1883.

NEW ZEALAND.

THE KUMARA SLUDGE-CHANNEL

(REPORT UPON THE QUESTION OF INCREASING THE CARRYING CAPACITY OF).

Presented to both Houses of the General Assembly by Command of His Excellency.

Mr. H. A. GORDON, Inspecting Engineer, to the UNDER-SECRETARY, Mines Department.

SIR,— Mines Department, Wellington, 15th June, 1883.

In accordance with instructions in the matter of widening the Kumara Sludge Channel I have the honour to report on the same on all its bearings.

The tunnel in which the ground-sluice or sludge-channel is constructed is 85 chains in length, of which 40 chains of the lower end is 9 feet 10 inches wide on the clear inside the timber, and 7 feet high in the clear from the bottom of the sluice. The upper portion of the tunnel, 45 chains in length, is 7 feet wide in the clear inside the timber, and 7 feet high from the bottom of the sluice; but, although the tunnel is 7 feet high from the bottom of the channel, the side timber or props do not go down to that depth in the wide portion of the channel, which is the portion that the channel is proposed to be widened.

The sludge-channel or sluice is only 3 feet 6 inches wide, and is placed in the centre of the tunnel, leaving a roadway of 2 feet 8 inches wide on each side of the channel. The bottom of the sluice is sunk down for 2 feet under the level of the roadway, and 18 inches below the level of the bottom of the props. The channel is formed with a grade of 1 in 26, or about 3′ 10½″ in the 100, and is made of 2-inch silver-pine planking, with frames of 4 inches by 4 inches of same timber, placed 4 feet apart from centre to centre; the sides are 3 feet high, and the bottom is covered with paving blocks, made of red pine, 8 inches in thickness, cut endways; but these have been found to wear so rapidly away that stone pavement has been substituted as the wooden blocks get worn out.

The maximum carrying capacity of the channel is equal to about what fifty-four heads of water will carry into it, with the ordinary process of hydraulic sluicing. This is taken from actual work. The greatest number of claims that have used the channel at the same time has been nine, and the amount of water that each used was six heads; but, to enable the channel to carry away the *débris* and tailings that this quantity of water washed into the channel, an additional supply of water was required to be turned into the head of the channel as flushing-water to keep it clear. This additional quantity of water varied, in proportion to the nature of the material, from twelve to twenty heads.

When the channel is in full work the wooden paving, which is the principal item of expense in the maintenance, has to be replaced at least once in three months, and the cost of same, including turning the blocks and side lining, is about £10 15s. per lineal chain. During the first year that the channel has been in use, that is, up to the end of April last, the total receipts have been £1,037 1s. 8d., while the cost of maintenance for the same period has been £2,064 15s. 3d., or, in other words, it costs twice as much to maintain as the amount received for the use of the same. The following table shows the monthly receipts and expenditure for the period mentioned:—

Receipts.	£	s.	d.	*Expenditure.*	£	s.	d.
1882—May	51	15	0	1882—May	16	4	0
,, June	36	8	4	,, June	88	7	10
,, July	51	16	8	,, July	52	18	5
,, August	61	0	0	,, August	92	10	9
,, September	89	8	4	,, September	114	10	6
,, October	105	9	2	,, October	280	13	10
,, November	22	12	6	,, November	270	5	7
,, December	84	15	0	,, December	162	19	1
1883—January	104	16	8	1883—January	227	4	5
,, February	157	6	8	,, February	253	4	4
,, March	160	5	0	,, March	144	12	4
,, April	111	8	4	,, April	361	4	2
	£1,037	1	8		£2,064	15	3

This makes the average monthly expenditure to be £172 1s. 1d., while the average monthly receipts only amount to £86 8s. 6d. The following table will likewise show the number of claims that have been worked by the aid of the channel, the average number of days each worked, and the number of men employed :—

Month.	Number of Claims using the Sludge-Channel.	Number of Men employed in Claims using the Sludge-Channel.	Average Number of Days that each Claim has used the Sludge-Channel.
1882—May	4	23	27
,, June	7	29	13
,, July	7	35	16
,, August	9	49	14
,, September	12	67	16
,, October	17	84	15
,, November	14	72	4
,, December	18	98	10
1883—January	17	92	13
,, February	18	104	18
,, March	20	118	15
,, April	19	112	12
Totals	162	883	173

This shows the average number of men employed in claims using the sludge-channel during the first year that it has been in operation to be 74 nearly, and the average number of days in each month that each claim has used the channel for four hours each day to be 13½. It likewise shows the cost of maintenance to be about £12 15s. per day of four hours each, or about £1 per man per week for each man that was sluicing into the channel, whereas the charge for using the channel is only 10s. per man per week. The total cost of the sludge-channel up to the present time is about £17,200.

Having now gone into the present receipts and expenditure, and shown clearly that the fees charged for the use of the channel are only one-half what it has cost to keep it in maintenance, the next question that presents itself is, can the cost of maintenance be lessened by adopting other systems of paving; or will the widening of the channel lessen the cost of the maintenance for the future?

The nature of the ground in the vicinity of Kumara, and generally on the West Coast, is entirely different from the ground in Otago, which is worked with extensive sludge-channels: in the latter place the material is of a fine nature and does not wear away the paving at nearly so rapid a rate; and the absence of large stones rolling down the channel makes the pavement far easier kept in position; therefore the same description of a sludge-channel that is used for working the ground in Otago would not be suitable for working the ground in the vicinity of Kumara.

The most reliable information that can be got on the system of paving sluices is from the hydraulic workings in California, which are somewhat of a similar character to the workings about Kumara. There is a book recently published by Alfred G. Lock, F.R.G.S., entitled, "Gold: its Occurrence and Extraction," which gives valuable information on the subject of ground-sluices, giving the fall required and the class of paving that is most economical to use. It may not be out of place here to give some idea of the magnitude of some of the hydraulic operations that are carried on in California, showing the large amount of money that is spent by private enterprise in works of this nature. The following table will show the magnitude of some of the works:—

Name of Company.	Length of Tunnel.	Average Grade of Tunnel.	Reported Cost.
	Ft.	Ft. per 100.	£
North Bloomfield	8,000	4½	100,000
American	3,900	6¼	28,000
French Corral	3,500	4⅔	33,000
Bed Rock	2,600	5¼	...
Farrell	2,200	3½	...
Sweetland Creek	2,200	4⅔	18,000
Manzanita	1,740	4⅙	12,000
Boston	1,600	7¼	8,000
English Mine	1,400	7	...

This author goes on to show that the dimensions of a sluice in California are determined by the quality of the material to be treated, which is governed by the water-supply. One 6 feet wide and 3 feet deep, with a 4- to 5-per-cent. grade, will take 3,500 miners' inches of water which is equal to about 5,250 cubic feet of water per minute; one 4 feet wide and 2½ feet deep, with 2½-per-cent. grade, will take 1,200 to 1,500 miners' inches, equal to 1,800 to 2,250 cubic feet per minute; or with 4-per-cent. grade, will take about 3,000 cubic feet of water per minute to work it. This infor-

mation is corroborated by Mr. Hamilton Smith, jun., of San Francisco, in answer to a letter that the Manager of the Kumara Water-race sent, asking for information on the different systems of pavement for ground-sluices. He says: "In our North Bloomfield Tunnel, which is some 10,000 feet long, we have a grade of 4½ to 100. At the upper end we have a sluice 6 feet wide, and 2½ or 3 feet deep above paving, and about 2,500 feet long; the upper 1,000 feet is paved with wooden blocks 13 inches deep, which required replacing every fortnight; the lower 1,500 feet is paved with boulders of very hard rock, generally black quartz set in 18 inches in depth, and which wears four to six months. The rest of the tunnel, some 7,500 feet, the water and tailings run on the natural floor of the tunnel, which was driven through hard metamorphic state. The tunnel has been in use eight years, and in this time has worn down about 2½ to 3 feet. The wooden paving is much more readily and quickly moved than stone paving, and hence is used at the head, where we wish to clean up every fortnight. Those clean-ups only occupy about ten hours' time, say twelve hours from the time that the water is turned off until it is turned on again: to do this some forty or sixty men are employed. In this tunnel we run constantly day and night about 4,000 cubic feet of water per minute; occasionally, however, we use 6,000 cubic feet of water per minute. In this mine it requires from 18 to 25 cubic feet of water to wash and transport 1 cubic foot of gravel measured in the bank. The gravel contains many large boulders, and the sluice will transport readily a boulder weighing 500 lb. or more. Cast-iron paving has been used, but proved too costly. In a few instances along the line of the Central Pacific Railroad all worn-out rails have been used, weighing about 56 lb. per yard, at a cost of $35 per ton, which is equal to about £7 6s; the rails being laid lengthways in the sluice."

The experience of mining companies in California show that wooden block pavement is the most expensive system of paving sluices; but it is used because it is readily replaced when the boxes are cleaned out, and therefore seems to be more used for saving the gold at the head of the sluice. The wear and tear, however, seems to coincide approximately with the wear and tear in the Kumara Sludge-channel, *i.e.*, the wooden blocks had to be replaced once a fortnight in the Californian sluice, where they work day and night continuously; or, say, twelve days of twenty-four hours each, equal to 288 hours, that the blocks last apparently without turning; and the wooden blocks in the Kumara Channel lasts approximately about three months, working on an average thirteen and a half days of eight hours each per month. This makes 324 hours, and shows that the wear and tear are greater in the former sluice. Having compared the wear and tear of the wooden block pavement with mining companies who have had larger experience in hydraulic operations, the same basis may be assumed for the wear and tear of stone pavement. It appears to last from four to six months in the Californian sluices, and, to take the minimum period as a basis, then four months, or, say, seventeen weeks, equal to 2,448 hours, that the stone paving lasts. This shows that stone paving would last in the Kumara Sludge-channel for twelve months, working steadily for eight hours each day; and on this basis the monthly cost of maintenance ought not to exceed, say, £183 per month, which is arrived at in the following manner:—

Description.	Unit.	Quantity.	Rate.	Amount.
				£ s. d.
Stone pavement	lin. ch.	85	£16	1,360 0 0
One man to look after channel	days	313	12s.	187 16 0
Light (candles)	lb.	8,854	10d.	368 18 4
Incidentals, lump sum	...	...	...	277 4 0
Total, per annum				£2,193 18 4

By adopting stone-paving it will reduce the carrying capacity of the channel to some extent; probably it will only take forty-eight heads of water, instead of fifty-four which it carries with the wooden pavement; and therefore calculations ought to be based on this carrying capacity to get at the approximate revenue. This quantity of water would employ about one hundred men, and the income from those, at the present charge for the use of the channel, assuming them to use it twenty-one days each month, would be £175, or £8 less than the cost of maintenance.

Before going into the cost of receipts and expenditure if the channel was widened, it will be necessary to first determine the width. This can be done from the carrying capacity of the supply-races and tunnel. These have lately been widened in order to carry 100 heads of water, and, when the present works are completed for the storage of a large body of water, I think that at least seventy-five heads can be safely calculated on, unless in unexceptionally dry weather. If the channel is widened at all it therefore ought to have a carrying capacity equal to seventy-five heads at the least, which is 4,500 cubic feet of water per minute.

The North Bloomfield Company's sluice, before referred to, has to carry a similar quantity of water, and has somewhat of a similar grade. Their sluice has a fall or grade of about 1 in 22½, and the Kumara Channel 1 in 26. Mr. Gow, the manager of the Kumara and Waimea water-races, thinks that 4 feet 6 inches would be wide enough, but this is at variance with the experience of mining companies who have carried on large hydraulic operations for a number of years in California, who show that it ought to be at least 6 feet wide.

In order to widen the channel to 6 feet, one side of the tunnel for 38 chains would require new props 18 inches longer than the present ones. To do this, and widen the channel, I estimate would cost £3,500; but this widening could be done in such a manner that it would not stop the miners using the channel for more than about ten days. The cost of maintenance, if the channel was widened, would be about as follows:—

Description.	Unit.	Quantity.	Rate.	Amount.
				£ s. d.
Paving wide portion of channel	lin. ch.	60	£30	1,800 0 0
Paving narrow portion	...	25	£16	400 0 0
One man to look after channel	day	313	12/	187 10 0
Light (candles)	lb.	8,854	/10	368 18 4
Incidentals, lump sum, say	...	...	...	337 10 0
Total per annum				£3,093 18 4

The cost of maintenance will therefore be about £258 per month, and the receipts, based on seventy-five heads of water being always available, which will employ about 160 men, these working twenty-one days per month, would be £280, or £22 more than the cost of maintenance; but, although it works out in this form, I am a little doubtful of it coming out this way in the actual working of the channel. However, to look at it in any form, the fees charged are not sufficient to clear the cost of maintenance and pay interest on the outlay. There are two important points to bear in mind in dealing with this subject: first, the channel has never been steadily used; and, second, when it has been used it has only been for eight hours per day. In California, where hydraulic operations are carried on largely, they work continuously day and night, and, from all information that can be gathered on the subject, the faces of gravel are much deeper than they are at Kumara, and the gravel somewhat of a similar character; therefore, if the Kumara Sludge-channel were used sixteen hours out of the twenty-four, it would employ equally as many men as it would do if widened, and only working eight hours per day.

Taking into consideration the whole bearings of the case, and that the cost of maintenance has hitherto been twice the amount of fees received from the channel, different paving will have to be used in order to reduce the cost of maintenence, and I think this can be done by solely adopting stone paving; but it will require to be of greater thickness that what is at present being substituted for wooden blocks, viz., 8 inches, inasmuch as when it begins to wear thin it will be difficult to keep it in position with heavy boulders rolling down the channel, which will tend to break it up, and therefore it ought to be used under such conditions as are calculated to give it a fair trial. Whether the channel is widened or not, the paving ought to be about 14 inches in thickness, and this would necessitate the sides of the channel being raised one board higher.

I would therefore recommend that the present channel be raised one board higher on the sides, that the bottom be paved with stones 14 inches in thickness, and that the channel be worked to its fullest carrying capacity for sixteen hours per day. This would allow thirty-two claims to be worked, employing about two hundred men. The channel is only used for four hours by each party of miners per day, as it takes them the remaining four hours to break up and stock the stones that are too large to put into the sluice. By using the channel sixteen hours per day, will employ equally as many men as the channel would do if widened, working only eight hours per day; and I do not see any tangible reason why the channel should not be used continuously (which would employ about three hundred men), the same as the hydraulic mining companies in California work their sluices; the conditions of channels and nature of material sluiced being somewhat similar. I estimate the cost of raising the sides of channel as suggested to be about £550. The paving being required in any case, does not enter into the cost, so as to entail an additional outlay.

Before going into the question of widening the present channel, or increasing in any way the carrying capacity for tailings, it would be well to consider the area of ground that is available for stacking tailings, and the height of the channel above the bed of the Teremakau River, when they get that distance, in order to obtain an approximate idea how long it will take to raise the bed of the river, so as to interfere with the fall of the channels.

From statistics taken from Mr. Lock's book, before referred to, he states that, from surveys made by the State Engineer of California, "The bed of the Yuba River, at Marysville, is now filled up to the level of the streets of that city, where prior to the era of hydraulic mining there was a well-defined channel of clear water 20 to 25 feet in depth, and that the Feather and Sacramento Rivers have shoaled in a lesser degree, but still almost sufficiently to destroy their usefulness as highways of commerce."

Assuming that it will take on an average 22 cubic feet of water to wash and transport 1 cubic foot of gravel, measured in the bank—which is admitted by all American authorities on the subject to be about a correct estimate—or, to put it in round numbers, it takes 600 cubic feet of water to wash away a cubic yard of gravel, then the carrying capacity of the present channel, if used continuously day and night, is capable of transporting about 6,912 cubic yards per day, and the various other sluices that are at work, independent of the Government water-race, may reasonably be expected to wash and transport about 2,088 cubic yards daily—that is, on the assumption that they are used continuously—making a total of 9,000 cubic yards of gravel per day; and taking the average number of working days to be twenty-one days each month, or, say, 250 per annum, then the quantity of tailings transported annually would be about 2,250,000 cubic yards; or, in other words, if the present channels or sluices were working continuously for 250 days per annum, they would transport an area of ground equal to about 23¼ acres, averaging 60 feet in depth.

With reference to the question of lighting the tunnel with an electric light, as suggested by Mr. Gow, the Manager of the Waimea-Kumara Water-races, it is a question well worthy of consideration, as the first cost of the plant is almost the only cost, and as the power required to drive a dynamo-electric machine is at the present time running to waste. At the upper end of the sludge-channel there is a shaft about 50 feet in depth, where there is a fall of water steadily going down during the

time that the channel is being used. This can be utilized to drive a small turbine wheel to work a dynamo-electric motor; therefore the cost only amounts to the tear and wear on the plant, which is very small. I have consulted Dr. Lemon, Superintendent of the Telegraph Department, on the subject of lighting the sludge-channel with an electric light, and he kindly supplied all information relative to the first cost and placing it in position, which amounts to about £700, exclusive of the motive power; and he estimates the tear and wear on same will be about £30 per annum. A turbine water-wheel, with intermediate shafting and belts, and small house to cover the dynamo-electric motor, I estimate will be about £300, making the total cost to be about £1,000. In providing an electric light Dr. Lemon strongly advises the use of Siemen's dynamo-electric motor as being the safest, best adapted for the situation, and the least liable to go out of repair. He has one of these in use, which certainly gives a large number of lights for the power employed in working it. A 1-horse-power gas-engine, which is worked up to 1½-horse power, produces twelve lights, each equal to from twelve to fifteen candles. The estimate is based on a dynamo-electric machine capable of lighting fifty lamps. This number may not be required, but it is better to provide for a machine sufficiently powerful, as the extra cost is but trifling, the greatest expense being in the main leading wire, which cannot be curtailed in any case on account of its length. To take the minimum cost of candles which I have estimated that it will take to light the channel, only using it eight hours per day, amounts to, in round numbers, £369. This would clear the cost of the electric light, plant, and maintenance in a little less than three years; and, if the channel is used for sixteen hours per day, the outlay in candles in about eighteen months would amount to the cost of the electric light.

I would therefore recommend that steps be taken to procure an electric light, and have it placed in the channel tunnel as soon as possible. Dr. Lemon has kindly offered his services (if the Government decide to place it in the tunnel) to superintend its erection and instruct the Manager of the water-races with reference to the working of the machine, &c.

In concluding my remarks on the whole subject, the cost of stone paving placed in the channel under favourable conditions has not yet been tried; and this ought to be done in order to get correct data to work on before increasing the size of the channel. The electric light, if placed in the tunnel, will likewise materially cheapen the cost of widening the channel at a future time, if found necessary, to accommodate a larger number of miners.

I have, &c.,

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Inspecting Engineer.

The Under-Secretary, Mines Department.

By Authority: GEORGE DIDSBURY, Government Printer, Wellington.—1883.

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