PAPERS AND REPORTS

RELATIVE TO

THE RANGITATA RIVER.

PRESENTED TO THE HOUSE OF REPRESENTATIVES, BY COMMAND OF HIS EXCELLENCY.

WELLINGTON.

1872.

PAPERS AND REPORTS RELATING TO THE RANGITATA RIVER.

No. 1.

EXTRACTS from REPORT by Mr. W. T. DOYNE, C.E.

SIR,— Christchurch, Canterbury, 20th June, 1864.

I have the honor to report, for the information of His Honor the Superintendent, that I have now completed the investigation required to be made by me under the instructions conveyed to me by the Provincial Secretary in his letter, No. 816, of 26th March last, viz. :—

INSTRUCTIONS.

No. 1. To report upon the selection of the best site for constructing a bridge over the Rakaia, and the character of bridge best adapted to the case.

No. 2. To examine the River Waimakariri, with a view to considering the desirability, or otherwise, of constructing large works to prevent its further encroachment on Kaiapoi Island.

No. 3. To examine the Rangitata, with a view to advising the Government as to the best measures to be adopted to turn the creek, if such measures be advisable.

In compliance with these instructions, I have successfully examined the three rivers named, and have prepared such sections, surveys, and diagrams as seemed necessary to a complete study of the special questions referred to me.

This systematic investigation of each river soon made it apparent that they are all governed by one general code of laws, under which they periodically change their courses, and that the study of these general laws was indispensable to a right understanding of each special case. Indeed, I found it impossible to avoid being led into the examination of the general question of the origin of these plains, and the part which the rivers have played and are now playing in their formation. From their past and present history we can best judge of their tendencies for the future, and by comprehending the natural laws that are in force, avoiding the danger of unneccessarily opposing them, and instead, bringing them to aid in the objects desired.

The Plains.

The great plains of Canterbury, which lie on the eastern side of the Middle Island of New Zealand, extend from north-east to south-west for a distance of 100 miles along the sea coast, with a depth of from thirty to forty miles into the interior, where they are abruptly terminated by meeting the base of the mountain ranges, which ascend in mountains heaped on mountains until they reach the perpetually snow-capped summits of the great Southern Alps.

These plains slope gradually from the mountains to the sea at the rate of about 40 feet to the mile for the first fifteen to twenty miles, and at an average of 24 feet to the mile for the remainder.

Between Kaiapoi on the north, and Timaru on the south, they are intersected by numerous rivers, which travel in tolerably direct lines from the foot of the mountain ranges to the sea.

The rivers between Kaiapoi and Orari (near Timaru) have certain natural characteristics which divide them into distinct classes.

The Rivers.

The Waimakariri, the Rakaia, and the Rangitata, which take their rise deep in the mountain ranges, and are chiefly fed by the melting of the snow and the glaciers.

In their passage through the mountain ranges (a distance of from forty to fifty miles each), they cut out and carry down with them great quantities of the rocks, boulders, gravel, and sand, of which the ranges are composed. These they discharge through the gorges by which they debouch on the plains, and, carrying them down the river courses, discharge a portion into the sea and deposit the remainder on the way, according as the force of the stream diminishes, either from diminished fall or increased width.

This material, as found in the river beds, is altogether silicious, and, from the great water-wear to which it is subjected, is deposited in every variety of size and form, from impalpable dust to boulders measuring two cubic feet.

This accumulation in the bed of the stream throws the water against the low banks, which, being of similar material, are quickly undermined, and the river widens out until it has no power to carry forward any but the lightest portion of the materials brought down. Thus a barrier becomes heaped up for several miles in length, raising the bed of the river above the banks and causing it to overflow. It soon cuts out a new course for itself, which it deepens and widens until the old one becomes completely abandoned and is restored to the plains, the new course becoming the true river. In time, this new course goes through precisely the same changes, and is again filled up and restored to the plains.

As the plains diminish in fall towards the sea, this tendency on the part of the rivers to fill up their beds increases, and in this way all these rivers are now so gorged that they cannot move the shingle forward beyond a point about fifteen miles from the sea.

At this point each river must now overflow its banks and find a vent in new channels, unless prevented from so doing by considerable engineering works. The tendency of these rivers to leave their courses depends, as I have explained, upon the force which they can apply to keep the shingle in motion; and this force depends, first, upon the rate of fall; secondly, upon the width of the stream being confined within certain limits, so as to concentrate the power of the water and cause it to travel with the required velocity.

These rivers differ slightly in their volume of water, in the fall of their beds, and in the class of material they bring down; and, therefore, to be able to say what are the exact conditions of inclination and width of bed, which would confine each to its course, and would enable it to carry the material forward, would require a much more elaborate and costly study than my opportunities have enabled me to make, and more than I feel justified in advising the Government to enter upon at present; but I may give the general conclusions which I have arrived at, and which may be taken as approximately correct—namely, when the inclination of the bed is less than 24 feet in the mile, the space over which these rivers can change their courses must be confined to within half a mile in order to keep the course open.

This opinion refers solely to those cases where the river bed is composed of shingle and sand, as in the case of the Rakaia and Rangitata. Where the river runs through silt and clay, a much less fall is required, as in the case of the Waimakariri near its mouth.

I believe that these plains may be rightly viewed as the delta of these great rivers, the mouths of which are at the gorges, through which they discharge their waters from the mountain base; and, in my opinion, the evidences which we are able to collect, as to the formation of these plains to a depth of 80 feet at many places, show that the same operations, which we see now going on, have been working for a long period, and may be quite sufficient to account for the whole construction of the lower plains, without resorting to any complicated theory.

To express this in a few words—the mountains are continually disintegrating; the debris is carried to the plains by the rivers, and is there distributed in the manner described.

The Rangitata.

I have examined this river with a view to considering the desirability of constructing works to return the Southern Creek or overflow-channel into its original course.

I am of opinion that no expenditure should be incurred for this purpose, for the following reasons:—

The water has left the old and taken to the new course, in accordance with the natural law which has been already described. The bed of the river is choked up by its own deposits, and has spread out to such an extent that it has no power to clear the way.

If works are constructed to prevent the banks being overflowed at the several points which form the entrances to the present overflow-channels, the banks will certainly be overflowed at other points lower down, and a continued series of works along both banks to the sea would be required to permanently confine the river within bounds.

I do not think advantages, at all commensurate with the outlay, would follow the construction of works for the purpose of saving a few hundred acres of land of a very poor quality; and instead of going to a large expenditure, to control the river and prevent its interrupting the lines of traffic, as at present laid out, I advise that they shall be diverted to a point higher up the river where it has no tendency to leave its course.

With a view to finding such a site, I have had some levels taken, but owing to the very difficult nature of the ground, they have not cleared up the question as satisfactorily as I could wish: a much more extended examination by levels and surveys would have to be made, than the time allowed to Mr. Kitson enabled him to carry out. I think, however, a good site may be selected between five and eight miles below Marshall's Ferry, to the west of the section E M, marked on plan No. 3. I send herewith a plan of the Rangitata, No. 3, with a diagram marked on it showing the lines on which the levels were taken, marked E M, F L, G K, and the position of the level course by the blue dotted line G L, which has nearly the same direction as those at the Rakaia, being N. 27° 30′ E., Magnetic. I also send No. 4, three sections.

The Secretary for Public Works.

No. 2.

Report by Mr. Paterson.

Sir,— Dunedin, 1st November, 1869.

I have the honor herewith to transmit plan showing proposed reserves for bridges and roads at the River Rangitata, and general map showing present and proposed road and railway routes between Timaru and Ashburton.

Before selecting a site for the bridge, I examined the river from its mouth up to Peel Forest, beyond which I did not extend the examination, considering that a bridge any further up the river could not be of much general utility or advantage.

My inspection of the river at once convinced me of the imprudence of attempting to bridge the Rangitata at any point below the upper end of the large island, about four miles above the ferry, on the line of the present main road from Christchurch to Timaru.

Below the upper end of the island there is no well defined terrace on the southern side of the river to form a barrier to its encroachment in that direction, and the adjoining plains on that side are in many places only slightly elevated above the present level of the river bed; the force of the water at this part of the river is also now insufficient to clear the channels of the shingle brought down during the floods, and the consequence is, that as these channels become choked up, new channels are occasionally formed, and to such an extent is this action in operation, that within a period of only a few years, the course of the main body of the water has, at one part of the river, been changed to the extent of nearly two miles.

Indications of further changes and encroachments are apparent at many places, especially on the southern side, and any works undertaken with the object of controlling the course of the river in that direction, would necessarily be both costly and troublesome to construct and maintain, and would further be continually liable to accident and destruction from the effects of the floods. Under such circumstances, I do not think it would be prudent to erect a bridge across the river at any place below the upper end of the large island.

Between the upper end of the island and the upper ferry the river bank becomes better defined, and the channel deeper the higher the river is ascended, and at many places the water, during ordinary conditions of the river, flows entirely in one channel.

I made several careful examinations of this part of the river, and had levels and sections taken at various places which appeared to offer the greatest advantages as a site for the bridge.

About four miles below the Upper Ferry, the general direction of the main terraces and river course changes from about South by East, to about South-east by East, the change in direction amounting to about 40° towards the East. Near this elbow the river at present flows in one channel, which infringes upon the main terrace on the north side, and I am informed that, within the last five years or six years, the river has cut into the main terrace (which is here between 60 and 70 feet high), to the extent of about 30 feet, for a length of several chains.

From personal observations, and from information derived from persons acquainted with the river, I am inclined to think that the channel and banks have been altered to a much greater extent below this great natural bend than they have above it; this opinion received partial confirmation from the plans furnished to me by the Provincial Government, which proves that at some parts of the course the main banks have not been altered to any appreciable extent since the surveys were made several years ago.

The selection of site was finally limited to that now recommended, and to another about two miles lower down, about a quarter of a mile above the hut and stockyard erected on the river flat on Mr. Wilson's run. The latter site possessed the greater advantage of general convenience, and of shortening the length of the main road by about two miles and a half, but on making detailed examinations and sections of the river bed and adjoining ground, I was reluctantly obliged for many reasons to abandon it, in favour of that higher up.

A comparative idea of the leading features of these two sites may be obtained from the following particulars:—

	Upper Site	Lower Site.
Width between sound banks	1,160ft.	1,550ft.
Area between banks available for flood waters above ordinary bed of river, superficial feet	6,380	4,130
Average depth for flood waters	5.50	2.66

The slope of the river being also greater at the upper site, it possesses much greater capacity than the lower one for the discharge of flood waters without overflowing the banks; the channel being also narrower and deeper tends to retain the river within present limits, and to aid its action in carrying off shingle brought down by the floods; the higher banks also interpose a greater obstacle to any tendency of the river to leave its present course and cut new channels through the shingle plains.

I therefore recommend the site shown on the accompanying drawing as possessing the balance of advantages in its favour for the construction of a bridge across the river, in a position which is reasonably convenient for the traffic from both the upper and lower districts of the plains.

The new route between Timaru and Ashburton, either by Geraldine or the Orari, will be about seven miles longer than the present road by the lower ferry; the upper portion of the plains and the agricultural districts around Geraldine will be benefited by being placed in close proximity to the main line of road.

The detailed plans and sections of the site recommended are not yet completed, nor have I had time to fully mature my ideas as to the most suitable and economical class of structure to be erected, but I may mention that, from sketches and calculations already made, I think I see my way to providing a bridge with piers of indestructible materials, and a superstructure of timber, which will not exceed the amount of money now at the disposal of the Board for that purpose.

In anticipation of the approval of the site recommended, the drawings for the bridge are now in course of preparation.

I would also suggest that the accompanying drawing should be sent to the Provincial Government, with a request that the reserves for the bridge, and the lines of road in connection with it, should be made without delay.

I have, &c.,
J. Paterson.

P. B. Luxmore, Esq.,
Chairman, Timaru and Gladstone Board of Works.

No. 3.

Report by Messrs. C. N. Bell and T. S. Tancred.

Sir,— Public Works Office, Christchurch, 25th July, 1872.

In accordance with your instructions we have examined the River Rangitata, with a view to report upon the best crossing for the Great Southern Railway.

We find that by taking the upper crossing and passing over the bridge just completed, the line will be lengthened five and a half miles, and will have to ascend an extra height of 315 feet.

The existing bridge is not in our opinion sufficiently strong to carry combined road and railway traffic. We find that the main girders have barely sufficient strength, and that the cross girders are decidedly too weak; considerable expense would therefore be incurred in strengthening the bridge. The formation of the combined road and railway approaches to the bridge would involve heavy cuttings and embankments.

We estimate the cost of the construction of the extra five and a half miles of railway, together with the necessary combined approaches, at £17,600.

We also calculate approximately that the annual cost of engine power and maintenance of the railway for five and a half miles of road and 315 feet ascent would amount to £2,600.

We are of opinion that more traffic would be developed by the line which we recommend below.

The crossing of the river which we recommend to be adopted is situated about seven miles below the existing bridge. The river at this point is very much wider than at the bridge, and its banks much lower. Within the last few years the river has shifted into an old bed to the southward. We think that the deserted bed might be embanked over with the exception of 25 chains left as a flood opening, and the existing bed be spanned by a trestle bridge, 60 chains in length.

We should recommend that the site of the above bridges should be one mile and a quarter or thereabouts above the parliamentary direct line, for the following reasons:—

1. That the terraces on the south side are better defined, and the river less liable to change its course.

2. That, owing to the uncertainty attending the ultimate course of the River Orari, the railway must cross that river at a point two and a half miles above the parliamentary crossing on the direct line.

3. That the proposed crossings of the Rangitata are in a direct line from the Ashburton to the above point on the Orari.

4. We think the Rangitata, though continually liable to shift in its wide bed, has little tendency to wear away its banks, and with such an extent of bridging as we have suggested, the line of railway would incur no risk.

We would suggest, in the construction of the bridge over the Rangitata, the simplest style of skeleton trestle with good piles of hard Australian timber, heavily shod with steel-pointed shoes; the boulders and shingle in the river bed being large, nothing but the best piles and heavy shoes would stand driving.

We are of opinion that a strong and durable bridge could thus be built upon the line suggested for a sum but little in excess of the amount required for the additional works on the upper route, thus saving the annual outlay of £2,600 referred to above for extra engine-power and maintenance on the upper route.

Charles Napier Bell, M.I.C.E.,
Thomas Selby Tancred, District Engineer.

J. Carruthers, Esq., Engineer-in-Chief.

RANGITATA BRIDGE.

Weights on Span.

	Lbs.	Tons.
Weight of girders, 8 tons = ...		16
Weight of cross girders, 800 lbs. each × 9 = ...	7,200	
Road bearers, 104 cubic feet @ 35 lbs.	3,640	
Planking	10,850	
Ballast, 62 × 13 × ¼—201 cubic feet	44,120	
	45,810=	20·5
Fixed load		36·5
Rolling do.		60·0
		96·5
Load on each girder		48·25

W

A′ 12 sq. inches $\frac{a.d.c.}{c}$ = 83 = 6 times maximum load.

d = 78
l 756
c 75

W = 48·25 tons $S = \frac{Wl}{8d.} = 58\frac{2}{12}$ area bottom flange, 4·8 strain per inch.

l = 6·3 feet.
d = 6·5 feet.
s Strain centre.

Consequently the girder is barely strong enough. Road-bearers also require to be made heavier.

Weight of roadway on each cross girder	1·35 tons.
„ rolling load (say)	6·6 „
Strain due to distributed load = ...	2·5 „
„ „ rolling load = ...	24·0 „
Area bottom flange cross girders = ...	3·2 sq. in.

Consequently cross girders too weak.

			Miles.
Going Southwards—			
Extra traction power required 315 feet height =	...	...	19·75
Less descent by gravity only	...	...	9·0
			10·75
Going Northwards, 312 feet = ...	...	...	19·25
Less descent by gravity only	...	...	21·0
			1·75
Average power required for ascent	...	...	19·0
Additional length saved	...	...	4·50
			5·50
			10·00

Cost of engine power, at per train mile, 1s. 9d. =	£0	17	6
Cost of maintenance, at per train mile, 2s. on $5\frac{1}{2}$ miles	0	11	0
	£1	8	6
Less wages of guard, driver, stoker, per train	0	3	6
	£1	5	0

Trains per annum—
Days of 6 trains, 313 = 1,878
„ 4 „ 52 = 208

2,086 × £1 5s., or £7 2s. 6d. per day.

Saving per annum on traction, say = £2,607.

Saving of cost of construction on $5\frac{1}{2}$ miles at £1,850 = ...	£10,175
Extra works on line excavation	5,600
„ culverts and diversion	1,000
Metal for road, say 3,200 at 2s. 6d.	400
„ fencing dis. 120 at £3 10s.	300
	£17,475

No. 4.

Report by Mr. W. N. Blair.

Rangitata Bridge.

Sir,— Timaru, 4th September, 1872.

I have the honor to acknowledge the receipt of your letters of the 14th August and this date, forwarding a copy of Messrs. Bell and Tancred's report on the crossing of the Rangitata River, and asking if they are right in saying that the bridge is not strong enough to carry a railway, and also for information with reference to the strata gone through in sinking the cylinders.

The bridge was originally calculated for a dead weight of 10 cwt. and a moving load of 15 cwt. per running foot, with a maximum strain of 5 tons per square inch on the iron. The dead weight is however only a little over 7 cwt. per foot, so the rolling load may be increased to 18 cwt. without altering the strains on the metal. Besides, in designing the various parts of the girders a fair margin was left beyond the actual quantity required.

In calculating the strength of the bridge, Messrs. Bell and Tancred have taken the weight of the main girders at 16 tons, and each of the cross-girders at 800 pounds; the actual weights are $11\frac{1}{4}$ tons and 676 pounds. They also propose to load each span with about $10\frac{3}{4}$ tons of ballasting, a thing which was never contemplated and which is not required. The total fixed load on each span assumed by them in calculating the strength of the bridge is $36\frac{1}{2}$ tons; the actual load is barely 21 tons.

They have taken the rolling load at 60 tons, equal to 19 cwt. per running foot. A train of the ordinary locomotive engines used on the heavy English lines, which is the greatest load that can be put on any bridge of this description, would only weigh about 16 cwt. per foot.

I do not know the weight of the 5′ 3″ Canterbury locomotives, but two of the ordinary engines for the 4′ $8\frac{1}{2}$″ gauge in Southland weigh $14\frac{3}{4}$ cwt. per foot.

Under "The Railway Act, 1870," the break of gauge is fixed at the Rakaia, so the locomotives requiring to cross the Rangitata must weigh very much less per foot than any of the above—in all probability 12 or 13 cwt. will be about the mark.

After allowing for the rails and timber work required to adapt the bridge for railway traffic, the total load on each girder will be 35 tons, as against $48\frac{1}{2}$ taken by Messrs. Bell and Tancred. With the former weight the metal will not be strained to 4 tons per square inch. Notwithstanding the excessive loading, Messrs. Bell and Tancred's figures show only a strain of 4·8 tons on the square inch, which is lower than the standard of 5 tons fixed by the Board of Trade in England; and some bridges are built with a much greater strain; for instance, the metal in the Menai Straits Bridge is strained to 5·62 tons; the Newark Dyke Bridge, to 5·32; the Saltwater Creek Bridge, in Victoria, 5·29; and the Jumna Bridge, in India, to 5·14. When it is considered that the iron in the Rangitata Bridge can stand without injury a strain of 20 tons on the square inch, the margin is ample.

With reference to the cross-girders, instead of 3·2, as given in the report, the section is 3·8, and the strain due to the dead-weight about 10 cwt. against $2\frac{1}{2}$ tons. With a weight of $2\frac{1}{2}$ tons on a wheel the rolling load would give a strain of $16\frac{1}{2}$ tons, or a total for each girder of 17 tons, which is less than 5 tons on the square inch of metal.

In sinking the cylinders of the Rangitata Bridge a bed of boulders about 10 feet thick was met with four feet below the water-level. They ranged from 1 to 8 cubic feet; one taken from the twelfth pier measured 3 feet 6 inches long by 2 feet broad and 16 inches thick.

I have, &c.,
W. N. Blair,
Engineer, Rangitata Bridge.

The Chairman of the Timaru and Gladstone Board of Works.

Extract from Report by E. P. Blyth, Inspecting Engineer, concerning Material for Rangitata Bridge manufactured in England, as to tests applied to Girders.

Two of the girders were tested as follows:—They were placed with bearings and distance apart, as they will be in the structure, and tied together by the bracings. Weight of girders, 11 tons; weight placed on centre bay, 30 tons, equal to 60 tons distributed on a clear span of 63 feet.

The deflection with the load averaged $\frac{15}{32}$ of an inch; the permanent set $\frac{7}{32}$. This was however really the bringing of the girders to their bearing, and not, properly speaking, permanent set. The load was left on for about forty hours.

Other two girders were taken, with a distributed load of 60 tons, and gave a total deflection of $\frac{5}{8}''$. I considered these tests so satisfactory that I did not think it necessary to test others, as all the parts of the girders were made from templates, so that they would exactly correspond, and those tested were rivetted up completely (instead of being merely bolted), and the rivets afterwards cut out. This, of course, could not have been done to all the girders without great expense and loss of time, so I arranged to have a perfect test of four girders, instead of an imperfect test of each.