1904.

NEW ZEALAND.

NEW ZEALAND WATER-POWERS, ETC.

(REPORTS ON), FOUNDED ON AN EXAMINATION MADE DURING OCTOBER, NOVEMBER, AND DECEMBER, 1903, BY MR. L. M. HANCOCK, M.A.I.E.E., ELECTRICAL ENGINEER AND GENERAL SUPERINTENDENT OF THE TRANSMISSION DEPARTMENT OF THE CALIFORNIA GAS AND ELECTRIC CORPORATION.

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

PRELIMINARY REPORT.

SIR,— Auckland, New Zealand, 25th December, 1903.

In regard to the examination of the water-powers of your colony, having in view electric transmission of energy, I beg to make the following preliminary report:—

Arriving in Auckland the 5th day of October last, I was met by your Mr. P. S. Hay, and upon consulting with him I found that practically no complete surveys had been made of any of the localities where it was thought that power could be developed, so that it was evidently best to visit the localities selected and make preliminary measurements to determine whether it were necessary or advisable to secure complete surveys, and while visiting power-locations to examine at the centres of industry the conditions bearing on location of works, material for construction, special designs necessary, labour, climate, and any other local peculiarities that might crop up.

From the conditions presented in maps and otherwise, and from study of the localities, it was evident that it would be suitable for transmission purposes to district the colony, and the following outlines are suggested: (1) Wellington, including Palmerston North and Masterton; (2) Auckland, including Cambridge and Thames; (3) Napier, including Gisborne and Hastings; (4) New Plymouth, including Wanganui; (5) Christchurch and Lyttelton; (6) Dunedin and Port Chalmers; (7) Invercargill; (8) Timaru and Oamaru; (9) Greymouth and Hokitika; (10) Westport; (11) Nelson; (12) Blenheim. These are selected as natural centres for the first calculations, expecting that they would be found on full investigation to be suitable centres, around which would grow systems that would supply the adjacent territory.

Although the possibilities opened up at a marvellous rate as we looked the situation over and the future of the whole colony seemed gloriously bright, yet it is evidently wise to select for initial development some few places where power can be developed at the lowest cost possible and with the least delay, also under the most favourable conditions for hydraulic development and for transmission to a centre of industry that could make the quickest use of and was in the greatest need of the energy. With this in view we commenced our tour.

Leaving Auckland on the evening of the 5th October we went to Whangarei and thence to the Wairua Falls, where we found that much more power can be developed than was at first thought.

Returning to Auckland and going thence to Rotorua, we visited the Okere Falls, a beautiful place and a very valuable asset. Continuing our journey we reached Wairakei, and, making it our headquarters, we examined the Waikato watershed, visiting the following places: Atiamuri Rapids, Rainbow Falls, Gorge below Orakei Korako, Orakei Korako Rapids, Aratiatia Rapids, Huka Falls, Lakes Taupo and Rotoaira. In this region, which is quite unusual in many ways, immense quantities of power can be developed, and, though somewhat distant from centres of industry, it will some day prove of wonderful value to the colony.

Passing from the Waikato watershed we reached the Rangitikei, a strange district, but one in which it is possible to develop a considerable amount of power. Leaving Hunterville by train it was but a short ride to the noted Manawatu Gorge, strange and beautiful in many ways but not up to what was thought for power purposes. From Woodville by train to Wellington was a delightful ride through an excellent district.

From Wellington we took boat to Lyttelton, thence train to Christchurch, from which as a centre we examined the Waimakariri, a very large stream where power can be developed when the need warrants. We examined it as far up as the confluence of the Broken River, giving it a good deal of attention because it was the first shingle river we were examining. From the Waimakariri we journeyed to Lake Coleridge and the Rakaia, and back to Christchurch. Lake Coleridge seemed so likely a place that we arranged to study further the question of locating a power-station there.

The Rangitata was the next on the list, but we were satisfied after considerable study of conditions that it was not necessary to spend much time on it, especially as those most familiar with it could not mention any place where it would be possible to locate power-stations to advantage.

However, we arranged to give this river as thorough consideration as any of the others.

Proceeding by train we reached Fairlie where we examined the Opihi and the Opuha Rivers. Journeying through Burke's Pass we reached the watershed of the Waitaki, a wonderful region, where great quantities of power can be developed when needed. We examined the rivers and lakes very carefully, Tekapo, Pukaki, and Ohau, with their rivers, and the Waitaki down to Kurow.

At Kurow we took train to Dunedin, from whence we examined the watersheds of the Clutha and Taieri Rivers. The whole region is a very rich one, where an abundance of power can be developed. We first went to Lawrence, from whence we examined the Clutha from Beaumont to Miller's Flat. Returning to Dunedin for maps and other data we took train to Ida Valley, examining on the way the Deep Stream and the Taieri up to the lake. At Ida Valley we took coach to Ophir, where we examined the Manuherikia. Passing on to Clyde, Cromwell, and Pembroke, we had an excellent view of the Clutha and its surroundings. At Pembroke we examined Lakes Hawea and Wanaka, and then hurried on to Wakatipu. We made Queenstown our headquarters and visited the outlet of the lake and the Shotover River, going up it as far as Skipper's. From Queenstown we proceeded *viâ* Lumsden and Mossburn to Lakes Te Anau, Manapouri, and Monowai. We spent several days examining the lakes and rivers of this region, which has great possibilities. A number of locations were examined which will prove of great value later on.

At Otautau we reached the railroad again, by which we journeyed to Invercargill, Dunedin, Christchurch, and Springfield, and thence by coach to Otira, where we stopped to examine the Otira and Rolleston Rivers, beautiful gorges both, and susceptible of considerable development.

From Otira we travelled to Greymouth, where we stopped a short time for consultation with the local engineers and for map-study. We proceeded from Greymouth to Reefton, and thence to and through the Buller Gorge to Nelson, a wonderful district, full of possibilities, and which furnished us a delightful ride. On the way we stopped a number of times to examine the river and its tributaries, especially the Inangahua and the Rotoroa.

Reaching Nelson we spent a day in examining maps for accurate information of the district, and in making a trip up the Maitai River. At Nelson we took the coach to Blenheim, and after a casual observation of the Pelorus, Wakamarina, Wairau, Waihopai, and Awatere we returned to Wellington.

The tour gave us a wonderful impression of the possibilities of the colony, its sublime scenery, and the bright future ahead. Both Islands have great reserve resources which only await development to richly repay the investments. The wonderful development already reached is worthy of great praise.

From observation of existing conditions we found it evident—First: That the business of the colony is developed to such an extent that large investments in transmission-work will be profitable. Second: That the industries of the colony are growing healthfully, and that there is throughout the country a general feeling of confidence in the Government and in general trade conditions. Third: That the Government will be supported in carrying out a great industrial undertaking of this nature. Fourth: That the climate and the local conditions are such that it is certain that work of this nature will be successful. Fifth: That the water-power is ample for all existing needs and any future growth and extensions that may ever be devised.

Following up the ideas advanced, it seems that a very suitable place to start operations is at Lake Coleridge, to supply Christchurch and its tributary district. This location offers the following advantages: (*a.*) Simplicity of installation. (*b.*) The storage of a great quantity of water. (*c.*) No enormous cost for initial installation. (*d.*) The plant can be enlarged as needed. (*e.*) Development can be carried up to a very large amount later as it is required.

Starting with the existing low-water flow from the lake of 82 cubic feet per second, 4,645-horse power theoretical can be developed for twenty-four hours' service. The expression "theoretical horse-power" does not consider any losses. If only an eighteen-hour service is necessary, 6,967 theoretical horse-power can be developed; or, if only a twelve-hour service is necessary 9,260 theoretical horse-power can be developed without drawing on the reserve storage at all. If the storage is considered, the development can be carried very much farther without getting any additional water into the lake. The transmission-line from the generating-station to Christ-

church would be short, and the needs of the district are such that a large amount of power could be made use of quickly. At the rate American cities utilise electricity, Christchurch and its suburbs, with Lyttelton, should use 6,000-horse power for lighting alone. With this in view, together with the trams and the possible equipping of the Christchurch and Lyttelton tunnel with electric traction (ample power for which can be supplied from the above source), the initial installation should be 10,000-horse power, and complete plans should be made at the start for the complete installation. The total power available at Lake Coleridge as per reports received is 93,000-horse power theoretical continuous, or twenty-four hours per day, with the Harper and Wilberforce waters diverted into the lake.

I would recommend that further search be made near Wellington, Auckland, and Dunedin for suitable power-locations easily developed to 5,000- or 10,000-horse power.

In regard to cost and selling-price I cannot say much in this preliminary report, except that handsome returns on any investment will be secured by a very reasonable charge if all the conditions are carefully considered.

In regard to rainfall, snowfall, and height of lakes and rivers, I find that you have no complete records, especially for the thinly settled portions and the higher altitudes. I would suggest that you have a great many public servants scattered over the colony who could easily keep these records, and the necessary expense to equip them for the work is very slight; also many of the stations in the back blocks would keep records if encouraged, and these would be most valuable of all.

Incessant travelling during my stay in the colony, together with the approaching holidays, made it impossible for me to complete even this preliminary report before sailing. However, a full report will be forwarded as soon as possible.

In closing, I would say that I have seldom seen so promising a country, and I am sure that you will find that, next to your railroads, the utilisation of your water-powers by means of electric transmission of energy will do more to advance your material interests and to mitigate the evils of our civilisation than any other agency you can employ.. The world is looking to you for the solution of many of its difficulties. The investigation you have had me make is in line with answering their queries, and the utilisation of the forces of nature is one of the quickest means of reaching the solution.

Yours, &c.,

L. M. Hancock, M.A.I.E.E.,
Electrical Engineer.

Hon. W. Hall-Jones, Minister for Public Works, Wellington, New Zealand.

GENERAL REPORT.

San Francisco, California, 12th February, 1904.

Bay Counties Power Company: History and Results.

To satisfactorily solve the question of applying long-distance electric transmission to a new locality it is wise first to make a study of what has already been accomplished. In view of the fact that you have selected me for the work of examining the rivers of New Zealand on account of my connection with the Bay Counties Power Company, a bit of the history of that development may be to the point.

In 1895 capitalists were interested in a plan to utilise the waters of the South Yuba River, in Nevada County, to drive electric generators, and transmit the power eight miles to Nevada City, Grass Valley, and the adjacent mining district. Nevada City had a population of three thousand and Grass Valley six thousand. Each had gasworks, and each was supplied with electricity by means of small independent plants. Grass Valley was distant about eight miles and Nevada City about five miles from the generating-station. Two 500-horse power generators were installed, to be driven by impact water-wheels, supplied with water under 85 lb. pressure by means of a 48 in. pipe and three miles and a half of flume, 6 ft. wide and 5 ft. deep. Water was diverted into the flume by means of a log-crib dam, rock-filled, 28 ft. high and about 200 ft. long.

Work was started in July, 1895, and the plant was put into commercial operation early in February, 1896. Lighting for the towns was the first business secured, and after that had been worked up pretty well efforts were made to secure business-furnishing power to the mines. This was very slow, however, and it was two years before the original installation was loaded. At that time plans were completed to double the capacity at the power-house, and to instal a reserve water-supply. This was completed and put into service late in the year; ere this, however, both the little electric plants and one of the gas plants had been purchased. The other gasworks was purchased later.

While work was being pushed in Nevada County a scheme was floated in the adjacent county of Yuba to utilise the waters of the Brown's Valley irrigation system to drive generators near Brown's Valley and transmit the energy to Marysville, a distance of eighteen miles. Marysville was a very active business centre of five thousand inhabitants. The large flour-mill, cold-storage

plant, woollen-mill, and other small industries, besides the town of Yuba City across the Feather River, with its county buildings, barley-mill, and packing-houses, made a very fine load when taking their energy from the plant mentioned. Marysville already had an electric plant, operated by steam in connection with a gasworks, both of which were purchased, and the lighting, gas, and power interests combined soon after the transmission system was gotten into operation, which occurred early in 1899.

The year 1898 was very dry, and all water interests suffered terribly. Some of the water systems were out of service completely. It was this occurrence which emphasized the value of the Yuba River for power purposes, and measurements were at once taken and plans made to utilise it to its fullest extent. This valuable water-right was in the possession of the Yuba Power Company owning the Marysville transmission plant. Contracts were made with the Nevada County Electric Power Company, owning the Nevada County system, for 3,000-horse power, and with the Sacramento Electric, Gas, and Railway Company for 5,000-horse power. The distance to Nevada County was only seven miles and a half, but to Sacramento was over sixty-one miles. During 1899 work was prosecuted with vigour on the new and large plant, which was named "Colgate," Current was put into Sacramento in September, and a month or two later a thirty-mile line to Oroville went into service handling gold-dredgers.

It was in the winter of 1899 that the plan was conceived of running a long line from "Colgate" to the Bay of San Francisco. So the Nevada County and the Yuba County plants were consolidated, and work was at once started on this new plan. Surveys for the 140 miles of line were started in the spring of 1900, and current was put over the line to the bay on the 17th February, 1901. Contracts had been made for lighting the little towns *en route*, and for handling the street-cars in Oakland. Also, the Standard Electric Company, which had been working on its long-distance plant for some time, had trouble unexpectedly developed, and in order to hold their contracts, engaged to use all the power the Bay Counties Power Company could spare. It was during the summer of 1901 that the systems of the two companies were connected, and a distance of over two hundred miles handled commercially and continuously for a number of months.

The machinery now operated by current from this system includes the following: For mining purposes—air-compressors, pumps, hoists, stamp mills, rock-breakers, concentrators, gold-dredgers; for commercial service in towns and along the main arteries—machine-shops, foundaries, planing-mills, ice machinery, laundry machinery, pumping for drainage, waterworks, flour-mills, feed-mills, woollen-mills, silk-mills, cement-works, fruit-canneries, creameries, agricultural-machinery factories, tanneries, smelters, boot and shoe factories, oil-refineries, ship-yards, jute-mills, street-railway systems, irrigation, interurban railroads. Thus you will see that the uses to which electric power has been applied extend to almost every industry where power is needed, besides the ever-present electric-light and fan motor. Heating and cooking have not been done to any great extent, largly on account of the initial cost of the apparatus. This objection is now overcome to a great extent, prices having been established on the necessary articles so that they are in reach of every one; it only remains to educate people to use them.

The record has been with the Bay Counties development that they were never able to furnish all the business that offered; even with the very large plants building they will not be able to keep the supply up to the demand. This has been the record of the majority of other plants also. You will find it the same with any development you may propose to instal.

Narrative.

Leaving San Francisco the 17th September, 1903, after an uneventful voyage we arrived in Auckland on the 5th October, and were met by your Mr. P. S. Hay and Mr. A. Ross. We took the steamer "Wellington" for Whangarei Harbour that evening, and arrived early on the morning of the 6th, where we were met by Mr. Dickson, who helped us in every way and accompanied us on the trip. We drove at once to Poroti, where we lunched, and, leaving our baggage, proceeded to the Wairua Falls. The roads were very bad, and we had gone only part way when it commenced to rain, and continued nearly all the afternoon. We made what examination was possible, and saw at once that the information given us was not complete enough for our purpose. We took barometer-readings, and made as careful an examination as the storm would permit. After finishing our work we returned to Poroti, where we stayed all night.

October 7: We returned to Whangarei in the forenoon, and in the afternoon we visited the kauri-gum warehouse and the cement-works.

October 8: We took the steamer "Wellington" for Auckland, where we arrived that evening.

October 9: Mr. Hay had some railroad-work that demanded his attention, so I busied myself in Auckland preparing for the trip overland to Wellington.

October 10: Went by train to Rotorua, where we stayed over Sunday.

October 12: Took a launch across Lake Rotorua to Okere Falls; visited the present generating-station and examined the conditions there; also took barometer-readings at the lake and down the river some distance. I also looked into the question of providing additional supply of electricity for Rotorua. This question will be reported on separately. The plant now in service to supply Rotorua is an excellent one, and is very well taken care of.

October 13: Took a motor-car from Rotorua to Wairakei. This trip, although it consumed the whole day, was a very enjoyable one.

October 14: Visited the Huka Falls, Lake Taupo, and the Aratiatia Rapids.

October 15: Took saddle-horses and rode to the Orakei Korako Rapids and down the river to Atiamuri, examining on the way the Orakei Korako Rapids, the gorge just below the Orakei Korako Rapids, Rainbow Falls, and the Atiamuri Rapids. We were so fatigued by the time we reached

Atiamuri that Mr. Hay and I stopped overnight, sending our saddle-horses back by the Maori guide.

October 16: Secured a trap to take us back to Wairakei in the forenoon, and in the afternoon visited the Aratiatia Rapids again. A rainstorm, however, interfered with our work to some extent.

October 17: Examined some of the geysers at Wairakei, and then took coach to the Spa and Taupo. At the Spa we had the guide show us the effect of submerging a geyser. This we were very anxious to see on account of some of the work if carried out flooding a number of them. We reached Taupo a little before noon, and boarded the steamer at once for Tokaanu. It was late when we arrived, but we took advantage of the remaining daylight to climb a near-by hill for a view of the surrounding country.

October 18: We drove to Lake Rotoaira, noting conditions and getting barometer-readings going and returning.

October 19: Took the regular coach from Tokaanu to Waiuru, and on the 20th from Waiuru to Mangaweka. At Taihape we were met by Mr. Cook, the resident engineer, who accompanied us to Mangaweka. A few miles out from Taihape we left the coach and walked down the river over the new railroad-work to Mangaweka. We noted especially some locations on the Rangitikei where it is proposed to develop the water-power.

The morning of the 21st we took a private trap, drove down the river to examine it in several places, and then drove to Hunterville, where we took train for Woodville.

October 22: Took a trap at Woodville and drove through the Manawatu Gorge, examining it carefully both going and returning; also drove some distance past the lower end of the gorge. That afternoon we took the train at Woodville for Wellington, where we arrived late that evening.

We were busied in Wellington till the evening of the 26th, when we took the steamship "Mararoa" for Lyttelton and Christchurch.

Arrived at Christchurch on the forenoon of the 27th, and after spending some hours looking up information in regard to local streams, took the train to Sheffield that afternoon in company with Mr. Dobson.

On the morning of the 28th we visited the Waimakariri Gorge at the railroad-bridge, and in the afternoon went to Springfield and up the railroad to Broken River, examining the Waimakariri that far. Returning to Springfield that evening, we made arrangements to get away early on the morning of the 29th by special conveyance to Lake Coleridge and the Rakaia. We did not get started as early as planned; however, we visited the lake and the river, taking aneroid-readings at several places. Besides observing the Rakaia near the lake, we visited it at the gorge where the wagon-bridge crosses it. Continuing, we reached Coalgate late that night.

October 30: Took the early train to Christchurch where we spent the balance of the day. Here we were joined by Mr. Wilson, who was to accompany us till we should reach Oamaru.

October 31: Took the morning express from Christchurch to Timaru, and from thence to Fairlie by local train.

November 2: In the forenoon Messrs. Hay, Wilson, and myself were driven to the gorge of the Opihi, and spent all the forenoon considering that proposition; in the afternoon drove to Tekapo, taking aneroid-readings all along our route. After dinner made a trip on foot down along the banks of the Tekapo River.

November 3: Drove to and past Balmoral Station some miles, and putting saddles on our horses rode across country a number of miles, examining the district over which a survey of a canal was being made to take water from Lake Tekapo to Lake Pukaki. Deciding to go clear down to the banks of Lake Pukaki, we consumed the whole day, so returning were quite late in reaching the hotel at Lake Tekapo.

November 4: Drove from Tekapo to Pukaki and arrived early enough to climb the high hills back of the Government hotel, where we got an excellent view of the region.

November 5: Drove to Ben Ohau Station in the forenoon; after lunch saddled our horses and rode *viâ* the Ohau River bridge to Lake Ohau.

November 6: Started out early on horseback and rode across the Ohau River bridge down the west side of the river to its junction with the Waitaki, and thence along the Waitaki to the Goose Neck. The last half-mile the hills were so steep that we left our horses with a rabbiter, whom we had impressed as a guide, and proceeded on foot to the top of the ridge, where we got an excellent view of the river for a long distance farther. It was growing late, so we hastened to retrace our steps, stopping long enough to drink a "billy o' tea," which some workmen along the road had promised us, and never was tea more welcome. We had hardly travelled over thirty miles, and had twenty more to go before we could get our dinners. As the sun was setting that evening we had a rare view of Mount Cook. Never shall I forget it. We were in the shadow of the clouds; a rift, however, let through a flood of light upon the distant majestic mountain, snow-covered, illuminating it, while all the other peaks were in shadow. Then in the next half-hour there were variations of light and shadow which were beyond man to describe. The time, the surroundings, the distance, our isolation—all affected us, and, though at first we expressed our wonder by exclamation, as the magnificence of it grew on us we became silent, gazing with admiration inexpressible.

November 7: Left Ben Ohau Station and drove to Ben More Station for lunch, thence *viâ* Omarama to Otimatata.

November 8: Walked from Otimatata up the Waitaki to the confluence of the Ahuriri, climbing some very high hills, taking aneroid-readings and searching for trig-stations. Returning to Otimatata we drove to Kurow that evening.

November 9: Took the early train from Kurow to Oamaru and Dunedin.

November 10: Spent the forenoon at Dunedin looking up information, and in the afternoon took the train to Lawrence.

November 11: In company with the local surveyor, Mr. Edie, we drove to Beaumont and up the east bank of the Clutha to Miller's Flat, examining the conditions both going and returning.

November 12: Took the early train returning from Lawrence to Dunedin, where we spent the balance of the day looking up maps and information.

November 13: Took the Otago Central train at Dunedin, intending to stop off at Middlemarch to examine the Deep Stream; however, it commenced raining just as we started and kept it up all day. We did not stop at Middlemarch on account of the rain, but continued to Ida Valley, and from thence by coach to Ophir that evening. It continued raining all that night and nearly all the forenoon of the 14th; however, we struck out on horseback towards noon to examine the Manuherikia. Our luggage we sent ahead by trap to Chatto Creek, where we were to meet it. We rode over the steep hills and along the gorge the greater part of the distance. Picking up our trap at the creek and sending our horses back to Ophir, we drove on to Clyde.

November 15: In the afternoon drove from Clyde to Cromwell.

November 16: Wishing to cover extra territory, we took a private conveyance and drove up the east side of the Clutha to Hawea Flat, and thence to Pembroke.

November 17: Rode on horseback from Pembroke to the outlet of Lake Hawea and examined the south end of the lake, taking aneroid-readings at various times along the banks of the lake, and at all the low places in the moraine. It commenced raining early in the day and kept it up almost constantly, until, returning, we had reached the hotel at Pembroke.

November 18: It stormed so incessantly that we were unable to do any outdoor work, so we sat by the fire and wrote up our notes.

November 19: Had the steamer on Lake Wanaka take us up to the narrows between the lakes where, taking our aneroids, we climbed over the pass to Hawea, taking readings as we went along and observing the local conditions. This day was an excellent one for noting rain-conditions. We had wondered what the rainfall would be in the mountains above where any records are kept. This time we were in sight of the high mountains all day, and saw a number of rainstorms in progress—in many cases, as many as three or four, each many miles from its neighbour; and while these storms were raging on the mountain-tops there was very little rain falling on the low ground.

November 20: Took a private conveyance from Pembroke to Queenstown.

The morning of the 21st November we spent in searching the Queenstown offices for information, and in the afternoon drove to the outlet of the lake, across the lower Shotover crossing, and up the east side of the river till we reached the Arrowtown Road by which we returned to Queenstown. At the bridge over the gorge of the Shotover we took barometer-readings, also along the road into Queenstown.

November 22: Drove over the road up the Shotover to Skipper's and back.

November 23: Took the boat to Kingston and the train from Kingston to Lumsden and Mossburn, from whence we proceeded by private conveyance to Lake Te Anau.

November 24: Spent the day examining the south end of the lake. In the forenoon crossed in a small boat to reach the east side of the outlet, and in the afternoon walked from the hotel along the east and south banks of the lake to the outlet.

November 25: Took the steamer to the Middle Ford of the lake and, landing, walked to Lake Hankinson. The small boat on this lake was not available, so we could not get past it or explore further. Returning to the hotel we had an early dinner, and drove to Manapouri that evening.

November 26: Took the steamer on Manapouri and visited the upper end of the lake, where we landed and walked up to the Spey Burn; returning, we visited the inlet of the river from Lake Te Anau.

November 27: Took a private conveyance from Manapouri to Blackmount, where we arrived at about noon, and after lunch walked to Sunnyside Station.

November 28: Walked to the Monowai River, which we examined from its junction with the Waiau to the lake; and, returning, reached Sunnyside late that afternoon.

November 29: Walked from Sunnyside to Blackmount where we arrived at about noon.

November 30: Took the mail-trap from Blackmount to Otautau *viâ* Clifden.

December 1: At Otautau we took the train for Invercargill and Dunedin where we stopped over till the 3rd, on the morning of which we took the express to Christchurch; a stop overnight here, and thence to Springfield, where we took the coach to Bealey and Otira, arriving at our destination on the forenoon of the 5th December. That afternoon we took a trap and drove back up the gorge almost to the pass, examining existing conditions.

December 6: Rode on horseback up the bed of the Rolleston as far as it was possible, then tying our horses we went on foot till we reached a massive barrier. Storms were gathering so we hastened to return. We were not quick enough, however, and had to finish our ride in a drenching rain.

December 7: Took the train from Otira to Greymouth where, in order to consult with local engineers and surveyors and to get information and data, we stopped until the afternoon of the 8th, when we departed for Reefton.

December 9: At Reefton we took a covered trap for Buller Gorge and Motupiko. It was storming the greater part of the day, but we reached Inangahua Junction early, and leaving our luggage drove down the gorge towards Westport as far as Hawk's Craig. It stormed almost incessantly, so that it was difficult to see the country or take any observations, so we returned to Inangahua Junction for the night.

December 10: Starting early we drove up the Buller River taking observations, and reached Longford by evening.

December 11: Drove from Langford through to Motupiko where we caught the evening train to Belgrove. Here we were met by a trap which took us on to Foxhill, our stopping-place for the night.

December 12: At Foxhill we took the early train to Nelson, where we arrived at 9 a.m. The balance of the forenoon we spent looking up maps and information for this district. The afternoon we spent in looking over the Maitai River.

December 14: Took the regular coach to Blenheim, which we made our headquarters for examining the rivers of the district. This occupied the 15th, 16th, and a part of the 17th. The afternoon of the 17th we went to Picton by train, and from thence by boat to Wellington, completing our tour of inspection of the most important water-powers of the colony.

General.

In visiting your colony I have brought to bear on the subject the experience of eight years devoted to transmission-work, having handled successfully every item of detail of engineering construction and operation, including hydraulic, mechanical, and electrical; also a great deal of the general business of the plant came under my care.

I took up your work thinking it would be largely similar to the growth of the Bay Counties Power Company, and with the idea that you would want to do the most work with the least money; that the needs of the colony were to be considered as a whole, and that the best interest of all was to be considered and harmonized.

It seems that there should be some focal points selected where initial work could be commenced and the maximum results achieved with the minimum of expense of time and money; in other words, to get something going and doing successful work as soon as possible. I have made a study of the localities visited with this in view. The following method of carrying out the work with reference to the twelve districts mentioned in the preliminary report is suggested:—

Wellington District.—That examination of the streams on the east side of the Tararua and Ruahine Ranges be made between Wellington and Napier to see if some place cannot be found that will yield five or ten thousand horse-power. If this cannot be found, develop Waikaremoana.

Auckland District.—See if Wairua Falls will answer; if not, investigate Okere Falls, and should they not be adequate, utilise some one of the Waikato locations.

Napier District.—Develop Waikaremoana.

New Plymouth District.—Search will have to be made in that neighbourhood for some location suitable.

Christchurch District.—Develop Lake Coleridge.

Dunedin District.—Search for a location within fifty miles where from five to ten thousand horse-power can be developed; if this cannot be found, arrange to develop the power available at Hawea.

Invercargill District.—Investigate Lake Monowai.

Oamaru and perhaps *Timaru.*—Connect them to the Hawea development; or, if that is not put through now, search for a location that will give them 5000-horse power.

Greymouth.—Develop Lake Kanieri.

Nelson, Blenheim, and *Westport.*—Search will have to be made for suitable places.

I have tabulated all the data obtained, and present it in the following list of the principal locations where power can be developed. This information is—

1. The name of the river or lake.
2. The drainage-area.
3. The run-off per square mile of drainage-area.
4. The storage-area. This is the area of the lakes in the watershed, and is intended to give some idea of their equalising effect on the streams.
5. The flow in cubic feet per second. In some cases this was gauged by the Government Engineers; in others the figures given were obtained by estimating from the drainage-area, and the rainfall taken from the records of the nearest station which had furnished reports, using conservative methods in each case.
6. The difference in level, in feet, to be utilised. This is usually termed the "head." This was determined—(1) from maps and railroad records; (2) by actual survey made either just before or just after our visit; (3) by aneroid-barometer readings taken at the time of our visit.
7. The theoretical amount of horse-power it is possible to develop at each locality.

We actually visited all but six of the places mentioned. These we omitted, not because of any lack of value, but because our time was too limited.

Besides the locations herein listed there are doubtless numerous places where power can be developed that have not been thought of as valuable sites. Search will have to be made to find these. For the initial development for nearly all the large places it would be far preferable to work up some smaller amount of power at a place not very far away, say within fifty miles of the large centres. Thus, while getting work started in a minimum of time and expense, you would also start the growth of the idea, and people would become more and more accustomed to the service. You would also save any long negotiation of large loans to carry out the greater work. You would be doing also what is exceedingly necessary—that is, training your own people to do this class of work.

While the cost per horse-power developed in the larger plants is very reasonable if the whole amount available is utilised, the initial interest-charge is very heavy for the plant to carry if

only a small portion of the power is utilised, which is sure to be the condition with the majority of the places examined.

Name.	Drainage-area.	Run-off per Square Mile of Drainage-area.	Lakes' Area in Water-shed.	Flow per Second.	Head.	Horse-power.
	Sq. m.	Ft.	Sq. m.	Cub. ft.	Ft.	
Wairua	241·5	1·1	None	275	150	11,000
Mangakahia	33·2	1·12	None	375	150	
Okere Falls	192	2·61	35	500	106	75,000
Huka Falls	1,287	3·91	240	5,000	66·6	34,840
Aratiatia Rapids ...	1,287	3·91	...	5,000	110	62,480
Orakei Korako ...	1,287	3·91	None	5,000	100	56,800
Rainbow Falls... ...	1,287	3·91	None	5,000	30	17,000
Atiamuri	2,014	2·48	None	5,000	50	28,400
Rotoaira	48	1·748	6	84	525	5,000
Rangitikei	1,224	1·753	None	2,144	200	48,710
Manawatu ...	1,252	0·800	None	1,000	50	5,680
Waikaremoana ...	166·4	4·16	23	692	1,000	78,600
Wairoa	473	1·098	None	520	125	7,384
Waimakariri	978	2·42	None	2,000	90	20,440
Lake Coleridge ...	380	4·42	13	1,675	469	94,677
Rakaia	1,013	4·94	13	5,000	50	56,800
Lake Heron	66	4·55	2	300	250	8,520
Rangitata	608	4·92	...	3,000	100	34,080
Opihi	135	0·89	...	120	60	817
Lake Tekapo	611	8·35	34	5,100	555	320,396
Lake Ohau	420	13·8	24	5,800	250	164,720
Ohau River	...	...	...	5,800	100	65,888
Lake Pukaki	523	12·95	31	6,800	50	38,624
Waitaki	...	...	...	17,700	30	60,321
Clutha	...	...	...	22,000	50	124,960
Manuherikia	820	0·61	None	500	410	23,288
Lake Hawea	560	9·81	42	5,500	192	119,961
Lake Wanaka	1,024	17·58	69	18,000	...	...
Lake Wakatipu ...	1,176	10·2	110	12,000	50	68,160
Shotover	184	5·44	None	1,000	75	8,520
Lake Te Anau... ...	1,356	1·77	142	2,400	700	190,848
Lake Manapouri ...	1,750	1·72	50	3,000	600	204,480
Waiau	3,561	1·06	182	3,790	50	21,520
Waiau	3,653	1·23	194	4,390	50	24,935
Lake Monowai ...	9,216	6·5	12·8	600	250	17,040
Otira	6·45	24·8	None	160	500	9,088
Rolleston	5·55	43·4	None	240	500	13,632
Lake Kanieri	16	3·88	5·9	62	200	704
Inangahua	442	...	None	...	...	...
Buller	1,754	1·14	28	2,000	100	22,720
Rotoroa	170	4·42	8·96	7,500	400	34,080
Wairau	686	14·5	None	10,000	25	28,400
Awatere	504	1·9	None	1,000	50	5,680

Wairua Falls.—In the Wairua River, in Whangarei County, about fourteen miles from Whangarei and eighty-four miles from Auckland. It has the great advantage of being the nearest to the great industrial centre of Auckland. Surveys were not complete, so that the total possibilities could not be passed on. The locality made a great impression regarding its possibilities, and is well worth a complete survey. I have used only a head of 150 ft. in the calculations, but if the surveys show it is possible—and I think it is—a dam 30 ft. to 50 ft. high can be built, giving the benefits of storage and increasing the possible development, if eighteen-hour service is sufficient, to more than 15,000-horse power, which would make it an excellent place to develop at once for the Auckland service. This depends somewhat on what can be done with the waters of the Mangakahia; if they can be diverted into this reservoir the figures given above are very conservative.

The main disadvantage under which this locality labours is that it is somewhat remote, and that machinery and material will have to be rehandled several times. This, however, is not prohibitive. One great advantage is the presence of the cement-works near Whangarei, which can supply an excellent grade of cement, and also utilise a good deal of power when the plant is in operation.

I would recommend that complete surveys be made here as soon as possible. There should be contours run every 10 ft. from the possible power-house locations, which it is thought should be on the north side of the river, up to the falls and to a level of 50 ft. above them. From the falls up the stream on both sides contours should be run every 10 ft. up to a level of 50 ft. above the falls.

These should all be extended till they intersect the river. The 30 ft. and 50 ft. contours above the level of the falls should be run around to the north till they intersect the Mangakahia. After this work is completed the possibilities of this location can be stated fully, and not until then. I would also suggest that records be kept of the rainfall, snowfall (if any), heights of streams, and frequency and force of thunderstorms for the district.

Okere Falls.—Situated in Rotorua County, in the Kaituna River, which is the outlet for Lakes Rotoiti and Rotorua. There appears now on nearly all the maps a second outlet to Lake Rotoiti (the Pahopaki River), but as we did not visit it, I judge the maps are in error. The falls themselves are of no great value for power purposes, but the total drop in the river in a distance a trifle less than a mile gives an available head of 101 ft. This, with a dam which should raise the height of Lake Rotoiti 5 ft., will give a total of 106 ft. maximum and a storage that will be of exceeding great benefit in cases of drought; in fact, the storage secured by raising the level of the lakes as suggested will be sufficient to maintain the flow of 500 ft. per second for ninety-one days, not counting any losses. The rainfall for this region as recorded at Rotorua is about 50 in. per year, and the precipitation is well distributed over the entire year. This district is a strange one, and tends to make one chary of recommending a large outlay of capital in it; but as one gets more accustomed to it this feeling wears off to a great extent. The measured outflow of this lake seems high for the area drained, but, of course, the equalising effect of the storage of the lakes is very great.

This location is thirteen miles from Rotorua, the terminus of the railroad, so that transportation would not be a serious item against it. The distance from Auckland (153 miles) is the most unfavourable condition.

The maps and surveys furnished me of the falls district are not complete enough to make any complete estimate of cost of the plant. I do not think, however, that it would be excessive.

In order to decide whether this location can be developed to advantage it would be necessary to know whether the level of the lakes can be raised, and how much for storage purposes. To determine this, contours will have to be run wherever land is considered valuable to determine the extent of the damage. As near as can be estimated, if 10,000-horse power in machinery is installed, provision should be made to ultimately raise Lake Rotoiti 5 ft. and Rotorua 3 ft. In the immediate neighbourhood of the falls contours should be run every 10 ft. on the west side of the river from 10 ft. above the level of the lake near its outlet to at least a quarter of a mile below the lowest point indicated on map 2496, and from the river to at least a half-mile west of it. Also, several fly-lines should be run down the east side of the river to determine if there is a better route for races or pipe-lines. The country immediately north of Lake Rotorua should be prospected to see if it is possible to cross it to advantage with a pole-line, as it will greatly increase the length of a line heading for Auckland if it has to be carried around the south side of the lake *viâ* Rotorua.

If the amount of power listed can be developed here without too great expense it will be better than the powers in the Waikato for the initial development to supply Auckland District, for two reasons at least. It is twenty-five miles nearer, and transportation from the railroad is not near so serious.

I would suggest that more complete records be kept of the heights of the lakes and streams and of thunderstorms for this district. The rainfall for this watershed is not accurately known, though at Taupo Township it is recorded as 50 in.

We now reach the power-locations of the upper Waikato, by far the largest river, and its drainage-area of 5,600 square miles, the largest of any stream in the North Island. It not only drains very high bush-clad country, but also has Lake Taupo as an enormous equaliser, and its variations should be very gradual. The places where power can be developed are as follows:—

Atiamuri Rapids.—Situated at the crossing of the Rotorua-Taupo Road, it is thirty-two miles from Rotorua by road and thirty-six miles from Pataruru, from which a great many of the supplies for the Taupo district are handled *viâ* Atiamuri. To utilise power here there would need to be a very heavy expense for a dam to raise the water-level 20 ft. or 30 ft., according to what the benefits would be. This probably is not the best place to put in the initial development, but it is certainly a valuable location. The amount of power listed as available here is very conservative. However, there will be no storage to amount to much, so that only the minimum flow can be depended upon. Before anything further can be stated as to the possibilities or cost, surveys will have to be made to get the exact head available, the possible height to which a dam can be built, condition of foundations, land submerged, interests that may be interfered with, and power-house location and length of pipes. I would suggest that rainfall, heights of the river, and thunderstorms be observed here, and records kept so that all the data possible will be available.

Rainbow Falls.—Situated only about three miles and a half above the Atiamuri Rapids, it has very closely the same flow; in fact, I have used the same flow in cubic feet per second for all these locations, disregarding altogether the drainage-area below the lake, because there are no lakes in it, and hence the minimum flow is probably small. There would be needed here only a small dam to control the flow; in fact, a high dam would be excessively expensive, because very long. The head as given can be easily secured, but the machinery expense, on account of the very low head, will be very heavy. There have been no surveys here, and it is more than probable that conditions will not warrant their being made for some time to come, unless conditions at other places do not turn out as flattering as is anticipated.

Gorge below Orakei Korako.—The Waikato at this place has cut through the high ground, and made its way between very high vertical walls. This is about three or four miles above the Rainbow Falls, and appears to be of such a formation that a very high dam could be built here. It may be possible, by the construction of a dam here, to divert the water into a race to carry it past the Rainbow Falls and utilise the drop there in combination with that created by the dam. The appearance of the country does not encourage this view; however, a survey will show what is

possible. The cost of this scheme would be excessive, on account of the great quantity of water to be handled and the high dam necessary. I do not think it is necessary to spend any time or money on this location now.

Orakei Korako Rapids.—While there is apparently great energy wasting here, it is not in a favourable location to be developed, and has not advantages enough in its favour to warrant any investigation at present. The head is very much less than at the Rainbow Falls, and the banks of the stream are not nearly so favourable for a dam. It would be extremely costly to develop.

Aratiatia Rapids.—Situated in the Waikato, about four miles below the Huka Falls, this is at once the most beautiful and most valuable power-location on the river. In many respects the rapids are more beautiful than the falls, which can boast of only one advantage, that of the possibility of a small dam controlling the outflow of Taupo. There is such a slight grade between the falls and the rapids that it is possible to build only a 10 ft. dam at the head of the rapids without flooding the falls. This limits the energy available at the rapids to 56,800-horse power, obtained by means of a fall of 110 ft. A dam only 10 ft. high and 10.1 chains long ought to be built very reasonably. However, the section of the river is not completed for the deep part of the stream, and that is where the expense will come in. No contours are shown to tell whether the terraces will carry the necessary races.

The only place at present to which it seems wise to transmit power from this district is Auckland and its suburbs. There are so many more suitable places to develop near Wellington, Napier, and New Plymouth that it is better to utilise them instead of transmitting the energy so far, on account of the expense. This is, however, a very valuable power-location, and, I think, the best one on the river; however, more complete surveys will have to be made before any estimate can be made of the cost of its development. This location shows, with Huka, the disadvantage of considerable distance from the railroad, hence a large expense would be incurred in transporting machinery and material.

Huka Falls.—This is the most noted power-location of the Island, and it is very valuable; but it is not so good as the Aratiatia Rapids, and will be even more expensive to develop. It is a beautiful spot and justly attracts a great deal of attention. The surroundings are such that the contrasts make the district one that charms. To a certain extent you are not pleased at first, but as time goes on you get an entirely different feeling, and when away you want to see it all over again.

The flow of the stream as given by P.W.D. 20642 is 6,346 sec. ft. Professor Forbes gave it as 5,600 sec. ft., but I am inclined to think that 5,000 sec. ft., the figure I have taken, is nearer the minimum. The development of this locality would be quite expensive on account of the low head and the heavy excavations necessary for the power-house.

What was said in regard to Aratiatia applies here with equal force. It does not seem wise to transmit energy from this district at present on account of the expense; however, the time will come, and it depends on yourselves how soon you will develop one or more of these locations.

The rainfall for this watershed is only recorded for the Taupo Township. I would therefore suggest that plans be made to get records for as high altitudes in this district as is possible. I think you will have no trouble in getting some of the stations to record them, as well as the height of the lakes and rivers, and the frequency and force of thunderstorms. It would be especially advisable to secure records of the height of Taupo each day during the year.

In view of the fact that a dam at Huku will submerge some geysers near the Spa, it will be wise to have some experiments carried out with the local geysers to find what degree of activity they will maintain when submerged by a given depth of water; also what temperatures are maintained, and at what temperature action commences, and whether, when a great quantity of cold water is over them, they will become a leak.

Rotoaira.—This little lake of six square miles nestled away in the high ground above Lake Taupo is worthy of some attention. The inflow is limited and the natural drainage-area very small. The distance and the limited amount of power available with small expense do not seem to justify any surveys at present. It would be advisable, however, to gather what information is possible in regard to rainfall, snowfall, height of the lake and river, and storm data for future reference.

Rangitikei River.—The locations examined on this stream were all near Mangaweka and Hunterville. This stream has a very large drainage-area, and at the time we visited it had a magnificent flow of water. While I do not think it was the minimum, however, there are no lakes in its watershed to equalise the flow, and even though the greater part of the country above is brush-clad, there will be a great variation in the flow of the stream. Any development at the points examined would be, on account of the very high and long dams suggested, exceedingly expensive, which the needs of the district do not now warrant. Complete surveys alone will decide the feasibility of these plans to utilise these locations, but I would not recommend spending the money now.

Manawatu.—The location visited was the justly noted gorge between Palmerston North and Woodville. We spent considerable time here, but do not see that any money can be spent here to advantage. The head available is so slight and the plans to utilise it necessarily so extensive that the cost is prohibitive. The variation in the height of the stream between minimum flow and flood is so great that it would be difficult to handle. I also doubt if surveys would reveal as much head available as I have listed, hence, though the place is beautiful from a tourist's point of view, it is worth little at present from a power standpoint.

Waikaremoana.—We were unable to visit this very interesting and beautiful spot on account of lack of time, but the surveys furnished, together with the gaugings, indicate a very valuable power-site. The total head cannot be utilised unless the underground channels are choked. This, however, may be an impossibility. As it is, the lake is a very valuable equaliser. The recorded variation of 12 ft. allows for the storage of sufficient water to keep up the full flow of the river over four months. One great disadvantage is the numerous outlets at different levels; however,

there is so much power available that the best and cheapest part of it can now be utilised, and it will be many years before you will want the total capacity of the location developed. I would advise having complete surveys made of this locality, having contours run both sides of the river, so that races and pipes could be located to utilise about 1,000 ft. head. The contours should be run 10 ft. apart, and the locality should be studied also, to find if there is a limestone reef in the district, and for other peculiarities. It would be wise, too, to have rain and thunderstorm records kept here also.

Wairoa.—This is another of the power-sites we were unable to visit. Its nearness to Waikaremoana, together with its low head, and the small minimum flow of water without any lakes in its watershed, make it of little value on account of its neighbour. However, upon closer examination it may be that it could be developed cheaply. In order to determine this a complete survey would have to be made. The information is incomplete, so that it is impossible to make any estimates in regard to it.

Waimakariri.—This was the first of the rivers with wide shingle beds to be examined, and it was not necessary to a transmission engineer. The flow of the stream is ample, but when it comes to building a high dam to withstand this torrent, and to take the wear of the tons upon tons of silt and shingle, it gives the thoughtful man pause. In view of the fact that there are far better places to develop power, this river had better be left to its own sweet will for the present. Mr. Dobson's plan to utilise a part of the flow at the Gorge Bridge is the most sensible plan proposed, but his plans were for only a small development. For the present generation you will not need to trouble this stream.

Rakaia.—This stream we examined immediately after the Waimakariri. It is so similar in many respects that we did not spend much time on it. It has a wonderful flow of water, and were it not for the great quantities of shingle moving in its channel, there would be more encouragement to attempt to utilise it. It will require a high dam, and there is scarcely any opportunity to gain additional head by running races along the terraces, so that all the head available would probably be that created by the dam. This, of course, can only be determined by surveys. The most suitable plan suggested for these works was at the gorge where the wagon-bridge crosses it. I do not think it advisable to spend any time on this location at present.

Lake Coleridge.—This location impressed me as a very valuable power-location, and one where development can be started at a minimum of expense, and, as the demand increases, additions can be made at a proportional expense. There will be no large dams to be built, no shingle or silt to contend against, storage can be increased as needed, and the inflow of the lake increased as required. The surveys furnished me are favourable—in fact, more so than I anticipated—so I have selected this location to outline a plan for service to Christchurch and its district, giving as closely as possible the cost of the entire plant and the cost of operation of the plant, and the cost of energy delivered. Unfortunately, the sections made and referred to on the maps were misplaced or lost in transit, so that I did not receive them; therefore I cannot make the estimate as accurately as I would desire.

Rangitata.—This is very similar to Waimakariri and would be equally as expensive to develop. A complete survey should be made of the location selected by Mr. Wilson and reported on by him in December, which site is probably the best that can be found, but the great cost of so high a dam, with immense quantities of shingle to fight, would be a very expensive affair. The shingle and silt would be destructive, not only to the dam and its parts, but to the pipe, wheels, gates, and the whole of the hydraulic equipment; besides, some of the head would have to be sacrificed to make sure the wheels would be kept clear of it. This stream should not be considered for the initial development, but further study should be made of it if it should prove to be near to some great centre of development. There are so many other localities where immense quantities of power can be developed without these difficulties that this stream should not be considered now.

Lake Heron.—This district we were unable to visit; however, it is not probable that this can be developed to advantage now, on account of the long race necessary to secure the limited fall and available energy; then, too, there seems to be no storage of water at the end of the race, which is very necessary to secure constant service. The description Mr. Wilson gave is very good, but if it is thought advisable to develop here complete surveys will have to be made, so that plans can be devised for carrying out the work. I would suggest that all the further information possible in regard to this district be secured, such as rainfall, snowfall, thunderstorms, &c.

Opihi.—We spent a good deal of time on this in proportion to its value. We could not determine just where it would be best to do development-work. Surveys will have to be made for that purpose. I would suggest, however, that if development is attempted a dam of medium height—say, 25 ft. or 30ft.—be built in the gorge below Fairlie, and that a flume be built along the side of the gorge to secure as much head as possible in a short distance—say, one mile or less. I am under the impression that a much better location ought to be available in this neighbourhood for an equal amount of power that can be more cheaply developed. I would not attempt development here only as a last resort, unless a survey should show better conditions than our examination disclosed.

Lake Tekapo.—This is a beautiful lake and very valuable as a power-location. There are several plans to utilise its waters, but surveys are not in my possession so that I have no means of knowing their relative merits. All of them, however, will be very expensive—not very expensive per unit ultimate development, perhaps; but the investment will be very heavy at the start, and the greater part of it will have to be made to get any machinery in operation. I do not think the present needs warrant the spending of so much money.

Lake Pukaki.—This location is in the list of those too expensive to figure on developing now. There is a magnificent flow of water from this lake, and it is possible to develop a large amount of power, but the interests of the colony do not warrant this. There is nothing that can be done here but to build a high dam and utilise the head created by it.

Lake Ohau.—Some surveying will be needed here to determine the best manner to proceed. It appears as though a considerable head could be secured by damming the outlet of the lake and carrying a race a few miles along the terraces to the south of the Ohau River. This, too, would be a very expensive piece of construction not warranted at present.

Ohau River.—There is an excellent site for a dam just above the wagon-bridge over this river, and it is thought that a race would be carried down the river for a few miles to advantage. I do not think that anything more than the head created by the dam could be utilised to advantage. This is, of course, very expensive. Surveys would have to prove or disprove either idea.

Waitaki.—The best place we could find in this stream for any development-work was in the gorge near the confluence of the Ahuriri. Here there are foundations suitable for damming this stream to the height mentioned. The works would have to be exceedingly massive, and this is in the same expensive list as many of the other power-locations examined; and, although there is so much power-development possible, the demands do not now warrant even surveys.

Clutha.—We examined this stream in numerous places, and found none where it would be possible to develop power without excessively large dams. Then, too, the variations of this stream are exceptionally great between low water and "flood." Any power-station of the usual type would be completely submerged by such a flow of water as is usual during the "flood," and all electrical apparatus would be almost hopelessly ruined. There is also a good deal of silt and shingle moving in the stream, caused by mining and dredging. This would play havoc with the water-wheels and gates. The expense of development here is too great and the difficulties too many to warrant work being done.

Manuherikia.—In many respects the location examined on this stream is a valuable one, but there were no surveys of the district and it has not been possible to secure any. I do not think, however, that it is worth while under the present conditions to try to develop this water. There is so much mining-work going on that the water is very muddy the greater part of the time. This alone would render a stream unfit for power purposes, unless there were nothing else available.

Lake Hawea.—By means of a dam 50 ft. high at the outlet of this lake it will be possible to secure a maximum head of 192 ft. by cutting a tunnel through the narrow piece of land between this lake and Wanaka from the lagoon to a point near trig-station U, as outlined on P.W.D. 20668. This would make available nearly 120,000-horse power theoretical for continuous service, or for eighteen-hour service fully 160,000-horse power theoretical. In order to utilise this a tunnel of 550 square feet in cross-section, or 26½ ft. inside diameter would have to be constructed. If two tunnels were used each would have to be 19 ft. inside diameter; or, if three were used, each would have to be 15¼ ft. inside diameter. Of course, these tunnels would not have to be round if it were found best to make them some other shape. The location for the power-house is an excellent one. Dunedin, the principal customer, is distant 116 miles in an air-line, but by almost any feasible route this would be increased to over 150 miles at least. This, however, is not a prohibitive distance, but indicates something of the expense that will have to be incurred to utilise this energy. The remoteness of this location from the railroad would make hauling a very large item of expense. This is an extremely valuable site, however, and will be fully developed some time; but for the present a location that can be developed at less expense would answer the purpose better.

Lake Wanaka.—If an attempt is made to bring water across into this lake from Hawea, it will preclude any plans to utilise the water from this lake by means of a dam at its outlet. The plan mentioned is probably the best one for this district.

Lake Wakatipu.—This is the most popular lake of the colony. The only plan proposed to utilise the flow from this lake is to put a dam at its outlet and raise the level of the lake. This would submerge some very valuable property at Queenstown and Kingston, as well as in numerous places all around the lake. This, and the expense of the dam and whole equipment, will probably preclude doing anything of the kind. The present outlet of the lake, however, seems an excellent place for a dam. There is rock cropping out across the channel and on each side which ought to insure good foundations, and there are near-by quarries for construction-material.

Shotover River.—This stream flows through a very strange and rugged country. The flow of the stream is not equalised by any lakes, and the mining and dredging along its course keep it muddy continually. Although there is a location near where the Arrowtown Bridge crosses it where a dam could be erected, the condition of the water and the expensive works necessary will probably preclude anything being done here. A survey, however, is the only thing that will decide finally if this is a suitable location. Under present conditions, however, the muddy water should settle the point against it.

Lake Te Anau.—This is one of the most beautiful lakes. There are two plans to utilise its waters—the one to take them across to Manapouri and utilise them under a pressure of about 137 ft., the other to take them through Lake Hankinson and a tunnel to the Tasman Sea. The former plan I do not think is practical; the latter is surely exceedingly expensive, and the plant when finished, in order to deliver its product, would have a long line over exceedingly rugged country, where it would be hard to care for it. Both schemes would require a high dam at the present outlet of the lake, and both would be exceedingly expensive. Surveys would have to be made to determine the feasibility of each or both.

Lake Manapouri.—There are two plans to utilise the waters of this lake—the one to take the water through a tunnel to the ocean, the other to utilise it by means of a dam at the outlet of the lake. If the Te Anau waters are taken to the sea, there will be a very limited amount left to be taken from Manapouri. However, if either plan be carried out, the other never will be. Surveys will have to be made to determine the merits of each plan.

Waiau River.—This stream has several places in it where dams can be erected and the fall created utilised. Surveys, of course, will have to be made to determine where this can be best done. All of these places, however, will require long, high dams that will be very expensive to build.

Lake Monowai.—This peculiar boomerang-shaped lake seems a very likely place to develop, and I would suggest that a survey be made to determine its value.

Otira River.—This stream is very famous by reason of the remarkable scenery along its course. Its main value will be in connection with the construction and operation of the Arthur's Pass tunnel. For this purpose it will furnish ample power to operate all the construction machinery and the trains themselves after the tunnel is completed. For any large quantity of power it will be quite expensive per horse-power developed. There would have to be a good deal of tunnelling to avoid the shingle-slides, which are quite frequent and dangerous.

Rolleston River.—This stream is quite similar to the Otira, and is valuable mainly in connection with the same work, the idea being to combine their waters and utilise them in one large plant. It would require considerable tunnelling to make safe and constant service. The main trouble here would be from frosts in winter decreasing the flow seriously. Observations on this subject would be very valuable.

Lake Kanieri.—We were not able to visit this site, but from the information gathered we judged it to be the most suitable place to develop for furnishing Greymouth, Hokitika, and Ross Flat. The surveys we could find, however, were not complete enough to form a basis for any calculations. I think it is worth while to have complete surveys made of the location.

Inangahua.—This stream will probably not be used for power purposes on account of any works that could be constructed to advantage flooding very valuable agricultural and pastoral land.

Buller.—Near Lyell there is a place in the river where works could be established, but the lack of a market and the very great variation of the stream from low water to "flood" will be a very serious drawback.

Lake Rotoroa and the *Gowan River.*—This is the most valuable location in the district, and, I think, could be developed to better advantage than any other in the Buller watershed. However, there is but a very limited market for its energy within a reasonable distance.

Maitai River.—This stream has no value whatever for power purposes.

Wairau River.—This is another of the wide shingle rivers that is very difficult to deal with. If, however, a suitable place can be found to divert the water without starting new troubles, it is probable power enough for the district could be provided from this stream easily. It is not wise to do anything with this stream except after extremely careful consideration.

Waihopai River.—It is probable that for the small amount of power needed in this district a small stream like the above will answer the purpose admirably; this, however, will have to be determined by surveys.

Awatere River.—Another of the wide shingle rivers, with the additional defect of muddy water. Dams can be built in several places, but the expense and lack of market for so much power does not warrant their construction.

This list of places examined is a wonderful showing for a country of this size. The fact that the North Island of only 45,565 square miles and the South Island with only 59,054 square miles contain such a wealth of power speaks volumes for their future.

It is wonderful how the development of our present-day civilisation has been made on a fuel basis. The greatest industries of to-day, aside from the agricultural and pastoral, are metallurgy and manufacturing, and they have reached the greatest degree of perfection where coal was cheap; in other words, near the coal-mines. Thus the black diamond of England and America, stored ages since and held for our time, has contributed wonderfully to the latter-day material wealth. The full sway of this monarch has now been challenged by a new claimant that has only lately appeared. Electricity has accomplished so much in metallurgy that one is almost amazed. In manufacturing it has made terrible slaughter—slaughter of those who resisted and stuck to old methods. In other fields, too, it is advancing, and, supported by a powerful ally from the mountains, the white diamonds of the waterfall, it is making an attack all along the line. What the ultimate result will be no one can foresee. Thus the development of your water-powers—your white diamonds—will not injure any industry; on the contrary you will find a still greater demand for coal, wood, and all kinds of fuel. The reasons for this are many; the main one is that works of this kind bring into existence trades and industrial undertakings that are ranked as manufacturing, and this is what New Zealand needs. She can produce food and clothing of unequalled quality and quantity, considering her area; now she must encourage classes that will consume these products so that she will not have to go so far for a market; in other words, create at home, as far as possible, a market for your products. Encourage manufactures; make concessions to them for a term of years to get them started. If necessary, give them land, remit their taxes, and in different ways encourage industry.

With this cheap power available wonders can be accomplished for the colony. It has been found in a good many cases that industries spring up in a locality where there is an abundance of cheap power, and judging from conditions in the colony this will be true of any development you may put in. Every city, town, and hamlet can be furnished not only with power and light, but with heat also. The supplying of power from large systems, where they pass through the small towns, at rates that could not be thought of hitherto, will help in a wonderful way to build them up. Industries that thrive best in small places will be encouraged, the population will be better distributed, and many of the evils of a crowded city avoided. This immense supply will enable each home in the colony to enjoy luxuries that in other countries are enjoyed only by the rich. The home, when electric cooking, heating, and lighting are installed, will be a model of convenience and comfort. The servant question will be nearer solution, and the drudgery largely done away with. In the factory and shop electricity will do the work that is now so wearing, and in every department of life applications of it will be used that will bring about material advancement to a wonderful degree.

The manufacturing of all Australasia and a great portion of the Orient could be done here better and cheaper than anywhere else. Being so near these markets with this unlimited power,

and having a climate not surpassed and hardly equalled anywhere, and suited to a degree to manufacturing purposes, the possibilities of the colony are almost beyond the bounds of fancy. The opening of the Orient and the demands it will make on civilised nations will be something marvellous. If New Zealand wants to share in this business you must prepare her for it. Your products should be exploited carefully, and instead of shipping away any raw material it should all be put in a finished condition at home. Your wool should all be in condition for immediate use; instead of being shipped in the bale it must be worked up somewhere. Why not at home? Why cannot raw material be shipped into the country and, after being worked into the finished article, be forwarded for consumption?

Your advantages are numerous—we might say unequalled. You have splendid harbours, which means easy access by sea. You have a superabundance of reliable and cheap power, and an excellent climate. The ships of the world should stop at your doors and contribute their share to your advancement. They will do it if you insist. You have already a great deal of wise legislation on other subjects; bring to the question of the advancement of the colony and its growth as a manufacturing centre this same energy and thought, and great results will not be lacking. In order to carry out this plan suitable working relations with consuming nations must be established. Make concessions to them, and see that you get concessions in return. The cold countries need meats and wool; you have them both. Put them into such good shape that people simply cannot get along without them; but have this work done at home, where, with your water-powers developed, you can do the work better and cheaper than it can be done elsewhere. I do not wish to disparage what you have already accomplished, for you certainly have achieved wonders, and almost accomplished the impossible. You deserve the greatest compliments for the results you have achieved, but there is so much possible in the immediate future that your efforts should be redoubled.

Estimate for Lake Coleridge Development.

This location impressed me favourably from the start—first, on account of the possibility of storage; second, on account of the head available in a very short distance; third, on account of the possibility of connecting the pressure-pipes direct to the lake so that water would be used only as needed; fourth, on account of its nearness to a large centre of industry. On the whole, the surveys have more than realised my hopes.

The present development recommended is that of 10,000-horse power in four units of 2,500-horse power each—about one-ninth of the maximum possible development. There will have to be a tunnel through the hill, the cost of which I cannot give because no sections were forwarded. The inside section of the tunnel should be at least 42 square feet. This will provide for a development of over 25,000-horse power, with a minimum head of 469.3 ft., without raising the level of the lake. If a dam 30 ft. high is erected this can be increased to nearly 30,000-horse power. I have entered as the cost of this tunnel and headworks, with pipes down to the power-house wall, $400,000, which I think ought to cover it unless some unusual unforseen contingency should arise.

It is exceedingly unfortunate that "Longitudinal Section 1," as indicated on P.W.D. 20697, was omitted from the papers forwarded to me. In the hurry occasioned by the approaching holidays it probably was overlooked. However, I have estimated the cost of all the other items from the power-house to and including the sub-stations; however, I have not counted in the cost of the attendance of these stations. As I understand, you expect to sell energy to the local people and let them retail it.

Detail Cost.

	$
Generators, 2,000 kw., four of	57,200
Exciters, four of	3,064
Transformers, 750 kw., twelve of	42,260
Switchboards and lightning-arresters	9,501
Water-wheels and rigging	75,000
Cranes, two 25-ton and one 1-ton	7,500
Transformer, water system	1,200
,, oil system	1,000
Lubricating-oil system	1,300
Power-house building	18,000
Foundations	37,920
Dwellinghouses	10,500
Shop building	1,000
Warehouse	1,000
Shop tools	5,000
Haulage from railway to power-site	11,288
Erection of machinery	9,050
Freight	33,276
Wire for transmission-line, double line, seventy miles	142,500
Line-supports	126,000
Insulators	67,200
Eight sub-stations	95,000
Emergencies	4,241
	$760,000
Allowing for cost of balance of water system	400,000
	$1,160,000

This equals per horse-power $116.

Cost of Power per Horse-power per Annum.

	$
Interest at 4 per cent.	4.64
Labour charges (operation)	12.73
Supplies, half of 1 per cent.	0.58
Repairs, three-quarters of 1 per cent.	0.87
Depreciation, 8 per cent....	9.28
Taxes, 1 per cent.	0.12
Total	28.22

This is the cost of furnishing 1-horse power twenty-four hours per day for one year or for 8,760 horse-power-hours, or a cost of $0.00335 per horse-power per hour. Now, should there be only a period of eighteen hours per day for six days in the week when this power could be utilised, the cost would be proportionately greater, or $0.00502 per horse-power-hour, or $0.00669 per kilowatt-hour.

I have endeavoured to make the figures not very high or very low, but think you will find them conservative. Of course, they are based on American practice. I am in communication with European concerns, and shall soon be able to tell whether they could do better or not. However, the European manufacturers have never built any machinery for very long-distance work, and you would have considerable experimenting on your hand. They do magnificent work, and could in a few years make anything needed after they had sufficient experience.

The figures presented are based on costs of machinery that is now in operation, and which you would know would be satisfactory from the start.

Irrigation and Drainage.

In connection with the electric transmission of energy generated by water-power, the subjects of irrigation of dry and so-called desert lands, and the reclamation of lands periodically submerged by rivers when in flood, or the drainage of shallow lakes, are of vast importance. They not only add greatly to the productive area of the country, but require power from the system to accomplish their object.

The location of pumping plants that are a marvel of simplicity for furnishing water for irrigation of orchards, fields, and gardens, and for drinking-water for cattle, also for removing surplus water from valuable land during or after storms, is possible, and their working, by means of electrically transmitted energy, is accomplished with little expense and the greatest certainty.

You have great areas of land that would be wonderfully productive if they were irrigated; you have also numerous shallow lakes whose beds are wonderfully fertile. Could these be systematically drained they would furnish homes for a great number of people. There are in three of your shallow lakes over 62,000 acres, which, if drained and under cultivation, could support a population of over twenty thousand people. Both drainage and irrigation can be successfully accomplished with energy from the distant water-powers.

Electric Power for Railroads.

There has been endless discussion on this subject. Electric engineers on one hand have claimed that "there is no work of any kind now being done by steam that cannot be done cheaper and better by electricity"; while the steam engineer has attacked the electrical engineer with his breakdowns and unreliable service of pioneer days, and the claim that electricity could not, with a reasonable investment, handle the railroad service of to-day as furnished by steam. Neither are wholly right nor wholly wrong. A middle ground has been taken by our conservative engineers. They are attacking every new problem presented with such skill and thorough sincerity that great undertakings, yesterday thought impossible, are to-day an accomplished fact.

The heaviest service now in operation is probably the Baltimore tunnel; the heaviest under construction is the New York Central tunnel in New York City. The largest straight-away electric railroad is probably the Cleveland, Dayton, and Toledo Traction Company, with headquarters at Hamilton, Ohio. This system spans a great part of the State of Ohio. Both services in operation are, beyond a doubt, very successful.

The method usually adopted where a road is being operated by steam is to instal on the busiest portion a system of electric traction that will not interfere in any way with the steam service; then gradually diminish the steam service and increase the electric; then gradually extend the electric equipment to other parts of the system as the demand and other local conditions dictate.

The New Zealand railway systems would have to be thoroughly studied before any definite outline of a plan could be recommended. There is no question about the water-power of the colony being ample to handle the whole system, nor is there any doubtful engineering question involved. It is purely a question of business policy. I have no doubt that there are numerous places now where it would be very wise and good business policy to equip with electric traction. Some of these places are the suburban sections of roads near Wellington, Auckland, Christchurch, and Dunedin, and the Christchurch-Lyttelton tunnel. These would be excellent places to begin; then as traffic increased, which it is bound to do, you would be well situated to handle it.

The energy for this service is abundant, and with the progress in view for your excellent colony, these matters should be put into condition to meet the demand in sight.

Yours, &c.,

L. M. Hancock, M.A.I.E.E.

The Hon. W. Hall-Jones, Minister for Public Works, Wellington, New Zealand.

Approximate Cost of Paper.—Preparation, not given; printing (1,425 copies), (not including plates), £8.

By Authority: John Mackay, Government Printer, Wellington.—1904.

Price, 6d.]