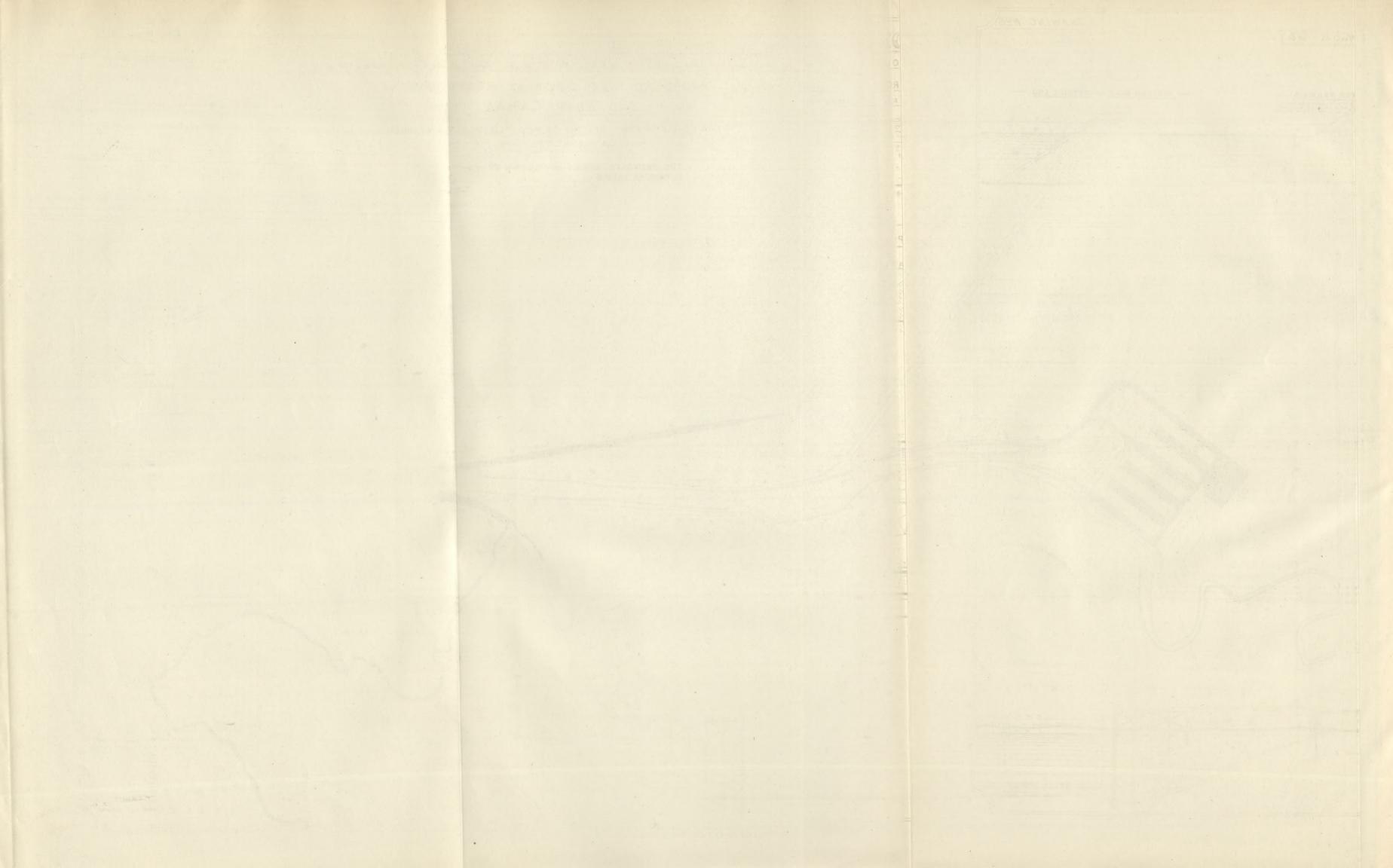


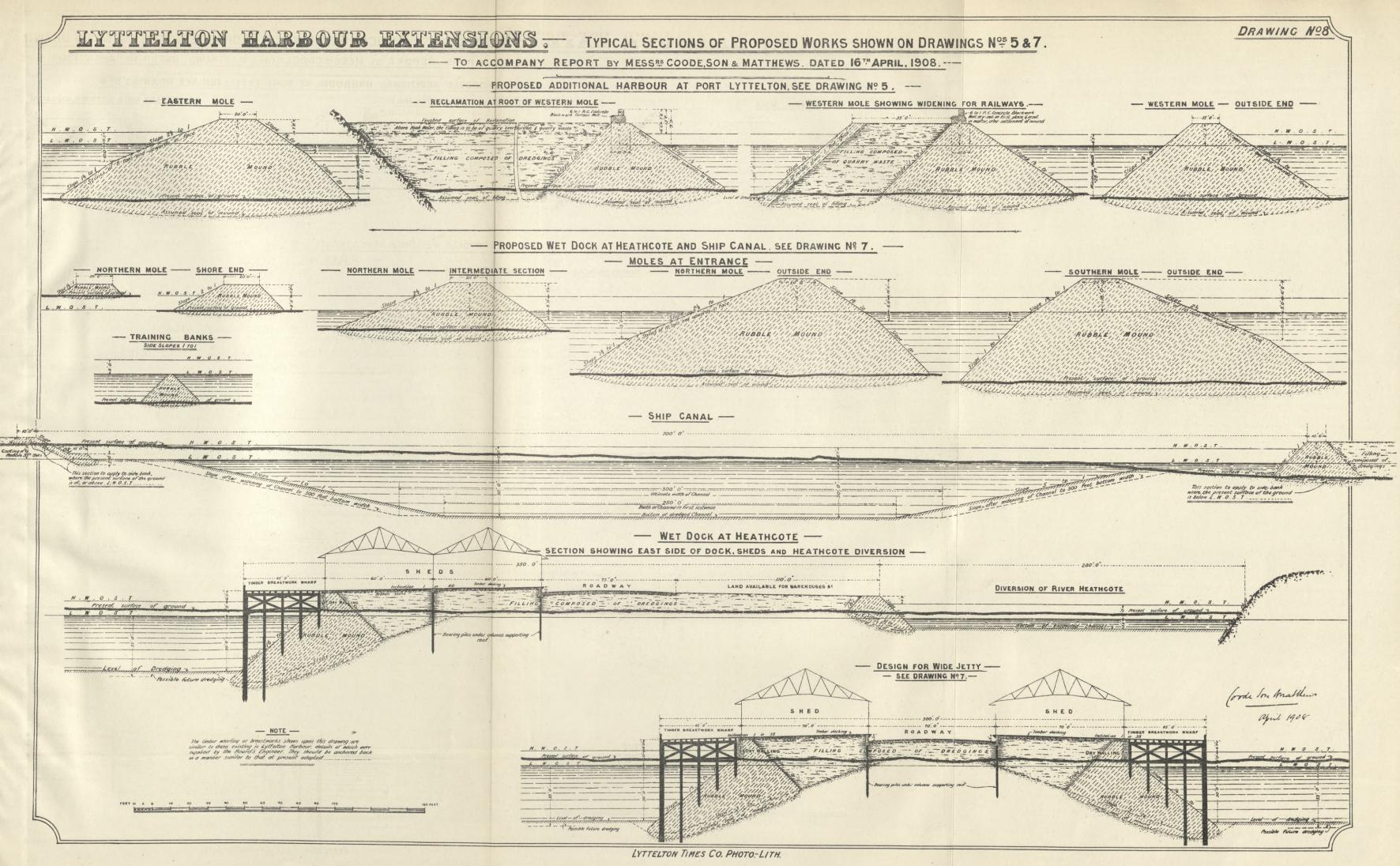


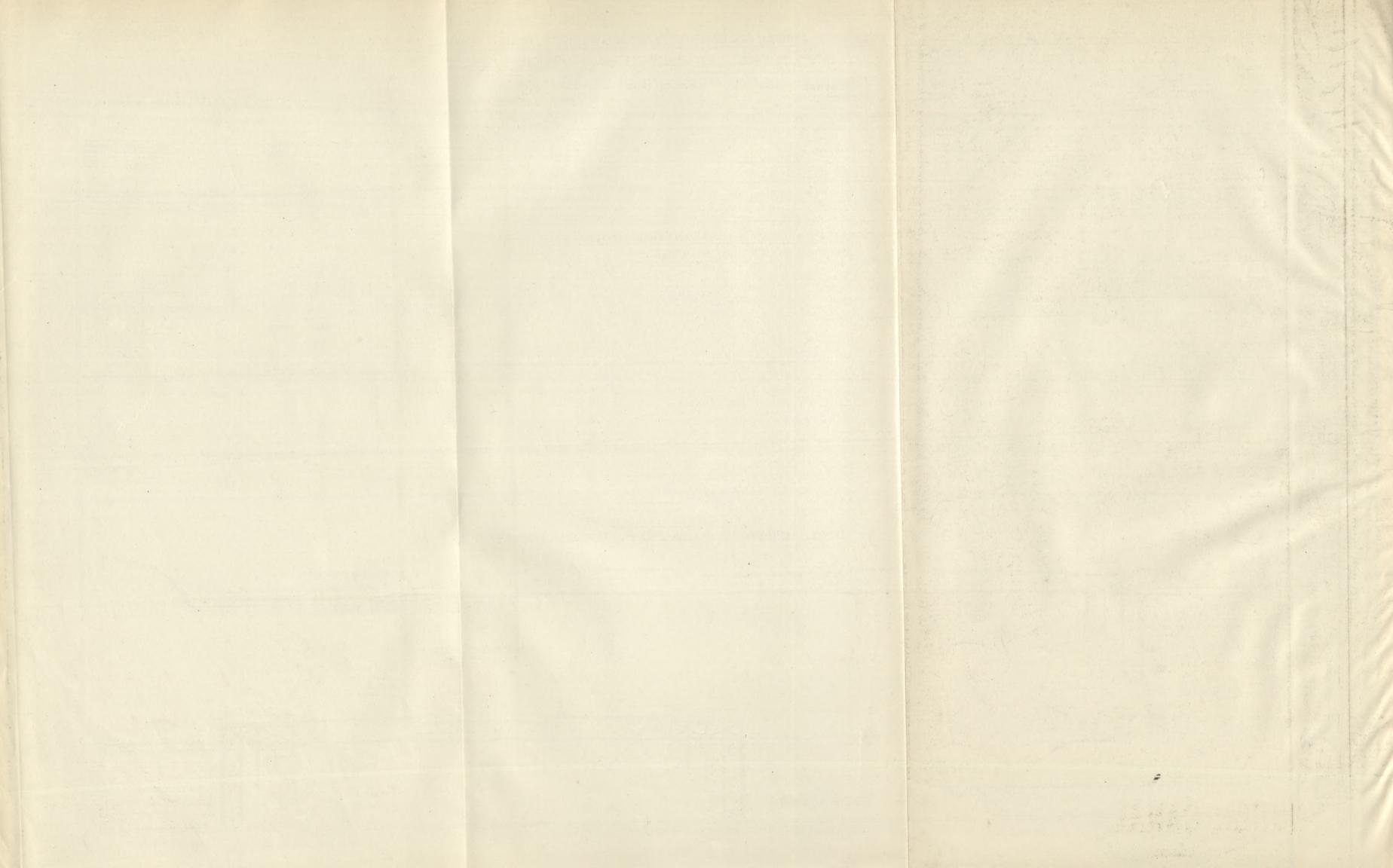


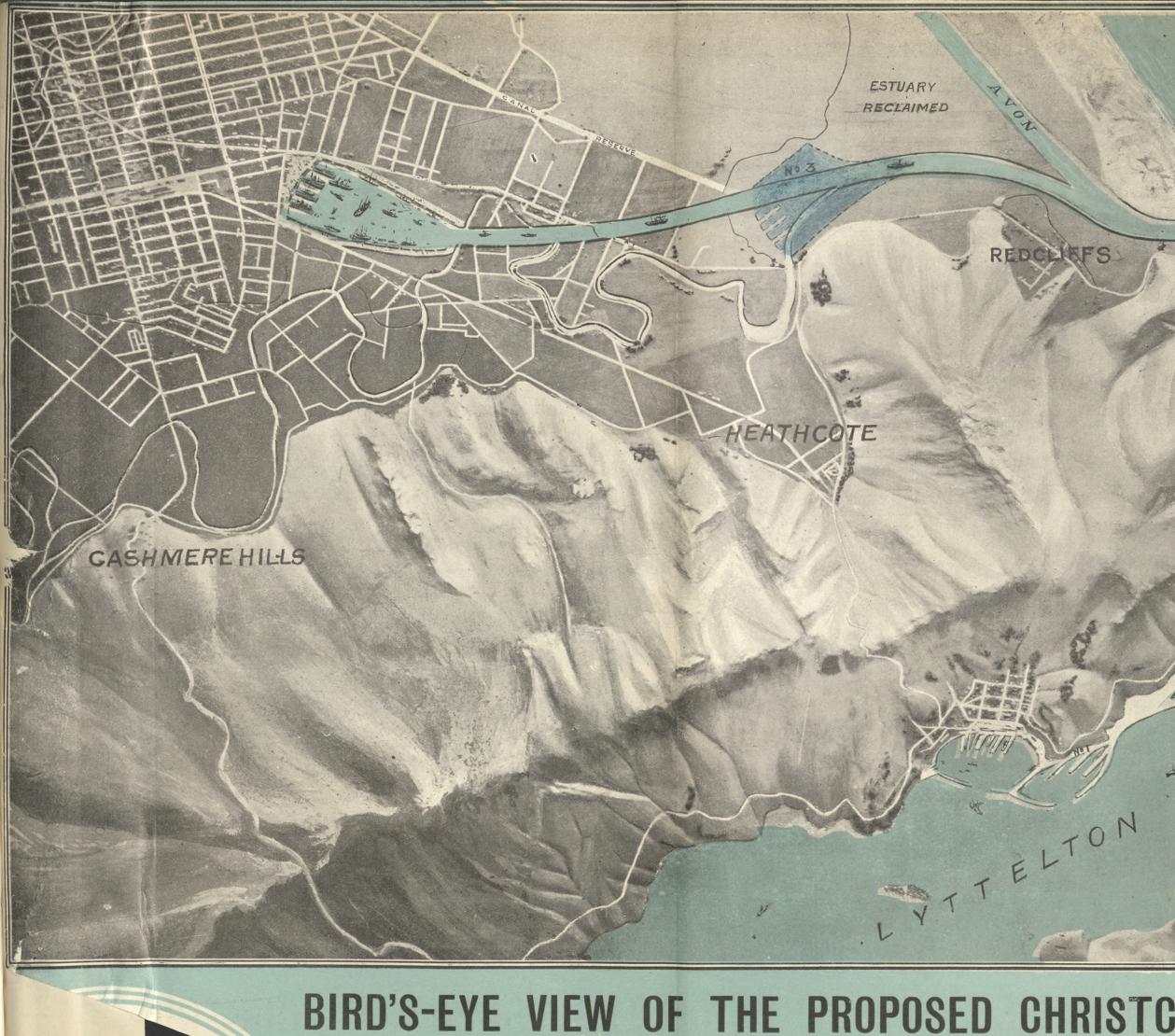












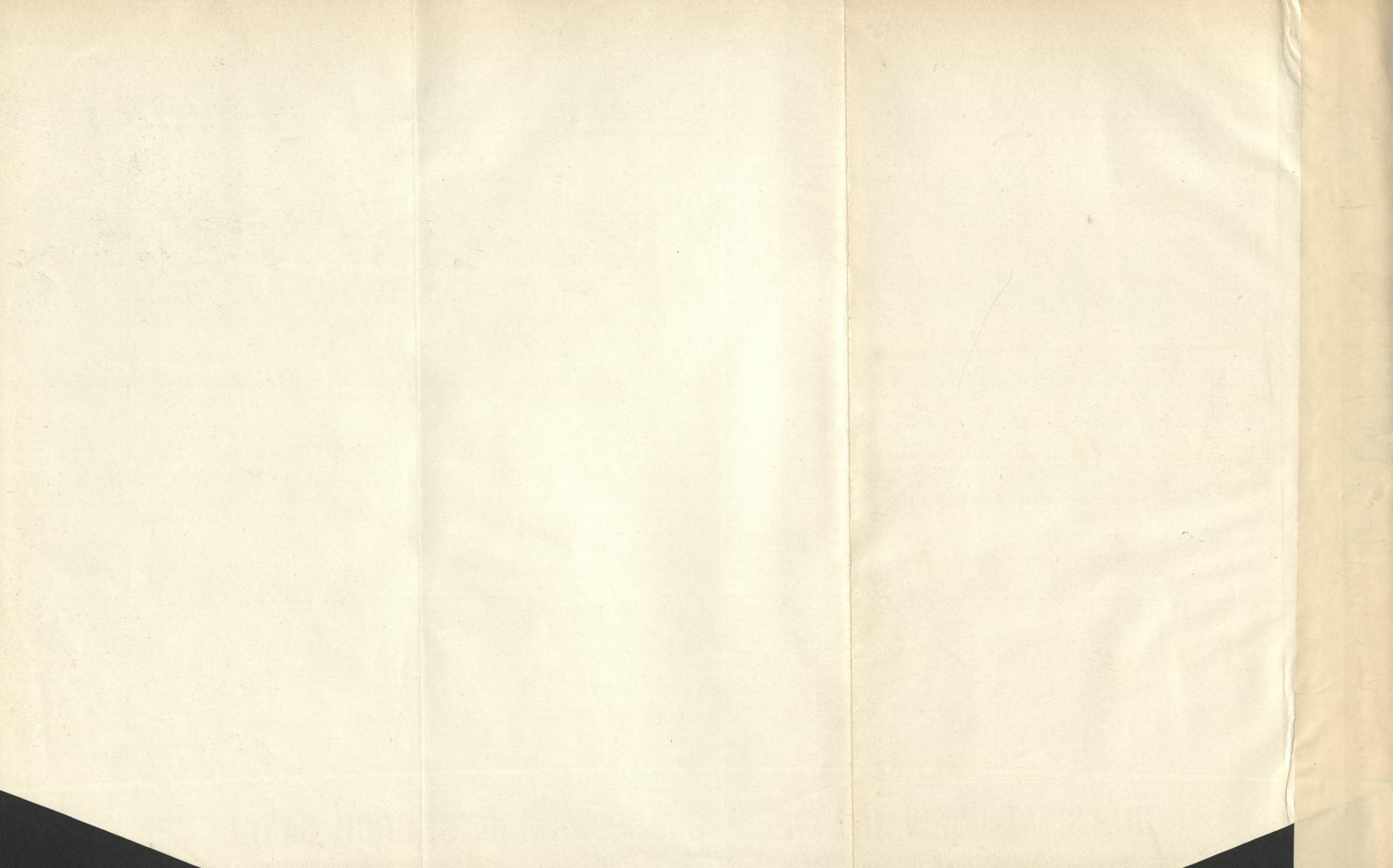
No. 1, Sticking Point;

No. 2, Gollan's Bay;

No. 3, Estuary, Heathcote;

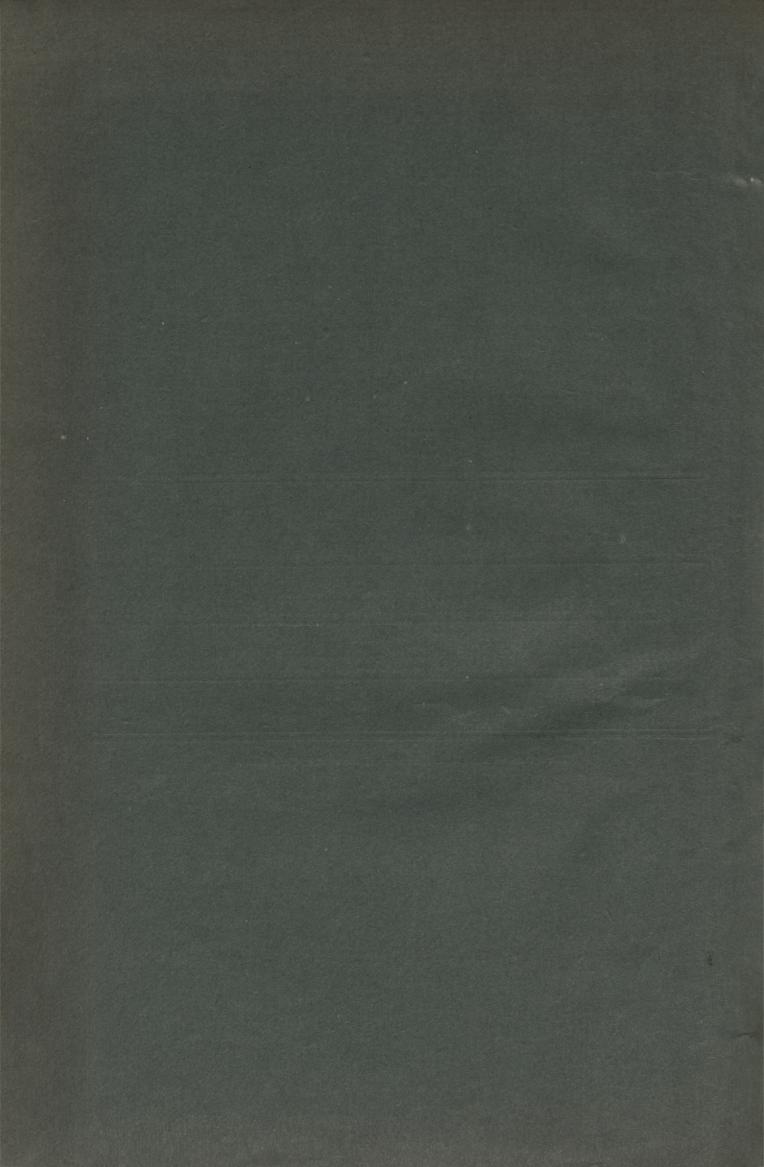
一些 TAYLORS SUMNER MISTAKE 10th HARBOUR 124111 1 SFAL OF THE PROPOSED CHRISTCHURCH CANAL.

No. 4, Canal.



Memorandum on the Subject of Further Harbour Extensions, and on the Feasibility of Constructing a Canal from the Sea towards Christchurch.

The Lyttelton Times Co., Ltd., Printers, Gloucester St., Christchurch



ENGINEER'S OFFICE, LYTTELTON HARBOUR BOARD, 25th November, 1905.

Memorandum on the Subject of Further Harbour Extensions,

and on the Feasibility of Constructing a Canal from the

Sea towards Christchurch.

IN accordance with paragraph 5 of my General Instructions, dated 21st January, 1903, and further instructions of 3rd October, 1904, I now submit the following report on the subject of "In what direction further harbour extensions can be made and the estimated cost," and also on "The feasibility and advisability or otherwise of the formation of a canal from the sea at Sumner to Christchurch, and also of other accommodation for shipping at Sumner."

As pointed out in my Annual Report dated 16th January, 1905, assuming a steady growth of trade on the basis of the figures from 1893 to 1904, in about 1925 the accommodation in the inner harbour at Lyttelton may be exhausted, in which case extensions will be necessary outside the present moles.

On the accompanying plan of part of Port Lyttelton are shown outline plans of two propositions for such harbour extensions, capable of being worked through the Moorhouse Tunnel.

Sticking Point Harbour, No. 1.

No. 1 proposition shows a small additional enclosed harbour in connection with the reclaimed land eastward of Officers' Point, a curved breakwater being run out in a South-westerly direction from Sticking Point, and another protecting mole being built in a south-easterly direction from the elbow of Officers' Point breakwater, leaving an entrance 500 feet wide.

This arrangement would enclose a water area of about 90 acres, and effective berthing lengths of about 3,800 feet at breastworks, and 5,200 feet at four jetties, or a total of 9,000 feet of deep water berthage.

Such a basin would be less subject to shoaling than the present inner harbour, because it would be free from the discharge from drains and less exposed to the south-westerly wash from the upper bays, and its jetties and breastworks could be conveniently connected to the present railway system. Its disadvantages would be that it would not be a commodious harbour for the largest class of steamers now afloat, bringing ships in and berthing them would be fully as inconvenient as at present, and dredging outside would still always be necessary, as the natural depth abreast of the entrance is only 22 feet at low water datum.

The cost is estimated at :-

					£	s.	d.	£	s.	d.	
Breakwater	a statistics but				38,015	0	0				
Protecting Mole					26,400	0	0				
Dredging inside					27,185	0	0				
Breastworks					68,400	0	0				
Jetties, No. 4					90,000	0	0				
feasibility of constructio					Connedu			250,000	0	0	
Contingencies, 10 %	S -C (3.5)	d sartingda	a the acces	ma diam	Chillisterini			25,000	0	0	
							-				
				Total			to	275,000	0	0	

This estimate makes no provision for rails on the wharves, which, under our present constitution are laid by the Railway Department, who work the cargo, nor for payment to the Government on account of reclaimed land eastward of Officers' Point, work which has been assessed by them at a cost of $\pounds_{26,000}$.

The accommodation provided would thus cost about £30 11s. per lineal foot of efficient berthage.

Gollan's Bay Harbour, No. 2.

The second proposition provides for a completely new harbour at Gollan's Bay, with the necessary reclamation to connect it with the present railway system.

The water area enclosed would be about 200 acres, and the ultimate effective berthage about 5,000 lin. feet at breastworks, and 17,000 lin. feet at the 12 jetties, which could each be suitable for berthing a 700-foot vessel, and still leave manœuvring space between the ends of the jetties on opposite sides of the harbour. The entrance would be situated in 30 feet at low water datum, so that no dredging outside the moles would be required. The dredgings from the inner harbour could be used to make reclamations, unless it was found, as has previously been the case, that the waste from the quarrying operations was supplying sufficient material for this purpose. The reclamation bank extending from Officers' Point to Sticking Point would be extended as shown, enclosing the small bay between Sticking Point and Battery Point, and continued in an easterly direction to torm a shelter from the south-west, and to carry a series of jetties running north-east and south-west, so that vessels could berth head or stern to wind as they do at present.

l estimate the cost at	:					r		d	£	s.	d
Breakwater						£ 58,216	0	0	た	э.	u.
Western Mole a	nd Reclam	ation	Bank from	Sticking	Point	139,906	0	0			
Reclamation Ban	k inside Me	oles				20,515	0	0	218,637	0	0
Dredging and R	eclaiming	with	Dredgings	0 335	006.9	42,000	0	0	210,037		Ŭ
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Contingencies, 10	% on abov	/e			Constant of the second				33,564	0	0
									369,201	0	0
Jetties, No. 12									300,000		
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about $f_{,30}$ per lin. fee	et of effecti	ve be	rthage.	111	and the second second				10091201		-

This estimate, like the last, makes no provision for rails on the wharves, nor for payment for the Sticking Point reclamation.

In comparing the costs of these proposals, it is necessary to take into account the cost of keeping open a dredged channel into the Sticking Point harbour. A moderate estimate would be £3000 per annum, which, capitalised at $4\frac{1}{2}$ per cent., equals £66,667, which should be added to the cost of the Sticking Point harbour, bringing the cost up to £341,667, or nearly £31 per foot of berthage. Or, comparing them on a basis of equal additions to the berthage, the Gollan's Bay harbour would only require three of the twelve jetties, making the cost only £435,201 as against £341,667 for the Sticking Point proposal. That is to say, for a 50 per cent. increase to the present accommodation, the Sticking Point proposal is the cheaper; but looking further ahead and taking into account the increase in the size of vessels to be provided for, it would be better to go straight to Gollan's Bay, and provide a commodious tidal basin there suitable for the largest vessels.

Harbour Entrance at Sumner, No. 3.

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In considering such proposals as these, involving the expenditure of $\pounds 275,000$ or $\pounds 369,000$, as the case may be, in the first instance, and of nearly $\pounds 700,000$ ultimately, it is necessary to take into consideration the question of whether it is desirable or good economy that the trade of the district should depend on railway communication through the hills. I am not among those who think that the capacity of the present tunnel is likely to be soon overtaxed, as I know that it is capable of dealing with a large increase to the present traffic, and when necessary it can be duplicated, though the cost of such duplication, which would probably be at least $\pounds 125,000$, would really be a charge against the harbour works, however it might be paid for.

The point is that as regards general merchandise, coal, timber, and imports generally, the district is handicapped by the railage charges, and though these could be considerably reduced, and still leave a large margin of profit, they are not likely to be so reduced as to put Christchurch and the district served by its Port on an equality with large seaport centres. Under the present system manufactures will always be handicapped. The position as regards export of produce is not so acute.

Consequently data have been obtained with a view of ascertaining the feasibility of constructing a canal from the sea towards Christchurch, and the accompanying plan No. 2 shows outlines of two such propositions.

Port or Tidal Basin at Heathcote, No. 3 "A."

This proposition provides for a tidal basin formed in the Estuary, near the mouth of the Heathcote River, connected to the sea by means of an open cutting 30 feet deep at low water springs, with bottom width of 200 feet, and side slopes calculated at 5 to 1 inside the present Sumner Bar, and 6 to 1 outside the Bar, opening into the open sea just outside Sumner Head in five fathoms at low water of spring tides. The channel would be protected on the north side by a mole about 7500 feet long, of similar construction to the outer mole now being built at Timaru, and the entrance would be narrowed to 700 feet between the centres of the moles by a short mole from Sumner Head, covering the half tide rock near there. The ebb currents in the channel through Sumner Bay would be directed and confined on the north by the north mole, and on the south by a low training wall to be covered at quarter-flood, thus allowing for the dispersal of waves and for the free ingress of the flood-tide. The present Sumner Bay would thus be converted into a wave-trap or stilling basin, its shoalness precluding its use as an anchorage, unless dredged out, which is not contemplated in this proposition, as anything in the nature of a harbour of refuge or anchorage for large vessels would be unnecessary with Port Lyttelton so near; while vessels waiting for a pilot could lie off or anchor outside in fair weather. The sides of the channel from the mouth of the Estuary to the Port would be protected by means of reclamation banks, behind which the dredgings would be deposited, which would result in the reclamation of upwards of 800 acres of land.

At the Port itself sufficient land would be reclaimed round the margin, seaward of the present highwater line, for administration, storage and other purposes, no provision being required for land resumptions.

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Under this system the cargo would be handled by the Board as at Wellington.

The construction of these works would occupy from five to seven years.

Canal from the Sea and Port at Wilson's Road, No. 3 "B."

This proposition provides for a tidal basin or port just below Wilson's Road, opposite the Linwood Railway Station. The ultimate area would be 162 acres, which would form the basis of the necessary land resumption here of 236 acres. Only 70 acres, however, would be excavated at first, the basin being enlarged as trade increased. The depth in the Port would be 30 feet at low water, and it would be connected with the sea by means of an open cutting, with 130 feet bottom width and side slopes at the natural angle of the material, out to the present high-water mark, and 200 feet bottom width thence seawards, the lower works being identical with those described under proposition 'A"

At the Port the wharves would be provided with sheds, cranes, etc., as before, but no rails would be laid on any except the export wharf, along the south side of the basin, which would be connected with the railway system.

In this proposition it would be necessary to provide for the acquisition of 358 acres of land, 122 acres for the canal and 236 acres for the terminal port; while the whole of the Estuary would be required to dispose of the dredged spoil.

Under this system also the cargo would be handled by the Board as at Wellington.

The construction of these works would occupy from seven to ten years.

ESTIMATES OF COST.

Port at Heathcote Bridge.

Conti

ESTI I S

I estimate the cost of Proposal 3 " A," with a Port at Heathcote as hereinbefore described, at :-

Estimate of Cost of Proposal 3 "A" with Port near Heathcote Bridge, with area 176 acres, channel 30 feet at low water, 200 feet bottom with side slopes, 6 to 1 outside present bar, and 5 to 1 inside bar.

		£	S.	d.	£	S.	d
PLANT, including necessary Cranes and Dredges		152,000	0		2	5.	·
PRELIMINARY EXPENSES in connection with Quarry, Rails and Tempora Bridge	ary	11,750	0	0			
		11,750		_	163,750	0	0
NORTH MOLE, with Staging		168,000	0	0	103,730		
South Mole		16,340	0				
the second se				0	194		
The second							A state
RETAINING WALLS to contain Dredgings		3,575	0	0	upsequa		
DREDGING		100000	-	bla	194,963	0	0
Present Bar to Open Sea	bijk al	22,316	0	0	mail		
Present Bar to Port				0	anninger.		
Tidal Basin or Port	gui	241,354	0	0			-
WHARFAGE	2	130,000	0	0	391,682	0	0
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	ateos			0			
CRAWLON OFFICIE		30,000		0 .			
Design and the second		10,000		-2013	Intel		
	inter-rela	10,000			207,500	0	0
		daubi 12		-dyt)	207,500	0	0
and the mill of Million on hear steel, as to a district mail start P	00 305			1,340	957,895	0	0
ingencies and Engineering Expenses 10 %		NE GERT		-	95,789	0	0
a settle and the subgright makes the support restant site, for the loss		18 200		_	2011-2		-
The second	OTAL		11.	£I	,053,684	0	0
IMATE OF COST OF FIRST INSTALMENT OF WORKS-				-			-
Potel Detingto J Cost on share	1	(0.	du	1			
Total Estimated Cost as above		053,684	0	0			
Saving by only Excavating 50 Acres of Tida ¹ Basin, continuing as extension become necessary		200,000	0	0			
		200,000	-	-			

TOTAL COST IN WORKING ORDER

£853,684 0 D

Port at Linwood.

Land

And I estimate the cost of Proposal 3 "B," with a Port at Linwood as hereinbefore described, at :-

Estimate of Cost of Proposal 3 "B" with Port near Wilson's Road, of area 162 acres, channel 30 feet at low water, 200 feet bottom width from sea to high-water mark, and 130 feet bottom width from high-water mark to Port.

from high-water mark to rolt.	M be handle		r	s. d	ndy this	s.	d.
Plant including necessary Cranes and Dredges			152,000	0 0			
D 11 1 December 1	autoro bhunor	Solto L. ve	11,750				
					163,750	0	0
North Mole, with Staging			168,000				
South Mole Training Wall in Sumner Bay	The inert all	bris 'the	16,340				
Reclamation Walls to contain Dredgings			7,048				
Rechamation wans to contain Dreugings	to minad light	es for a b	3:373	0.0	194,963	0	0
Dredging-					-)1))-5	1	19.0
Present Bar to Open Sea	man an mint	1	22,316	0 0	horaquiner		
Present Bar to High-water Mark		Ja and Fre	174,861	0 0			
High-water Mark to Port			121,916				
Tidal Basin or Port at Wilson's Road, with area 1	162 acres		359,571	0 0			
Wherface				0.0	678,664	0	0
Wharfage Sheds	and manak 19913	mon F. Grun	130,000				
Rails on Wharves			37,500 5,000				
Cranage Outfit	e provided a	a promite p	30,000				
with slide of the basing wheth would be connected with	a buit special	ananya m			202,500	0	0
					RATE AND AND	100	2113
					1,239,877	0	0
Contingencies and Engineering Expenses 10 %	er of whitemson	an ad white	na di mo		123,987	0	0
	TOTIT	OST OF CO	Arconnega	IN	7 262 961	-	Tal
Land Resumptions and Compensations for Canal	101AL C	USI OF CO	ASIRUCI	ION	1,363,864	0	0
For Tidal Basin, Store Space, etc.	236 acres						
adied be the Brand Se at Wellington	alt the state				ader this		
	358 acres				379,528	0	0
					mitten ad		_
					£1,743,392	0	0
				-	20 - 11 4 3 13 9 4		-
Cost of Canal Proper, not including Land Resumptions or Com	upensation to	property					
owners, about £900 per chain, or £72,000 per mile.	inpensation to	property					
THE PART OF A THE OF	THE A DATE						
ESTIMATE OF COST OF FIRST INSTALMENT OF THE	WORKS.						
Total Estimated Cost of Construction as above			,363,864	0 0			
Less Difference in Cost of Tidal Basin Constructed 70 Acr	res in extent, in	nstead of					
162 Acres as finally proposed			210,000	0 0	1,153,864	0	0
The second s			-	7 1910			
Add estimated Cost of Resumption and Compensation-							
For Canal	122 acres						
For Tidal Basin, Store Space, etc.	236 acres		1 000 10	1577			
and a second the former and a second s	358 acres					-	-
	350 acres				379,000	0	0
				all sin i			-
The set Starge and	TOTAL COST 1	N WORKIN	IG ORDER	2 1.761	£1,532,864	0	0

The cost of the project 3 "B" modified to provide a depth of 26 feet in the channel, and with the lesser width of 130 feet on the bottom continued out to the site of the present bar, at :--

Estimate of Cost of Proposal 3 "B" with Port near Wilson's Road, cut to 70 acres, with provision for subsequent enlargement to 162 acres, channel 130 feet bottom width, cut to 26 feet at low water.

						£	s.	d.	£	s.	d.
	Plant, including Cranes and Dredges					152,000	0	0	~		
	Preliminary Expenses		- A	A 112	196 1	11,750		0.410.01			
				Aller and the second				1220	163,750	0	0
	North Mole, with Staging					168,000	0	0	103,100		~
	South Mole					16,340	0	0			
	Training Wall in Sumner Bay					7,048	0	0			
	Reclamation Walls to contain Dredgings					3,575	0	0			
				the las			-	_	194,963	0	0
	Dredging-								-94,9~3	Ĭ	~
	Present Bar to Open Sea					15,667	0	0			
	Present Bar to High-water Mark					139,176	0	0			
	High-water Mark to Port					103,549	0	0			
	Port 70 acres, 30 feet deep					155,458		0			
	Marke .			it sent at a	0	-001400	-		413,808	0	0
	Wharfage			an and	Esquel.	130,000	0	0	413,000		No.
	Sheds					37,500	0	0			
	Rails					5,000		0			
	Cranage Outfit					30,000	0	0			
		-	and an an	and a set with		30,000	-	_	202,500	0	0
				e meteric					202,500	9	-
									975,021	0	0
	Contingencies, etc					and the second					0
	allolitotiza en j				20° A.C	Summan			97,302	-	_
									1,072,525	0	0
1	Resumption					and the			379,528		0
	100 Commence		Amora annot	-				-	5751520	-	_
				TOTAL				£	1,452,051	0	0

Works at the Entrance.

The system of construction proposed for the north mole would be that which is proving sufficiently stable and effective at Timaru; the stone in large blocks would be brought by rail from quarries betweer Bell's Baths and Sumner Head, carried across the present entrance by means of a temporary bridge, with opening span to admit the dredges, and tipped from a staging. Such work at Timaru, where the haulage is longer, costs 2s. 10¹/₂d per ton tipped in the work. Taking into account the shorter haulage, and that all the smaller stuff quarried would be used in the foundation of the mole and in the training wall and reclamation banks, it would be quite safe to estimate the cost of the work at 2s. 9d. per ton or 4s. 10d. per cubic yard, exclusive of all costs for plant, staging, railway, bridge, and all preliminary work. The weight of the stone is about 163 pounds per cubic foot, and the proportion of voids about 20 per cent. at Timaru.

The short mole from Sumner Head would be constructed in a similar manner to the north mole, but is much nearer to the quarries.

The dredged and trained channel through Sumner Bay should not require much attention after the completion of the works, as the current between the north mole and the low training wall would prevent any deposit in that part of the channel, and the movement of the sea and cross currents at the entrance would prevent the deposit of the alluvium there. There might be some slight deposit of sand there which would require the occasional attention of a suction dredge, but at the worst the quantity would be inconsiderable.

With regard to the sand travel, which is under present conditions slowly causing accretion on the Sumner beach and in the corner at Bell's Baths, the north mole would cut this off and the prevailing direction of the waves would prevent it extending along the mole towards the entrance. A comparison of the soundings in Sumner Bay, with such as are available showing former conditions, indicates that the quantity of sand is not such as to become a menace for hundreds of years, if at all.

The sea bed at the proposed entrance is composed of muddy sand, changing to almost pure sand at the site of the present bar and for some distance inside.

A comparison of the recent soundings with those of the Admiralty chart, dated 1849, indicates a condition of stability in the natural conditions of the sea bed at the site of the proposed entrance.

The whole of the material is suitable for handling with a suction dredge, that in the outer part might have to be carried to sea, but in the inner part the spoil could all be pumped over the north mole.

Dredged Channel from the Entrance to High-water Mark.

The material here throughout is sand and alluvium, very suitable for being dealt with by a suction dredge, which could dredge and discharge the spoil over the reclamation banks in one operation. Such work is now being carried out on the Brisbane River in Queensland at about 2d. per ton.

Channel from High-water Mark to Port near Linwood.

The material to be dealt with is sand, alluvium, and gravel. It could all be removed by means of suction dredges, but the spoil would need to be carried down in hoppers and would be deposited in suitable positions to be discharged over the walls by pump dredges stationed in the lower channel.

The tidal basin or port would be excavated in the same way.

The sides of the whole of the channel would be allowed to assume their natural slopes. Such slopes in existing ship canals vary from 1-1 to $2\frac{1}{2}-1$, but the estimated costs have been based on still flatter slopes to be on the safe side.

It is not expected that the upper part of the channel, and the canal proper, would maintain their depths without continuous dredging in some part or another, and I have assumed that in the project for a Port at Linwood a sum of $\pounds_{15,000}$ per annum would be necessary to provide for this, and that $\pounds_{10,000}$ would be necessary in connection with a Port near Heathcote Bridge.

Canal Reserve.

I cannot see any special benefit in attempting to make use of the Canal Reserve. It could never, in my opinion, have been laid out for the purpose of constructing a ship canal, or its width would have been more than $2\frac{1}{2}$ chains, and I doubt whether the whole of this width would be available without compensation to the property owners on both sides, as it is also a road reserve. Even if the whole width were available without compensation the small saving in land resumption would not make up for the increase in the length of the canal to reach an equally central site for the Port. The land, which would require to be reserved, however, seems to me to be somewhat less valuable than that required for the work on the lines indicated, and on the whole, where so many interests are involved, there is plenty of room for difference of opinion as to the best location. For the purpose of settling the feasibility, or otherwise, of a canal towards Christchurch, a decision on this point is hardly necessary at this juncture.

Any smaller canal than one suitable for the largest vessels, does not seem to me to be worth discussing. The works at the entrance would need to be the same, land resumption in need of future development would need to be the same, and work at a port at Sumner would, as regards wharfage, etc., cost as much as at Linwood; while, after all the expenditure had been incurred, the conditions would not be much improved, if at all, on those at present obtaining.

Possible Savings on the Estimated Cost.

There are many directions in which savings would almost certainly be effected in the actual execution of the works. For instance, the construction of the training walls would almost certainly induce such scour in the channel during the progress of the work that the amount of dredging would be considerably reduced. Then the height of the north mole has been calculated at 6 feet above high water of spring tides. It is unlikely that the full height would be required, the stilling effect being only that needed for safe navigation purposes, which is much less than would be necessary were vessels required to berth and discharge cargo along the mole. Further, it is hardly likely that the sides of the cutting would assume such flat slopes as those allowed for. As nearly half the amount of the excavation estimated on is included in the allowance for side slopes, it will be seen how important this point is.

I have preferred, however, to keep these savings, among which must be included the fact that the canal could be used and would be producing revenue long before its completion to the full width and depth, as a set-off against such contingencies as are bound to arise in a work of this magnitude, and against additions to the capital cost on account of interest during construction.

The value of the contingent reclamations has not been taken into account. In the case of Proposal 3 "A" the area reclaimed would be about 800 acres, while in the case of Proposal 3 "B" the whole of the estuary, except the ship channel and the necessary channels for the Avon and Heathcote rivers, would be reclaimed, an area of 1477 acres. A great deal of the land would not be very valuable for some years at least, but those portions facing the channel would be a valuable asset immediately.

Financial Aspects.

The above remarks only deal with the constructive aspect of these propositions. The financial working aspect cannot, however, be overlooked even at this preliminary stage.

With regard to Propositions 1 and 2 for extensions inside Port Lyttelton, they are at best only extensions of the present harbour, and would only be undertaken under pressure, or threatened pressure, of trade overtaking the present accommodation. They provide no remedies for the present disabilities, nor can they do so. When necessary, they or something else must be undertaken, and there is an end of it.

Propositions 3 "A" and 3 "B" are on a different footing. Their function is not only to provide further accommodation, but to entirely reorganise the sea-borne trade of the district. It is therefore necessary that some comparison, however rough, be made of the conditions and costs under this system and under the present one. Dredged Channel from the Entral

The first stage is to estimate the cost of working them.

For a rough estimate, it will be sufficient to take the cost of working the present harbour, as all the conditions which affect this one will be somewhat similar, with the exception of the cost of working the cargo, which will be taken separately.

Channel from High-water Mark to Fort near

Estimate of Annual Working Cost, Proposal 3 "A."

HARBOUR IN ESTUARY, NEAR HEATHCOTE BRIDGE.

	£	S.	d.	à .	s.	d.
Annual Working Cost of Port on basis of present Harbour, not including Dredging or Interest on Loans	18,871	0	0	ison on		
Dredging for Maintenance	10,000			and sides		
Annual Cost of handling Cargo on basis of probable trade in 1910, say	fav eln	ins	ai	da guile		
600,000 tons, @ 1/	30,000	0	0	58,871	0	0
Interest on Cost of Construction of first instalment of Work £853,684, @41/2 %	38,416	0	0	30,07-		
Interest on balance of Unredeemed Loans on account of Works at present Lyttelton Harbour, say £ 200,000 in 1910, @ 4½ %	0.000		-	tuod tive a		
Lyttelton Harbour, say χ 200,000 in 1910, ($@ 4\frac{1}{2}$ %	9,000	0		47,416	0	0
ection with a Port near Heathcote Bridge.	aneo a			mon ad	1.Te	-
TOTAL ANNUAL COST		0	0	£106,287	0	0

Estimate of Annual Working Cost, Proposal 3 "B."

PORT NEAR TO LINWOOD RAILWAY STATION.

Annual Working Cost of Port on basis of present Harbour, not including Dredging or Interest on Loans	£ 18,871	0		£	8.	d.
Dredging for maintenance	15,000			68,871	0	0
Interest on Cost of Construction of first instalment of the Work £1,153,636, at 4½%	51,913	0	0	bunyol	1943	
in 1915, @ 4½ %	d)	<u></u>	-	58,663 17,055		

TOTAL ANNUAL COST £144,589 0 0

Revenue likely to be available.

It is not necessary at this stage to discuss the various sources of revenue. It will be sufficient for our present purpose to show at what date sufficient revenue could be collected to meet the necessary yearly cost without excessive charges.

A comparison with a model port like Wellington will, therefore, not be out of place.

At that port, with a quantity of about 630,320 tons of cargo inwards and outwards, not including transhipments, they were able to collect a revenue of about £113,583, exclusive of rents, which works out at about 3/6 per ton of cargo.

In these comparisons and estimates all classes of goods have, for the sake of simplicity and con-venience, been converted into tons.

On the above basis the cost of cargo from Lyttelton to Christchurch, and *vice versa*, amounted in 1904 to more than £169,607, made up of the total revenue of the Board, and the handling and railage between Lyttelton and Christchurch. This works out at something over 7/- per ton on 486,135 tons; but the total charges could, perhaps, be reduced to about 5/- per ton by reductions in the railage.

I propose, therefore, to discuss the question on the above basis of so much revenue per ton of cargo, without going into the question of how the charges should be allocated.

In this connection it is necessary to make some estimates of the quantities of cargo to be dealt with at various dates as a working basis. I have, therefore, shown in diagram form the quantities of inward, outward and total cargo, exclusive of transhipments, which passed over the Lyttelton wharves from 1881 to 1904, a period of 23 years, with fair lines showing average increases of cargo during the whole period and during the last 11 years.

There is room for difference of opinion as to which of these lines of average (if either) should be used as a basis of estimates of future trade. The average for the last 23 years seems a decidedly conser-vative view to take, while that for the last 11 years, may, to some people, seem unduly optimistic. Accurate trade predictions are impossible, and I express no opinion; but as some basis of discussion is necessary, I have worked out the following table on the basis of both these lines of average increase of trade.

This table shows the revenue that would be available at future dates on the basis of the average increases for the last 23 years and for the last 11 years at various total charges per ton of cargo, the lowest rates being substantially on the basis of the Wellington charges, and the highest on the basis of what the charges under the present system might be reduced to.

The table will, therefore, show by inspection, at what dates the canal proposition becomes a workable scheme on the above assumptions.

That is to say, it shows that, taking the conservative view based on the average increase for the last 23 years, and on a working basis equal to 5/- per ton, the Canal scheme would be financial in 1917, at 4/6 per ton in 1923, and on a basis of 4/- per ton in 1931; or taking the optimistic view of trade expansion based on the average rate of increase for the last 11 years, it would become financial in 1910 at 5/- per ton, in 1917 at 4/- per ton, and in 1921 at 3/6 per ton. It also indicates that a Port near Heathcote Bridge would be a financial success to-day by reducing the total charges from 7/- per ton to 5/- per ton; that in 1907 the charges would be reduced to 4/6 per ton; and that if the work were commenced now, by the time it was finished the charges would be reduced to 4/- per ton.

In speaking of a basis of 4/-, etc., per ton, it must not be assumed that such rate would be the direct wharfage rate on the cargo; some of it would take the form of dues on the ships, pilotage, etc., so that the actual wharfage rate would be much less than the assumed total charge for estimating purposes.

In the following table what may be described as the financial points in connection with Proposal 3 "B" are underlined with a double line, similar points in connection with Proposal 3" A" with a single line.

Conclusion.

In this report I have endeavoured, while withholding my own opinions as far as is consistent with my office, to so put the matter before those interested, that they shall have something definite on which to base their judgments.

The plans accompanying this report are :--

Diagram of annual increase of trade, 1881 to 1904. General plan (No. 1), showing limits of Port, with outlines of various propositions indicated in red colour.

Plan (No. 2) of Sumner Bay and suggested Christchurch Canal.

THE CHAIRMAN,

LYTTELTON HARBOUR BOARD, Christchurch.

CYRUS J. R. WILLIAMS, M. Inst. C.E., Am. Soc. C.E., Engineer to the Board.

7

TABLE I.

Assumed quantity of goods to be dealt with and approximate income derivable from trade generally at various future dates.

YEAR.	On basis of average increase for the last 23 years.					On basi	On basis of average increase for the last 11 years.				
	Total Estimated Quantity of Cargo, in tons.	Estimated Income derivable on basis of 3/6 per ton.	Estimated Revenue derivable on basis of 4/- per ton.	Estimated Revenue derivable on basis of 4/6 per ton.	Estimated Revenue derivable on basis of 5/- per ton.	Total Estimated Quantity of Cargo, in tons.	Estimated Revenue derivable on basis of 3/6 per ton.	Estimated Revenue derivable on basis of 4/- per ton.	Estimated Revenue derivable on basis of 4/6 per ton.	Estimated Revenue derivable on basis of 5/- per ton.	
102165 H	Tons	£	£	£	£	Tons	£	£	£	£	
1905	460,000	80,500	92,000	103,500	115,000	490,000	85,700	98,000	110,250	122,500	
1906	470,000	82,250	94,000	105,750	117,500	510,000	89,250	102,000	114,750	127,500	
1907	480,000	84,000	96,000	108,000	120,000	530,000	92,750	106,000	119,250	132,500	
1908	490,000	85,750	98,000	110,250	122,500	550,000	96,250	110,000	123,750	137,500	
1909	500,000	87,500	100,000	112,500	125,000	570,000	99,750	114,000	128,250	142,500	
1910	510,000	89,250	102,000	114,750	127,500	590,000	103,250	118,000	132,750	147,500	
1911	520,000	91,000	104,000	117,000	130,000	610,000	106,750	122,000	137,250	152,500	
1912	530,000	92,750	106,000	119,250	132,500	630,000	110,250	126,000	141,750	157,500	
1913	540,000	94,500	108,000	121,500	135,000	650,000	113,750	130,000	146,250	162,500	
1914	550,000	96,250	110,000	123,750	137,500	670,000	117,250	134,000	150,750	167,500	
1915	560,000	98,000	112,000	126,000	140,000	690,000	120,750	138,000	155,250	172,500	
1916	570,000	99,750	114,000	128,250	142,500	710,000	124,250	142,000	159,750	177,500	
1917	580,000	101,500	116,000	130,500	145,000	730,000	127,750	146,000	164,250	182,500	
1918	590,000	103,250	118,000	132,750	147,500	750,000	131,250	150,000	168,750	187,500	
1919	600,000	105,000	120,000	135,000	150,000	770,000	134,750	154,000	173,250	192,500	
1920	610,000	106,750	122,000	137,250	152,500	790,000	138,250	158,000	177,750	197,500	
1921	620,000	108,500	124,000	139,500	155,000	810,000	141,750	162,000	182,250	202,500	
1922	630,000	110,250	126,000	141,750	157,500	830,000	145,250	166,000	186,750	207,500	
1923	640,000	112,000	128,000	144,000	160,000	850,000	148,750	170,000	191,250	212,500	
1924	650,000	113,750	130,000	146,250	162,500	870,000	152,250	174,000	195,750	217,500	
1925	660,000	115,500	132,000	148,500	165,000	890,000	155,750	178,000	200,250	222,500	
1926	670,000	117,250	134,000	150,750	167,500	910,000	159,250	182,000	204,750	227,500	
1927	680,000	119,000	136,000	153,000	170,000	930,000	162,750	186,000	209,250	232,500	
1928	690,000	120,750	138,000	155,250	172,500	950,000	166,250	190,000	213,750	237,500	
1929	700,000	122,500	140,000	157,500	175,000	970,000	169,750	194,000	218,250	242,500	
1930	710,000	124,250	142,000	159,750	177,500	990,000	173,250	198,000	222,750	247,500	
1931	720,000	126,000	144,000	162,000	180,000	1,010,000	176,750	202,000	227,250	252,500	
1932	730,000	127,750	146,000	164,250	182,500	1,030,000	180,250	206,000	231,750	257,500	
1933	740,000	129,500	148,000	166,500	185,000	1,050,000	183,750	210,000	236,250	262,500	
1934	750,000	131,250	150,000	[168,750	187,500	1,070,000	187,250	214,000	240,750	267,500	
1935	760,000	133,000	152,000	171,000	190,000	1,090,000	190,750	218,000	245,250	272,500	

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Revenue likely to be available.

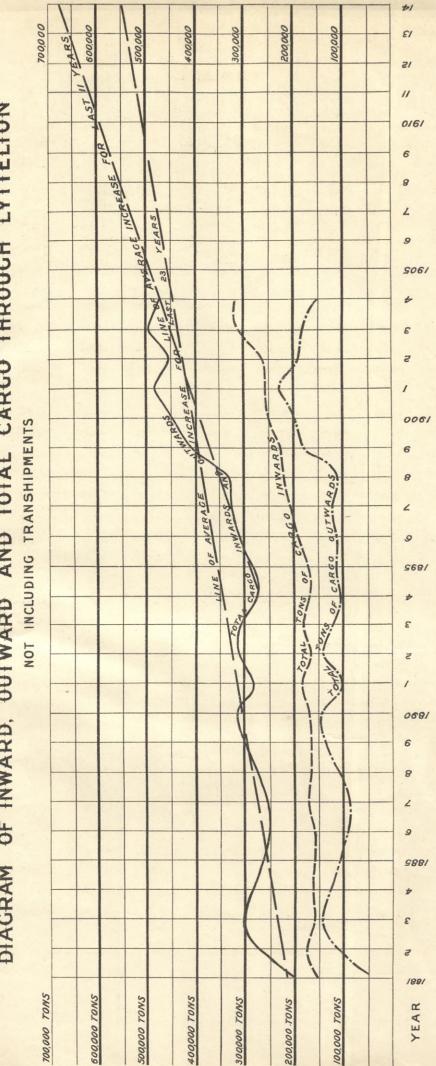
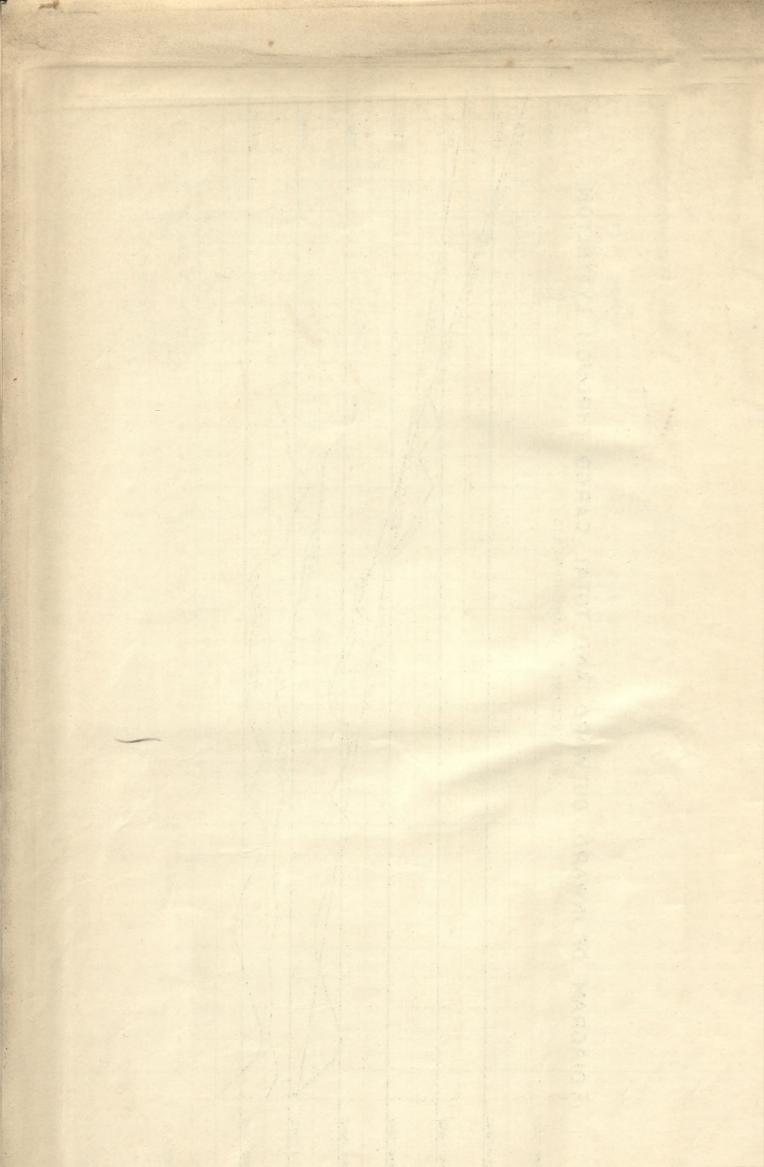
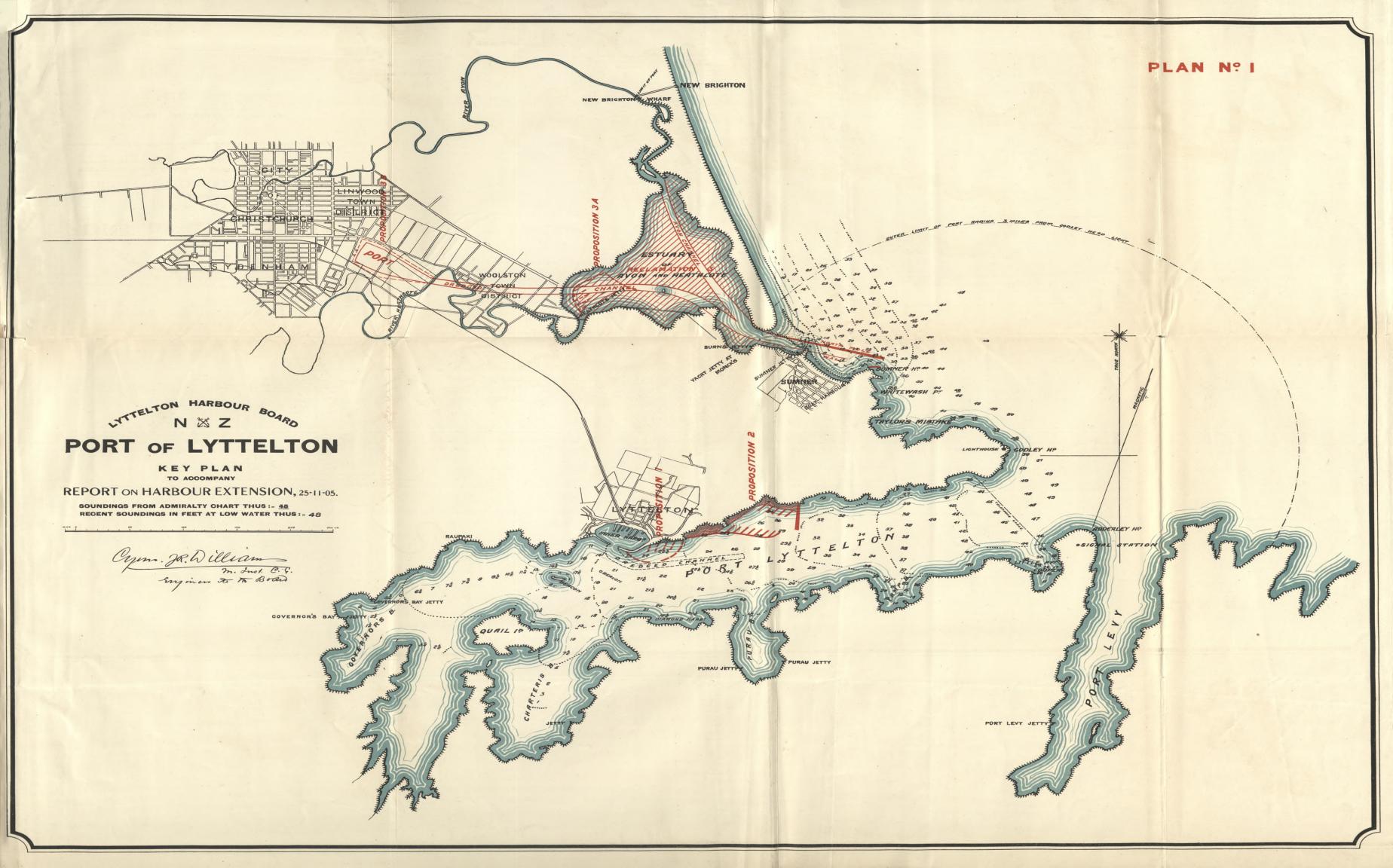
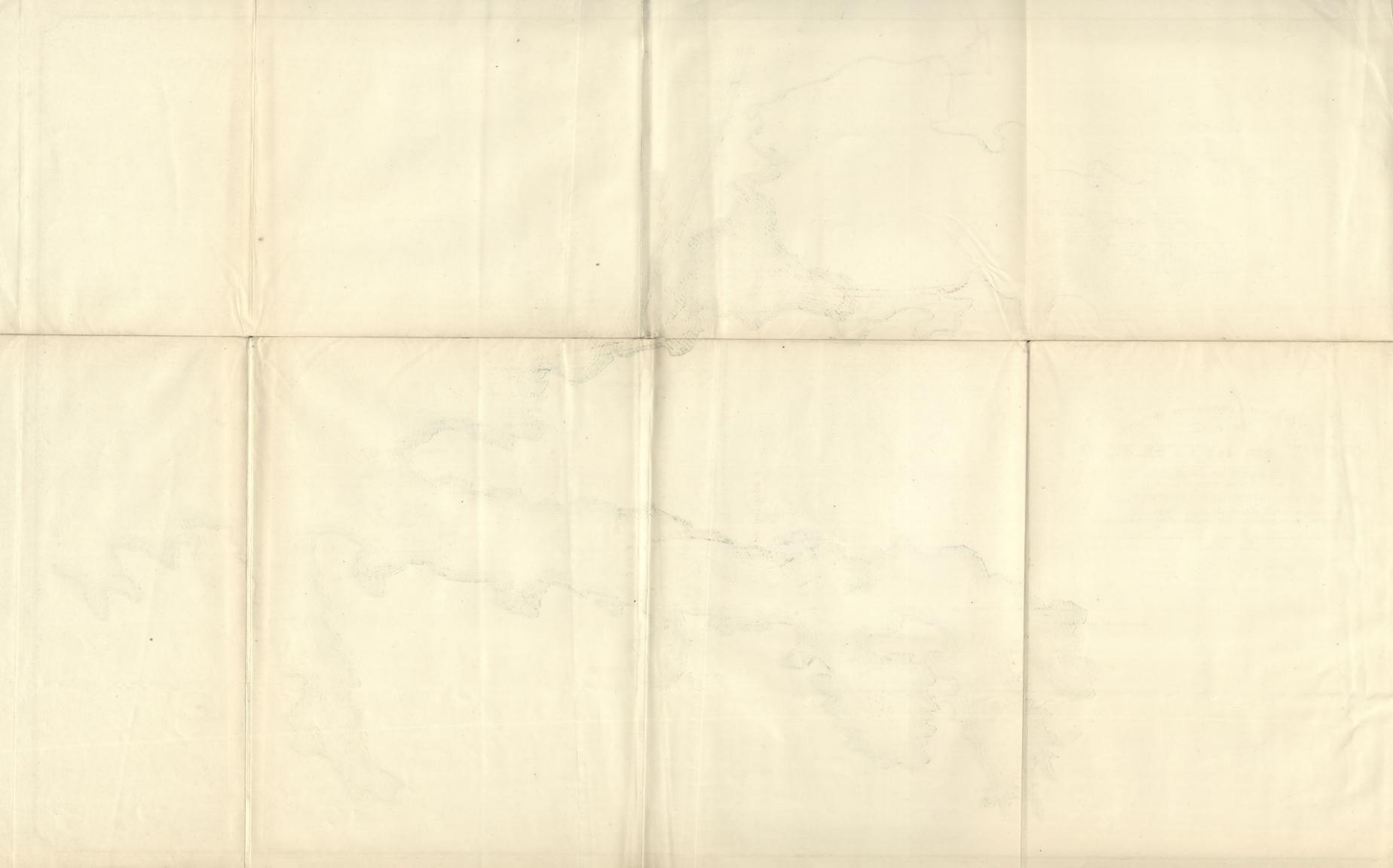
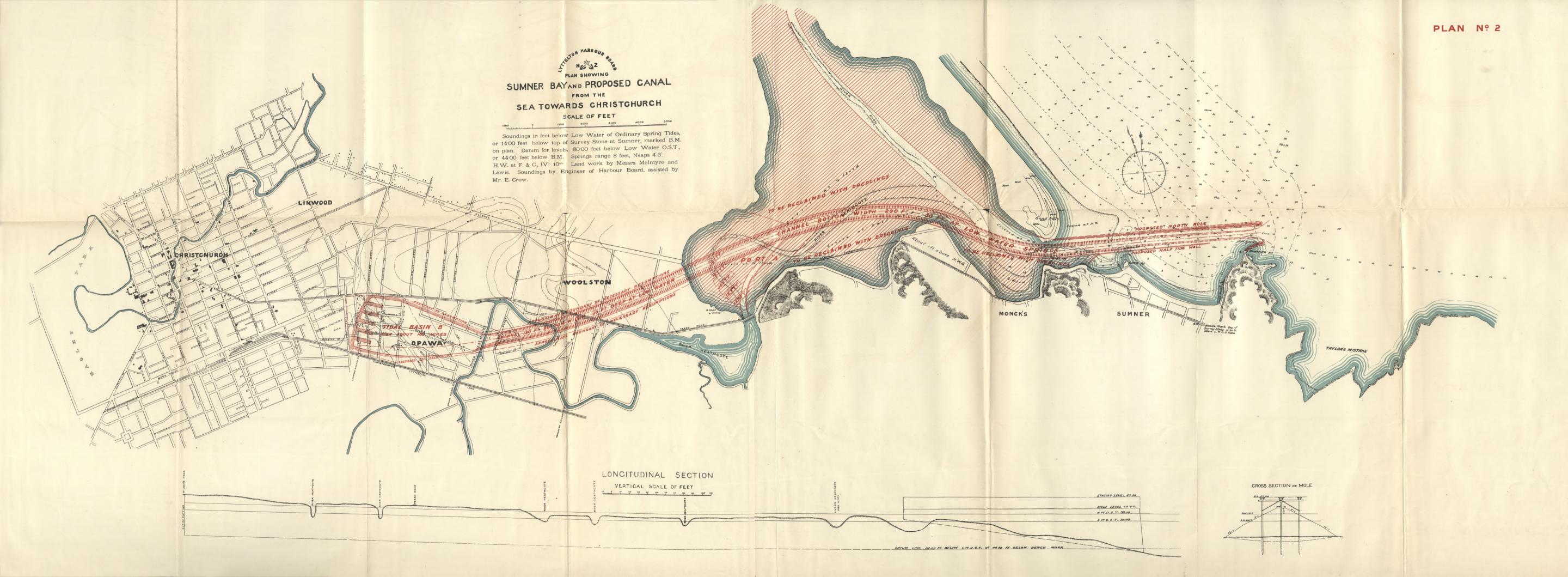


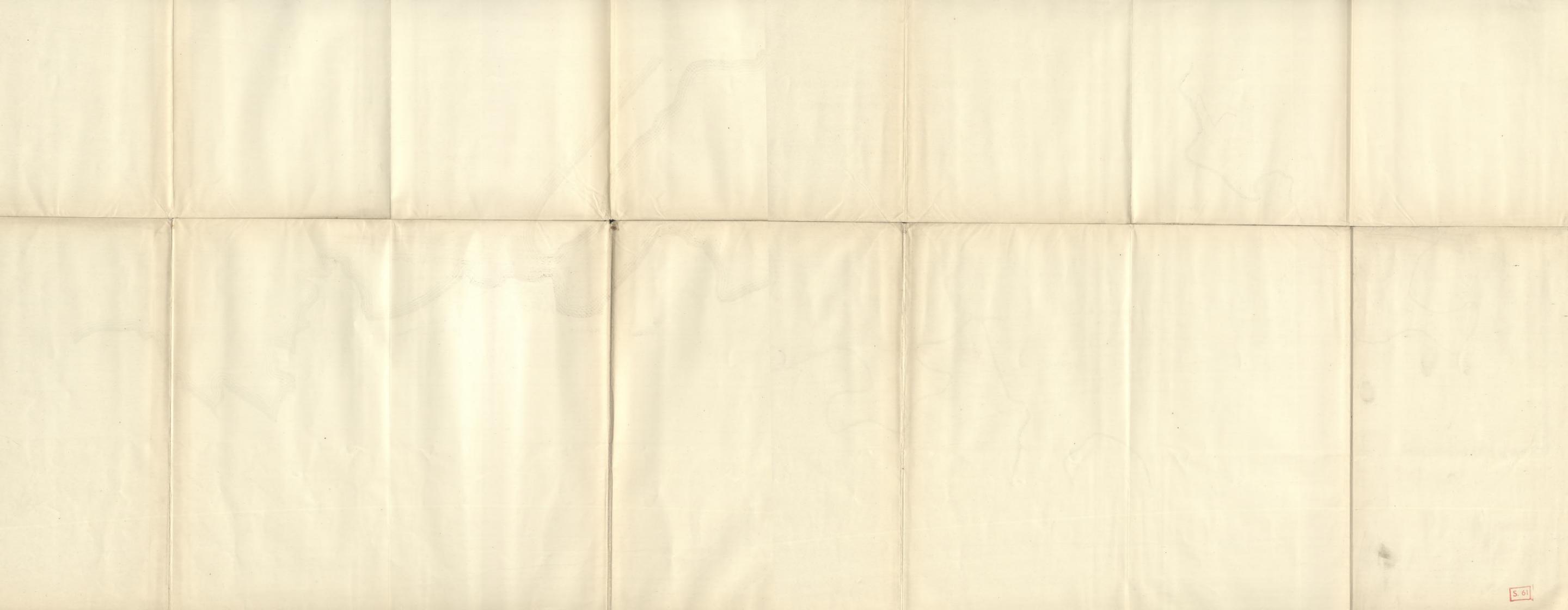
DIAGRAM OF INWARD, OUTWARD AND TOTAL CARGO THROUGH LYTTELTON

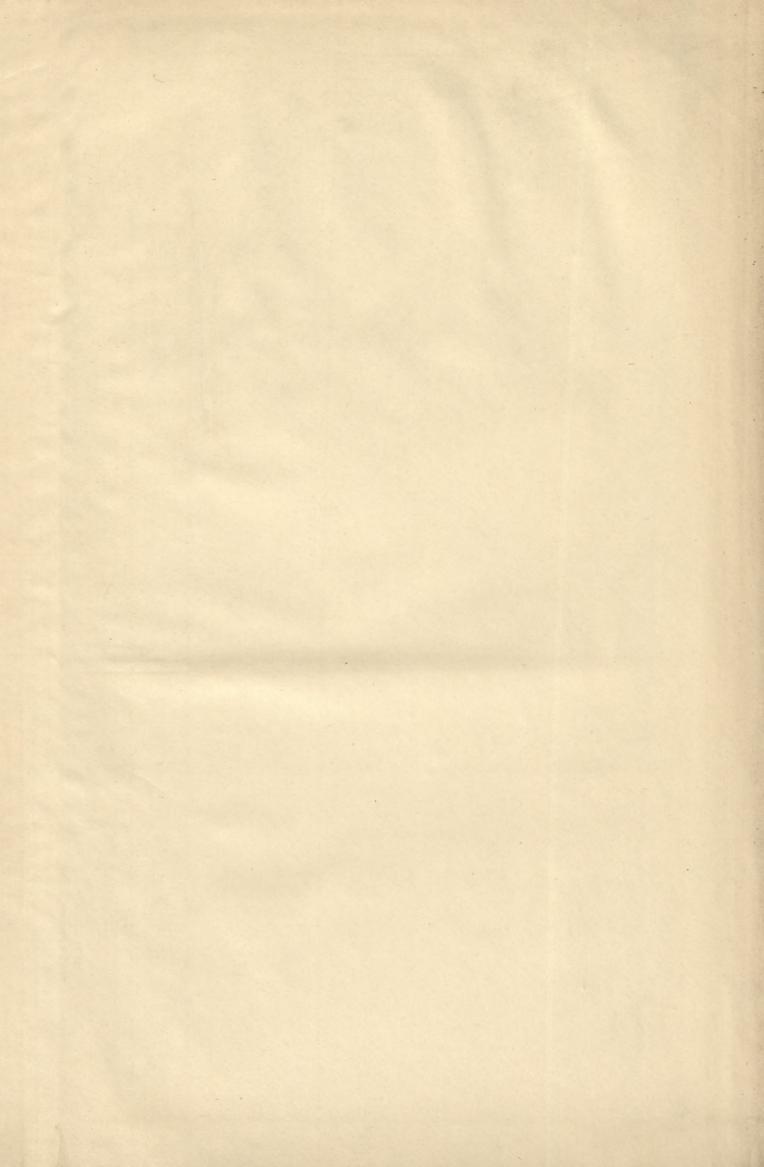




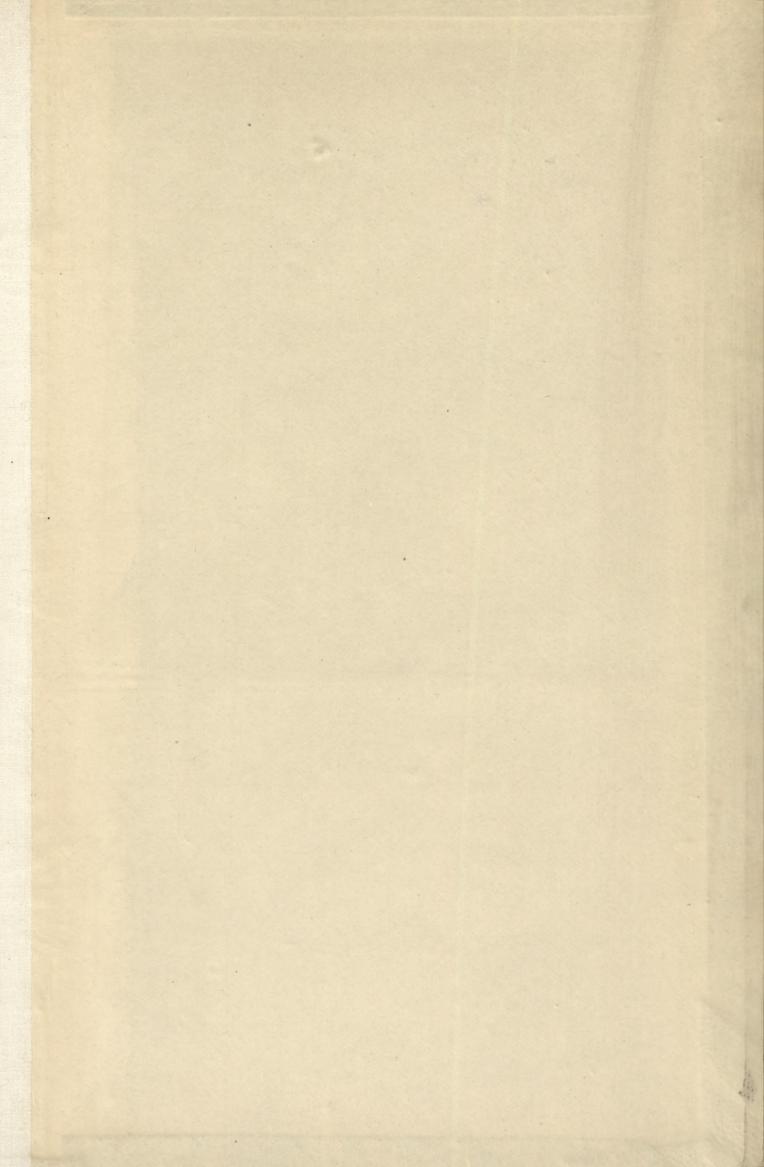














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