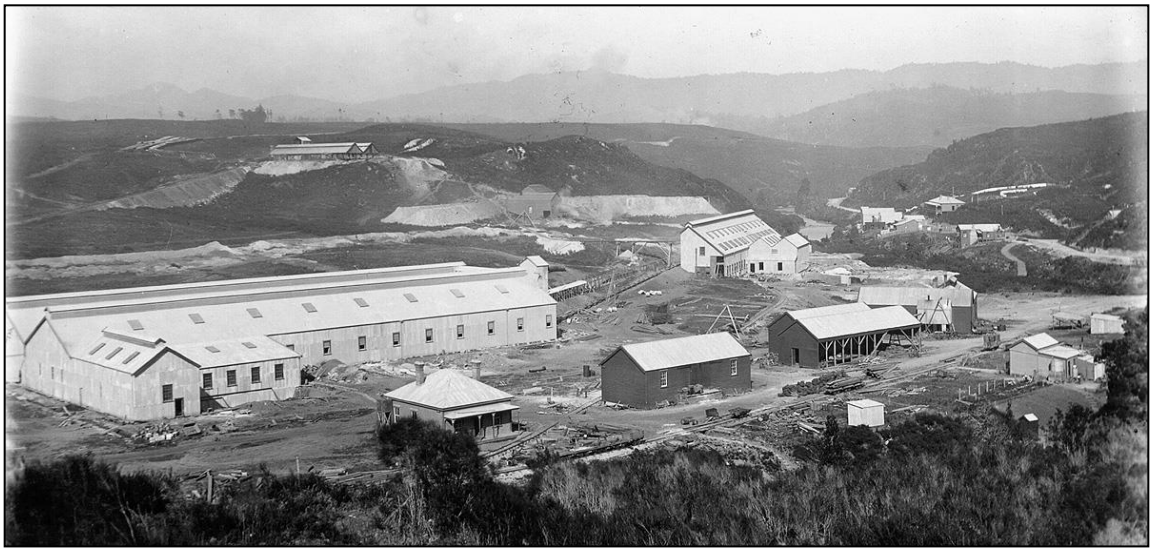
Waihi Gold-mining Company's

Victoria Battery, Waikino

Structures, processes, flow sheets



Victoria Battery 1898. M. Roycroft.

Eric Lens, December 2022

Victoria Battery Structures, processes, flow sheets

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Executive Summary

The Waihi Gold Mining Company established the Victoria Battery in 1897/98. 100 stamps commenced dry crushing early March 1898. The crushed ore (fine sand) was treated by cyanide percolation in large sand vats.

A further 100 wet stamps were added, and the whole battery started wet crushing early August 1902.

At this point the processes flow-sheet became more complicated, with sands, concentrates and slimes (very finely crushed ore) being treated separately. This arrangement proved to increase bullion recovery, but required specialised structures and processes to be established.

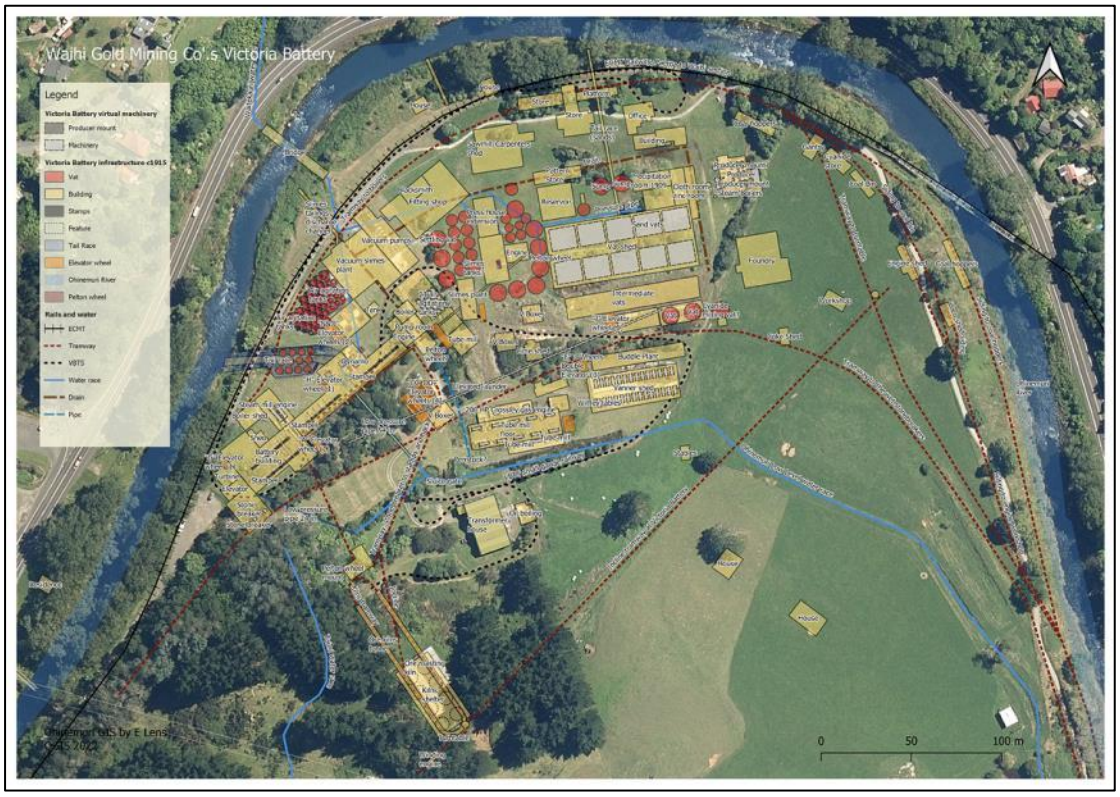
These are detailed in the bulk of the document. The available contemporary photographs are assembled, discussed, and arranged by year. The site quickly became congested. Many questions remain.

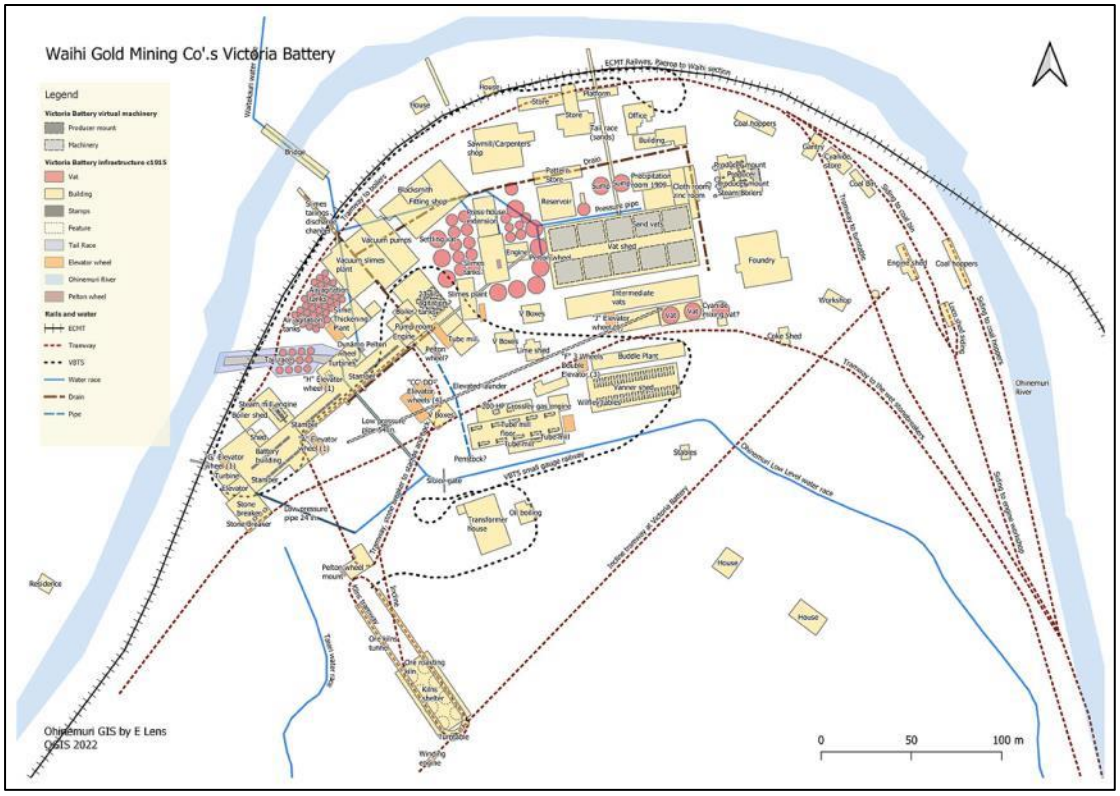
After electrification in 1913/14, the structures of the battery site remained relatively unchanged until their demolition after closure in 1952-4. The concrete and stone foundations of these structures are what remain today, modified or obscured by scavenging activities before the Department of Conservation acquired the site in 1987. The Department and the Victoria Battery Tramway Society have further modified the site over the years.

The Victoria Battery GIS is an integral part of this project. The research and interpretation here presented have informed the expansion and updating of the GIS.

The images discussed in the text are also available separately.

Current GIS map





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Introduction

The Waihi Gold Mining Company established the Victoria Battery in 1897/98.

Waihi ore (and Hauraki ore in general) was difficult ore to process. Refractory, with gold finely divided and often intimately bound to sulphide minerals. Ore roasting and dry crushing followed by cyanidation had been established as best practice at the Waihi Battery, and thus this was the process set up at the new Victoria Battery. Huge ore roasting kilns were built, with vast quantities of firewood required. Miners and battery hands were maimed by "the dust" (phthisis or silicosis).

100 stamps started dry crushing on March 2nd, 1898.

The ore was crushed to fine sand and transported to leaching vats by pipe conveyor. Cyanide solution was percolated through the sands; there was no agitation. Percolation was only successful if there was very little fine material (called slimes) in the sands. Roasting and dry crushing mostly achieved this.

Experiments in wet crushing, over many years, were on going. The increasingly mineralised ore found at depth in Martha mine added to the pressure to convert.

In May 1899 a start was made to erect a further 100 stamps which were to be wet crushing.

By mid January 1900 the 100 wet stampers were fully operational[1]. The original 100 dry stampers were converted during 1902[2].

The change to wet crushing, and the more mineralised nature of the ore required changes to the battery flow sheet.

Wet crushing, without preliminary ore roasting, produced more very fine material (slimes). Slimes prevented the percolation of cyanide solution through the crushed ore (called pulp). The slimes had to be separated and treated by agitation. The highly mineralised portion of the ore proved resistant to the regular process, so was also removed, and treated separately.

The three products were separated from the stamper output and treated individually; sands, concentrates, and slimes. The battery buildings, machinery and processes reflected this. Alterations and refinements were made over time. The difficulty of agitating slimes was largely overcome by air agitation in tall tanks.

John Bacon summarizes the wet flow sheet.

> Victoria Battery Flow Sheet
>
> Treatment before 1912 - Grinding to 70% through 200 mesh, followed by plate amalgamation, then Wilfley table concentration. The Wilfley table concentrates were reground and cyanided in the concentrates treatment plant.
>
> The Wilfley table tailings were then classified into –
>
> (a) Sands - cyanided by a percolation method.
>
> (b) Slimes - cyanided by an agitation method.
>
> Treatment from 1912 to 1947 - Amalgamation practice ceased on 12th May 1912, and the flowsheet was continued as before to produce Wilfley table concentrates, sands and slimes for cyanide treatment in separate sections for each product.
>
> Treatment from 1947 to 1952 - The sand treatment plant closed down in 1947 and the flow sheet changed to:

[1] SUPERINTENDENTS ANNUAL REPORT. Waihi, 27th January, 1902. (For the year 1901)
[2] SUPERINTENDENTS ANNUAL REPORT. WAIHI, 24th January, 1903. (For the year 1902)

(a) Concentration on Wilfley tables.

(b) All sliming of Wilfley table tailings.[3]

Zinc shavings or zinc fume (finely divided zinc) precipitated the bullion from the pregnant cyanide solutions. The resultant "black slimes" were sent to Waihi for refining.

All tailings were consigned to the Ohinemuri River.

[3] Extract from An Outline Of Milling Operations At The Victoria Battery, Waikino 1898 – 1954. John Bacon, 1998

Dry Crushing

Building the plant

The Waihi Gold Mining Company had operated the Waihi Battery at Union Hill since 1888. When the cyanide process was adopted in 1894, the battery crushed dry and treatment was by percolation through sands. Experiments with wet crushing were not considered successful, at least in part because more fine material was created (slimes) which hindered successful percolation of the cyanide solution.

So the new battery, and many others, would be dry crushing.

Percy Morgan:

> In the Ohinemuri district in particular, Waihi practice was naturally followed as much as possible, and thus dry crushing, succeeded by cyanidation, became the leading process of ore treatment in this part of the Hauraki field. Existing wet crushing batteries were converted into dry crushing plants, whilst a number of new batteries were specially designed and built for the process. During 1896 and 1897 dry crushing was at its zenith; every battery in the Ohinemuri district, including the new 100 stamp battery built at Waikino by the Waihi Co., dry crushed its ore.[4]

The whole document gives a very good description of dry crushing practice. See: The Rise And Fall Of Dry Crushing On The Hauraki Goldfield in the appendices, page 170.

It is clear that as early as 1895, or even 1894, the Waihi Company was planning the battery at Thorpe's Hill Waikino (or Owharoa as it was probably known then). H.A. Gordon, Esq., F.G.S., Inspecting Engineer. AJHR 1895:

> Water-races from Waitekauri and Ohinemuri Rivers, also from the Mangakara Creek, have been surveyed to the site at the foot of Thorpe's Hill, and during the year will be used for further crushing.[5]

The New Zealand Herald and Auckland Weekly News Exhibition Number, 1898, has an enthusiastic piece on the Victoria Battery:-

> THE PREMIER MINE OF NEW ZEALAND. WAIHI G.M. CO.'S PROPERTY.
>
> THE EARLY HISTORY OF THE MINE. A RECORD OF WONDERFUL PROGRESS.
>
> The Waihi Company, however, decided to double the crushing plant, and with the promptitude that has heretofore characterised its operations, placed this important work in hand without delay. At Waikino, some eight miles distant, picturesquely situated in close proximity to the Ohinemuri stream, the Victoria battery of 100 stampers has been completed, thus more than doubling the crushing capacity, and having a similar effect upon the output. Substantial dams have been constructed — the dam across the Ohinemuri was a costly undertaking — and high and low pressure services obtained for the turbines and Pelton wheels. From Waihi to Waikino a railway has been constructed, the quartz trucks being conveyed to and fro by a powerful locomotive. The total cost of the work is estimated as having been close on £90,000. All the ore is kiln dried, and at Waikino the most up-to-date and original automatic appliances for facilitating work are in use, everything working with a smoothness and rapidity that cannot fail to impress visitors with the capacity of the management and the valuable co-operation that has been obtained from all concerned.

[4] The Rise And Fall Of Dry Crushing On The Hauraki Goldfield. By Percy Morgan. 1903.
[5] Appendix to the Journals of the House of Representatives, 1895 Session I, C-03. p62.

> Since the commencement of crushing operations at the 100-stamper battery, known as the Victoria, Waikino (which is but a short distance from the large area held by the Ohinemuri syndicate, with which the New Zealand Mines Trust are also associated) has progressed rapidly, and what formerly was practically a deserted locality is now a scene of great activity. Between the battery and the vat-shed, as will be seen from the illustrations accompanying this article [page 36], ample space has been left for the erection of an additional 100 head of stampers, which would increase the crushing plant of the Victoria battery to 200 head. The kilns, which may be seen at the rear of the battery, have been splendidly built; and the rapidity with which the trucks are filled with quartz from the kilns, switched on to a constantly-running wire rope, conveyed to the ore-bins, emptied by means of a clever mechanical contrivance, the trucks righted, and conveyed back to the kiln shoots, cannot fail to impress the visitor with the fact that nothing has been left undone to facilitate the rapid and inexpensive handling of the quartz. The workshops adjoining the larger buildings are well equipped with up-to-date appliances, and repairs to battery and machinery can be completed in an astonishingly short space of time.[6]

The Waihi Gold Mining Company established the Victoria Battery in 1897/98. 100 stamps commenced dry crushing early March 1898. The crushed ore (fine sand) was treated by cyanide percolation in large sand vats.

A wonderful description of the new battery is given in Papers and Reports Relating to Minerals and Mining, 1899.

> The ore is a close, hard, white quartz, in parts of a flinty appearance, and carries its value very finely disseminated, visible gold being rarely seen. Very fine crushing is necessary, it being found that pulp above 40 mesh retains gold that cyanide fails to reach. In consequence of this fine reduction, and also owing to the presence of clay, the pulp is very slimy, and with wet crushing packs in the vats so as to be unleachable. Various methods of treatment were tried, with indifferent results, prior to the adoption of the present system of dry crushing and cyaniding, by which an extraction of 90 to 92 per cent. is obtained. The difficulty is entirely mechanical, due to the fine state of the gold, and not in any sense a chemical one. The ore is first roasted in kilns with wood fuel – burned is really a better term - to dry and render it more friable for crushing. The company possesses two plants: the old mill at Waihi and the new Victoria battery at Waikino, started up in March of this year (1898)…
>
> The new Victoria battery contains several features of interest, and is situated five or six miles from the mine at Waikino, upon the Ohinemuri River. The kilns and rock-breakers are situated upon rising ground at the back of the battery, which latter, with the vat-house, occupies a level site.
>
> The ore is brought by a ground-train from the mine to the kilns. After burning, it passes through a gyratory breaker of the Gates type in a separate building, and thence is trucked to the stamps. The battery consists of a hundred stamps, of 960 pounds weight, arranged in a single line. Water-power is used, there being two Gilkie's turbines of the vortex type. The drive from the motors is situated in the middle of the battery, with fifty stamps on either hand. The mortars have back and front discharge, and two corresponding lines of worm conveyors. Automatic feeders are provided. Crushing through 40 mesh wire screens, the duty at ninety drops is 1.5 tons per stamp per twenty-four hours, the bulk of the product passing 80 mesh…
>
> The worms discharge the pulp to the conveyor, which delivers to the vat-house, some 225 feet distance. This conveyor is a steel-tube way, 15 inches in diameter, mounted upon anti-friction

[6] The New Zealand Herald and Auckland Weekly News Exhibition Number, 1898

rollers, and fitted with an internal fixed spiral. The whole rotates, being driven by an independent Pelton wheel.

The vat-house contains ten concrete rectangular vats, five on each side. Each vat is 50 feet by 40 feet, and filled to a depth of 2 feet, contains 150 tons ore, one day's supply. The pulp is delivered from the main conveyor to a rubber-belt elevator, discharging into a cross conveyor in the roof at right angles to main axis of the building. This again supplies two conveyors, one in each roof-truss, running the length of the house and central with each row of five vats. These three conveyors are of the same type as the main one connecting battery-shed and vat-house, and driven by the same motor. Over each line of vats is a traveller fitted with traversing gear and hopper. The pulp spouted down from the overhead conveyor is thus evenly distributed in the vats, and, being gently dropped in, does not pack. The filter-cloth is laid over a wooden-slat grating and caulked down with rope. No storage-hoppers exist, as, owing to ample vat-capacity, the vats themselves fulfil the same object. Down the centre of the house is an alley-way for pipes, floored with cement, drains being provided to catch any leakage…

Zinc precipitation is used, in wooden boxes. The remainder of the plant consists of two Tangye pumps with interchangeable connections, vacuum pump, two steel vacuum cylinders, two wood vats for waste liquors, and one iron mixing tank. The tailings are sluiced out with water, and all mixed and running-on of liquors is done in the day-time, to reduce night-work to a minimum.

The adoption of such large vats of concrete is a bold experiment, especially as the district is by no means free from earth tremors. Great care was taken with the foundations, and the concrete-work well tied in with wire. In March, 1898, the plant had only just gone into operation but no trouble had been experienced. In spite of this new installation the company is experimenting with a view to the possibility of wet crushing. The adoption of this would mean increased output from the plant, and dispense with the expensive burning of the ore.[7]

Superintendent HP Barry, in his Superintendent's Report for the year 1897:

NEW WORKS IN CONNECTION WITH THE "VICTORIA" MILL, WAIKINO.

A general plan, showing the Company's property at Waikino and the general position of the buildings and works has been made, a copy of which has been sent to you. Several photographs showing the various works whilst under construction, and also in their more finished state have also been sent.

All these works at the close of the year 1897 were in a very forward state, very good progress having been made in all branches of the works. As in the preceding year, wherever possible and advantageous, all these works have been done on contract, 47 contracts having been let, of which at the close of the year 41 had been completed.

TRAMWAY FROM MINE TO "VICTORIA" MILL, WAIKINO.

This line, which at the close of 1896 was only laid for a length of three miles, has been completed throughout, and is now in thorough working order. It has been well ballasted, the locomotive and quartz trucks having been employed for that purpose, and having conveyed many thousands of tons of metal. During the latter part of the year practically the whole of the stores, machinery, &c., required by the Company at Waihi have been forwarded by this means, thus reducing our expenses for carting. For the future the whole of such goods will be conveyed by this route, which will tend still further to reduce expenses.

OWHAROA FIREWOOD TRAMWAY.

[7] Papers and Reports Relating to Minerals and Mining. 1899. Pages 181-182.

During the year this line has been taken in hand and completed to the necessary distance (about 1½ miles) to enable firewood to be got out. A contract for 5,000 tons was let at a very satisfactory price, about half of which was cut at the end of the year, since which time the contractor has been delivering at the kilns steadily. The greater part of this line has been laid with heavy rails, either 28 or 40 lbs. to the yard.

INCLINE TRAM, FROM MAIN LINE TO KILNS.

This work has been carried out during the year, and the engine for hauling the quartz up fixed in position. For this purpose the traction engine, bought some time since, and which has been put to a variety of useful works, has been employed. The consumption of fuel will be very small. Three turntables have been constructed, one at the bottom and two at the top of incline, which work easily.

KILNS.

These kilns, six in number, each having a capacity of 500 tons, have been excavated, and at the close of the year the first three were bricked and practically finished throughout. The necessary drives connecting them with the stonebreakers were also finished. The kilns have been covered over by a suitable shed with iron roof.

STONEBREAKERS.

The erection of the two Gates Crushers was well in hand and that of the engine for driving them completed. For supplying the necessary steam a Babcock & Wilcox boiler has been erected and tested with a pressure of 200 lbs., which strain it stood satisfactorily. The boiler has been covered in and a start made with the building covering the breakers. The tramways from the breakers to the ore-bins and the return line from the bins to the breakers have been finished.

VICTORIA MILL.

The erection of this building has been begun and completed during the year. It is covered throughout of iron, and is a well lighted, roomy, and conveniently arranged building nearly 300 feet in length. The whole of the foundations are of a most solid and substantial nature, a large amount of stone work and concreting having been put in.

The whole 100 head of stamps (in one line) have been erected and all the conveyors, feeders, shafting pulleys and belts have been fixed in position, as also have two exhaust fans with their connections, and two elevators. The fixing of the trough conveyor between the elevators and the lining of ore bins was in hand at the end of the year, as was also the second turbine, the first having been completed as well as one of the two Pelton wheels which are required. Work in connection with the pipe conveyor to the tank shed was also in hand, but had been somewhat delayed owing to the Contractors being behindhand with the delivery of the pipes. The erection of the turbine and dynamo for electric lighting will be finished shortly.

TANK SHED.

The erection of this building, over 270 feet long by 114 feet broad, which, with the precipitating room attached, is of iron throughout, has been begun and completed during the present year. It is a very substantial and convenient structure with a double span roof.

The vats, of which there are ten, were in a very forward state at the close of the year, seven having been finished and filled with water, the remaining three being very near completion. These vats, as before stated, are 50 feet by 40 feet with a height of 4½ feet, inside measurements, all built in a most solid manner for permanent work, having a capacity of 150 tons each, so that 1,500 tons can be under treatment at one time. The filter bottoms of the first three had been finished by the end of the year and a start made with the filter cloths, after which

the vats are all ready for use. All the necessary pipe connections had been made with the first five vats.

The Precipitating Room was also well in hand and three precipitators put in, as also the two vacuum cylinders, vacuum pump and two solution pumps.

A dwelling house has been erected for the use of the clerk, and the Waihi Office connected by telephone with the Waikino Office.

The saw mill early in the year was thoroughly equipped and has been invaluable in connection with the new works.

NEW WATER RACES.

High Pressure System.—During the year the wooden dam on the Stoney Creek Race has been constructed. The remaining earthwork on all the high pressure races has been completed, slips removed and the races thoroughly puddled where necessary. Two flumes where the race crosses the road have been put in, the intake of the race completed, and all other flume work done, as well as a considerable portion of the necessary 1,600 feet of piping. The water from the Mangakara was available as motive power by the end of the year, and the whole power should be available as soon as it is required. The contractors for the supply and fixing of the 1,200 feet of pressure pipe have completed their contract, and the water was let in for testing. As there was some leaking the contractors were instructed to give the pipes another good coat of tar, which they have now done.

Low Pressure System.—The masonry dam on the Ohinemuri River has been finished and is a very strong and substantial dam. It is not likely that we shall have any trouble in connection with it in the future.

The two large flume crossings over the Ohinemuri have been taken in hand and finished during the year, both being strong pieces of work. The rest of the race has been completed, and any slips removed. The water has been let into it and run down for about half the total length. As the bulk of these races have had a summer and winter's weathering, I do not anticipate that there will be nearly as many slips or leakages as would otherwise have arisen.

The iron syphon pipe, 475 feet in length, at the close of the year had been practically completed by the contractors.

This race was also in a sufficiently forward state to allow of its being used as soon as required.[8]

The AJHR for 1897: Inspecting Engineer to 31 March, 1897 quotes HP Barry's General Report:

Owing to some little trouble in getting the road-bridge across the Ohinemuri River completed, work on the new reduction plant was somewhat retarded; but since the bridge has been finished and open for traffic the various works have been steadily pushed on. This bridge is a strong piece of work, 155 ft. in length, the main truss on trestles built on two concrete piers, the decking of the bridge being 30 ft. above normal level of water, which I think will insure its not being carried away by any flood which we are likely to experience. Wherever it was to the company's advantage, all the new works have been let by contract. In this connection seventy-four contracts have been let, nearly the whole of which have been completed. After getting quotations from several firms in different parts of the world, the contract for the supply of the one hundred head of stamps was let to A. and G. Price, of the Thames, New Zealand, who have already delivered a considerable portion of the machinery. The main shafting for the mill and the pulleys has been delivered, as also the two turbines and the two Gate's stone-crushers. The whole of the heavy timber for the mill is on the ground, including the twenty bed-logs, 4ft. 8in.

[8] Superintendent's Report. Waihi, February 11th, 1898.

by 2ft. 6in. by 18ft. in length, of good heart of kauri, which were sawn in our own kauri bush. The necessary excavations for these bed-logs, plates, and sills have been completed, and the masons have commenced the erection of the stone wall which is to carry the ore-bins. A considerable amount of work has been done on the tail-race, which has been taken out in a large open cut, but it is proposed to tunnel the rest of the distance. The following buildings were either completed or nearly finished at the close of the year : Store, 60ft. by 25ft.; sawmill, 80 ft. by 23 ft. ; carpenter's shop, 60ft. by 23ft. ; blacksmith's shop, 50 ft. by 25 ft.; machine and fitting shop, 60ft. by 25 ft.; office, 35 ft. by 29 ft.; locomotive-shed; store and dwelling house.

New water-races: The necessary motive-power will be obtained from a high-pressure system of races, having a fall of 198 ft., and a low-pressure system, having a fall of 54 ft. The high-pressure system consists of three races—the Mangakara Race and the Stony Creek Race, both tributaries of and falling to the Waitekauri Race. The Waitekauri Race, 6ft. by 2ft. 6 in. deep, and below the junction of its tributaries 7ft. by 2ft. 6 in., is upwards of four miles and three-quarters long, and commences at a dam a few hundred yards below the Waitekauri Gold-mining Company's mill. This race passes under the old kauri bush, through a tunnel 1,530ft. long, a portion of which has been securely cribbed where it passes through slidy ground. The Waitekauri dam is a substantial wooden structure, 16ft. high, with a spill of 68ft., the total length being about 170 ft., with the two wings built of heart of kauri throughout. I do not anticipate that we shall have any trouble with this dam for many years to come, as it was subjected to a very severe test soon after completion, when we experienced very severe floods, and it stood the test well. The dam on the Mangakara is a permanent piece of stonework, upwards of 30ft. in length, and running from 2ft. to 8ft. in height. The Mangakara Race, 5ft. by 18 in., is upwards of 22 chains long, passing through a tunnel 268 ft. in length. The dam on the Stony Creek will be a wooden structure upwards of 45 ft. in length. The Stony Creek Race is nearly half a mile long, 3 ft. wide by 18 in. deep. The pipe-line for conveying the water from these races to the mill is of wrought-iron, 2ft. 4in. in diameter, and upwards of 1,200ft. long. The low-pressure system consists of the Ohinemuri Water-race, four miles and an eighth long, 12 ft. by 4 ft. deep, running for the most part on the south bank of the river, but will cross at one place to the north bank by a high trestle flume, and recross again to the south bank after a distance of about a quarter of a mile. These crossings, although expensive, were unavoidable, owing to the nature of the ground. With the exception of these flumes just referred to and a wrought-iron syphon-pipe 5 ft. in diameter and about 475 ft. long, the whole of the race has been carried through a ground-channel, so as to obviate the constant repairs that would inevitably be necessary after the elapse of a few years where fluming to any extent on a water-race obtains. The dam on the Ohinemuri, at the intake of this race, will be a strong and solid structure of masonry. It was considered advisable to do this rather than to construct it of wood, so as to prevent any possible danger in the future through the wood rotting and serious damage being done to dams, bridges, flumes, &c, further down the river. The extra cost will not be very great. The water from this race, which has a fall of 1 ft. in 2,000 ft., will be conducted to two 200-horse-power vortex turbines by a pipe-line 4ft. 6 in. in diameter, branching off into two pipes of 3ft. 6 in. in diameter, fitted with equilibrium-valves for each turbine.

The length of the tramway from mine to Owharoa Mills is, approximately, five miles and three-quarters. It has been constructed of a gauge of 2 ft. 9 in., the smallest curve having a 6-chain radius. It has been well graded throughout, being, with only one exception (which has an up-grade of 1 ft. in 90 ft.), all down-hill with a load, the steepest grade being 1 ft. in 40ft. The line crosses from the north to the south bank of the Ohinemuri River, at a distance of two miles and three-quarters from the mine, by means of a strong truss bridge, upwards of 185ft. in length, and 30ft. 6 in. high from water-level to decking, and built of good sound heart of kauri and totara. The whole of the formation of this tramway has been completed, and upwards of three

> miles laid with heart of kauri sleepers and 40 lb. iron rails. All the culverts have been made with glazed earthenware pipes, which will be more durable than wooden culverts; and all the swamps which the line traverses have been drained by good substantial drains. The locomotive has been put together, and is now busily engaged ballasting the line and hauling building-stone to the mill. Twelve of the iron side-tipping trucks are on the ground, and we have received advice that fifty more, which should be sufficient for our requirements, are now on their way out from England.[9]

"The locomotive has been put together, and is now busily engaged ballasting the line and hauling building-stone to the mill." [10] This suggests that the tramway was built from Waikino to Waihi, the locomotive being used early on in the construction of the Victoria Battery. Also that the loco arrived in pieces and had to be put together, presumably at the battery site. It would be called "Ohinemuri".

> The first locomotive ordered in 1896, named Ohinemuri, was a 0-4-0T built by Manning Wardle, Leeds, England (maker's No.1329). It was a typical Manning Wardle type with square saddle tanks and canopy cab. The name was embossed on a brass plate on the tank sides, and the boiler was domeless. Weight was 16 tons, diameter of driving wheels 2'6", and cylinders 9" x 14". Later the wheel arrangement was altered to 0-4-2, and a windshield was added to the rear of the cab.[11]

AUCKLAND STAR, VOLUME XXVIII, ISSUE 249, 27 OCTOBER 1897, PAGE 2

> THE WAIHI COMPANY'S NEW BATTERY AT WAIKINO.
>
> (From Our Own Correspondent.)
>
> The highly important works being carried out by the above Company in connection with their new quartz mill at Waikino are now approaching completion, and it is probable that by the beginning of the new year the battery will be in working order, although many minor details may still require completion at that date. Considering the magnitude of the works undertaken, the impossibility of obtaining a regular supply of material, and the many unforseen difficulties which always crop up, the management have certainly made splendid progress. This can be attributed to the power of gold, directed by the energy and business capacity of the Company's superintendent, Mr H. P. Barry. And here it is only right that mention should be made of the worthy assistance rendered in their various capacities by Messrs Stafford (sub-superintendent), Roche (Superintendent of Works), C. Fraser (who prepared the plans of the battery), and C. E. Cooke (who is superintending the erection of the cyanide vats).
>
> It is impossible to describe otherwise than briefly the various works at this Victoria battery, at it has been named. A splendid locomotive line has been laid from the mine at Waihi to the battery, a distance of six miles, and along this the quartz will be conveyed in steel trucks, side tipping, and holding 1½ tons of ore each. The motive power used at the battery will be obtained from two water races—high and low pressure respectively. The high pressure race, which is conveyed over six miles from Waitekauri, has a fall of 198 feet, and contains 15 sluice heads of water. This race will drive two Peltons, each of 140 horse power. The low pressure race comes from the Ohinemuri river, across which a stone and concrete dam is being erected below the Silverton battery. This race is four feet deep, eight feet wide at the bottom and 12 feet wide at the top; has a fall of 55 feet, and will convey 60 sluice heads of water. It will be utilised for driving two Victor turbines of 200 and 100 horse power respectively, the water supply being divided by branch pipes leading to each turbine. These branch pipes are four feet six inches in diameter, diminishing to three feet six inches, and are fitted with equilibrium valves. Besides

[9] Appendix to the Journals of the House of Representatives, 1897 Session II, C-03 Inspecting Engineer to 31 March, 1897
[10] Appendix to the Journals of the House of Representatives, 1897 Session II, C-03 Inspecting Engineer to 31 March, 1897
[11] The New Zealand Railway Observer. Volume Four, page 81 (June 1947).

this water power, I understand an order has been sent home for a powerful steam engine to be used should the supply of water fail from any cause. One turbine (made by Gilbert Gilkes, Kendal) is in position, and the foundations for the second are well under way. The foundation for the reception of the two Peltons is also completed, and these will shortly be in position. The Peltons are of 140 h.p. each. Both Peltons and turbines are driven by rope pulleys. On the third floor of the battery the electric lighting plant, workshops, etc., will be located, and here also a complete control of the machinery is secured.

An important feature of the mill is that should anything go wrong with the stampers, only 5 stampers need be stopped at a time. Another most important feature, of this mill is the great amount of light and space which is secured.

As regards the treatment, the ore is first conveyed from the locomotive line up an incline tramway and dumped into the kilns, which are six in number, each having a capacity of 500 tons. This incline tramway will be worked automatically by a winding engine. There are two kiln drives, and running along these will be a cable tramway conveying the trucks from the kilns to the ore-breakers and back. The trucks can be switched off at the kilns by means of automatic clips, remain at the kilns till full, then switched on again and back to the ore-breakers, and all automatically. There are two ore-breakers, the first being a No. 5 Gates crusher, which is in position, and below this a No. 3 crusher will be erected at once. The coarse stone from the No. 5 will fall down into the No. 3 breaker, and will be reduced by it to the required fineness. These crushers, together with the cable tram for the trucks, will be worked by a l2 horse-power engine.

From the ore-breakers the quartz is conveyed in trucks by means of another cable tramway to the ore bins erected in the top floor of the battery, and there discharged by means of a pin, which, being placed at whatever bin the ore is required, causes the trucks, which have bottom discharges, to open, discharge into that particular bin, and continue along the tram, righting themselves automatically, and passing out at the other end of the mill; and thence back to the ore-breaker to be again filled. Thus by an ingenious arrangement, devised by Messrs Barry and Fraser, the ore receives absolutely no handling from it leaves the mines till it enters the bins; nor indeed till it is received into the cyanide vats. From the ore bins the quartz is fed by Challenge ore feeders into the stamper boxes.

There are 100 stampers erected ready for work, each weighing 1,000lb, and the whole capable of putting through 120 tons daily. From the stampers the ore is conveyed in the usual way to the tank shed, which is about 150 yards away. This tank shed is a massive structure, 270 feet long by 113 feet wide, and very substantially built. It will contain 10 cyanide vats; each 50 feet long by 40 wide by 4ft 6in deep, and each vat capable of holding 120 tons of ore, or just one days crushing. These vats are of concrete, with an outer layer of cement, being an innovation from the ordinary steel or wooden vats; and are of the most substantial nature. Neither are they circular as is usual. A vast quantity of concrete is being used in their construction, and to expedite the preparation, a cement mixer, driven by a traction engine, has been most ingeniously constructed, capable of mixing from 40 to 50yds of concrete daily. Five vats are completed, with the exception of the cementing, which has just been started. The other five are well in hand, one main wall being completed and part of the cross walls.

This work is being pushed rapidly ahead under the able direction of Mr C. E. Cooke. The only possible defect one can possibly fear with these concrete vats is the danger of leakage, and this is reduced to a minimum; and in my opinion will not occur.

At one end of the tank shed another building is being erected, 85 feet by 65 feet, for the reception of precipitation plant. The assay room, smelting house, and laboratory will also be adjoining the tank shed, and have still to be erected. Other necessary buildings, such as engine

> shed, offices, smithy,- etc., are dotted about, so that when the battery is ready for work quite a little township will exist about there.
>
> From the foregoing a slight idea of the works being carried out by this Company may be gathered, though it is only by an inspection that a thorough grasp of the whole can be gained.[12]

The incline up to the kilns is "worked automatically by a winding engine". How is this done? Three turntables are involved.

There is a continuous cable tramway within the kiln drives "conveying the trucks from the kilns to the ore-breakers and back".

And another continuous cable tramway: "From the ore-breakers the quartz is conveyed in trucks by means of another cable tramway to the ore bins erected in the top floor of the battery, and there discharged by means of a pin, which, being placed at whatever bin the ore is required, causes the trucks, which have bottom discharges, to open, discharge into that particular bin, and continue along the tram, righting themselves automatically, and passing out at the other end of the mill; and thence back to the ore-breaker to be again filled".

"Dry crushing" means that the ore has to get from the kilns to the sand vat house dry. The ore carts are out in the open between the stone breakers and the stampers. How was the ore kept dry?

[12] https://paperspast.natlib.govt.nz/newspapers/AS18971027.2.8.1
Auckland Star, Volume XXVIII, Issue 249, 27 October 1897, Page 2

Dry Crushing Flow Sheet

1897

Roasting kilns

Six kilns were built during 1897. Capacity 500 tons. The kilns covered over by a shed with iron roof. "The fuel used was wood, and the consumption was half a ton (by stack measurement) per ton of ore".[13] An initial 5,000 tons of firewood ordered from Owharoa. Two more kilns will be added in time.

Stone breakers

Two Gates Crushers driven by steam engine, in a building being built at end 1897 (see photographs showing the building under construction, and completed).

Ore was sent to the stone breakers by rail direct from the kiln tunnel. And from the breakers to the stamper building. The elevated portion of this tramway clearly visible in photographs.

Stamps

The stamper building and stamps are nearly complete by end 1897. Stamps will start early 1898.

> The erection of this building has been begun and completed during the year. It is covered throughout of iron, and is a well lighted, roomy, and conveniently arranged building nearly 300 feet in length. The whole of the foundations are of a most solid and substantial nature, a large amount of stone work and concreting having been put in.
>
> The whole 100 head of stamps (in one line) have been erected and all the conveyors, feeders, shafting pulleys and belts have been fixed in position, as also have two exhaust fans with their connections, and two elevators. The fixing of the trough conveyor between the elevators and the lining of ore bins was in hand at the end of the year, as was also the second turbine, the first having been completed as well as one of the two Pelton wheels which are required. Work in connection with the pipe conveyor to the tank shed was also in hand, but had been somewhat delayed owing to the Contractors being behindhand with the delivery of the pipes. The erection of the turbine and dynamo for electric lighting will be finished shortly. [14]

Sand vats

The tank shed and sand vats virtually complete in 1897.

> The erection of this building, over 270 feet long by 114 feet broad, which, with the precipitating room attached, is of iron throughout, has been begun and completed during the present year. It is a very substantial and convenient structure with a double span roof.
>
> The vats, of which there are ten, were in a very forward state at the close of the year, seven having been finished and filled with water, the remaining three being very near completion. These vats, as before stated, are 50 feet by 40 feet with a height of 4½ feet, inside measurements, all built in a most solid manner for permanent work, having a capacity of 150 tons each, so that 1,500 tons can be under treatment at one time. The filter bottoms of the first three had been finished by the end of the year and a start made with the filter cloths, after which the vats are all ready for use. All the necessary pipe connections had been made with the first five vats. [15]

EG Banks describes how they were operated:

[13] Milling and Treatment at the Waihi Mine, New Zealand. By E. G. Banks.
Paper No. 221. Paper presented at the Australasian Institute of Mining Engineers, Thames New Zealand 1911.
[14] Superintendent's Report. Waihi, February 11th, 1898.
[15] Superintendent's Report. Waihi, February 11th, 1898.

At the Victoria mill the crushed ore was conveyed direct to the vats by a system of pipe conveyors. At the Waihi mill the leaching vats were 22.5 ft. diameter and 3.5 ft. deep, constructed of wood, and holding 30 tons each; and at the Victoria mill they were 40 ft. by 50ft. deep, and 4 ft deep, holding 150 tons, and constructed of concrete.

The most suitable depth of ore was 2ft. to 2.5ft., and the solution was run in below the filter cloth until it showed on top of the charge; the remainder of the solution was then run on top. About 1 ton of solution (.35% to .5% KCy) to 3 of ore was used, and was allowed to remain in contact with the ore for 5 to 6 days, being then drawn off by a vacuum pump. Washes of weak sump solution and water were drawn through, and the residue discharged by sluicing through side discharge doors.[16]

The Precipitating Room

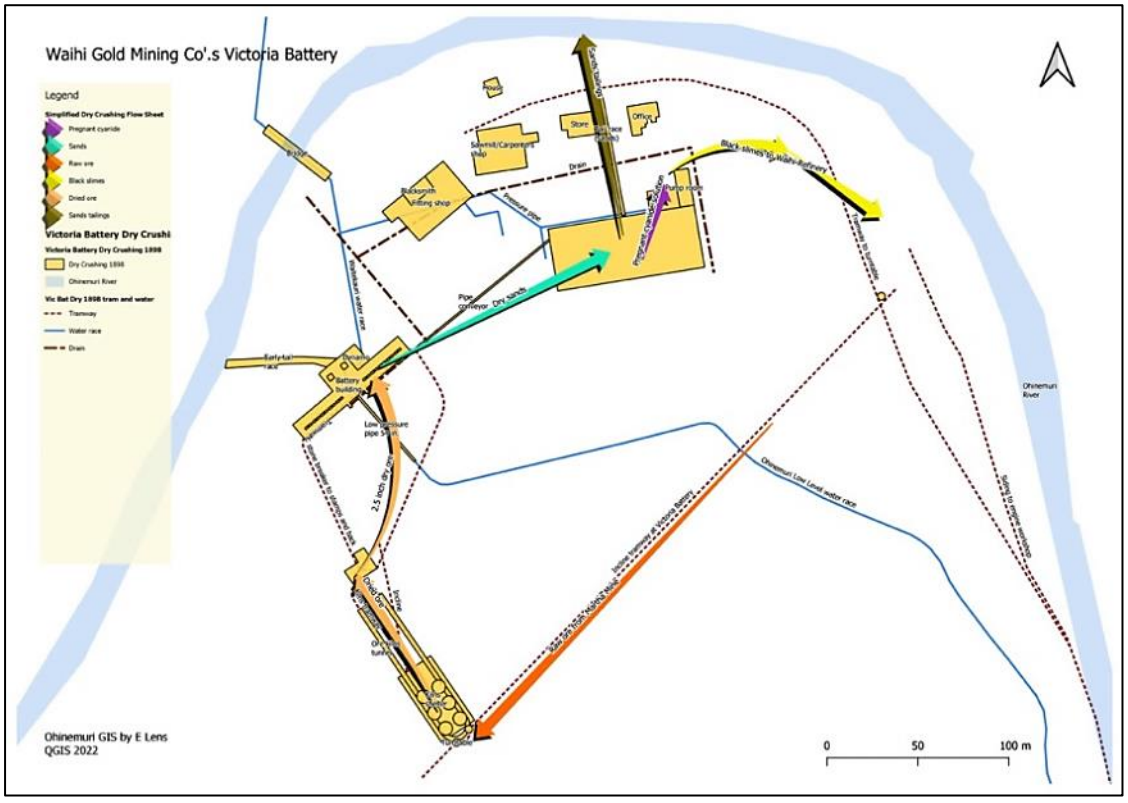
The Precipitating Room was also well in hand and three precipitators put in, as also the two vacuum cylinders, vacuum pump and two solution pumps. [17]

These buildings would be enlarged over time.

Tailings

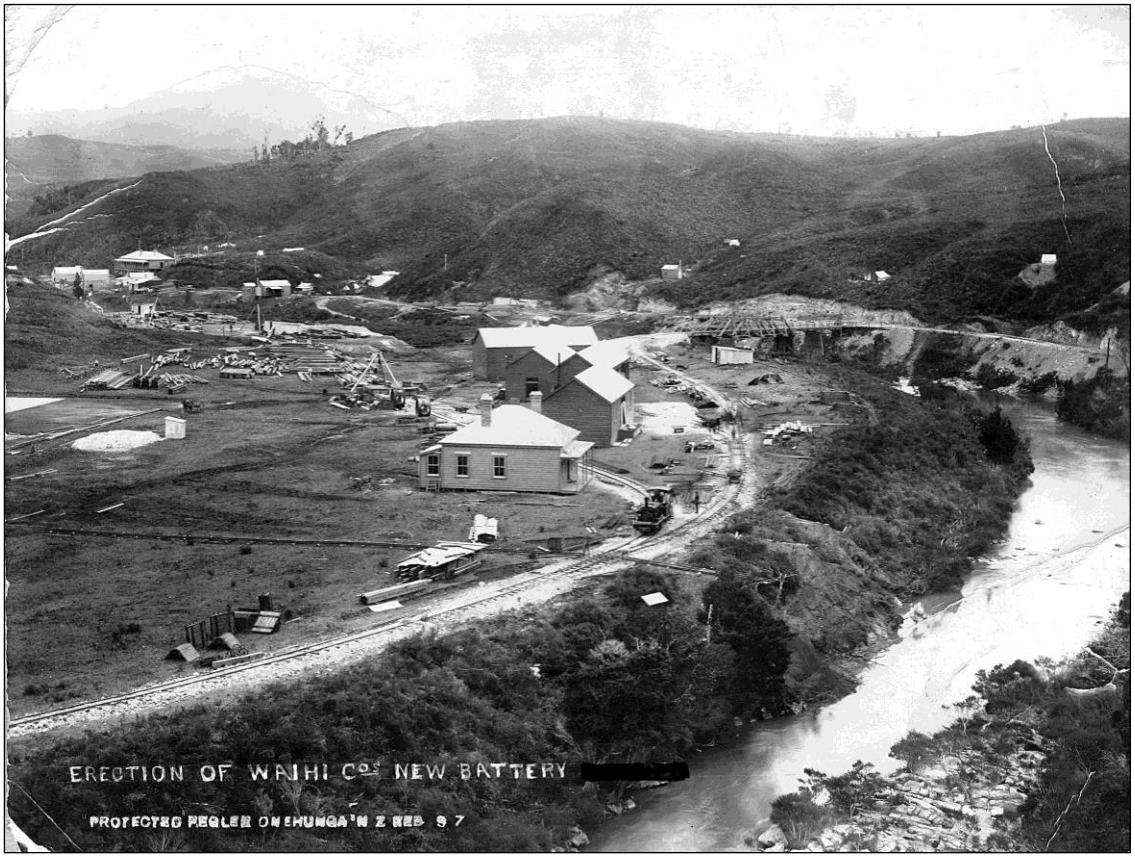
Sluiced to the Ohinemuri River via an in-ground wooden flume.

GIS map showing stylized dry crushing flow sheet



[16] Milling and Treatment at the Waihi Mine, New Zealand. By E. G. Banks.
Paper No. 221. Paper presented at the Australasian Institute of Mining Engineers, Thames New Zealand 1911.
[17] Superintendent's Report. Waihi, February 11th, 1898.

1897 Images in chronological order (maybe).



Perhaps the earliest image of the battery site, at the base of Thorpe's Hill. The buildings already erected are, from front to back, office, store, sawmill / carpenter's shop, and blacksmith / fitting shop. HP Barry's report, quoted by the Inspecting Engineer to 31 March 1897, adds a locomotive shed and dwelling. If the "house" in the centre of this image is the office, and then the dwelling is the house that is seen on the river bank in a later photograph.

At the extreme left of the photograph can be seen part of the concrete floor of the yet to be constructed vat house, and above that in the distance, a hint of the masonry wall for the stamper building. Beyond that, the hotel and other buildings.

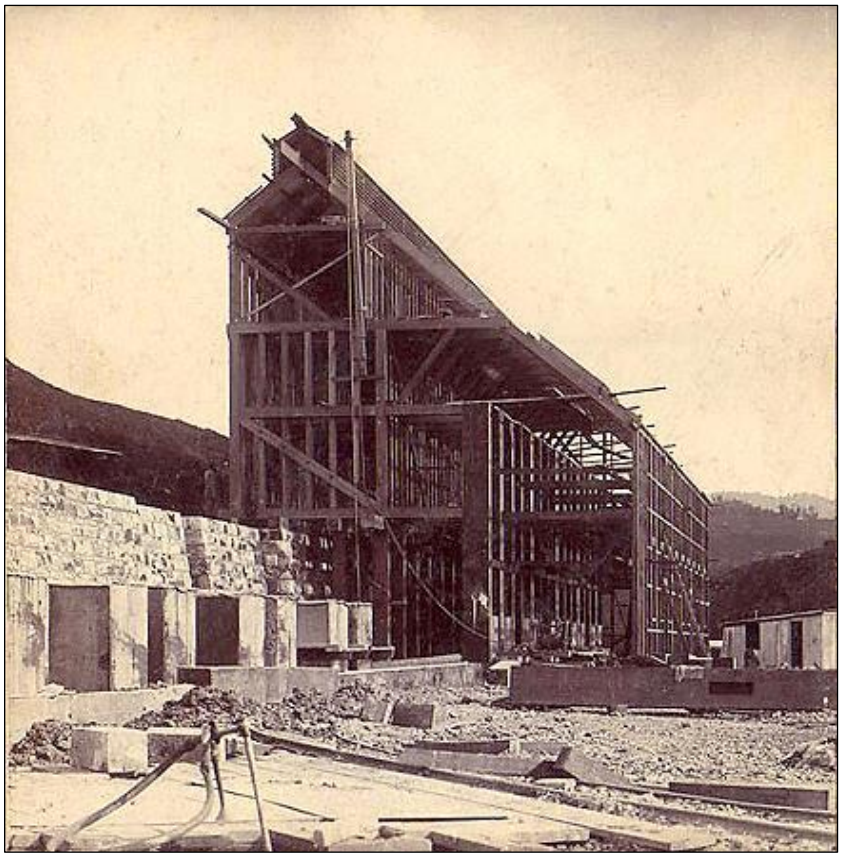
There is a suggestion of a ditch immediately beyond the concrete floor of the vat house which could be for the high pressure pipe to run the pelton wheel which will power the ore conveyors. The ditch angles off toward the bridge, where the high pressure pipe comes on to the site. This matches the alignment shown on the early map (see GIS). Closer to the camera is the hint of another ditch or drain, which also roughly matches the early map.

The strong bridge over the Ohinemuri River is complete. The tramway appears to have been extended to the bridge, to facilitate the movement of materials on to the site. The locomotive will be the company's first, Ohinemuri.

Several workmen, at least two horses, and piles of timber are on site. An interesting tramway, running from left to centre, provides for tipping waste into the river.

Photographer: Pegler, (early) 1897. Original title included the location: Owharoa (it has been blacked out here, but shows on other versions of this photograph).

VBTS collection.



This image shows the western half of the battery building under construction 1897. The masonry wall at left, showing the recessed section we see today. The large blocks in front of the wall are the huge timber foundations for the stamper mortars. A row of king posts show in the building, and one lies on the ground.

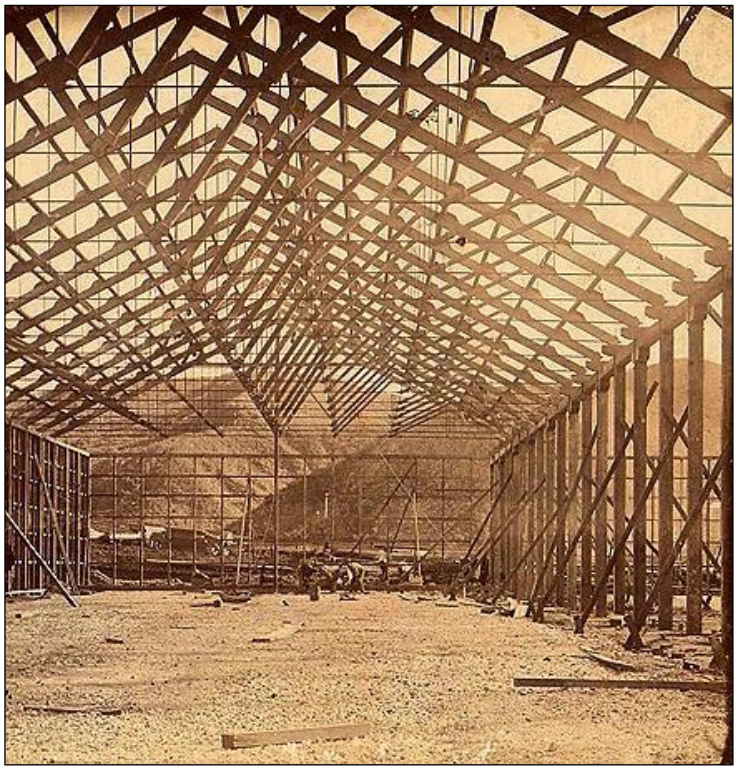
From an article published by Kae Lewis. Photographer unknown and no date recorded.

The Quartz Battery. Waihi Gold Reduction Works, Ohinemuri Gold Fields. Ex. T. F. M. W. W. (Photo #134)

This image, in the western half of the battery building, shows the massive king posts between which the stampers sit. Shafting is being assembled at the man's feet.

From an article published by Kae Lewis. Photographer unknown and no date recorded.

Quartz Battery, Waihi T. E. F. M. W .W. (Photo #123)

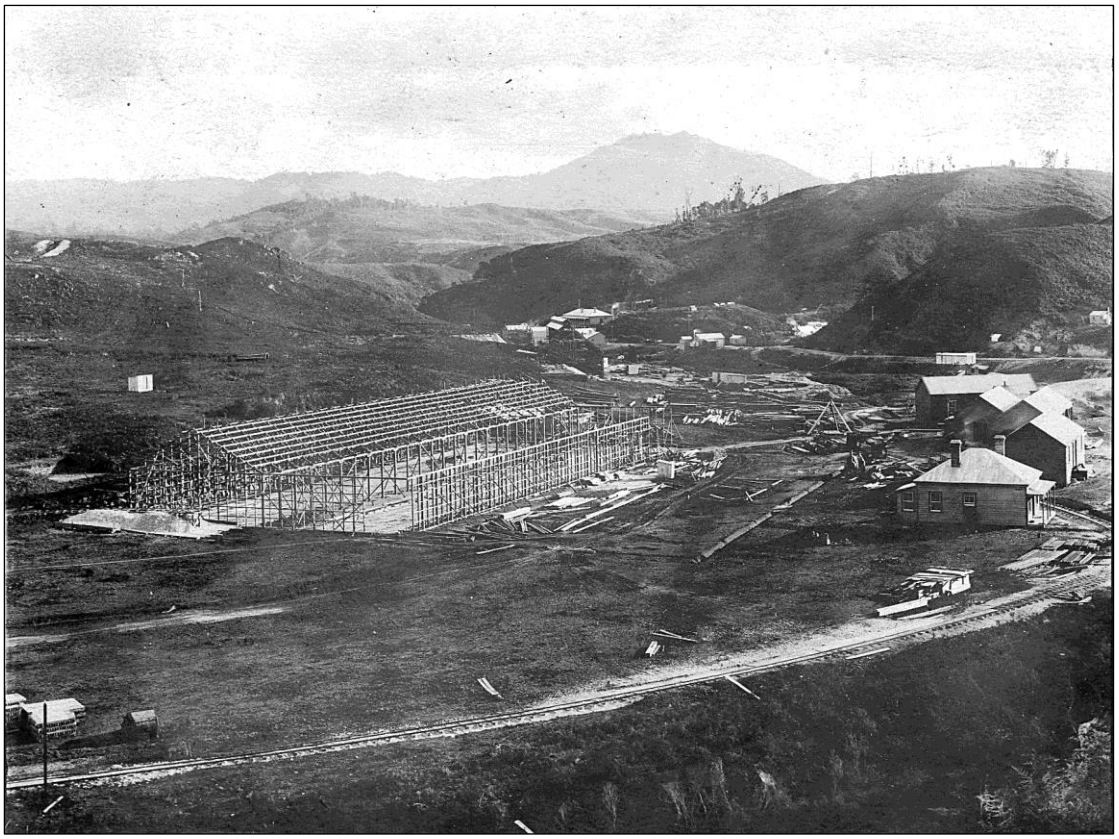


One half of the Vat House under construction, looking west. 1897

From an article published by Kae Lewis. Photographer unknown and no date recorded.

The Cyanide Vat House of the Waihi Gold Reduction Works, Ohinemuri Gold Fields. Expressly taken for Mr Walter Ware.

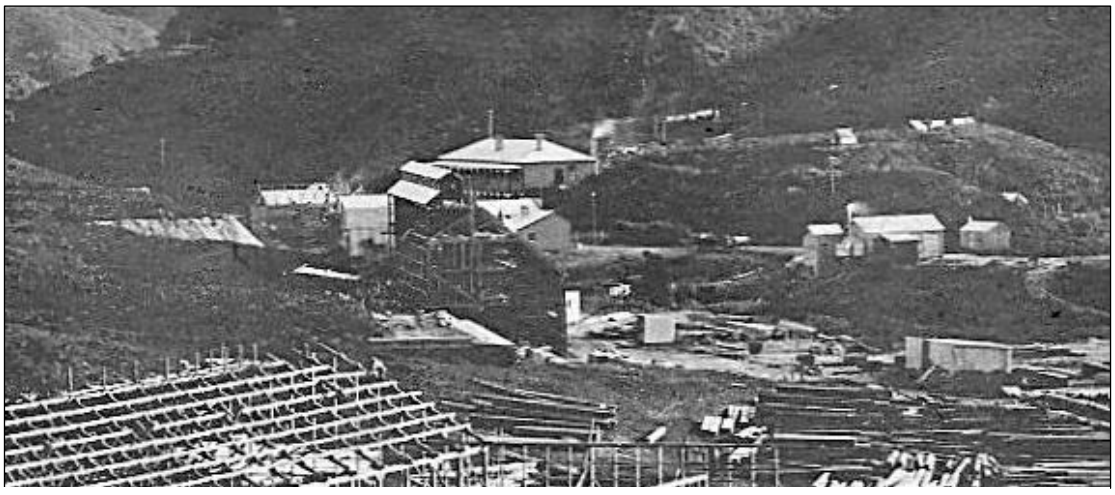
(Photo #143)



The vat shed building under construction, looking west. Early 1897. No kiln roofs yet.

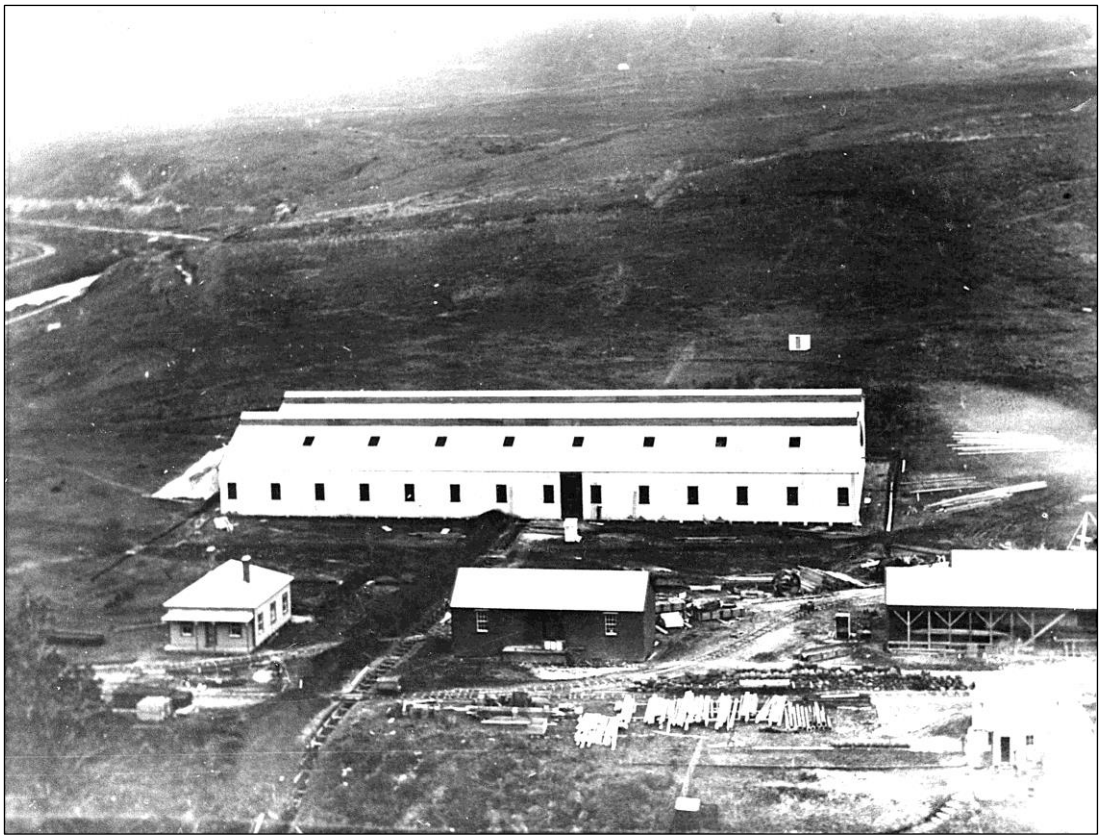
Between the vat shed and the office a very straight ditch/drain is visible. It matches the drain shown on the early map. See GIS. Water pipes and drains were established early.

Photographer possibly HP Barry. VBTS.



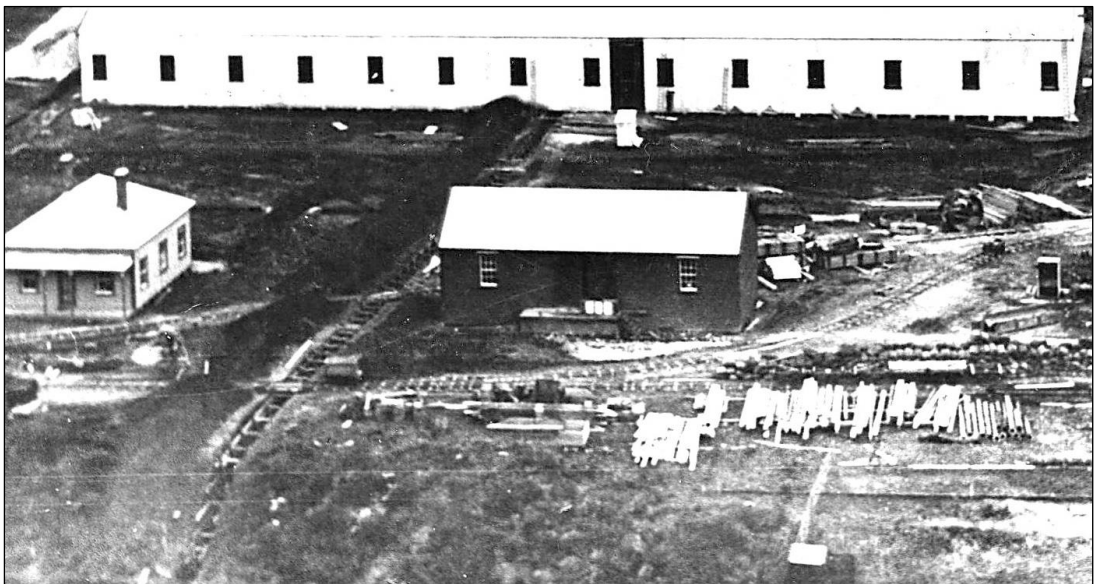
An enlargement from the above image showing the stamper building under construction. The western end is in advance of the eastern, closer, end.

Note also a workman on the roof structure of the vat house.

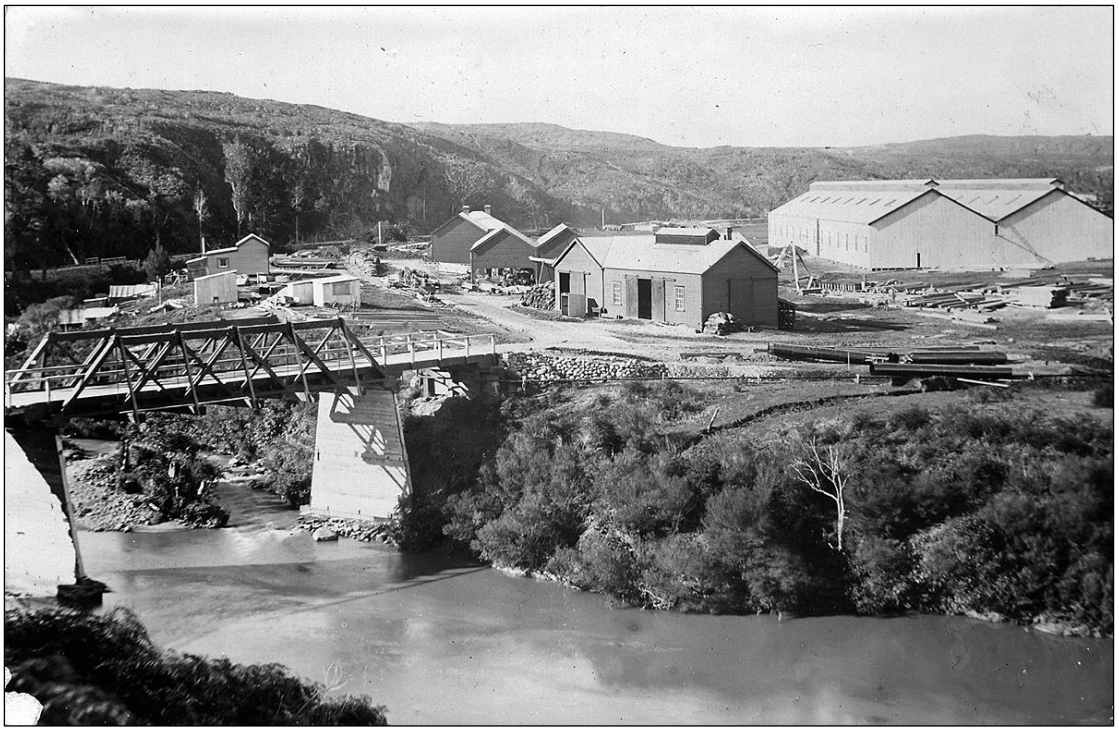


The vat shed building just completed, but as yet without the precipitation room. Mid 1897. We can now see how the tailrace from the vat house was constructed, as an open flume in a ditch, from the centre of the building. It is not visible in subsequent images, so must have been covered after construction, effectively creating a wooden culvert. Was this eventually replaced by a pipe?

Just to the right of the vat shed might be the pipe to feed the pelton wheel which will drive the conveyors. VBTS.



An enlargement from the above image showing the sands trailrace under construction.



The newly constructed vat shed to the right. No elevator additions on the end wall yet, and no precipitation room.

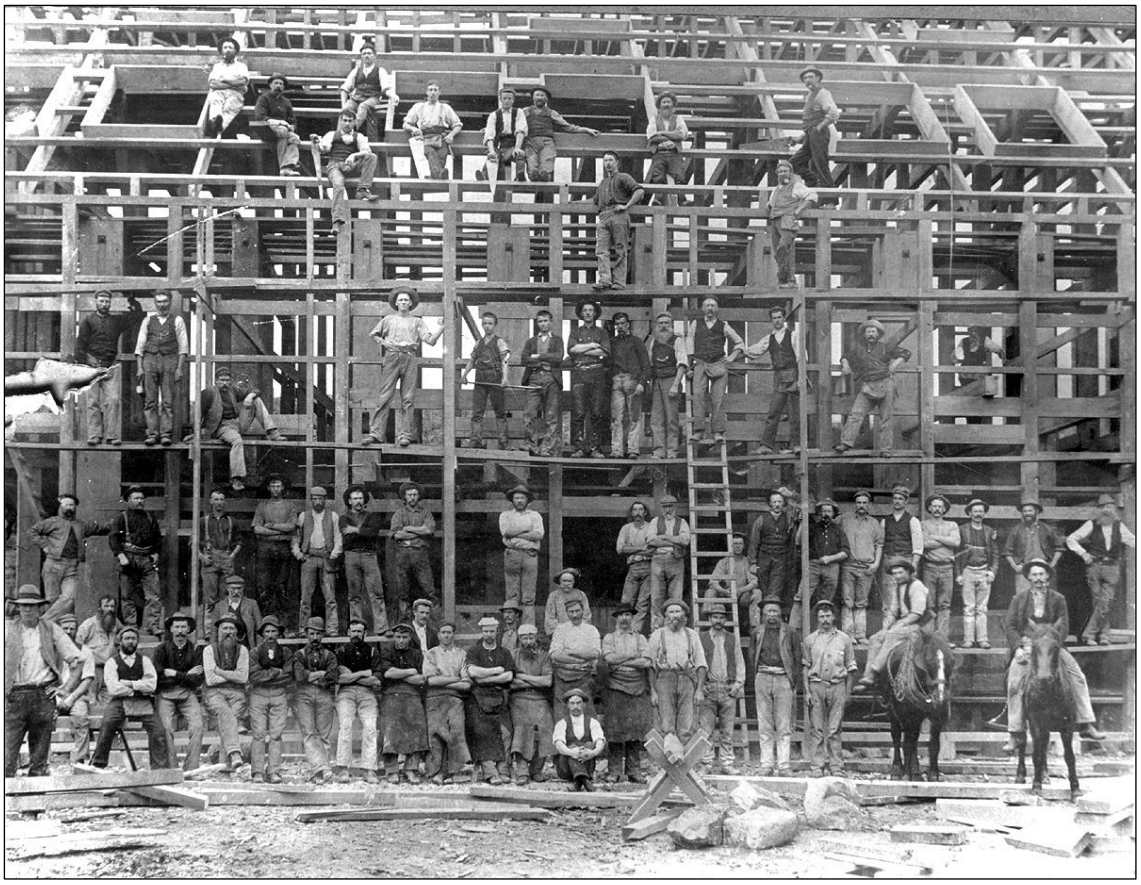
On the riverbank to the right are some large pipes. For the high pressure line to the pelton wheel? A small pipe is already there. Just below the pipes appears to be the ditch outlet for the site drainage network. Slimes tailings will also enter the river at this location after 1907.

The tramway does not extend to the bridge.

Beyond the bridge are the blacksmith/fitting shop, the sawmill, the store, and the office tucked in behind. On the riverbank one dwelling and some sheds and hovels.

The river is muddy. Is the battery already processing, or is the discolouration from Waihi batteries or flood?

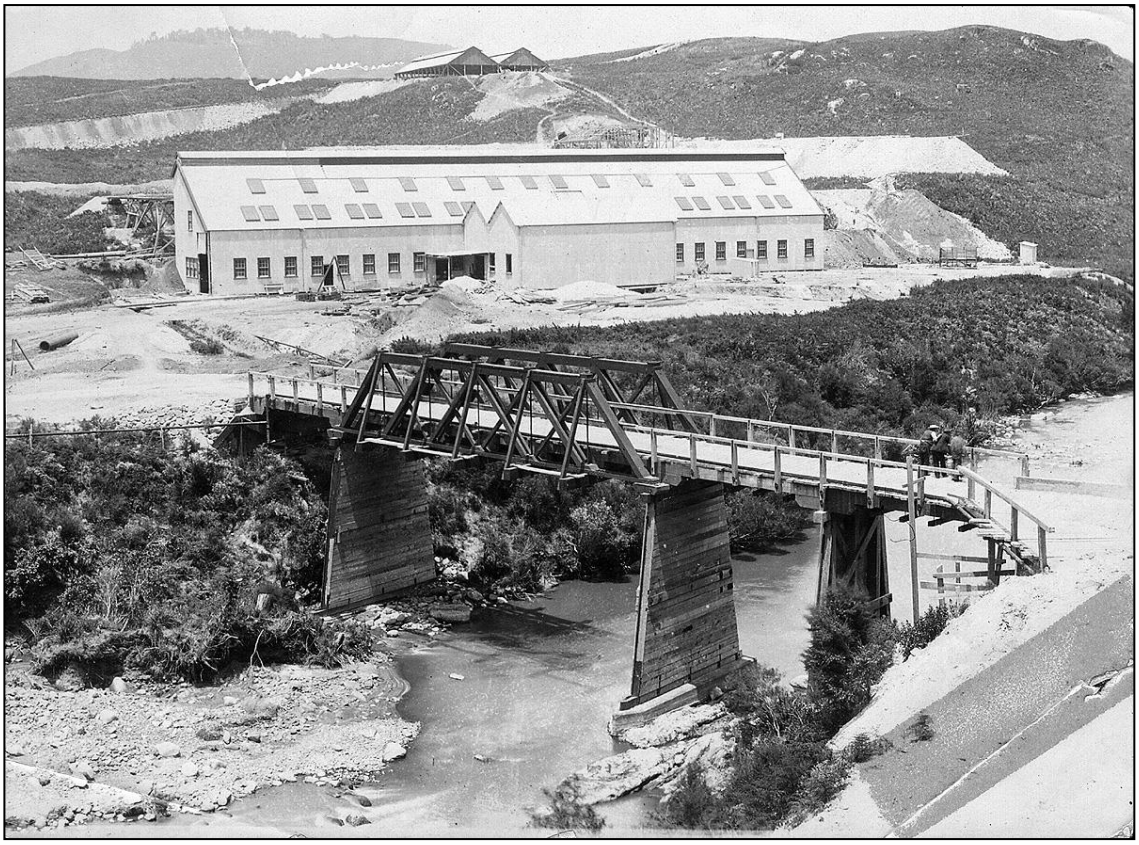
Photographer probably HP Barry. Staples Collection.



The stamper building under construction, looking south. 1897. It is not clear which end of the building this might be; the western end was built first. 69 workmen can be counted. The frames for the skylights can be seen behind the top row of men, and the top of the king posts below their feet.

We can be certain that this image is not the later stamper building because the skylights are grouped in pairs, as seen on the next photograph.

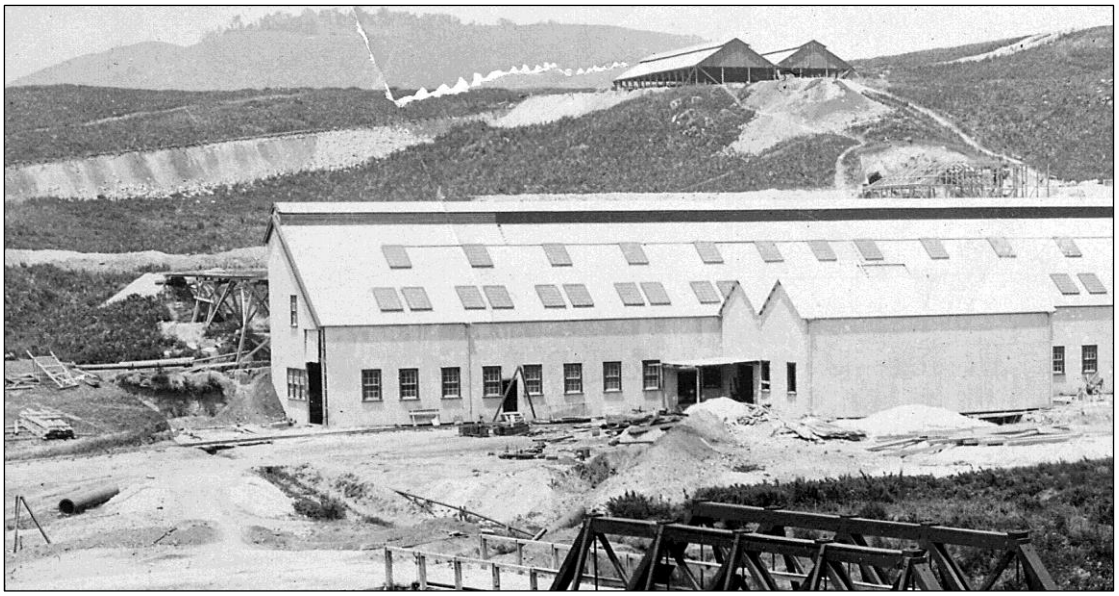
Photographer probably HP Barry. G Capper.



The stamper building completed, looking south. Late 1897. The bottom row of skylights are in pairs. This changes to singles in 1900. Why? To be used in the new battery building?

Note the three people peering over the bridge. More discussion below.

Photographer probably HP Barry. Staples Collection.



A crop from the above image.

The stamper building completed, looking south. Late 1897. The stone breaker building is under construction, visible as framing above the roof of the stamper building. It will have the Tangye engine removed from Waihi Mill to drive the stone-breakers. The kiln roofs are complete, and the incline to bring ore to them can be seen to the left. Below the kilns, what look like walking tracks are evident, and just above the stone breaker building one of the entrances to the kilns tunnel is visible.

To the left of the stamper building the trestle work supporting the ore tramway to the battery hoppers is evident. A second tramway services the other end of the stamper building. It can be seen in a later image.

This is part of a cunning arrangement: "*From the ore-breakers the quartz is conveyed in trucks by means of another cable tramway to the ore bins erected in the top floor of the battery, and there discharged by means of a pin, which, being placed at whatever bin the ore is required, causes the trucks, which have bottom discharges, to open, discharge into that particular bin, and continue along the tram, righting themselves automatically, and passing out at the other end of the mill; and thence back to the ore-breaker to be again filled. Thus by an ingenious arrangement, devised by Messrs Barry and Fraser, the ore receives absolutely no handling from it leaves the mines till it enters the bins; nor indeed till it is received into the cyanide vats. From the ore bins the quartz is fed by Challenge ore feeders into the stamper boxes*." - Auckland Star, Volume XXVIII, Issue 249, 27 October 1897, Page 2

Hints of the pipe conveyor lie on the ground beneath the trestle.

The building in front of the battery building with the double gabled roof sits above the turbines that drive the stampers. Note the small verandah at the left of this building. It is later replaced by a lean-to building. The pelton wheel and dynamo will be situated somewhere here (?).

In the middle foreground is evidence of the trench dug for the high pressure pipe for the pelton wheel which will run the dynamo. This pipe comes to the battery under the bridge. Evidence of the dynamo, pelton wheel and high pressure pipe can be seen today.

Photographer probably HP Barry. Staples Collection.

1898

Superintendent HP Barry, in his Superintendent's Report for the year 1898:

> VICTORIA MILL.
>
> This mill was started at the end of February, the full number of 100 stamps being dropped on 2nd March. Everything worked well without any hitch. After about two months' running, we began to have trouble with breakages of cam shafts; after trying different classes of steel, we find iron shafts the most suitable and will gradually replace the steel ones as they come out.
>
> We have also had some trouble in getting cams and tappets to stand the very heavy wear due to quick running.
>
> The only stoppage of the mill of any importance was caused by a severe flood on 23rd June, which blocked our water races for a couple of days.
>
> The cement vats have given every satisfaction; a very thorough inspection during the Christmas stoppage failed to discover any leaks.
>
> As the crushing capacity of the Mill slightly exceeded our estimate we have had to excavate another kiln, which is now in use.
>
> In order to provide against any possible stoppage to the conveyors owing to breaks on the high pressure race, an auxiliary Pelton wheel is being erected to be driven from the low pressure race. A reserve of 3,470 tons of ore has been formed at Victoria Mill to obviate any possible shortage in the supply to the mill owing to an accident of any kind on the railway from the mine.

Could the concrete structure beside the water race, with suggestion of a pipe, be the penstock for this auxiliary pelton wheel? The wheel could be the possible foundations beside the roadway up the hill, near the concentrates treatment plant. The pipe goes there. Or the wheel at the press house machine mounts (if it is a pelton wheel mount), down on the flat. It is close to the sand vats, and may have been reused when the press house was established.

None of this shows on the old map.

> TREATMENT OF ORE.
>
> The usual treatment has been followed of dry crushing and extraction of the bullion by cyanide solutions, the results obtained being an improvement on last year's work…
>
> Experiments have been carried on continuously with a view to lessen the working costs and increase the output of our plants, by adopting wet crushing. From amongst the vast number of different systems of ore treatment known, it is by no means a simple matter to choose the most suitable. In order to make working tests of the most promising methods a considerable experimental plant has been gradually erected, and different systems have been tried.
>
> We are now crushing about 160 tons of ore a month from our No. 3 and 4 Levels by a system of wet crushing that promises to be a good workable method. After a few months' run we shall have reliable results, and, if satisfactory, we shall be able to get out plans and estimates for the alteration of the whole of the Waihi Mill.
>
> The necessary alterations to the Victoria Mill would then be undertaken after the process had proved satisfactory at the Waihi Mill…
>
> POWER.

> The Tangye engine was removed [from Waihi Mill] to Victoria Mill at the end of last year to drive the stone-breakers…
>
> As there might be a slight shortage of power at the Victoria Mill in the driest season of the year, the engine that formerly drove the pump at No. 1 Shaft has been removed to the mill and a 150 h.p. Babcock & Wilcox boiler is being erected to supply it with steam. During the winter months the low pressure race has developed ample power to drive the whole mill, the high pressure water being used for driving the machine shop, conveyors, and for sluicing out purposes.

This engine is installed at the eastern end of the battery building.

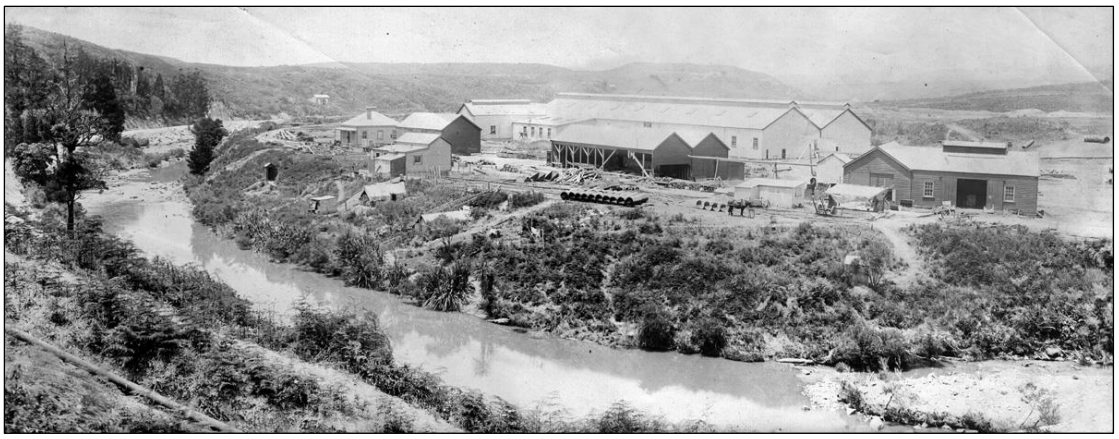
> RAILWAY AND TRAMWAYS.
>
> The main line from the mine to Victoria Mill has been maintained in first-class condition.[18]

[18] Superintendent's Annual Report. Waihi Gold Mining Company, Limited, Waihi, 10th February, 1899

1898 **Dry Crushing, Underway**

1898 Images in chronological order (maybe).

Crushing starts end February, all 100 stamps on 2nd March.

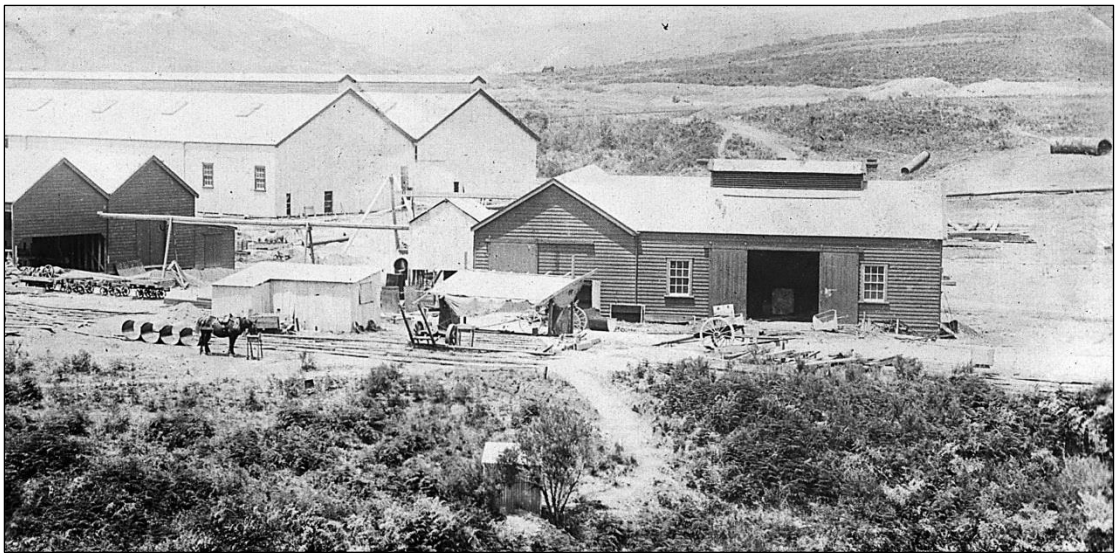


This image is a panorama of two images.

See below for discussion.

Photographer probably HP Barry. Staples Collection.

1898 **Dry Crushing, Underway**



This is a crop of the above image, a panorama of two images.

The building centre right is the blacksmith/fitting shop, hard left is the saw mill/carpenter's shop. The large double gabled building is the vat shed, and note that the end of this building does not show the conveyor between the roofs that appear in subsequent images.

The far right of the image shows the pipe conveyor delivering dry ore (sands) to the vat shed. Top right of the image shows spoil from digging the Ohinemuri water race.

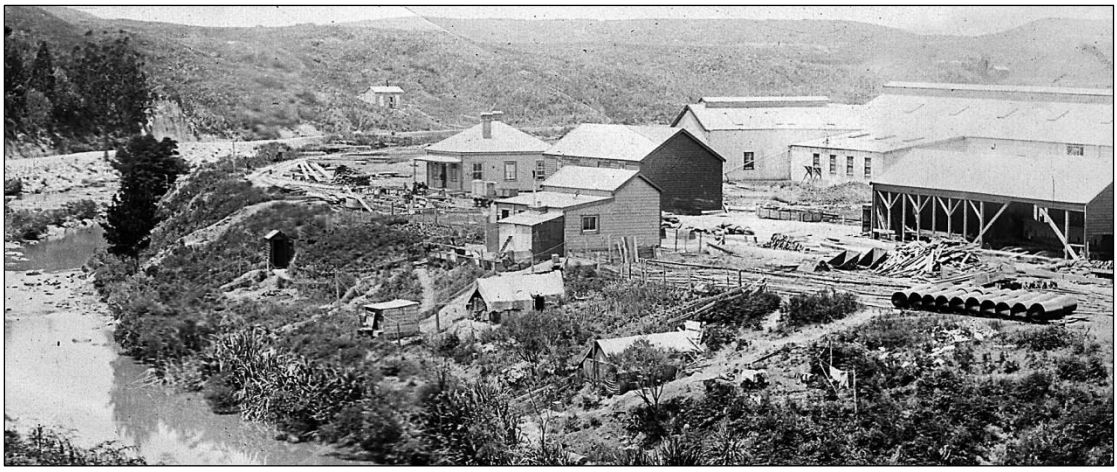
What looks like a filter cloth is drying on a frame in front of the fitting shop.

The horse is saddled, and eating/drinking from basin on a stand. Various horse carts are visible. Rail carts in front of the saw mill.

There is a small building on the river bank, with a well worn path to it.

Photographer probably HP Barry. Staples Collection.

1898 **Dry Crushing, Underway**



This is another crop of the above image, a panorama of two images..

The building right is the saw mill/carpenter's shop. Behind that the vat shed and precipitation room (small, 4 windows) and pump room. To the left of that the Store (dark wall), and then Office.

The house at image centre may be the dwelling referred to by HP Barry in his early 1897 report.

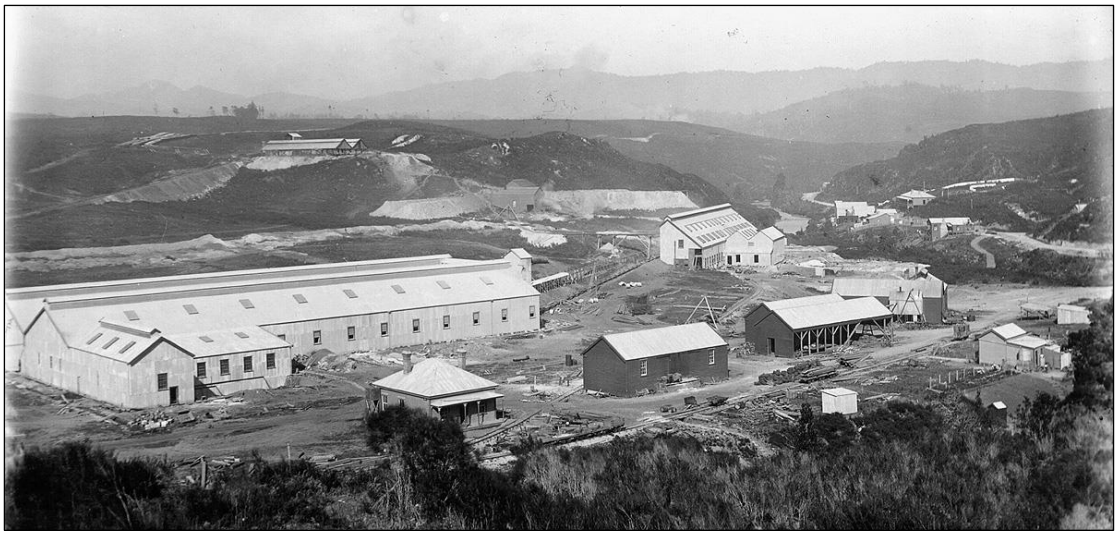
Two small shacks, washing on the line, a long-drop toilet and tracks down to the river's edge.

The road (our SH 2) has been recently widened.

The river appears dirty with tailings. They were discharged fron the sand vats via a covered wooden culvert.

Photographer probably HP Barry. Staples Collection.

1898 **Dry Crushing, Underway**



See cropped image below for discussion.

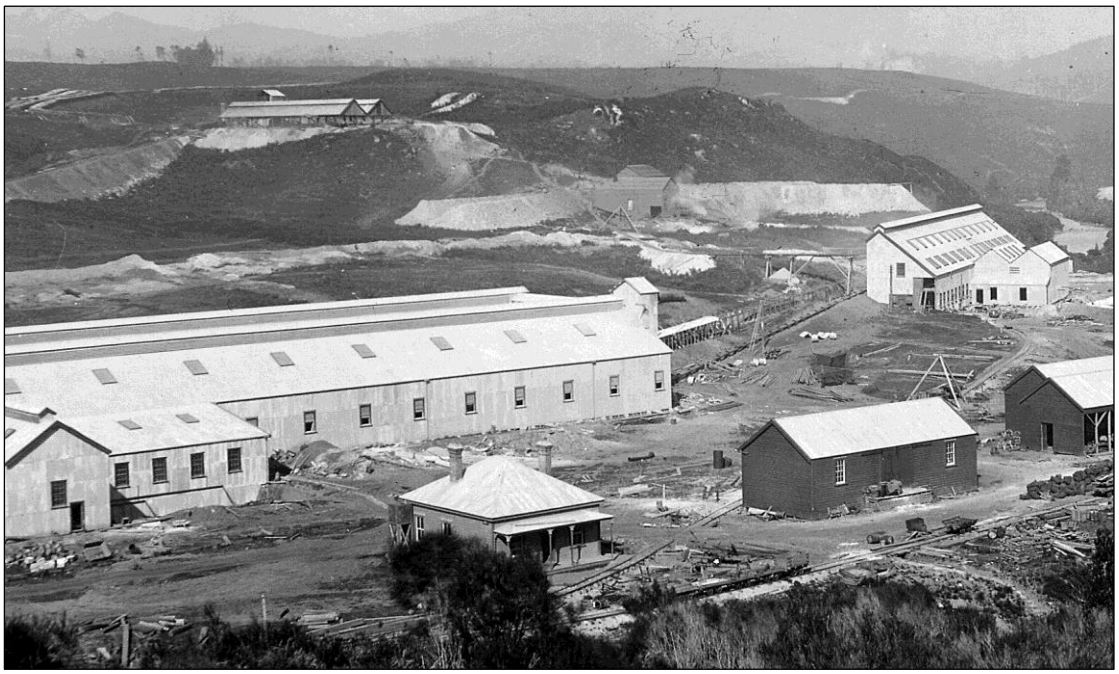
The precipitation building has just four windows, the pump room is to its left.

The dwelling on the riverbank has just a gable and two lean-to roofs.

The rails that extended to the bridge over the Ohinemuri appear to have been lifted now.

Photographer probably HP Barry. D McLeod, M. Roycroft (dated 1898).

1898 Dry Crushing, Underway



This image shortly after the start of crushing March 1898 (it is a crop from a larger version above).

The stone breaker building is now complete, with smoke from the stack and steam issuing from the right hand end of the building. One tramway bringing ore from the breakers to the battery building is on trestles as it nears the battery, and also bridges across the water race. The tramway formation for the other end of the stamper building can be seen above the trestled tramway. A separate tramway to each end of the battery building (see map). To the left of the kiln roofs are stacks of firewood each side of the tramway that brought it from the bush. Above the kilns roofs is visible the shed over the engine (at first a traction engine) and winch which draws the ore carts up the incline. HP Barry, in his 1898 report, mentions an ore stockpile of 3470 tons; this appears behind the ore kilns in later photographs.

The straight topped piles of light coloured material either side of the breaker building are the tip-heads of the material excavated to create the kilns (six of 500 tons capacity at this time).

The large building at left is of course the vat shed, but notice that it now has connection between the two gables, and a taller addition, at its right hand end. This is an elevator/conveyor addition. Between this and the battery building can be seen the rotating pipe conveyor. It is powered by pelton wheel. Parallel to this some other structure, partially roofed, appears to be under construction. Is this a covered belt conveyor designed to replace a probably troublesome pipe conveyor?

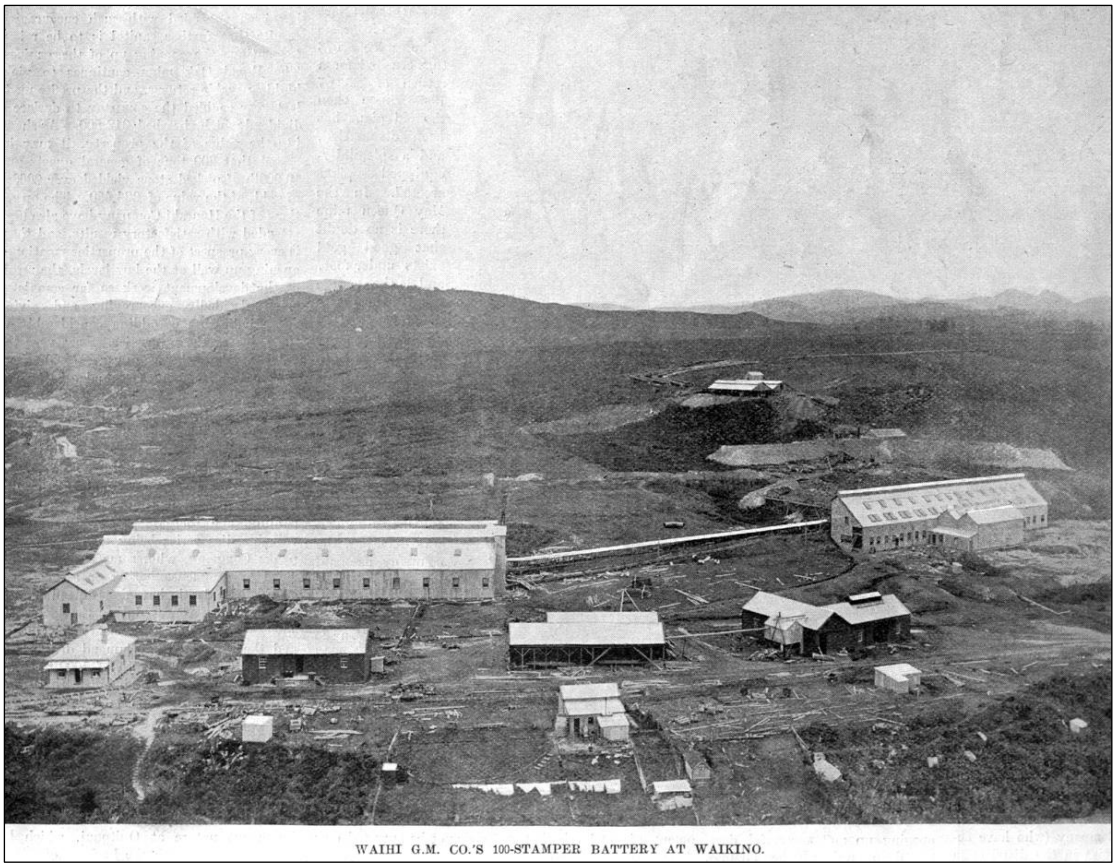
"*The pulp is delivered from the main conveyor to a rubber-belt elevator, discharging into a cross conveyor in the roof at right angles to main axis of the building. This again supplies two conveyors, one in each roof-truss, running the length of the house and central with each row of five vats. These three conveyors are of the same type as the main one connecting battery-shed and vat-house, and driven by the same motor. Over each line of vats is a traveller fitted with traversing gear and hopper*." - Papers and Reports Relating to Minerals and Mining. 1899. Pages 181-182.

The "doorway" in the side of the vat shed has been filled in.

The small verandah on the double gabled turbine/dynamo building has been replaced by a lean-to. Above the lean-to, on the wall, can be seen the bank of electrical insulators, distributing electricity about the site. It can be seen more clearly in later images.

Photographer possibly HP Barry. D McLeod, M. Roycroft.

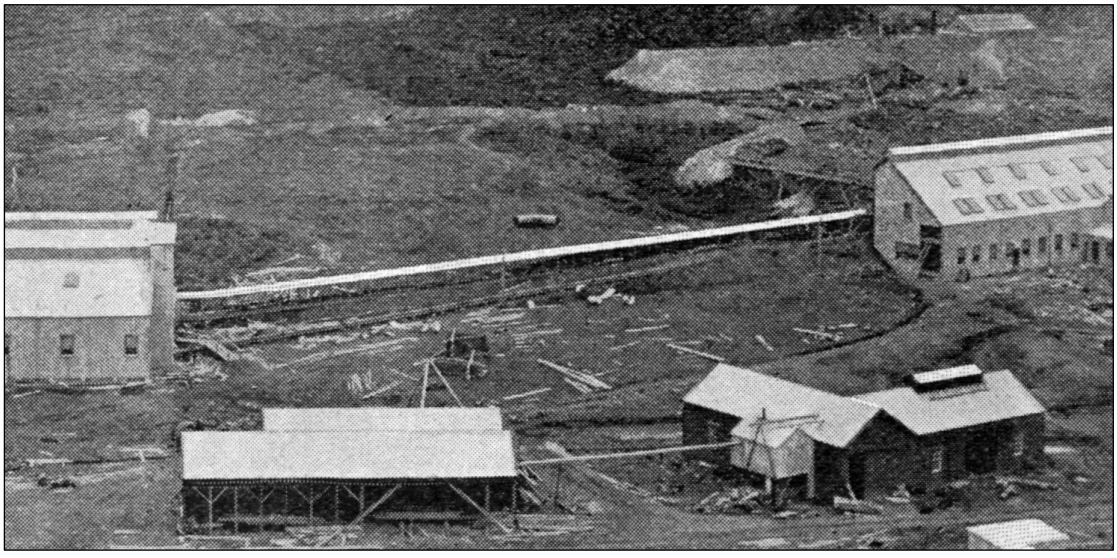
1898 **Dry Crushing, Underway**



WAIHI G.M. CO.'S 100-STAMPER BATTERY AT WAIKINO.

This image from the Auckland Weekly News 1898 is a little later than the previous photograph. The covered way is complete, covering what? It is not mentioned in the literature.

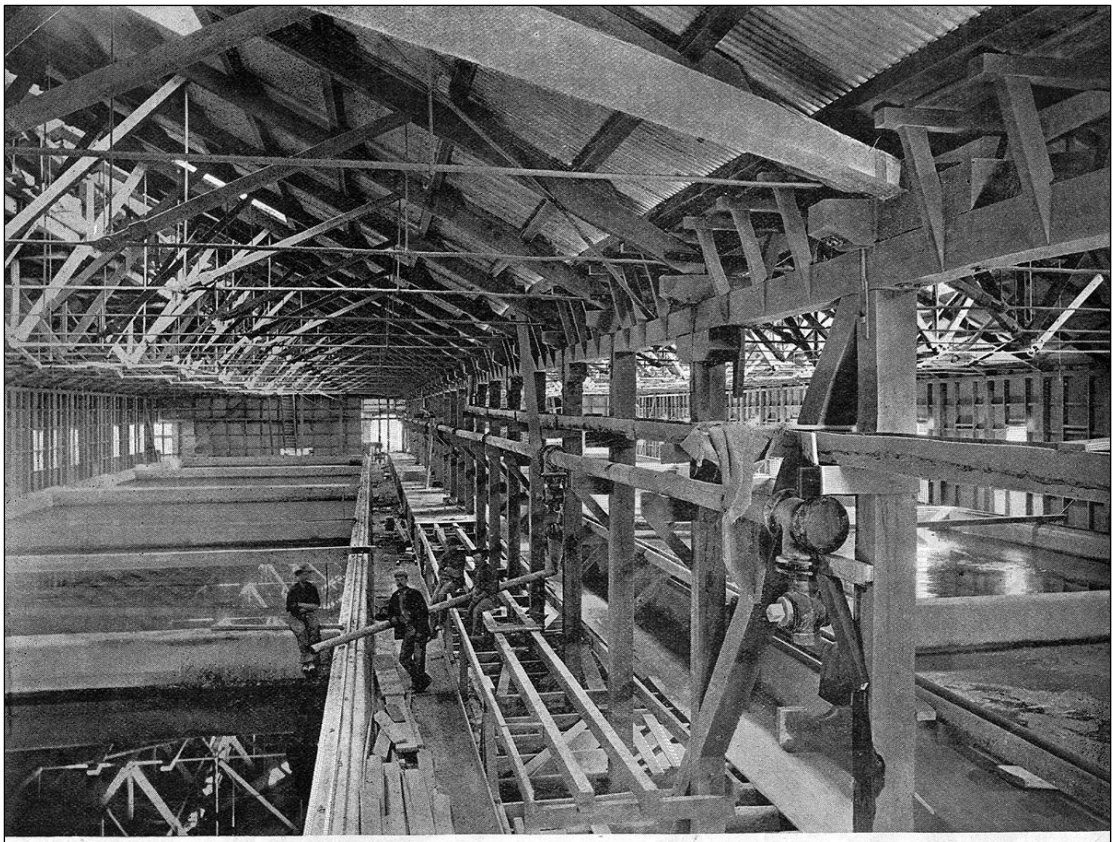
Washing is on the line to dry, and a set of steps on the river bank give access to the tailings discharge point.



Enlarged detail from the image above.

The covered way and pipe conveyor are prominent. A foot bridge gives access over the pipe conveyor at the end of the vat house.

What appears to be a pipe between the saw mill and blacksmith may be a water pipe for the pelton wheel(s)?



ANOTHER VIEW OF WAIHI G.M. CO.'S CYANIDE VATS AT WAIKINO.

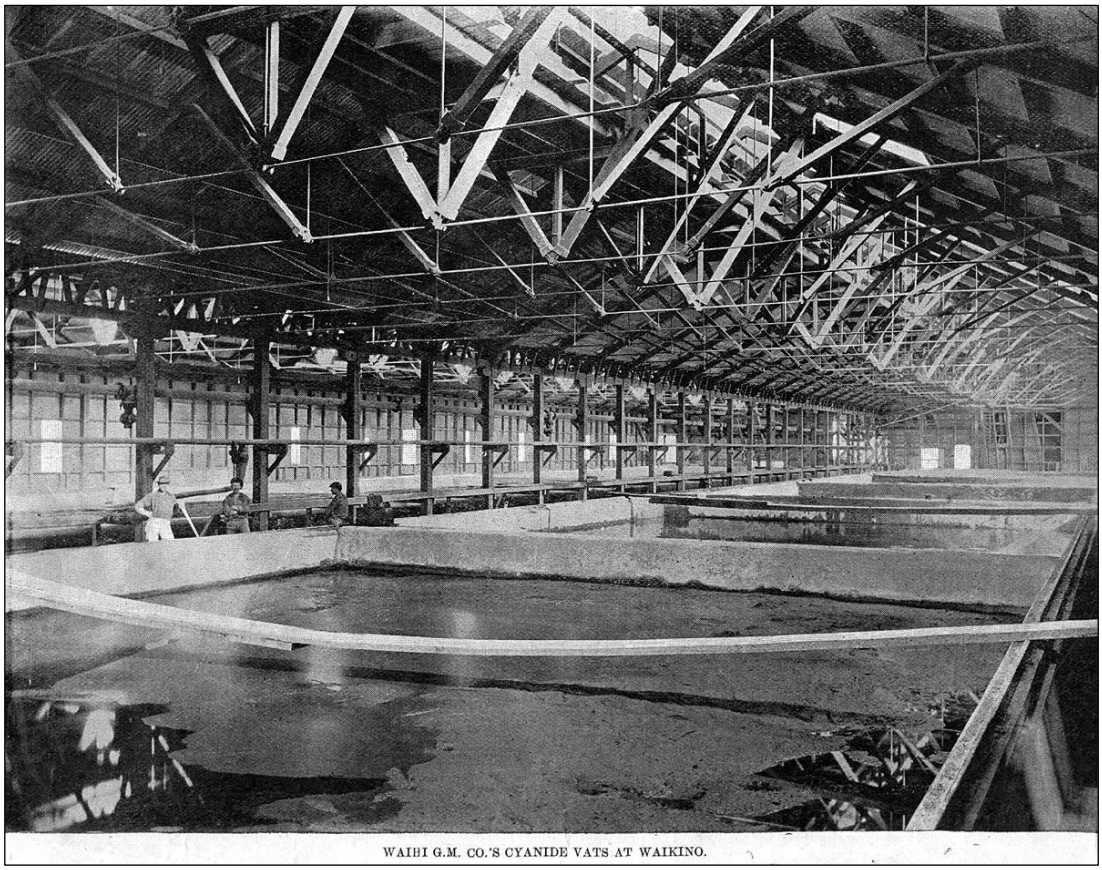
This image from the the same article in the Auckland Weekly News 1898. Although operating, it appears to be still under constructcion. This is the description in Papers and Reports Relating to Minerals and Mining. 1899:

"The vat-house contains ten concrete rectangular vats, five on each side. Each vat is 50 feet by 40 feet, and filled to a depth of 2 feet, contains 150 tons ore, one day's supply. The pulp is delivered from the main conveyor to a rubber-belt elevator, discharging into a cross conveyor in the roof at right angles to main axis of the building. This again supplies two conveyors, one in each roof-truss, running the length of the house and central with each row of five vats. These three conveyors are of the same type as the main one connecting battery-shed and vat-house, and driven by the same motor. Over each line of vats is a traveller fitted with traversing gear and hopper. The pulp spouted down from the overhead conveyor is thus evenly distributed in the vats, and, being gently dropped in, does not pack. The filter-cloth is laid over a wooden-slat grating and caulked down with rope. No storage-hoppers exist, as, owing to ample vat-capacity, the vats themselves fulfil the same object. Down the centre of the house is an alley-way for pipes, floored with cement, drains being provided to catch any leakage" - Papers and Reports Relating to Minerals and Mining. 1899. Pages 181-182.

The pipe visible in the image may be for water or cyanide solution. The conveyor system for the crushed ore (sand) is near the peak of the roof truss, top left of photograph. It is more easily seen in the next photograph.

The traveller is not apparent in either image, but can be seen in a later image (below plus one).

1898 **Dry Crushing, Underway**



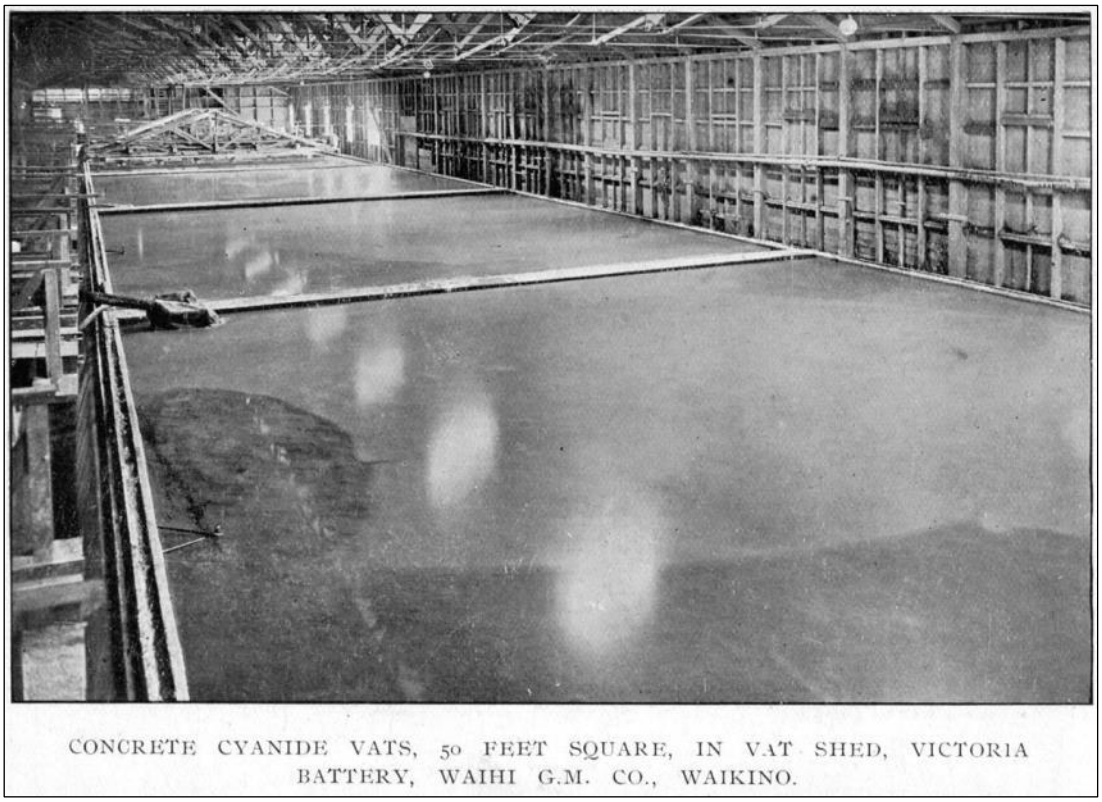
WAIHI G.M. CO.'S CYANIDE VATS AT WAIKINO.

This image from the the same article in the Auckland Weekly News 1898.

The coveyor system for the crushed ore (sand) is near the peak of the roof truss, top of photograph. It is difficult to make out.

The vats showing liquid contain approximately 2ft of sand on top of a filter cloth. The sands are flooded with cyanide solution, or possibly just a final wash of water. Each vat holds 150 tons, one day's crushing at this time (1898).

1898 **Dry Crushing, Underway**



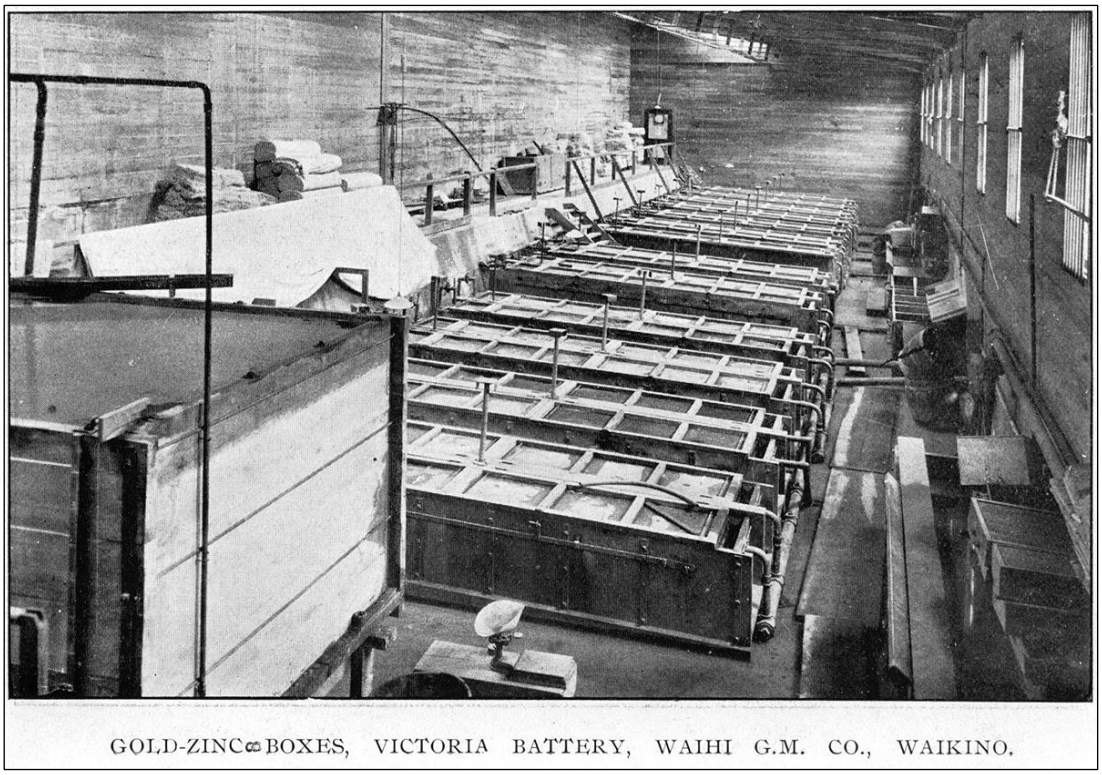
CONCRETE CYANIDE VATS, 50 FEET SQUARE, IN VAT SHED, VICTORIA BATTERY, WAIHI G.M. CO., WAIKINO.

From the album: New Zealand's Northern Goldfields; undated, but c. **1906**.

The traveller can be seen top left of image. It runs on a rail on each side of the vats, seen bottom left.

Note also that a greater depth of sand/solution is now used in the vats; compare with the earlier photographs.

1898 **Dry Crushing, Underway**



GOLD-ZINC BOXES, VICTORIA BATTERY, WAIHI G.M. CO., WAIKINO.

From the album: New Zealand's Northern Goldfields; undated. The same image appears in the Auckland Weekly News: Precipitating Room, Waikino, AWN 7.07.**1904**.

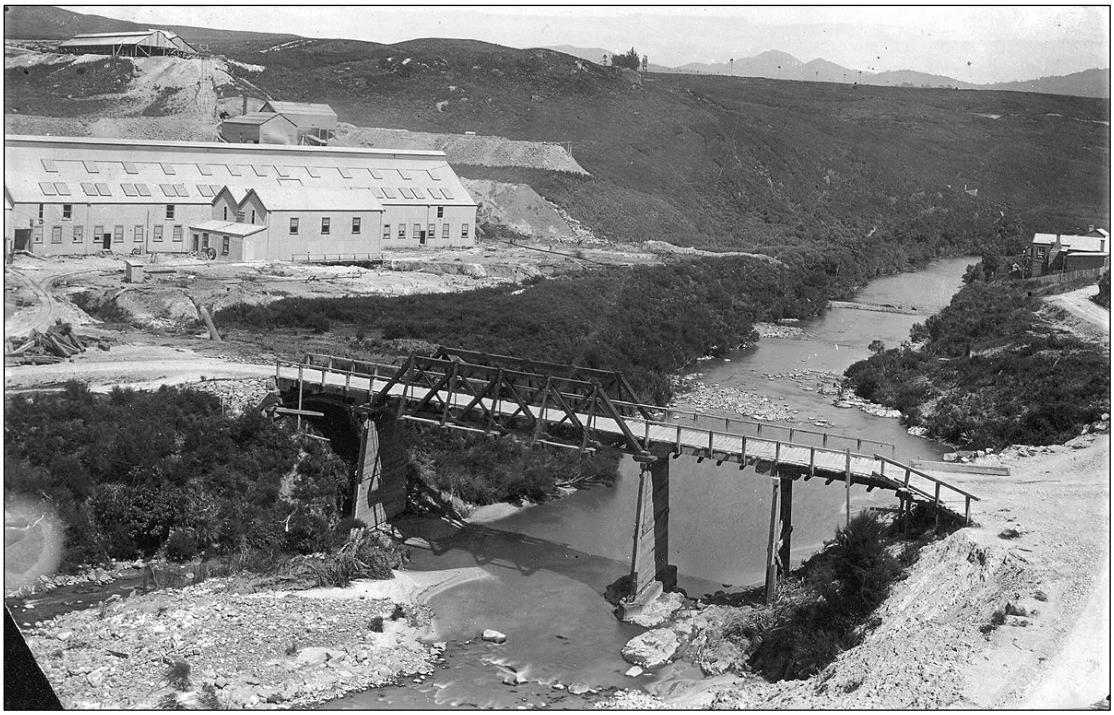
The zinc boxes in the precipitation room, adjacent to the vat shed. Three precipitators were in use at battery start, 13 can be seen in this image, 1904.

“The precipitation room is floored with concrete and surrounded with a concrete wall 18 inches high, so that, in the event of a fire, the gold slime would not escape beyond the room.” - Milling and Treatment at the Waihi Mine, New Zealand. By E. G. Banks. 1911.

Note the bars on the windows at right.

New Zealand's Northern Goldfields and Auckland Weekly News, 1904.

1898 **Dry Crushing, Underway**



Mid to late 1898, maybe 1899.

“This bridge is a strong piece of work, 155 ft. in length, the main truss on trestles built on two concrete piers, the decking of the bridge being 30 ft. above normal level of water, which I think will insure its not being carried away by any flood which we are likely to experience.” – HP Barry quoted by Inspecting Engineer, AJHR for 1897. The truss is a Warren Truss. There is no sign of rails on the bridge deck.

The Ohinemuri upstream from the bridge shows little flow. Most of the water has been redirected to the low level water race, and re-enters the river below the tail race of the turbines some 120m downstream of the bridge.

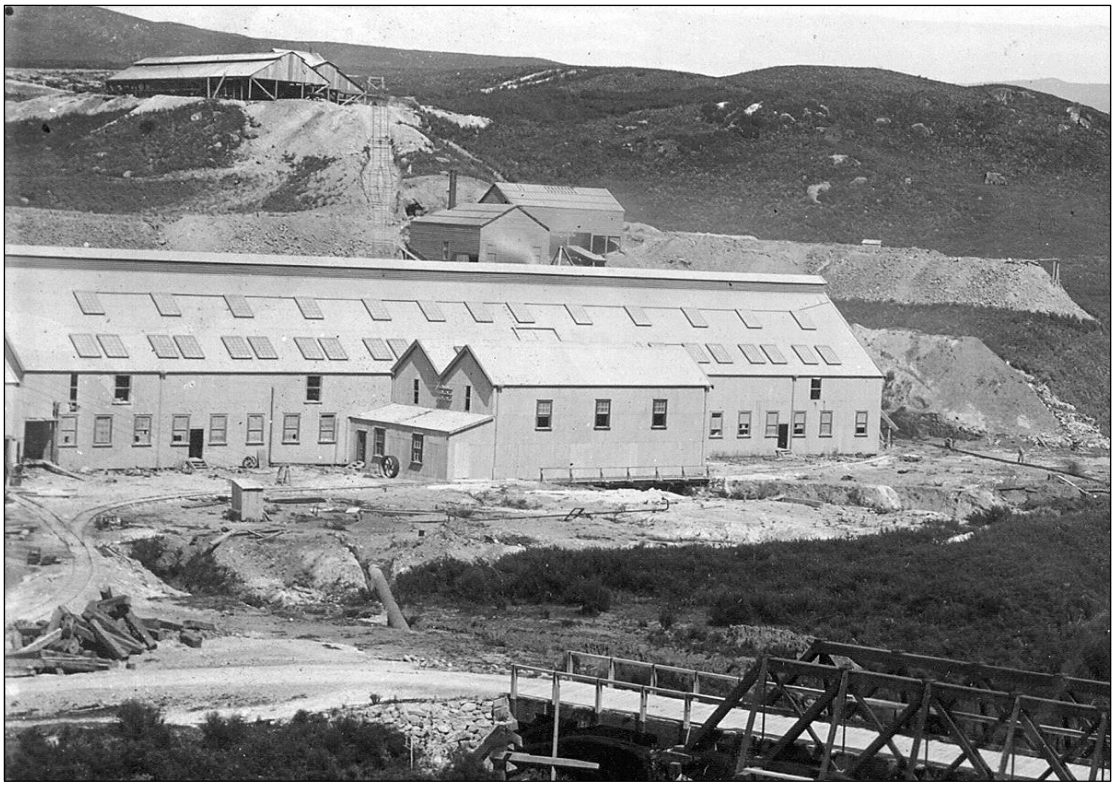
See crop below for more detailed discussion.

As the crushing capacity of the Mill slightly exceeded our estimate we have had to excavate another kiln, which is now in use.” – HP Barry Report for 1898.

Staples Collection.

Right hand image of three Kay Carter Archive VBTS.

1898 **Dry Crushing, Underway**



The left hand roof of the kilns has been extended forward to cover a new kiln excavated during 1898. Another kiln is added in 1899, and the other roof gets brought forward. “As the crushing capacity of the Mill slightly exceeded our estimate we have had to excavate another kiln, which is now in use.” – HP Barry Report for 1898.

Below the kilns a self-acting incline has appeared. There is no mention of it in the literature. As the new kilns are excavated above the working tunnel of the original kilns, the excavated material can not be taken out from the bottom, hence the self acting incline is used to remove the spoil. Maybe. Or, as ore is being stockpiled beyond (to the left) of the kilns, the incline allows for its transport to the wet breakers, whilst the kilns are still providing dried ore.

In the foreground the high pressure pipe is still exposed. Above the lean-to at the turbine house can be seen the bank of electrical insulators to distribute electricity from the pelton wheel (or turbine) powered dynamo. These foundations remain. The roofline of the lean-to will change in subsequent photographs.

One or more workmen are working where soon the extra 100 stamps and boiler/engine house will be built mid 1899.

Staples Collection.

1899

Superintendent HP Barry, in his Superintendent's Report for the year 1899:

> Victoria Mill.—This mill ran for the same time as the Waihi Mill, viz., 305 days 16 hours.
>
> An average of 98.286 stamps out of a total of 100 stamps, were at work full time. The average duty per stamp per diem was 1.815, an improvement of .314 on the previous year, partly due to the fact that the speed of the Mill was increased.
>
> At the commencement of the year the engine which had hitherto been used as a pumping engine at the No. 1 Shaft, was removed and erected at the Mill as an auxiliary to the water-power. A new Babcock and Wilcox Boiler was obtained for this purpose.

This must be the engine and boiler shown in the map at the eastern end of the battery building.

> The Mill ran by water-power exclusively except during eight days at the end of the year, when auxiliary steam-power was required.
>
> Early in October the arrangements for driving the stone-breakers by water-power, instead of steam-power as formerly, were completed, and the steam engine was then stopped.
>
> The cost of fuel for steam power during the year was £217 8s 10d.
>
> An extension to the fitting shop to accommodate a large lathe and other machine tools has been made.
>
> In the Mill, as the dust was at times troublesome, a large exhaust fan was obtained, and the two smaller fans which had previously been in use were erected at the kilns, with the result that the air was considerably more free from dust.
>
> As the amount of ore milled increased considerably, it was necessary to add another kiln with a capacity of 500 tons, making eight in all, with a total capacity of 4,000 tons.
>
> A shed for repairing the rolling stock has also been added.
>
> TREATMENT OF THE ORE.
>
> The process has been practically the same as that employed for the last seven or eight years, viz., dry crushing and extraction of the bullion by cyanide solution…
>
> A series of experiments has been carried out during the year, the results of which have demonstrated that a fair extraction by wet crushing can be obtained.
>
> The process which has finally been selected, is that of wet crushing with water, separation of the sands and slimes by means of spitzkasten, the sands passing to large intermediate vats (where a further separation can be effected by means of annular launders), being trucked thence to the leaching vats, the slimes passing to collecting vats, thence to agitators, and being finally dealt with by means of filter presses.
>
> A separate treatment being advisable for the higher grade heavily mineralised ore, chiefly found in the eastern block on the Martha Reef, this ore after being wet crushed, will be passed over vanners (six of which have been ordered), and a concentrate taken out…
>
> RAILWAYS AND TRAMWAYS.
>
> The main line from the Mine to the Victoria Mill has been maintained in very good condition.
>
> A new locomotive [Victoria], similar to the old one, except that it was provided with a bogie, was obtained and has been in use. The old one has also had a bogie fitted on to it with satisfactory results…

At Waikino the firewood tramway has had short extensions made to it, and the necessary rights from two or three holders of freehold land have been obtained for extending the line in a new direction in which a good supply of firewood and mining timber can be obtained.

This is up the Taieri Stream valley. The Waitawheta Road above the junction with Pukekauri Road follows this tram route for a short distance. The tramway crosses this stream near this junction.

The total quantity of firewood consumed by the Company for the year was 41,281 tons, costing £10,169 15s. 1d., which is equivalent to 4s 11.1d per ton of wood.

During the previous year the total quantity was 36,141 tons, costing £9,255 3s 10d., equivalent to 5s 1.4d. per ton, so that a saving of 2.3d. per ton of wood has been effected.

77,000 tons of firewood in two years.

A special reserve ore paddock has been made at Waikino, and now amounts to over 7,000 tons of quartz. This is outside of the ore in kilns, hoppers, &c., so that in the event of an accident occurring to the railway, there would still be a considerable supply on hand which would allow of time for effecting repairs.

NEW WORKS.

At the end of May your instructions were received to extend the Victoria Mill by at once putting in foundations for a further hundred head of stamps and the necessary treatment plant for wet crushing.

A third locomotive of rather greater steam capacity than the two now in use and 50 more side-tipping trucks were ordered, and the necessary rails for connecting the railway with the stone-breakers [the new wet stone breakers] and for providing a loop line for the trains to pass [at the “half way”?]. Contracts were let for the formation work of the new line. The stamp foundations were immediately taken in hand and completed by the middle of October. They were made very substantially, a very large amount of concrete being put in so as to prevent any possible trouble in the future.

Just previous to these instructions, half-a-million superficial feet of kauri logs were acquired from a neighbouring mine, which proved most useful for carrying out these works.

The existing saw mill at the Victoria Mill was enlarged so as to permit of the timber being cut into the necessary sizes for battery framing, &c.

Some difficulty was experienced in obtaining the necessary mortar blocks 18 feet in length, it being the beginning of winter, and these timbers being difficult to obtain and to get out of the bush in the wet weather.

A new water right for bringing in the Owharoa Falls Creek, distant about a mile from the Mill was obtained, and a contract let for forming the water-race, and a further one for the necessary pressure pipe, 28 inches in diameter and 350 feet long. It is intended to utilise this new power for driving the stone-breakers.

This dam was just a few metres upstream from the present road bridge on the Waitawheta Road. Evidence remains in the stream-bed.

An order was placed for two new stone-breakers, a No. 5 size and a No. 3 size, so that when the old and new plants are at work we shall have two breakers of No. 5 size and two of No. 3.

An order was placed with Messrs. Fraser & Chalmers for the mortar boxes, stems, cam shafts, cam shaft bearings, tappets, pulley centres, heads, shoes and dies.

In all 25 Contracts have been let here in connection with these new works, the chief of which consist of—

(a.) The supply of 5 Iron Intermediate Vats, 38 feet in diam., and 5 Collecting Vats, 32 feet diam.

(b.) The supply of launders for Intermediate Vats.

(c.) „ 2 Steel Sumps, 32 feet diam., and 1 mixing do., 20 feet diam.

(d.) „ 4 Iron Agitators, 20 feet diam.

(e.) „ the Main Line Shafting.

(f) „„ Pulleys, Clutches, Couplings, &c., for ditto.

(g.) „ Guide Plates, Belt Tighteners, &c., for Stamps.

(h.) „ Six Tailing's Pumps.

An order was also placed with Yates & Thom for a 520 H.P. Steam Engine which will be capable of driving the whole mill of 200 stamps by steam.

Three Babcock & Wilcox boilers are also being obtained.

At the present rate the mill building is nearing completion, and the other works are being carried out with the utmost dispatch.[19]

In a New Zealand Herald article about Wilson's Portland Cement Works, it is stated that "The Waihi Gold Mining Company used about 400 tons of Wilson's Portland for the Waikino battery, and are now using it for the new extension." [20]

[19] Superintendent's Annual Report. Waihi, 23rd February, 1900.
[20] https://paperspast.natlib.govt.nz/newspapers/NZH18990812.2.93
New Zealand Herald, Volume XXXVI, Issue 11140, 12 August 1899, Page 7

1899 Images in chronological order (maybe).

1899? Maybe still 1898.

Precipitation house is still small, four windows. The Auckland Weekly News image dated 14.12.1900 shows an enlarged building sporting 11 windows.

Loco shed or shed for repairing the rolling stock can be seen in the distance; built during 1899. This is the earliest photograph to show this building.

In the river, beyond the dying tree on the roadside, a sand bar of tailings are visible (from the vat shed). The dwelling on the riverbank has a simple gable roof and lean-to; actually two lean-tos. An addition to the left of the building appears in 1900.

Unid 019291 ATL.

Left hand image of three Kay Carter Archive VBTS.

1899 **Dry Crushing**

“At the end of May your instructions were received to extend the Victoria Mill by at once putting in foundations for a further hundred head of stamps and the necessary treatment plant for wet crushing.” “The stamp foundations were immediately taken in hand and completed by the middle of October. They were made very substantially, a very large amount of concrete being put in so as to prevent any possible trouble in the future”. Some difficulty was experienced in obtaining the necessary mortar blocks 18 feet in length, it being the beginning of winter, and these timbers being difficult to obtain and to get out of the bush in the wet weather.” – HP Barry, in his Superintendent's Report for the year 1899

“The extension of the Victoria Mill by the erection of 100 head of stamps for wet crushing, which was commenced in May, 1899, was so far concluded as to enable 50 stamps to start towards the end of September, by the 25th of which month the ore bins had been filled with quartz, crushed by the new stone breakers and elevated by means of the hydraulic lifts to the tramway floor over the ore bins.” . – HP Barry, in his Superintendent's Report for the year 1900

This photograph shows the new stamper building, which will house the additional 100 stamps in two rows of 50. Each side of the structure shows the tall kingposts, and the large timber mortar blocks are visible between these posts (left hand side of the structure). These wooden blocks would deteriorate over the years; some would be repaired with concrete, others replaced with concrete. At some later time large cast iron pedestals were placed under the mortar boxes.

This image must be mid October, 1899.

The building behind the new structure is of course the original stamper building.

Photographer possibly HP Barry. S. Elson.

1900

Superintendent HP Barry, in his Superintendent's Report for the year 1900:

> REDUCTION WORKS.
>
> Victoria Mill ... ... 55,732 „ „
>
> Do. ... ... 7,421 „ wet crushing…
>
> VICTORIA MILL.—DRY CRUSHING.
>
> The stonebreakers were driven by water power during the whole year, instead of steam, which was formerly used for the purpose. The engine and boiler have been left in position for use in case of any breakdown to the water power…

This is the stonebreaker building in front of the kilns. The wet crushing stonebreakers are at the back of the new stamper building.

The concrete foundations/sump of (what appears to be) a large pelton wheel remains to the west of the stone breaker building. The water to drive it must surely have come from the new Taieri water race? Barry calls it the Owharoa Falls race, but he says only that that water will be used to run the wet stone breakers.

Maybe it did come from the Waitekauri race.

> No alterations or additions to the plant call for any special mention.
>
> VICTORIA MILL—WET CRUSHING.
>
> The extension of the Victoria Mill by the erection of 100 head of stamps for wet crushing, which was commenced in May, 1899, was so far concluded as to enable 50 stamps to start towards the end of September, by the 25th of which month the ore bins had been filled with quartz, crushed by the new stone breakers and elevated by means of the hydraulic lifts to the tramway floor over the ore bins.
>
> As instructions for the erection of this extension to the Mill were received at the commencement of the wet season of the year, the difficulty and delay in obtaining the necessary heavy timbering, especially the twenty heavy mortar blocks, have already been pointed out.
>
> In order to erect the additions to the Victoria Mill in the most convenient position for economical working we had to put in more extensive foundations than were originally intended, causing some delay to the work.
>
> Other difficulties in obtaining the requisite machinery, much of which was not supplied within the time contracted for, accounts for the time taken to complete the Mill and treatment plant, and it must be borne in mind that the process to be employed was a new departure so far as this Colony is concerned, necessarily occupying more time than a similar extension for the dry crushing process would have entailed.
>
> The stonebreaking department consists of two Gates Crushers, a No. 5 and a No. 3 size, the ore after passing through one after the other is trucked to the hydraulic elevators and raised to the top of the ore bins, into which it is emptied after being weighed.
>
> The Mill (both wet and dry) can be driven by either water power or steam power, a 550 H.P. Yates and Thom engine having been erected for that purpose together with five Babcock and Wilcox boilers.

Twenty head of stamps can be set apart for dealing with the richer mineralised ore in the Mine; six Union Vanners having been erected for that purpose.

A "Wilfley " and a "Dodd" concentrator have been lent us by the makers for experimental purposes…

The stonebreakers were driven by water power brought in by means of a new race.

TREATMENT OF THE ORE.

Dry Crushing.—No change has been made in the dry method of treating the ore, which has prevailed for the past eight or nine years, viz., dry crushing and extraction of the bullion by cyanide solution.

The actual saving was 88.2 per cent. of the gold contents and 52.7 per cent. of the silver contents, or a saving of 84.7 per cent. on the total value contained in the ore…

Wet Crushing.—The process adopted has been, as already explained in last year's Annual Report, wet crushing with water, separation of the sands and slimes by means of spitzkasten, the sands passing to large vats where for the present, and until the dry crushing part of the Victoria Mill is converted to wet crashing, the treatment is completed.

The slimes pass to collecting vats, thence to agitators and are finally dealt with by means of filter presses, three of which of a capacity of 6 tons per charge per press are in use. Some difficulties arose in connection with the treatment of the wet crushed pulp, the two chief of which were: firstly, great difficulty with the tailings pumps employed for elevating the pulp as it flowed from the launders in front of the stamps to the elevated launder whence it flows by gravitation to the treatment vats.

First mention of the large elevated launder visible in many photographs. Pumps are used to elevate the pulp to this launder. Later, elevator wheels will be used.

The Mill was stopped from the 5th to the 9th October for this cause. It was found that the sand had cut deep holes in the clack facings and seatings, stopping the pumps from working. This difficulty was however overcome and has not again arisen.

The second and more permanent difficulty arose in connection with the filter presses. The utmost difficulty in preventing them from leaking was experienced, but by several alterations already carried out, a very great improvement has been made since the close of the year.

A small experimental slimes machine on an entirely different principle was obtained from G. Fraser & Sons of Auckland, and the results are sufficiently satisfactory to justify the purchase of one on a working scale…

It may be further stated that it will be found more economical, even though the cost per ton were to prove the same for the two processes, to employ one process only rather than to have 100 stamps crushing dry and 100 stamps crushing wet, as necessarily where two distinct processes are employed, the works connected with which cover a large area, there cannot possibly be the same economy in wages or materials, but especially in the former, as should otherwise be feasible were only one process in use…

WATER POWER.

The only addition to the race system made was the construction of the Owharoa Falls race, about one mile in length, the water being brought in by means of an open channel until the commencement of the pressure pipe 28 inches in diameter and about 350 feet long. The power from this is used for driving the Stonebreakers for the wet crushing and for supplying the plant with clean water.

RAILWAY AND TRAMWAYS

The main line from the Mine to the Victoria Mill has been maintained in very good condition. During the year a few of the older rails, which showed signs of wear, were replaced by new 401b. steel rails, the old ones being employed on the other tramways…

A loop line to allow of the trains passing one another midway between the termini has been constructed [the "half way"].

Between the double line at this point a coal hopper has been erected so that coaling can be done should any delay occur to one of the trains.

An application was lodged at the Warden's Court for permission to divert and use a small stream for the purpose of feed water for the boilers. This permission has since been granted.

An additional locomotive [Albert] of somewhat increased boiler power and 62 new side tipping "Hudson" iron trucks have been procured, which raises the total rolling stock for conveying ore on the railway to 3 locomotives and 122 side tipping trucks…

The Reserve Ore Paddock at the Victoria Mill has been added to and the total now amounts to 7,964 tons.[21]

AUCKLAND STAR, VOLUME XXXI, ISSUE 33, 8 FEBRUARY 1900, PAGE 2

HOW GOLD IS WON. MARVELLOUS WORKS AT WAIHI. THE NEW BATTERY AT WAIKINO.

A VISIT OF INSPECTION

The vastness of the operations carried on by the Waihi G.M. Company at Waihi and Waikino is not understood by those who have not been privileged to enjoy a close inspection of the enormous amount of work proceeding there from year to year, ever extending, and ever resulting in adding to that magnificent total of the wealth that has been wrested from the inner recess of the earth. This idea was very strongly impressed upon one of the members of our literary staff who recently visited Waikino and was shown over the battery by Mr Sam Fraser, the popular engineer and battery manager.

The first thing that strikes one is perhaps the fearful noise made by the hundred head of stamps pounding away like giant hammers and converting the hardest of quartz into powder fine as dust. On one side of the extensive structure that covers these hundred stampers, extensive additions are being made by quite an army of workmen, labourers, carpenters, iron workers, etc., for an additional hundred stamps now on the ground, and some of them actually in position. The timber is obtained from a sawmill attached to the battery, which is supplied with logs from the adjacent bush and converts these into planking or beams of the dimensions required. There is also on the ground an engineering shop and blacksmiths shop, where a great deal of work is done and all repairs are effected, avoiding serious delays, that would be caused had such work to be obtained from Auckland.

A railway, six miles in length, connects the battery at Waikino with the mine at Waihi, and carries an engine and trucks which deliver at the Victoria Battery over 220 tons a day. This is in addition to about 180 tons per day put through at the Waihi battery, and to provide against any accident at the mine some 7000 tons quartz are kept stored in a paddock at Waikino. A tramway extending into the bush three miles supplies firewood for the roasting of the ore—1200 tons per month being cut by contract. Coal is not used on account of the expense of carting, but when the Waihi-Paeroa railway is completed coal will no doubt be used instead of wood.

[21] Superintendents Annual Report. Waihi, 19th February, 1901.

Water power is obtained from three sources—the largest, equal to about 100 sluice heads, from the Ohinemuri river, has a fall of 55ft; then there is a supply equal to 20 sluice heads from the Waitekauri river, with 200 ft fall; also 20 sluice heads from Owharoa Falls, having 140 feet fall. This keeps the battery going with a full mill in winter, but in summer steam power is extensively used as an auxiliary.

After the quartz arrives from the mine by rail it is drawn up a grade of l in 9 about 160 feet, and emptied into kilns for roasting. There are eight kilns, each of which holds about 500 tons. The kilns are 25ft in diameter and 30ft deep. The manner in which the ore is roasted, is to throw into the kilns a layer of firewood which is ignited, then a layer of quartz, another layer of wood and so on till the kiln is full. There is sufficient sulphur in the ore to materially assist in the burning and the process of roasting occupies about six days. The quartz being baked finds vent through the shoots in the bottom of each kiln, where it is received in trucks attached to an endless steel rope, and is tipped into a Gates' crusher. In this ponderous piece of mechanism the ore is broken into pieces that would pass through a 1½ inch ring, and then it goes on to the mill, where the stampers reduce it to a powder so fine that it would be carried away by a gentle breeze.

The quartz as it leaves the stampers passes through a mesh of 900 holes to the inch into ten concrete vats, each capable of treating 170 tons. The dry stuff goes into these vats, which are charged with cyanide solution, which separates the gold and deposits it in the precipitators.

When the new plant is in working order the whole of this dry crushing will be done away with. The ore, on arriving from the mine, will be crushed with water, and the product will be elevated some 70 feet. Then it will be run with a launder to the treatment shed. About half-way there will be a series of separators for separating the sands from the slimes. The sands will pass into intermediate vats, five in number, with a capacity of 480 tons each. The slimes will pass on to receiving tanks, five in number, with a capacity of 480 tons. From these the slimes will pass into agitators, and the ore will be agitated for a time with cyanide, after which the slimes will be drawn off, passed through three filter presses, each holding 5 tons charges, pressed out and washed into the river. The gold is left on zinc shavings.

It is not anticipated that the Company will derive any money benefit by adopting wet crushing beyond the fact that it will enable them to treat a large quantity of rich ore which has proved refractory under the dry crushing process, but vast benefit will accrue to their employees, the dust pervading the atmosphere with dry crushing being very injurious.

It is expected the new plant, will be started in June or July, and of this hundred stamps 20 will be used for the treatment of the mineralised ore already referred to. It will pass to the stamps over six Union Iron Works concentrators. The concentrates will be sent for further treatment, and the residue will pass on with the other ore for wet treatment. There is already on hand a thousand tons of this refractory ore ready for treatment, and it should add considerably to future returns.

With the new stamps, the Company obtained for Waikino a large 600 h.p. engine with four Babcock boilers, and capable of replacing the water power at any time. There is also a complete electric light installation throughout the works.

The present battery staff is doing the whole of the work in connection with the extension at Waikino. The works are under the efficient supervision of Mr H. P. Barry, general manager, Mr S. Fraser, battery manager and engineer at Waikino, and Mr H. Roche, in charge of the cyanide process. Speaking of cyanide Mr Fraser remarked to our representative that there was an excellent opening in its manufacture for either Hellaby's or the Freezing Company. Cyanide, it appears, is the product of bones, hoofs and offal, material that enters largely into

> the manufacture of artificial manures, and no doubt a Government bonus could be obtained as a special inducement. The Waihi Company consumes five tons of cyanide every month. It is a deadly poison, and every precaution is taken against accident, the recognised antidotes being kept in a prominent place where the cyanide is used. The antidote is applied through the skin by means of a syringe…[22]

New Zealand Herald, Volume XXXVII, Issue 11491, 1 October 1900, Page 6

> THE WAIKINO BATTERY, EARLY START OF CRUSHING.
>
> The new 100-head stamper mill at Waikino is almost completed, and it is anticipated that crushing will be commenced with in the next week or two. The plant is designed for wet crushing, and has been fitted with the most modern appliances for the extraction of gold. Each stamp will crush from two and a-half tons to three tons per day. The weight of the stamp is 1250lb, being about 250lb heavier than those used in the other mill.
>
> Of the 100 stamps, 20 are to be reserved for crushing the heavily-mineralised ore, which, will be treated separately. Before leaving the stamps this class of ore will be passed over copper plates, from which it will be passed over a small plant of 6ft vanners where the sulphides will be separated, to undergo special treatment.
>
> With regard to the ordinary crushing each mortar box, or set of five stamps, is supplied with a 2in water pipe, the water and quartz being run into boxes simultaneously, and splashed through a 40in mesh, in the form of pulp. A gravitating chute in front of the boxes, continuing along the whole line of stamps, conveys the pulp along to a cistern, where four plunger pumps carry it to a height of 70ft through an 8in pipe, or rising main, into a launder, or chute, in the top of a trestle, which conveys the pulped ore to the cyanide plant.
>
> Every provision has been made for continuous crushing throughout the dry season by a splendidly-equipped auxiliary steam plant, so that the 200 head of stamps will be always kept running.
>
> When the new mill is thoroughly started, the Waihi Company will have 290 head of stampers operating, viz., 200 at Waikino and 90 at Waihi.[23]

A descriptive article on Waihi is also worth a look.[24]

In 1899 an engine and boiler were erected at the mill as auxiliary to water power. This can be seen at the left hand end of the battery building in photographs after this time.

Another kiln was added, making eight in total. Thus the right hand kiln roof is extended forward, to match the change in 1898.

1899 a new locomotive is procured; Victoria. 7000 tons of ore now paddocked above the kilns.

By end of year new battery building complete, the Taieri Stream water race under construction, and the large Yates & Thom 520 H.P. steam engine on order.

During 1900:

The dry crushing stonebreaker is driven by water power (not from the Taieri race? but from?).

The Taieri water race: “Owharoa Falls race, about one mile in length, the water being brought in by means of an open channel until the commencement of the pressure pipe 28 inches in diameter and

[22] https://paperspast.natlib.govt.nz/newspapers/AS19000208.2.7
Auckland Star, Volume XXXI, Issue 33, 8 February 1900, Page 2
[23] https://paperspast.natlib.govt.nz/newspapers/NZH19001001.2.60
New Zealand Herald, Volume XXXVII, Issue 11491, 1 October 1900, Page 6
[24] https://paperspast.natlib.govt.nz/newspapers/AS19000428.2.67.17
Auckland Star, Volume XXXI, Issue 100, 28 April 1900, Page 3 (Supplement)

about 350 feet long. The power from this is used for driving the Stonebreakers for the wet crushing and for supplying the plant with clean water." HP Barry[25]

50 stamps in the new building commence crushing wet by end September 1899.

The wet stonebreaker operational with two Gates Crushers, a No. 5 and a No. 3 size., powered by the Taieri water race. The ore is then trucked to the hydraulic elevators and raised to the top of the ore bins above the stampers.

A 550 H.P. Yates and Thom engine is erected together with five Babcock and Wilcox boilers. All stamps can now be driven by either water power or steam.

A substantial elevated launder becomes a prominent feature in photographs.

The wet process: "wet crushing with water, separation of the sands and slimes by means of spitzkasten, the sands passing to large vats where for the present, and until the dry crushing part of the Victoria Mill is converted to wet crushing, the treatment is completed".

The wet sands do not go to the vats in the vat shed; later, yes. At this stage they are processed in (circular) vats. These become the "intermediate vats"?

"The slimes pass to collecting vats, thence to agitators and are finally dealt with by means of filter presses, three of which of a capacity of 6 tons per charge per press are in use." "Tailings pumps employed for elevating the pulp as it flowed from the launders in front of the stamps to the elevated launder whence it flows by gravitation to the treatment vats. Six Union vanners in use." – HP Barry[26]

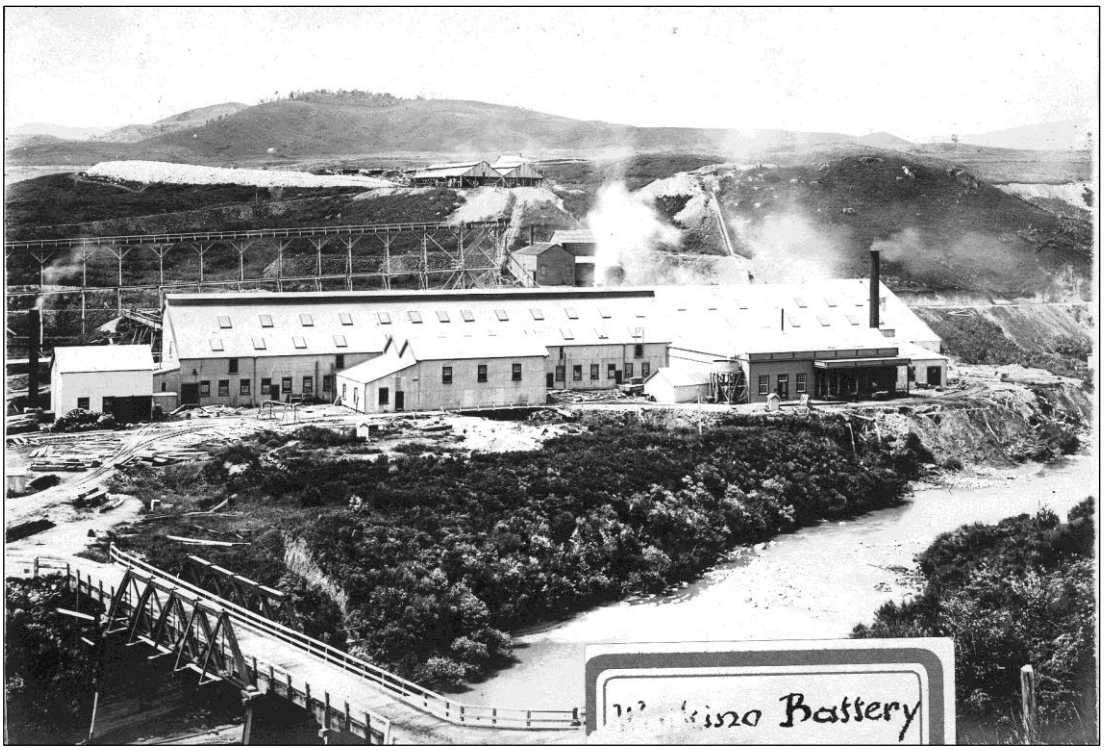
An additional locomotive: Albert.

Most of this will be visible on the next set of photographs.

[25] Superintendents Annual Report. Waihi, 19th February, 1901.
[26] Superintendents Annual Report. Waihi, 19th February, 1901.

1900 or 1901 Images in chronological order (maybe).

There is a gap in the chronology of images; we jump to this photograph.



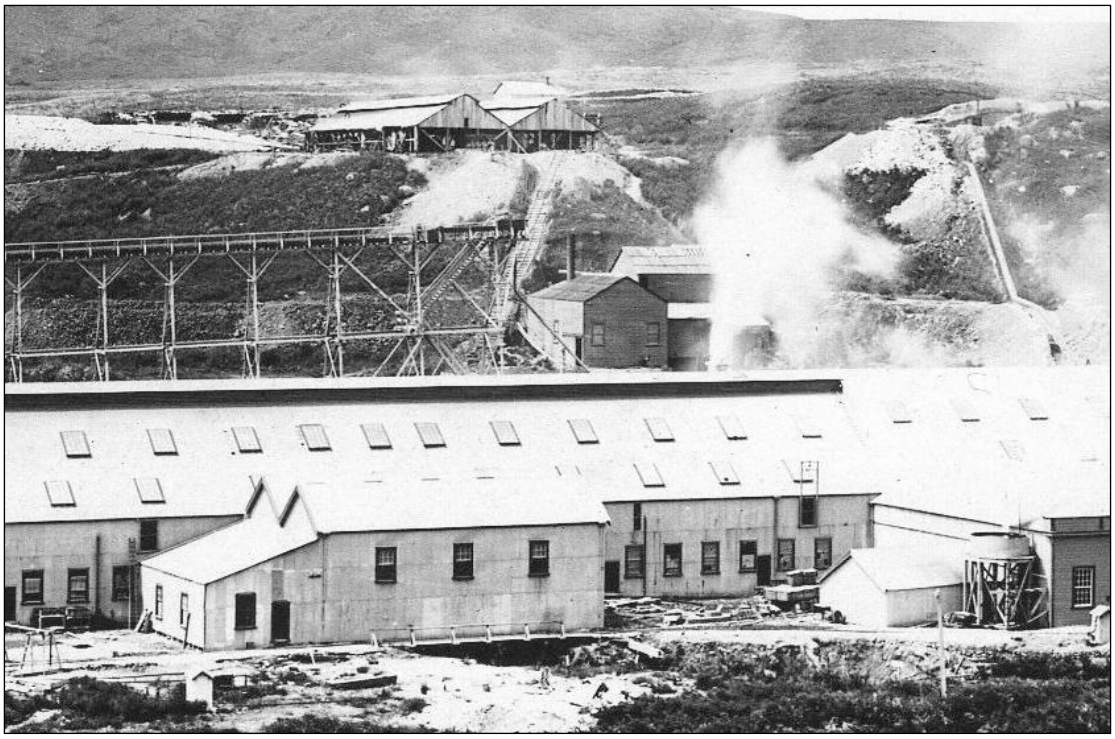
A good view of the large ore stockpile beyond the kilns.

The kiln roofs have both extensions; ie eight kilns. The elevated launder is prominent. The wet pulp is pumped up to this, and then flows in the launder by gravity.

Both boilers at the battery building are fired up. The river looks low; are they short on water power?

In front of the new wet crushing stamps are the engine and boilers. The ore elevator structure has not yet been added to the right hand end of the battery building.

VBTS



This image a crop from the photograph above. A good view of the kiln roofs, self-acting incline, elevated launder and dry crushing stonebreaker buildings.

Between the battery roof and the right hand end of the elevated launder is an angled then vertical pipe. Does it deliver the pulp from the wet stamps to the launder? Later a double lift elevator wheel will do this, 1903.

Prominent is a plume of steam or smoke or dust fom the dry stampers.

VBTS

This photograph was printed backwards, and called Waikino and Battery.

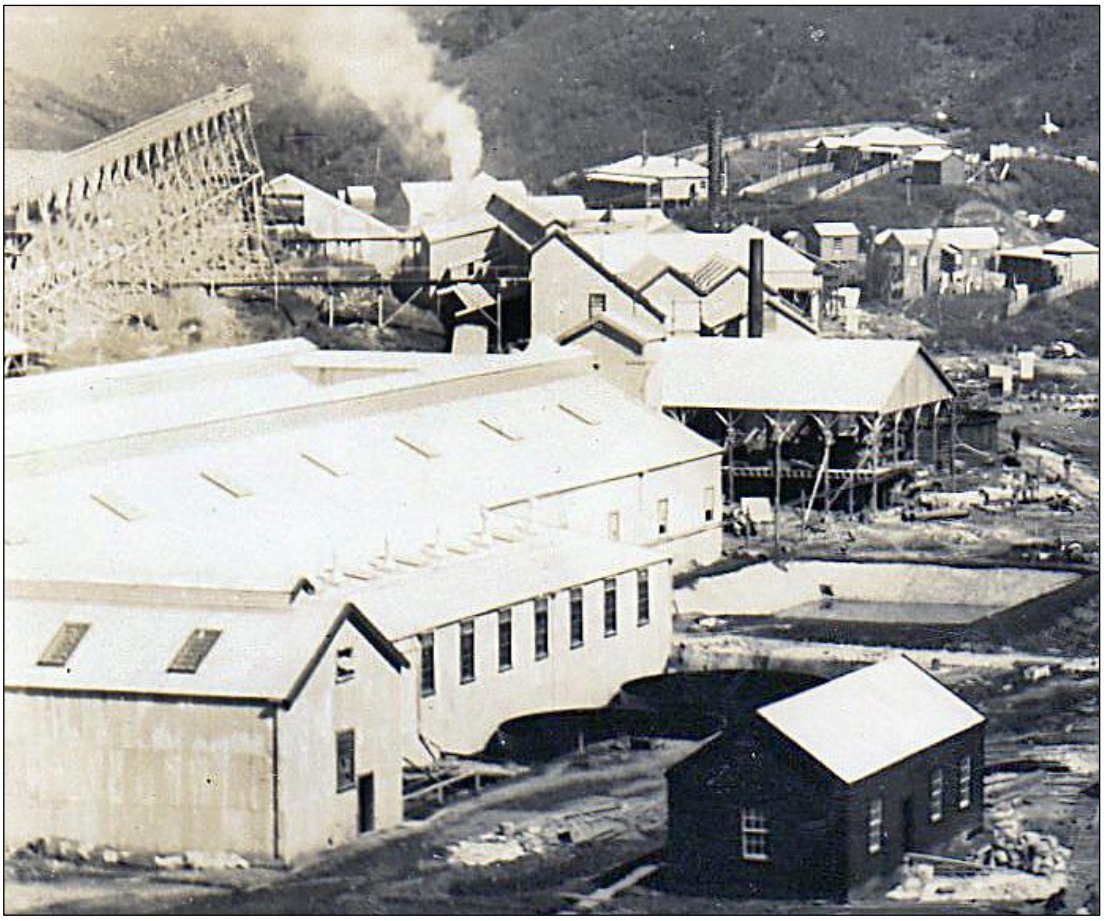
The elevated launder is prominent on the left, established mid 1900?

The laboratory assay office has been constructed in the foreground (when?)

There is only one dwelling on the riverbank, in front of the sawmill, so this photograph predates the December 1900 Auckland Weekly News images which show a second dwelling. Therefore mid 1900?

Enlarged portions are described below.

VBTS.



This, and the following image, is a crop from the image above.

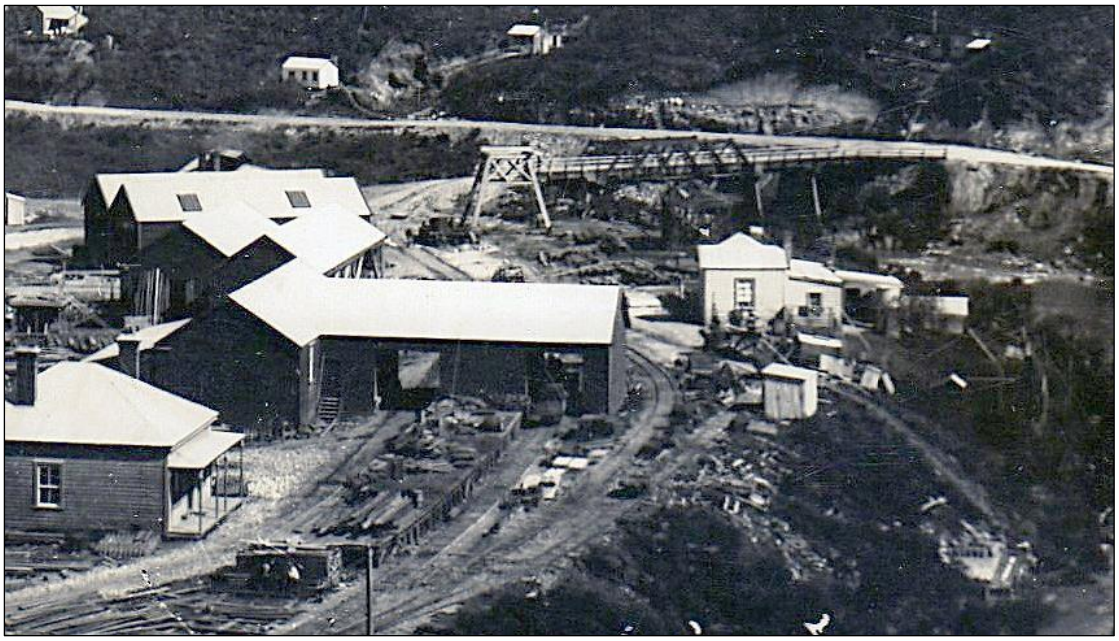
To the right of the elevated launder can be seen the two trestled tramways that form part of the loop line delivering loads of dry ore to the stamper hoppers, and returning empty trucks to the breakers. The big engine and boilers are in place. Steam or dust rising in a plume.

The building over the slimes vats (?) has a roof; later images show walls as well. Two or more workmen to the right of this building. The reservoir is clearly visible. It held water to be reused in the processing cycle. “Any surplus water drawn off at the V boxes not required at once at the mortar boxes, flows into a reservoir excavated in the ground, and thence is pumped into the boxes as required.” – HP Barry annual report for 1902.

Two large circular vats are set into the ground in front of the precipitation house.

The laboratory assay office has been constructed in the foreground (when?).

VBTS.

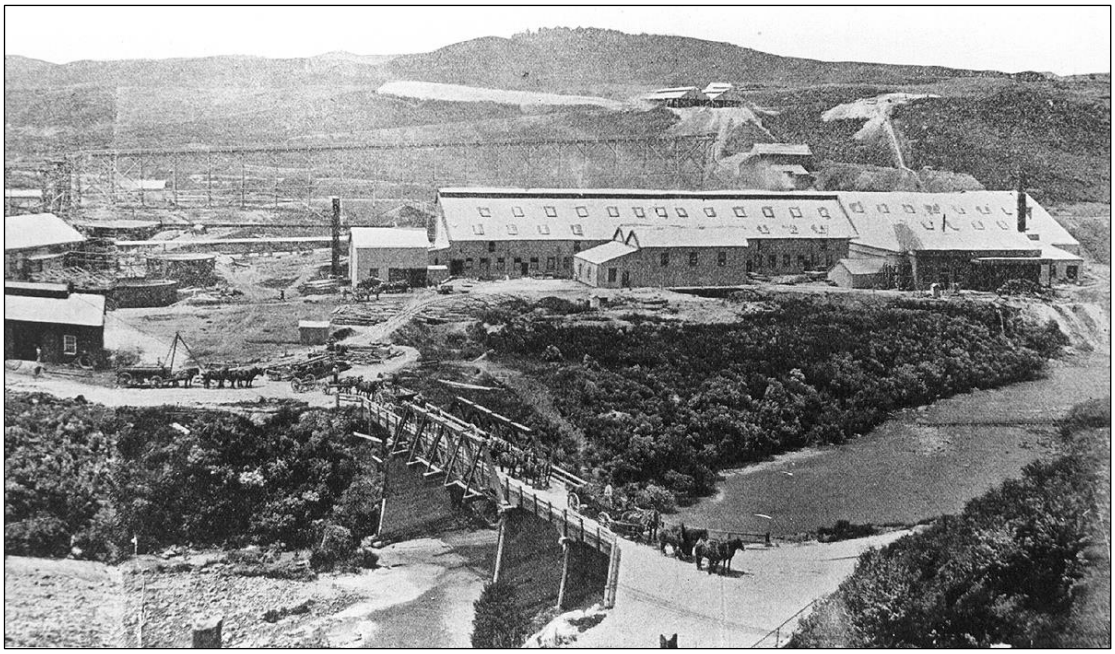


Still only one dwelling on the riverbank. It has aquired another gable-roofed room (facing us).

Office to left, store, then sawmill and blacksmith/fitting shop.

There is the suggestion of rails up to the bridge. The A-frame would allow heavy objects to off-loaded from carts.

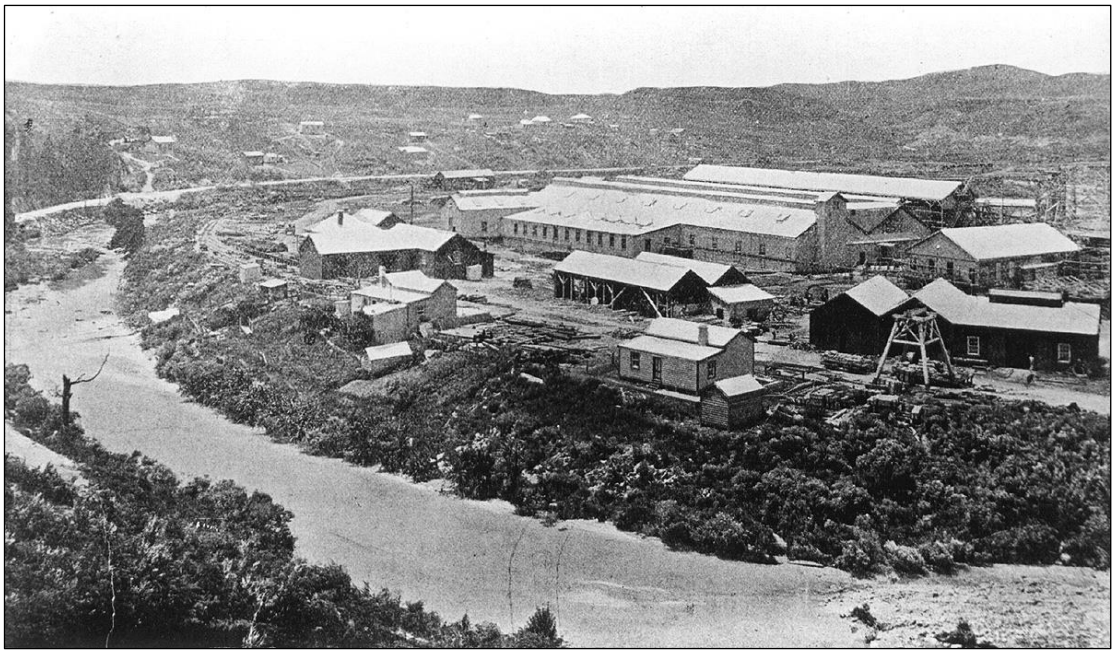
VBTS.



This, and the following image make up a panorama published in the Auckland Weekly News 14.12.1900.

The features seen here are better viewed in following photographs. Of interest here are the five teams of horses, all leaving the battery site. Have they just delivered some machinery? The third locomotive perhaps. An event worthy of photography. Locomotives were assembled on site.

Auckland Weekly News 14.12.1900. DoC Thames.



This, and the previous image make up a panorama published in the Auckland Weekly News 14.12.1900.

The long roof at top right of the image is the Intermediate Vat Shed. Here wet crushed sands are cyanided untill the dry crushing ceases. Then the sands will be dewatered here before being trucked the short distance to the concrete sand vats.

The precipition room has been considerably lengthen, from 4 to 11 windows. A building has appeared to the right of the vat shed, which a later map identifies as a press house (part of the early slimes treatment?).

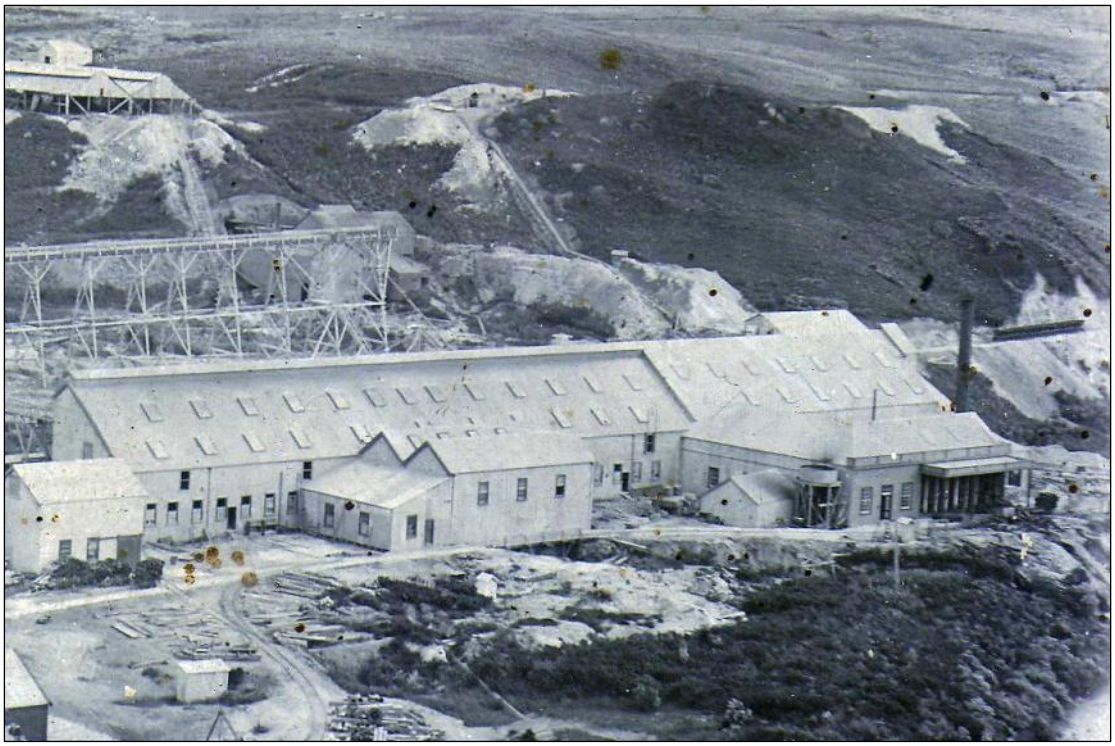
Another dwelling has been built on the riverbank near the blacksmith and fitting shop. Foundation platform of this building remain.

In the distance is the new rolling stock repair shed, added in 1899.

Auckland Weekly News 14.12.1900. DoC Thames.

See below for discussion.

Photographer possibly HP Barry. S. Elson.



This, and the following busy image are cropped from the full image above.

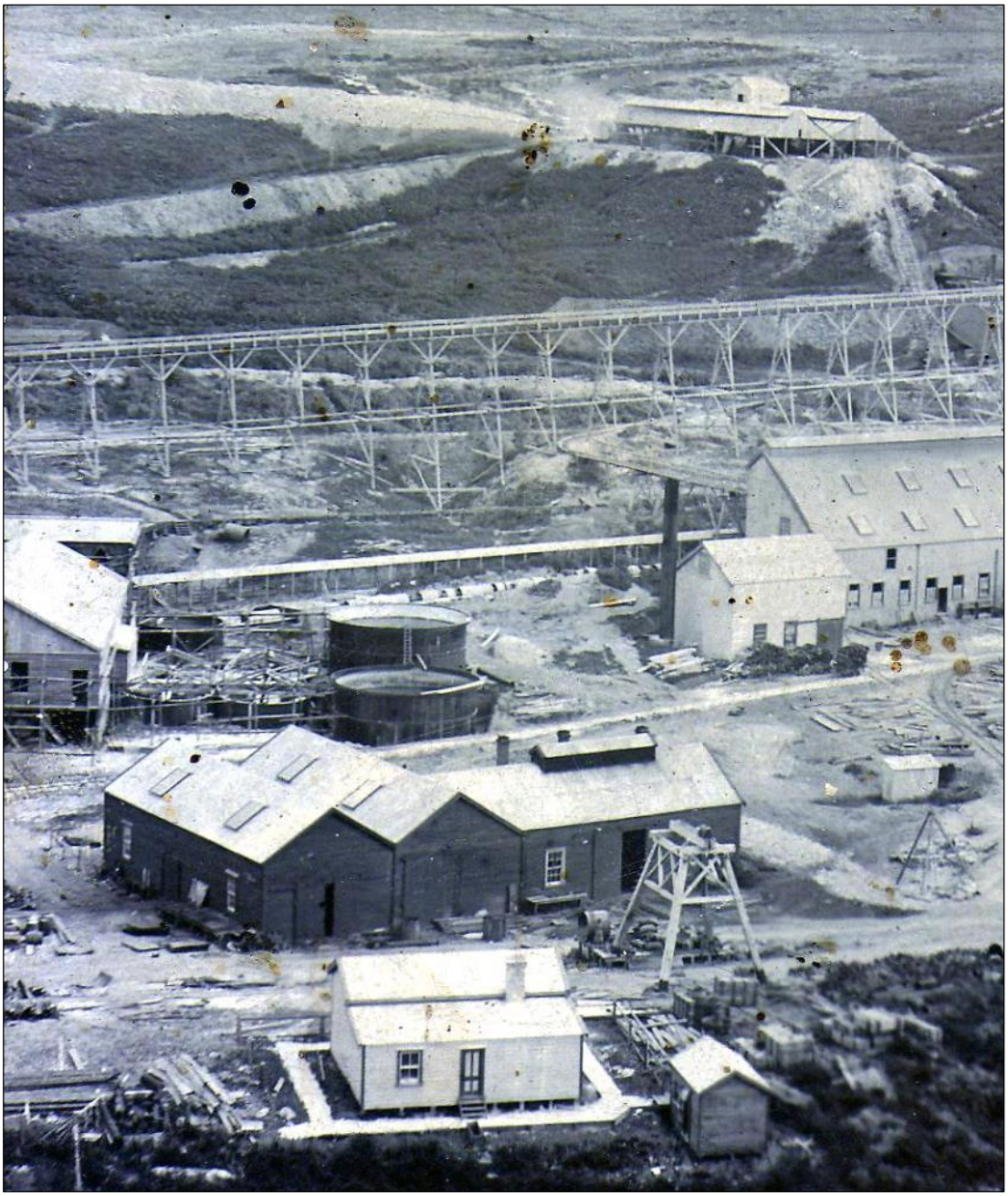
The kilns are still in use; smoke is visible in the next image. So still dry crushing. Full conversion to wet crushing occurs early 1901.

From right to left: the relief siding for the ore trucks that delivered ore to the wet stonebreakers, the boiler house, chimney and engine shed for the large Yates and Thom steam engine, the additional stamper building with stonebreaker and elevator roofs visible above, the Taieri (Owharoa Falls) water race and pressure pipe, the substantial dry crushing stonebreaker complex, the elevated launder on its substantial trestle work, the raised roofline and enlargement of the lean-to of the turbine building, the tramway and bridge across the tail race beside the turbine building, the incline from the kilns, and the original engine shed of the first auxiliary power steam engine.

Ore trucks on the relief siding suggests some stamping in the wet section. Barry says: “only a portion of the wet crushing Mill was running for a few weeks towards the end of the year 1900” (Barry for 1902).This would date this photograph at end of 1900.

A tramway gives access to the boilers of the new engine, but how is coal brought to the site?

VBTS.



The kilns are still in use; smoke is visible. So still dry crushing.

From the top down: the huge stock pile of ore to the left of the kilns. Was this dumped by hand? Does it have to uplifted again by hand? Is this what the incline is for, to allow this ore to be brought to the new stonebreakers, bypassing the kilns?

The kilns and the incline which brought the ore to them and the shelter over the winding engine, the substantial elevated launder and trestle work, the tramway and trestle bringing dry ore to the original stampers (or removing the empty carts, depending on which direction the continuous system worked), the new tramway delivering wet ore from Waihi, the covered way between the battery building and the vat house, the revolving tube conveyor which looks to be in pieces, the original engine shed of the first auxiliary power steam engine with chimney, slime vats (wet), the blacksmith and fitting shop, and a new residence with a lovely new path around it.

VBTS

A clear view of the reservoir. A landing and structure where the sand tailings enter the river, and a track down to it. Did it clog up at times?

Office as yet un-extended.

VBTS

1901

Superintendent HP Barry, in his Superintendent's Report for the year 1901:

> The total rainfall for the year was 68.07 inches, which compares with a total of 95.19 inches during 1900. This marked decrease has had great effect upon the question of water power which, both at Waihi and the Victoria Mill, has been less than was required, in consequence of which steam power was employed, and this has led to a considerable increase in the cost under the head of fuel for steam purposes, more particularly at the Victoria Mill…
>
> DRY CRUSHING—VICTORIA MILL (100 STAMPS).
>
> The water power available was insufficient for the whole 200 stamps at the Victoria Mill, necessitating the use for a considerable period of the large Mill Engine.
>
> The cost of the fuel for steam power for this engine has been divided equally between the dry and wet crushing Mills, and as only a portion of the wet crushing Mill was running for a few weeks towards the end of the year 1900, the cost of steam power for the dry crushing Mill shows relatively a considerable increase…
>
> During the month of April a fire occurred at the stonebreaker building, but the damage done was comparatively small, owing to the fire service which was available. Work with the stonebreakers was only interrupted for a day, the supply of ore in the Mill hoppers enabling the stamps to run uninterruptedly…
>
> WET CRUSHING.—VICTORIA MILL (100 STAMPS)
>
> Eighty-five stamps were started on the llth January, the remaining 15 stamps being got to work on the 15th January…
>
> Early in the year 20 head of stamps were put on to mineralised ore, the product passing over six Union Vanners.
>
> Later on in the year two more Union Vanners were erected, and an additional ten head were employed in crushing mineralised ore.
>
> Experiments were also made with concentrating with both a "Wilfley" and "Dodd" Concentrator, but these machines proved to be less suitable than the Union Vanners for dealing with this particular ore…
>
> A Blake Marsden stonebreaker which was in stock, was erected in the wet crushing stonebreaker building, in addition to the two Gate's Crushers already erected.
>
> Towards the close of the year a small steam engine was obtained and erected, so as to run the sand pumps which lift the pulp up to the trestle launder, which conveys it to the treatment department. These pumps are run by water power when available, obtained from the high pressure race.
>
> An extension to the office building at Waikino was necessary and has been made.
>
> VICTORIA MILL—WET CRUSHING.
>
> It must be borne in mind that this is the first year during which the whole of the 100 stamps wet crushing have been used; various alterations, modifications or improvements have suggested themselves, some of which have been carried out, others have been decided upon and will be effected.

The extraction will be benefitted by the conversion of the dry crushing mill at Waikino to wet crushing, as by this the treatment plant will be relatively enlarged, and in other ways, such as in the expenses of labour and cost of stores, the process will be cheapened.

A proportion of the coarser sands will be separated out and reground, the necessary arrangements for which are being made.

The consumption of cyanide in the wet crushing is heavy, but every endeavour will be made to reduce this expense.

An extension of the Press house was rendered necessary and has been made.

Some improvements were made in handling the Johnson Filter Presses and they have, on the whole, worked satisfactorily.

It was found after running for some time that the proportion of slimes to sands increased, and this necessitated the obtaining of additional Filter presses.

A small Dehne Press was obtained from the Sulphide Corporation, Limited, N.S.W., and one was ordered and obtained from J. Martin and Company, of Gawler, South Australia, fitted with fifty frames, 36 inches square, cakes 3 inches thick. This has proved satisfactory.

A second-hand steam engine was obtained in Auckland and erected so as to provide an alternative method of driving the pumps, compressor, &c., in the press house, which are driven by water power.

The old boiler from the No. 1 shaft, which was thrown out some time back, was taken down to the Victoria Mill and erected, to be used there as a vacuum cylinder in connection with the treatment of the sands in the intermediate vats.

Towards the end of the year the treatment of 10 tons of concentrates was commenced in the small concentrate plant which has been erected. The plant consists of a Mc. Kay Pan for re-grinding the concentrates, and two agitators.

The treatment has not been completed. The object is to see whether a saving can be effected by treating our own concentrates instead of sending them to Australia as is done at present.

CONVERSION OF DRY CRUSHING TO WET CRUSHING.

VICTORIA MILL.

So as to be in readiness to convert the present dry-crushing stamps to wet-crushing, it has been necessary to make considerable additions to the present wet-crushing plant.

An order was placed with J. Martin and Company, of Gawler, for three new filter presses, which have now come to hand. The price of these was £2,145 12s. 6d. A contract was let to A. & G. Price for six agitators, a collecting vat and a sump, all of which have been delivered and erected. The contract price for these was £1,105 18s. 0d..

A second pressure tank was also obtained from R. H. Yeoman for £180.

A chain elevator for raising the ore from the stone breakers to the Mill ore bins was obtained from England.

A contract was let for the supply of four sand pumps for raising the pulp from the mortar boxes to the trestle launder: the cost of these was £412.

The necessary excavations and foundations for these pumps were made and the pumps erected.

An extension of the trestle launder to connect with the column from these pumps has been constructed.

Part of the necessary shafting and drums for trucking the ore from the intermediate sand vats for re-treatment in the concrete vats were obtained, and a traveller over the concrete vats constructed.

An elevator wheel. 25 feet in diameter for lifting the slimes into the slimes tanks has been constructed at Waikino.

The first mention of an elevator wheel by HP Barry. It appears to be the first wheel installed at the battery, but is labelled the "I" wheel on the map. See GIS.

An article in the Auckland Star 29 March 1901 also mentions an (other?) elevator wheel. "Already 100 stampers each 1250lbs in weight are at work on the wet system. After leaving; the stampers the pulp ore passes over vanners which secure the concentrates, and the residue is then lifted by a wheel to a high level, from which it runs by gravitation to settling tanks, and is ultimately treated in the cyanide shed. The fineness of the gold is shown by the fact that what appears to be pure water running from the settling tank still shows an assay value of 5/, and it is therefore carried back again to the battery so as to reduce the loss to the smallest possible proportion."[27]

Within a few weeks everything should be in readiness to admit of the conversion of 50 out of the 100 stamps from dry to wet-crushing, and the remaining 50 can be converted soon afterwards…

RAILWAYS AND TRAMWAYS.

The main line has been maintained in good condition.

The carrying capacity of the ore tracks is being increased by raising the ends, which will be an improvement.

During the year the permanent rolling stock has been increased by the addition of 12 side tip ore trucks, 6 coal trucks, 4 goods trucks and 2 pairs of bogies…

The total length of these firewood tramways is 13 miles 32 chains, made up as follows :—

System supplying firewood to Mine		1 miles 14 chains.
„ „ to Waihi Mill ...	5 „	69
„ „ „ „ to Victoria Mill ...		3 „ 29 „
[total =]	13 „	32 „

Firewood tramway to Victoria battery is 3.4mi., or 5.5km. This brings the tramway head to approximately one kilometre up Franklin Road, in fact where the tramway becomes Franklin Road.

The construction of a coal hopper at Waikino by which the necessity of bagging coal will be avoided, was commenced towards the close of the year and is now well advanced.

COAL AND GOODS WHARF, PAEROA.

The increasing amount of coal consumed, and the large amount of stores which come forward, has rendered it advisable that the Company should have its own wharf at Paeroa.

Consequently a freehold section of between two and three acres fronting the river was acquired and a coal hopper has been constructed. This will obviate the necessity of bagging coal.

[27] https://paperspast.natlib.govt.nz/newspapers/AS19010329.2.62.4
Auckland Star, Volume XXXII, Issue 75, 29 March 1901, Page 5

TITLES.

Two “special sites” of 5 acres each for bye-washes on the Waihi low pressure system, and a 5-acre “special site” embracing the quarry near Waikino, were acquired...[28]

Inspecting Engineer to 31 December 1901

Waihi Goldmining Co.

Reduction-works, &c.—The respective tonnages crushed at the mills were as follows : Waihi mill (dry crushing), 45,389 tons; Victoria mill (dry crushing), 50,440 tons; wet crushing, 63,496 tons : total, 159,325 tons. The total average number of stamps running during the year, exclusive of Sundays and the period at Christmas during which the mills were closed down, was 276-710. The total average duty per stamp per diem was 1.96 tons. Wet crushing, Victoria mill (100 stamps): Eighty-five stamps were started on the 11th January, the remaining fifteen stamps being got to work on the 15th January. Early in the year twenty head of stamps were put on to mineralised ore, the product passing over six Union vanners. Later on in the year two more Union vanners were erected, and an additional ten heads of stamps were employed in crushing mineralised ore. A Blake-Marsden stone-breaker which was in stock was erected in the wet-crushing stone-breaker building, in addition to the two Gates's crushers already erected. A small Dehne press was obtained from the Sulphide Corporation (Limited), New South Wales, and one was ordered and obtained from J. Martin and Co., of Gawler, South Australia, fitted with fifty frames, 36 in. square; cakes, 3 in. thick. This has proved satisfactory. An order was placed with J. Martin and Co., of Gawler, for three new filter-presses, which have now come to hand. A contract was let to A. and G. Price for six agitators, a collecting-vat, and a sump, all of which have been delivered and erected. A second pressure-tank was also obtained from R. H. Yeoman. A chain elevator for raising the ore from the stone-breakers to the mill ore-bins was obtained from England. A contract was let for the supply of four sand-pumps for raising the pulp from the mortar-boxes to the trestle launder. An elevator-wheel 25 ft. in diameter, for lifting the slimes into the slime-tanks, has been constructed at Waikino. During the year the permanent rolling-stock has been increased by the addition of twelve side-tip ore-trucks, six coal-trucks, four goods-trucks, and two pairs of bogies.[29]

Fire in stonebreaker building 28 March. 1901.

Fire at four o'clock this morning in the Waihi Company's Waikino battery destroyed the shed containing the stone-breaker. It appears that roasted quartz from the kilns came down a wooden shoot into this shed, and apparently set fire to the shoot, which ignited the whole building. An engine and boiler in an adjoining shed were saved after great exertions, but the shed was considerably damaged. It is probable the fire may cause stoppage of the battery for one day, but not more.[30]

Fire at Waikino, 24 April 1901.[31]

Wet Stamps: 100 running by 15th January 1901.

[28] Superintendents Annual Report. Waihi,27 th January, 1902
[29] AJHR. Inspecting Engineer to 31 December 1901 C 3 P37
[30] https://paperspast.natlib.govt.nz/newspapers/AS19010328.2.52
Auckland Star, Volume XXXII, Issue 74, 28 March 1901, Page 5
[31] https://paperspast.natlib.govt.nz/newspapers/AS19010424.2.35
Auckland Star, Volume XXXII, Issue 96, 24 April 1901, Page 2

Eighty-five stamps were started on the 11th January, the remaining 15 stamps being got to work on the 15th January…

Early in the year 20 head of stamps were put on to mineralised ore, the product passing over six Union Vanners.

Later on in the year two more Union Vanners were erected, and an additional ten head were employed in crushing mineralised ore.

An extension to the office building at Waikino was necessary and has been made.

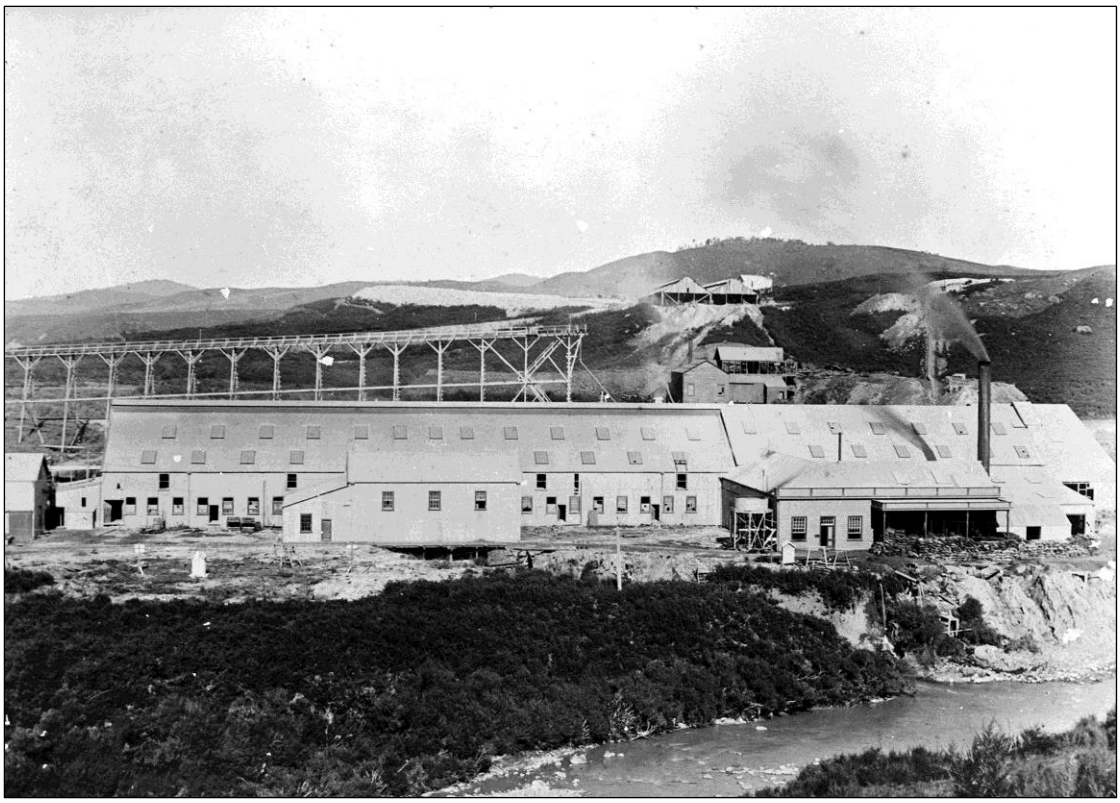
An extension of the Press house was rendered necessary and has been made.

Within a few weeks everything should be in readiness to admit of the conversion of 50 out of the 100 stamps from dry to wet-crushing, and the remaining 50 can be converted soon afterwards…

The construction of a coal hopper at Waikino by which the necessity of bagging coal will be avoided, was commenced towards the close of the year and is now well advanced.

1901 Images in chronological order (maybe).

Few images known.



This photograph appears to show the dismantling of the dry stone breaker buildings, hence the estimated date of 1901. To the right of the building is a hint of the space for the pelton wheel that powered the stone breakers. The base/sump of this wheel remains today. The boiler house and chimney are also prominent.

Beyond the kiln roofs the building which housed the winder for the original incline is clearly visible.

The boiler at the battery building is fired up (low river level, insufficient water power), and there are stacks of bagged material at the front door. Is this bagged coal? The small building behind the water tank, visible in earlier images, is gone.

The Taieri water race excavations and pressure pipe are to right of image.

The pipe used to pump the pulp up to the elevated launder is clearly visible at the right hand end of the launder.

The extreme right hand end of the battery building has been extended. To house the ore elevator and turbine? In 1902 the hydraulic elevator is replaced by a bucket chain elevator, and a taller structure was built to house it. This can be seen in the next image (1903).

There is clearly no elevator wheel at the right hand end of the turbine building. This was constructed 1903-4.

Hamilton City Library HCL 08463

1902

REPORT OF THE DIRECTORS

During the year the conversion of the remaining stamps at the Victoria Mill from dry to wet crushing was completed, the whole 200 are now wet crushing.

Superintendent HP Barry, in his Superintendent's Report for the year 1902:

> VICTORIA MILL, WAIKINO (200 STAMPS).
>
> At the commencement of the year 100 stamps at this Mill were dry crushing and 100 stamps wet crushing. On the 5th April 50 of the dry crushing stamps were stopped, and re-started wet crushing on the 10th April. On the 31st July the remaining 50 dry crushing stamps were stopped and started again on the 5th August, on which date the whole Mill of 200 stamps were wet crushing…
>
> During the whole year 30 stamps have been at work on mineralised ore…
>
> The smaller of the two turbines was removed early in the year and replaced by a 200 h.p. Gilkes' Turbine which was in stock.

So now two 200hp turbines running the stamps; from the low level race. This frees up the 100hp turbine to be installed in 1903 on an extension of the low level race.

> The hydraulic elevator formerly in use for raising the quartz after it passes the stonebreakers to the Mill ore bins was replaced by a new bucket chain elevator.
>
> For raising the pulp from the 100 head which were converted, four sand pumps were erected with separate rising mains to the trestle launder. A slimes elevator wheel was constructed at Waikino and has been erected. The number of steel agitator vats was increased to 10, collecting vats to six, and gold-bearing solution vats to three.
>
> Two more Martin presses were added, making a total of five Martin and two Johnson presses, besides a small Dehne press.
>
> During the year it was found that the percentage of slimes to sands was increasing; after experimenting with various forms of spitzkasten, it was decided to erect a buddle plant, so as to further separate the fine sands from the slimes.
>
> The object of reducing the bulk of the slimes as far as possible is owing to the greater cost of treating slimes as compared with sands.
>
> A Green's "Economiser" was erected and brought into use in connection with the Mill boilers towards the end of the year.
>
> An addition was made to the blacksmith's shop, and a power hammer, which was obtained from England, has been erected there.
>
> Another lathe has been procured, and a machine for staving up stamper shanks was constructed at the Waikino workshops.
>
> Two new sheds, one for the storage of cyanide and the second for storage of concentrates, have been added to the plant.
>
> After the stoppage of the dry crushing the No. 5 Gates' crusher was transferred from the dry crushing stonebreaker building to the present location. The plant now consists of two No. 5 and two No. 3 Gates' crushers, and a Blake Marsden crusher which is not in use.
>
> The ore is tipped direct from the trucks conveying it from the Mine into the breakers.

The kilns are now used as a means of storing a reserve of quartz, and contain rather over 2,000 tons…

A contract was also let and is still running for the transferring of the sands from the Intermediate to the Concrete vats.

A coal bin of a capacity of 300 tons has been constructed, into which the waggons conveying the coal from Paeroa can readily discharge…

VICTORIA MILL.—DRY CRUSHING.

As previously stated, the dry crushing process at this Mill was stopped on the 31st July…

VICTORIA MILL—WET CRUSHING.

After the stoppage of the dry crushing all the sands have been run into intermediate tanks, treated with a weak solution of cyanide, drained and then trucked by means of automatic haulage to-the concrete vats, in which the treatment is completed.

The buddle plant previously referred to was also erected.

With these exceptions the treatment closely resembles the wet crushing process described under the head of the Waihi Mill, with the further exception that the double filter press treatment has not yet been adopted…

The description of the ***Waihi Battery*** process gives some clues:

The adoption of the wet crushing process has necessitated very considerable alterations and additions to the plant.

The shed over the kilns has been removed and the old roofing, framing, &c., utilised where possible. The kilns are now used simply as storage hoppers for a reserve of ore.

The arrangement and position of the stonebreakers have been changed. A new No. 5 Gates' Crusher was procured and has been erected in a large concrete foundation, the ore being tipped direct into it from the tramway trucks. A revolving trommel and a second Gates' Crusher, No. 3 size, have also been erected, the ore passing through each in succession.

Water pipes have been connected to each of the mortar boxes and the pulp will flow to the first two elevating wheels, from which it will flow over the muntz metal plates and thence to the vanners.

For the present the Mill has been started on free milling ore, and the pulp is flowing direct to the third elevating wheel, as it will be some little time yet before the vanner and amalgamation department is completed, all the men having been withdrawn in order to complete the crushing department as speedily as possible.

A large two storey vanner and amalgamation building has been built, and twenty-six Union Vanners installed, the plates occupying the top floor, and the pulp after passing over them will be distributed to the 26 Union Vanners which have been erected on the lower floor, and which has been concreted throughout. The plates and amalgam traps have not yet been erected, and some of the details of this department are still unfinished.

The pulp passes from the third elevator wheel by means of a launder to the fourth and fifth elevator wheels.

The fourth wheel is the old one, which has not been used since the cyanide process was adopted.

Its position has been slightly altered and the wheel itself repaired. The other four wheels have been put together here, the buckets having been procured from A. & G. Price, Thames, and the timber sawn and dressed in Auckland.

After being discharged from the last elevator wheel the pulp passes into the separating boxes, whence the sands pass to the 32 wooden vats which were used in the dry crushing process, being fed into them by means of automatic distributors, and the treatment of the sands is completed in these vats.

The slimes flow to a nest of V boxes, where the clear water is drawn off for re-use in the mortar boxes, and the slimes pass to two steel collecting vats 32 feet in diameter by 14 feet in depth.

Any surplus water drawn off at the V boxes not required at once at the mortar boxes, flows into a reservoir excavated in the ground, and thence is pumped into the boxes as required.

From the collecting vats the slimes are forced by means of compressed air into the first filter press house, and are charged into the Johnson drying presses, of which there will be two. At present only one has been erected, as the second one is still required at the Victoria Mill, but will only be in use there for another week or so.

The object of these presses is to thicken the slime as much as possible, so as to reduce the quantity of cyanide necessary for making the water up to the requisite strength.

After passing the drying presses the slime cakes are partly broken up by means of a screw conveyor, which delivers them into a steel disintegrator vat, where they are further broken up; the cyanide solution is run into this disintegrator vat, and thence the pulp passes into agitator vats, of which there are five, four being 20 feet in diameter and 14 feet deep, and the fifth 32 feet in diameter by 14 feet in depth, all constructed of steel. From these vats the pulp, after agitation, both by mechanical stirring and by means of compressed air, is charged by means of compressed air into the second press-house, which contains four Martin filter presses, in which the treatment of the slimes is completed, the slime cakes passing away to the river by a long trestle launder .

A large steel vat has been erected for making up the necessary cyanide solutions, and a cyanide store erected immediately by this vat, the floor of which is level with the top of the vat.

We see something similar at Victoria, above, and slightly to the east of, the intermediate vats.

A shed for storage of lime has also been constructed and a wooden vat for dissolving the lime erected.

Two steel vats for receiving the gold-bearing solution have been erected, the larger of which is new, and the second was formerly an agitator vat, which was obtained at the commencement of the experiments made in connection with the adoption of wet crushing some time back. From these the solution flows into the precipitator room, in which are 13 precipitators, nine new ones and four old. The old precipitator room not being sufficiently large, a new one was constructed over it, and the old one being

> *subsequently removed. The floor has been concreted throughout and sloped so as to prevent any loss by leakage and when handling the bullion slimes.*
>
> Several small lots of concentrates have been treated in the plant erected for this purpose. The results so far obtained have not been quite satisfactory. It has been difficult to give them the uninterrupted treatment and close attention necessary owing to the work of conversion of the plant from dry to wet crushing, which has entailed a great deal of work. It is expected, however, that with some further tests the satisfactory treatment of the concentrates can be accomplished at the works…
>
> GENERAL.
>
> The construction of the Government Railway from Paeroa to Waihi has not made much progress.
>
> The line is practically completed as far as Karangahake, but has not been opened for traffic; it would still be useless for us until the frame bridge over the river is completed.
>
> The driving of the long tunnel at Karangahake has not been kept going to the extent that it might have been.
>
> Between the tunnel and Waihi very little work of any kind has been done, and at the moment only a few men employed.[32]

5th August 1902, the whole Mill of 200 stamps were wet crushing.

For raising the pulp from the 100 head which were converted, four sand pumps were erected with separate rising mains to the trestle launder. The addition to the elevated launder can be seen in photographs.

A slimes elevator wheel was constructed at Waikino and has been erected. Can we see this? It can be seen in the 1903 image from Papers and Reports Related to Minerals and Mining, 1904, right hand side.

A buddle plant is erected, behind the intermediate vats. It does not last long, removed 1908.

Two new sheds, one for the storage of cyanide and the second for storage of concentrates, have been added to the plant. Can we see them?

The kilns are now used as a means of storing a reserve of quartz, and contain rather over 2,000 tons. When do the roofs get removed? During 1903.

Milling and Treatment at the Waihi Mine, New Zealand. E. G. Banks. 1911

> The most promising results were obtained by wet crushing, plate amalgamation, concentration, and cyanide. In the first experiments the sand and slime were treated together in an agitator, the solution being separated by decantation; but later experience showed that it was more profitable to treat sand and slime separately.
>
> By September, 1900, 50 stamps were crushing wet at Victoria mill through 40 mesh screens. The ore crushed by these stamps was only lightly mineralized, and the pulp was not passed over amalgamation tables or concentrators, but was separated into sand and slime, the sand being collected in large steel tanks, in which it was given a preliminary wash with weak solution, then transferred to the large concrete tanks (40ft. by 50ft. by 4ft.) for final treatment.

[32] Superintendents Annual Report. Waihi, 24th January, 1903.

The slime was collected and thickened in 14ft. deep steel tanks, and from these was drawn into agitators and cyanided for 24 to 30 hours and then filter-pressed.

Towards the end of 1900 considerable experimental work was done with vacuum filtration of slimes at the Victoria mill.

The machine first used was a revolving cast-iron cylinder, 6ft. in diameter and 5ft. long. The periphery was formed of perforated iron plates covered with strong carpet or matting and an outer cover of canvas. Vacuum applied through the trunnion caused a layer of slime to adhere to the canvas as it dipped into a trough of slime. Wash water or weak solution was sprayed on to the slime to displace the gold solution, and the treated slime cake was taken off with scrapers just before again entering the slime trough. This machine worked well, and the capacity was large when the filter cloth was new, but fell off rapidly as the slime worked into and choked the cloth.

Soon after this the Eureka slimes machine (an Australian invention) was tried, but proved unsatisfactory. Filter-pressing results were so satisfactory that vacuum filtration experiments were for the time abandoned.

In January, 1901, a further 50 stamps were crushing wet, and in August, 1902, the 200 stamps comprising the Victoria mill were wet-crushing. Early in this year (1901) 20 stamps at the Victoria mill were set apart for dealing with the more heavily mineralized ore, the pulp being passed over amalgamated plates and six Union vanners, and then joining the pulp from the stamps on lightly mineralized ore.

By the end of 1901, 30 stamps and 8 Union vanners were running on sulphide ore. The concentrates produced were shipped to smelters in England and Australia.

During the latter part of 1902 the alteration of the Waihi 90-stamp mill from dry to wet-crushing was proceeded with without hindrance to the running of the mill, and in January, 1903, the alterations were completed without the loss of any milling time. The amalgamation and concentration sections were not completed until the end of May, and only lightly mineralized ore was crushed for the first few months.

In April, 1904, the question of vacuum filtration was again taken up, and a small experimental filter, to treat about ½-cwt. Charges, was constructed at the Waihi mill. Results were so good that a plant to handle 1 ton at a time was erected. This proving satisfactory on a working-scale, the method was adopted to replace 2 filter-presses used for dewatering slime at Waihi mill, and a plant was installed to assist the filter-presses in handling the large increase of slime due to increased output following the introduction of tube mills in May, 1905.

By May, 1907, the vacuum plant was extended to entirely replace the filter-pressing at the Waihi mill. The process is similar to the Moore, which was installed, but did not prove very successful, at the Mercur mine, Utah, U. S. A., in 1903; but the filter frame invented at Waihi was much superior to that first used in the Moore process. A detailed description of the process will be given under the heading “Cyanidation of Slime.”

During 1907 it was decided to erect a vacuum plant to deal with all the slime at the Victoria mill, and a section of this plant was completed and at work by the end of the year.

One of the biggest advances in the milling of Waihi ores was the introduction of tube mills. One was erected at Victoria mill in 1903, and three were installed at the Waihi mill by May, 1905, and results were so successful that another two were soon erected at the Victoria mill, and arrangements made to put in six more. By the end of 1907, 8 were working at Victoria

> mill and 4 at Waihi mill, and to-day there are 5 at Waihi 90-stamp mill, 11 at Victoria 200-stamp mill, and 1 at Union 40-stamp mill…[33]

The whole paper can be viewed in the Appendices, page 178.

[33] Milling and Treatment at the Waihi Mine, New Zealand. By E. G. Banks. Paper No. 221.
Paper presented at the Australasian Institute of Mining Engineers, Thames New Zealand 1911.

1902 Images in chronological order (maybe).

None known

Wet crushing.

1903

Superintendent HP Barry, in his Superintendent's Report for the year 1903:

> VICTORIA MILL (200 Stamps.)
>
> During the whole year 30 stamps with the necessary vanner plant were at work on mineralised ore, and crushed a total of 20,780 tons, which is included in the tonnage shown above.
>
> Formerly these stamps were of 1,250 lbs. weight, but after some months run during the year they were lightened, the wear and tear on the mortar boxes when crushing this class of ore being very severe.
>
> Coal has been used for the boilers. The cost of fuel is lower than during the previous year, more water power having been available.
>
> A third turbine of 100 h.p. which was in stock has been erected and brought into use during the month of August, and since then very little steam power was required. The necessary length of 300 feet of 24-inch wrought iron pipe line was obtained second hand, in good condition, from one of the neighbouring mines.

Is this the extension of the low level race, to a pressure pipe, to the stone breaker/ore elevator section of the battery? It is labelled “low pressure pipe 24 inch” on the old map. This would date the extension to 1903. The capacity of the low pressure race is increased to supply this turbine.

> The reserve stocks of ore on hand at Waikino have been somewhat increased, a new paddock having been started early in the year.
>
> A mechanical chain grate stoker was obtained from England and has now arrived at the Victoria Mill.
>
> To replace the two Johnson presses transferred to the Waihi Mill, two Dehne filter presses were obtained second hand, and a new one from Martin and Company.
>
> Owing to the wear and tear on the sand pumps used for raising the pulp from the mill to the distributing launders, and the heavy cost for keeping them in repair, it was decided to substitute four elevator wheels for this purpose.
>
> The greater part of the construction of these was carried out at the Mill, and three were brought into use when the Mill started on the 4th January, 1904.

The elevator wheels constructed to move pulp from the stampers to the elevated launder are clearly visible on many photographs. Three in use on 4th January, 1904. The images show one sump. Although not abundantly clear, it appears that this installation comprises two double lift wheels. The fourth wheel was added later in 1904.

Superintendents Annual Report For 1904. Waihi, 25th January, 1905

> The 4th elevator wheel has been brought into use for lifting the pulp from the Mill to the treatment plant, so that the sand pumps formerly used for that purpose have not since been required. [34]

The maps label these wheels as D D’ and C C’. The images published in Papers and Reports Related to Minerals and Mining, 1904, say “group of four elevator wheels”.

[34] Superintendents Annual Report For 1904. Waihi, 25th January, 1905

If Barry is reporting on this installation alone, then there has been no mention of the A and B wheels. These must be required to deliver the pulp to the D D' and C C' wheels, and so must be built simultaneously, or already exist.

These wheels are first mentioned in 1912. Reporting on 1911, SE Fraser states: "we decided to renew the "A" and "B" wheels (35 feet diameter, taking the coarse pulp from the 200 head) with wooden buckets". This suggests that these are the primary wheels for lifting from the stamps to the D D' and C C' wheels.

> A winding drum was placed in position on the Incline Tram in place of the traction engine, which was required for conveying the heavy parts of the "C" pumping engine from Paeroa to No. 5 Shaft at the Mine.
>
> It was decided to erect an Iron Foundry, so that the many castings required by the Company can be made on the spot; the excavations have been made and the concrete walls and piers for carrying the travelling crane erected.
>
> A 7-ton travelling crane is being obtained from England, and the necessary moulding sand has been procured.
>
> It was also decided to substitute a Belt Conveyor for conveying the ore along the top of the ore bins in place of the hand trucking, as at present. The necessary length of 24-inch belting has been ordered. It is hoped that some economy will result by thus altering the system…
>
> CONCENTRATES TREATMENT PLANT.
>
> A series of trials of the treatment of concentrates at the Victoria Mill instead of shipping them, have been carried out for some months.
>
> A complete unit of plant was erected and experiments made with grinding by means of McKay pans, Krupp ball mill, and Huntingdon mill. The experiments demonstrated the superiority of McKay pans for this purpose, but experience gained in other parts of the world tended to prove that tube mills were superior to the above as being the best machines for fine grinding, consequently, a tube mill was ordered and the necessary treatment plant designed, and concrete foundation work gone on with.
>
> Tenders were called for ten steel agitating vats 6-ft in diameter and 15-ft. 9-ins. in depth, and the vats have since been received and erected upon timber trestling, and the necessary V boxes were constructed.
>
> The Tube Mill came to hand in October, and was erected, and the shafting for driving it and the air compressor and pumps was installed. A pressure tank was also installed.
>
> An order was placed for a second-hand Dehne Filter Press (1 ton capacity) for this plant at a satisfactory price.
>
> Work in connection with the whole plant has just been completed.
>
> The carrying capacity of the Victoria Mill low pressure race was increased so as to permit of its carrying a larger volume of water when available, to supply the 100 H.P. Turbine which was erected. The banks were heightened and strengthened where necessary for a distance of about 2 miles, and the sides of the timber fluming heightened…
>
> GENERAL.
>
> Towards the end of the year considerably more activity has been shown in the construction of the Government Paeroa-Waihi Railway; the construction of the long tunnel at Karangahake has been kept going, and latterly the formation work of the line between that and Waikino has been taken in hand.

> During the last two months of the year, owing to the completion of the railway and traffic bridge at Karangahake across the Ohinemuri River, and the finishing off of the line from Paeroa to Karangahake, coal has been conveyed by rail as far as Karangahake, and carted thence to Waikino, effecting some reduction in the cost of carriage.
>
> In August two officials of the New Zealand Government Railway visited Waikino in connection with the exact route past the Company's works, and the question of the amount of compensation to be paid to the Company was then gone into. It will be necessary to move two of the Company's smaller dwelling houses, and one or two minor alterations will be necessary. The line will traverse the Company's freehold area at Waikino.[35]

Another turbine is added to the low pressure system. Where did it go? The wet stone breakers?

A new ore paddock created. Can we see it in the photographs?

A winding drum placed on the incline tram. Is this from the top of the kilns down to the battery? To retrieve ore from the paddock? Or the original incline to the kilns?

An iron foundry being erected.

Concentrates treatment plant completed by end of year. Ten steel vats 6-ft in diameter and 15-ft. 9-ins. in depth (height) and a tube mill. There are photos of both.

It will be necessary to move two of the Company's smaller dwelling houses (on the river bank), and one or two minor alterations will be necessary to accommodate the Government railway. In fact only one dwelling is removed, the other is turned on its foundations.

Telephone line erected. New Zealand Herald, 22 May 1903:

> The erection of telegraph poles for the purpose of establishing telephonic connection between Dr. Guinness' private residence and the Waihi mine was begun on Wednesday. It is the intention of the company to establish a complete circuit by which the doctor's house will be connected by wire with the mine office at Waihi, Silverton battery offices, the Victoria battery offices (Waikino), and Mr. Barry's (the company's superintendent) house. The circuit will also include telephonic communication from any of the abovementioned points with Mr. Bardon's pharmacy, and it is understood that the company contemplates extending the circuit to the hospital.[36]

Although published 1904, the following description by James Park corresponds with the activities of 1903.

The Cyanide Process Of Gold Extraction. By James Park. 1904.

> I am indebted to Mr. [E.] G. Banks, the company's metallurgist, for the following clear and succinct notes on Waihi cyanide practice at the different mills.
>
> Victoria mill.—The ore is pulverized by 200 stamps to pass through 40-mesh wire wove steel screens, and is then elevated by means of plunger sand pumps to launders which convey the pulp to nests of spitzluten where the separation of the sands and slimes takes place.
>
> Treatment of Sands.—The sands now to the intermediate sand collecting vats, of which there are five built of steel, 38 ft. in diameter by 8 ft. deep, fitted with an annular launder on the outside top edge to convey the overflow water, at times containing a little slime, away to the slime thickening boxes. The sands are charged into the percolating vats by means of an

[35] Superintendents Annual Report For 1903 Waihi, 21st January, 1904
[36] https://paperspast.natlib.govt.nz/newspapers/NZH19030522.2.65
New Zealand Herald, Volume XL, Issue 12277, 22 May 1903, Page 6

automatic revolving distributor, which is moved on an overhead traveller from vat to vat as required.

The vats are fitted with Roche's bottom-discharge doors. The filter-bed is arranged by a wooden grating covered with wool-pack. Each vat holds from 250 to 300 tons of sands. After draining to get rid of surplus water, a preliminary treatment is given with weak cyanide solution, followed by a strong (0.35 per cent, to 0.45 per cent.) solution and usual washes.

The old vat-house contains ten rectangular concrete vats, five on each side. Each vat is 50 ft. by 40 ft. and 4 ft. deep.

Slime Treatment.—The slimes from the spitzluten and the over-flow from the sand vats are - mixed with lime-water (about 2 to 4 lbs. of lime per ton of slime) and conveyed to a nest of 36 V-shaped thickening boxes in which the slimes quickly settle, and are then drawn off in a fairly thick state from the bottom of the boxes. The overflowing clear water is returned to the stamps.

The thickened slimes are collected in six steel vats 32 ft. in diameter by 14 ft. deep. In these the slimes rapidly settle, and as the clear water overflows, it is stored for re-use in the mill and spitzluten.

When the vat is filled with slime-pulp to within 2 or 3 ft. from the top, the inflowing slimes are cut off and the charge allowed to settle for about 24 hours. Whatever clear water may be on top is syphoned off, and the thickened pulp (now about 1 of slime to 1 of water) is ready for treatment in the agitators.

The agitators are built of steel, 20 ft. in diameter by 6 ft. deep, and hold about 25 tons of slime (dry weight), together with about 40 tons of cyanide solution. The strength of the solution is about 0.l per cent. The pulp is agitated by paddles, secured to a vertical shaft, actuated by overhead worm-gearing. The speed is 8 revolutions per minute.

After 24 hours' agitation the pulp is run to a pressure tank, and from thence is forced by compressed air into Johnson 6-ton filter-presses, where the gold bearing cyanide solution is extracted.

The zinc method of precipitation is used and does very good work, even on very dilute solutions.

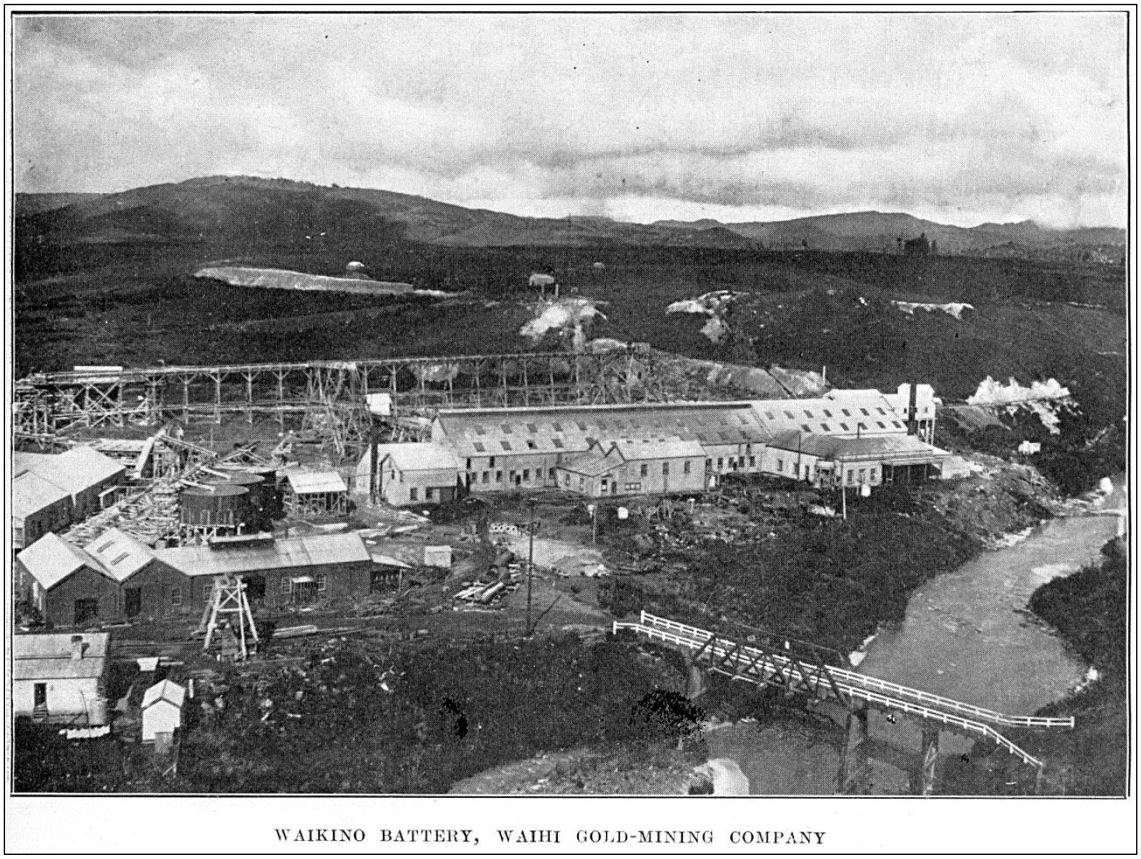
Vanners are being erected to concentrate the more heavily mineralized ore. The tailings from the vanners will be mixed with the lightly mineralized ore-pulp, and pass through the course of treatment just described.

An extraction of 85 per cent. to 90 per cent. of the ore value can be recovered by this process, but no particulars of the actual recovery or costs are yet available.

In the month of January of this year, the Waihi Company crushed 12,968 tons of ore, which yielded by cyanide treatment bullion valued at £29,055.[37]

[37] The Cyanide Process Of Gold Extraction. By James Park. 1904.
A Text-Book For The Use Of Mining Students, Metallurgists, And Cyanide Operators.
London: Charles Griffin & Company, Limited, Exeter Street, Strand. 1904.

1903 Images in chronological order (maybe).



WAIKINO BATTERY, WAIHI GOLD-MINING COMPANY

This photograph and the next are effectively a panorama. They were published in Papers and Reports Related to Minerals and Mining, 1904, so are effectively 1903. There is no sign of the elevated launder elevator wheels which were largely finnished by the end of 1903.

The roofs of the kilns have been removed. Two distinctive objects protrude at an angle from the kilns. They are seen in later images also. What are they?

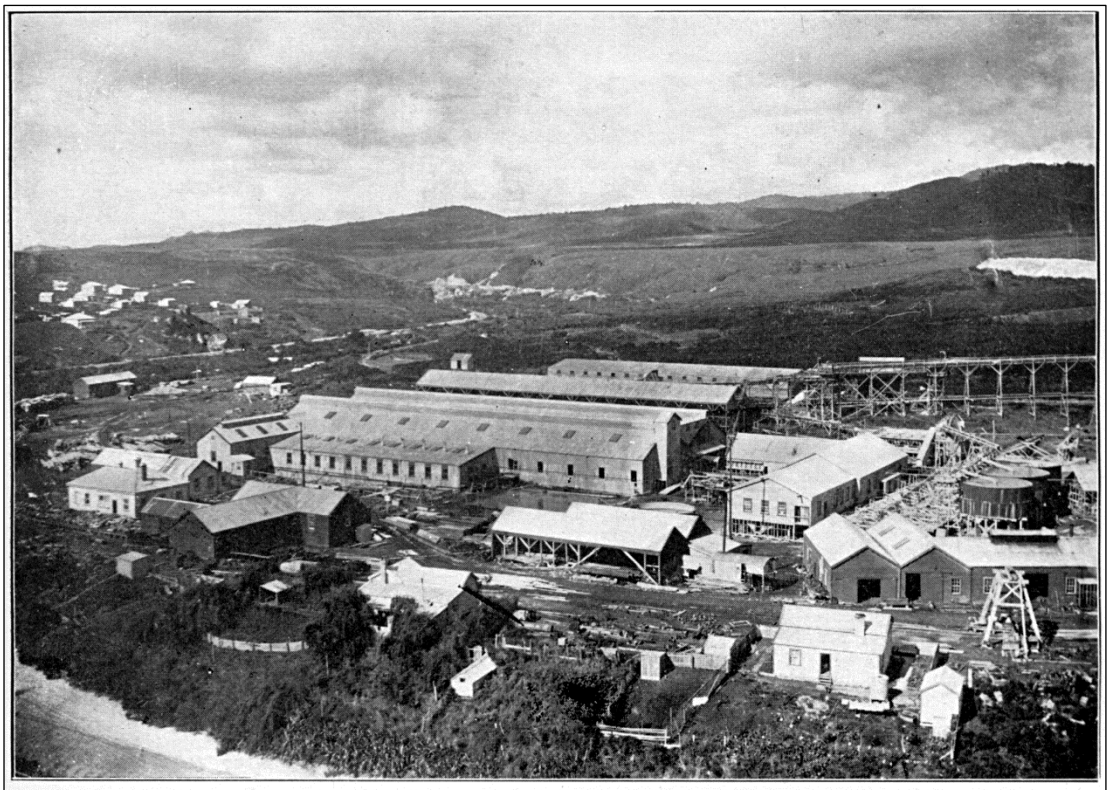
It appears that some of the ore stockpile has been removed. The dry stone breaker buildings are gone.

In 1901 an extension to the trestle launder was made to connect with the pumps from the soon to be converted dry to wet stamps. This can bee seen here (or is it something else?).

Just to the right of the three large steel vats is a roof and unfinnished walls. This may be the first experimental concentrates treatment plant There is little sign of the more elaborate plant, the construction of which is shown in the images below.

There is an addition to the far right hand end of the battery building; to accommodate the new chain elevator installed in 1902.

Papers and Reports Related to Minerals and Mining, 1904.



WAIKINO BATTERY, WAIHI GOLD-MINING COMPANY.

The lefthand portion of the panorama.

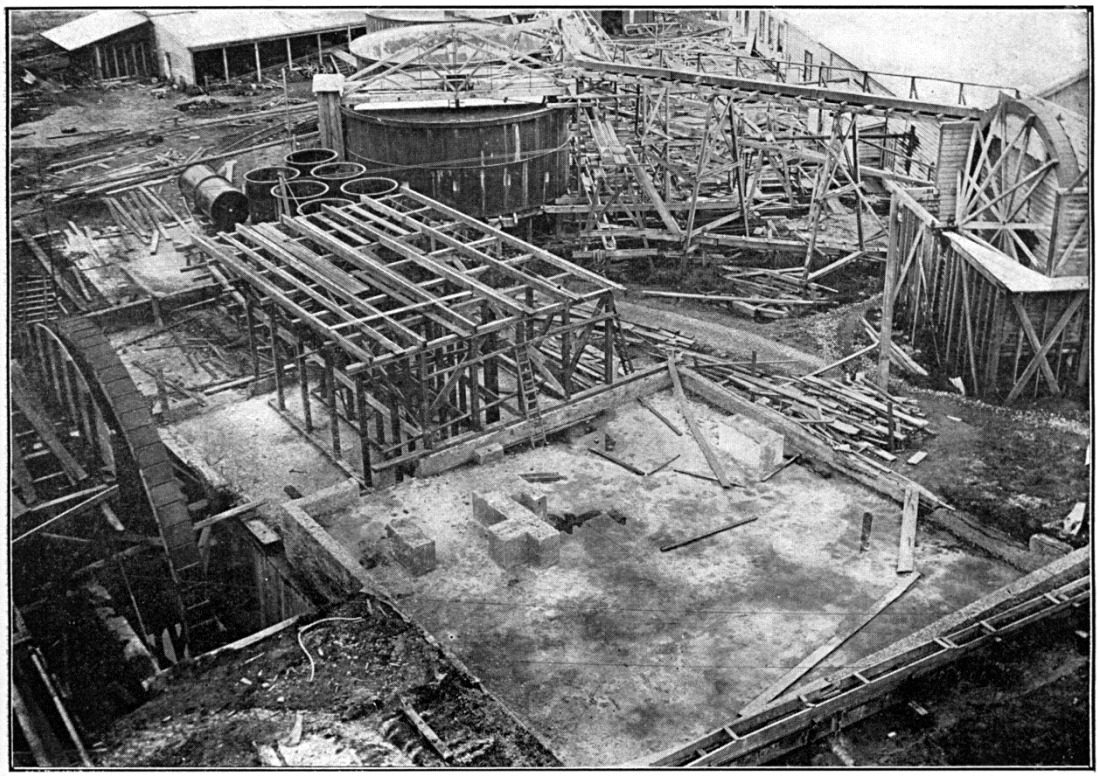
The long low building with many windows, beyond the intermediate sand vats, is the buddle plant, erected 1902. The large two storey vanner shed will be erected behind it in 1905.

The office was extended in 1901. Its frontage was a door and two windows, now it has four windows (extreme right of image). It gained a building behind it in 1900.

The store has aquired a new wing to the east. It can be seen obscuring part of the office. Another wing will be added in 1907.

The press house gained an extension in 1901. The press house is the building to the left of the three prominent tanks at right. The extension is the closer portion. A steam engine was also added 1901, the portion extending towards the vat shed. “A second-hand steam engine was obtained in Auckland and erected so as to provide an alternative method of driving the pumps, compressor, &c., in the press house, which are driven by water power” - Barry. No images show a smoke stack. If it was used, where did it get steam from?

Papers and Reports Related to Minerals and Mining, 1904.



CONCENTRATES TREATMENT PLANT, WAIKINO BATTERY, IN COURSE OF ERECTION (WAIHI GOLD-MINING COMPANY).

Concentrates Treatment Plant (CTP) under construction.

The photograph must have been taken from part of the elevated launder trestle, and is looking towards the river. The fitting shop can be seen top left, with the distinctive lean-to which can be seen in the preceeding images. Likewise the three large vats, and launder from the elevator wheel on the right. This slimes wheel ("I" on the map) was the first to be installed at the battery. Another wheel at left, possibly still under construction (B wheel).

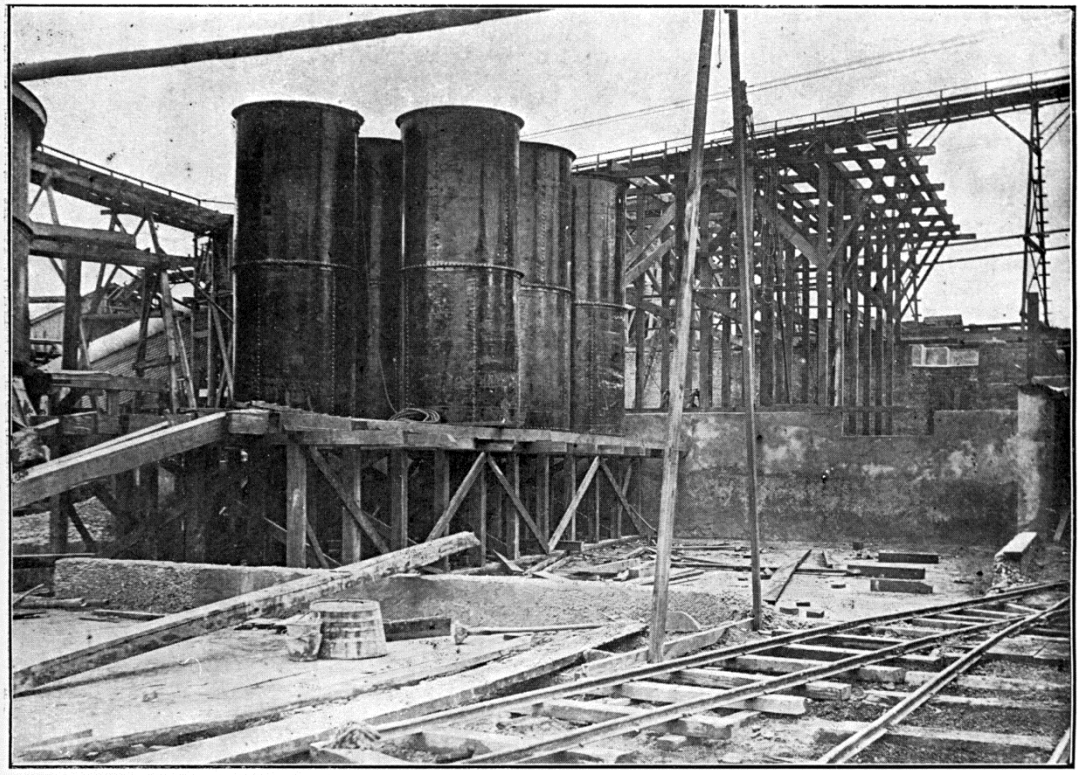
The first of the 10 tall tanks are seen here, and in the next photograph. This number will increase to 23 in time.

The open concrete floor in the foreground will accommodate the tube mill. In fact the distinctive concrete mounts for it are already in place. The concrete floor and low walls are designed to retain any overflow/spillage from the tube mill (not uncommom). The mill can be seen in position in a later photograph.

The tube mill was erected in October 1903, so this image predates this. This is the first tube mill installed at the battery. More will come.

Of note is the telegraph pole planted beside the stack of timbers on the ground to the right of the tube mill mounts. This can be seen in the photograph of the tube mill in place (1904).

Papers and Reports Related to Minerals and Mining, 1904.



CONCENTRATES TREATMENT PLANT, WAIKINO BATTERY, IN COURSE OF ERECTION (WAIHI GOLD-MINING COMPANY).

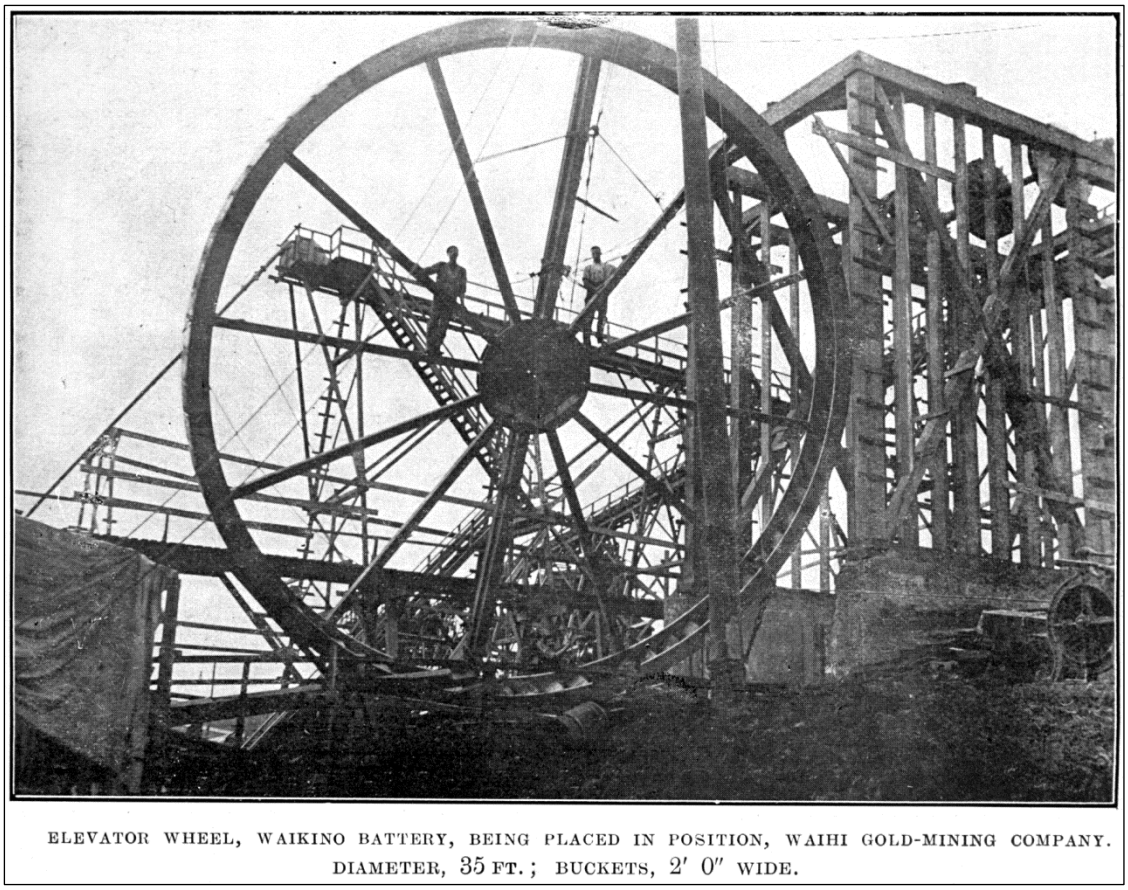
This photograph presumably taken at the same time as the one above.

“Tenders were called for ten steel agitating vats 6-ft in diameter and 15-ft. 9-ins. in depth, and the vats have since been received and erected upon timber trestling” - Barry, Annual Reports. These tanks will use compressed air for agitation. These then are the first air-agitation tanks to be used at the Victoria Battery.

Sadly, much of the concentrates treatment plant is now covered by the ramp constructed for the trommel during post-closure scavenging.

The elevated launder is visible in the background, top right.

Papers and Reports Related to Minerals and Mining, 1904.



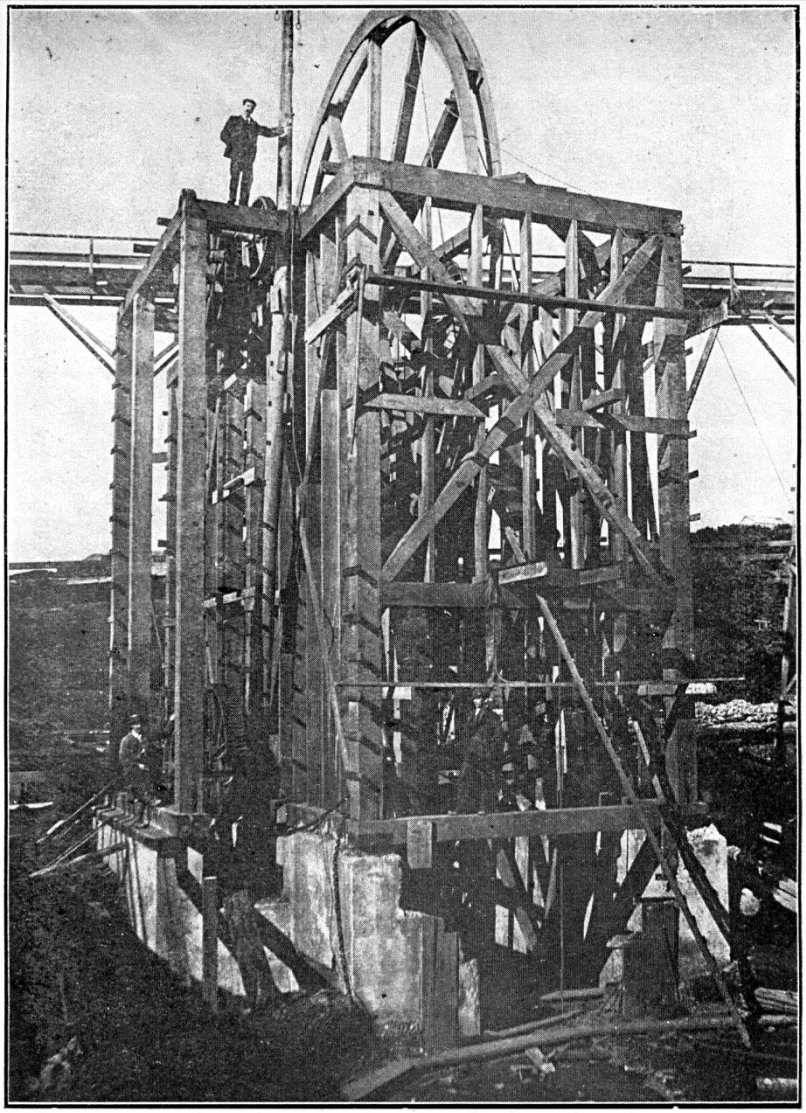
ELEVATOR WHEEL, WAIKINO BATTERY, BEING PLACED IN POSITION, WAIHI GOLD-MINING COMPANY. DIAMETER, 35 FT.; BUCKETS, 2′ 0″ WIDE.

This is the construction of the first set of wheels in the group of wheels that later include the KLM wheels. The other set of wheels (KLM) are added to the west in 1908.

The elevated launder is in the background, with the short extension visible directly behind the two workers. We are looking east.

The concerete foundations/sump are prominent today.

Papers and Reports Related to Minerals and Mining, 1904.



GROUP OF FOUR ELEVATOR WHEELS, DOUBLE LIFT, WAIKINO BATTERY, WAIHI GOLD-MINING COMPANY.

This is the construction of the first set of wheels in the group of wheels that later include the KLM wheels. Another set of wheels are added to the west (right) in 1908 (KLM).

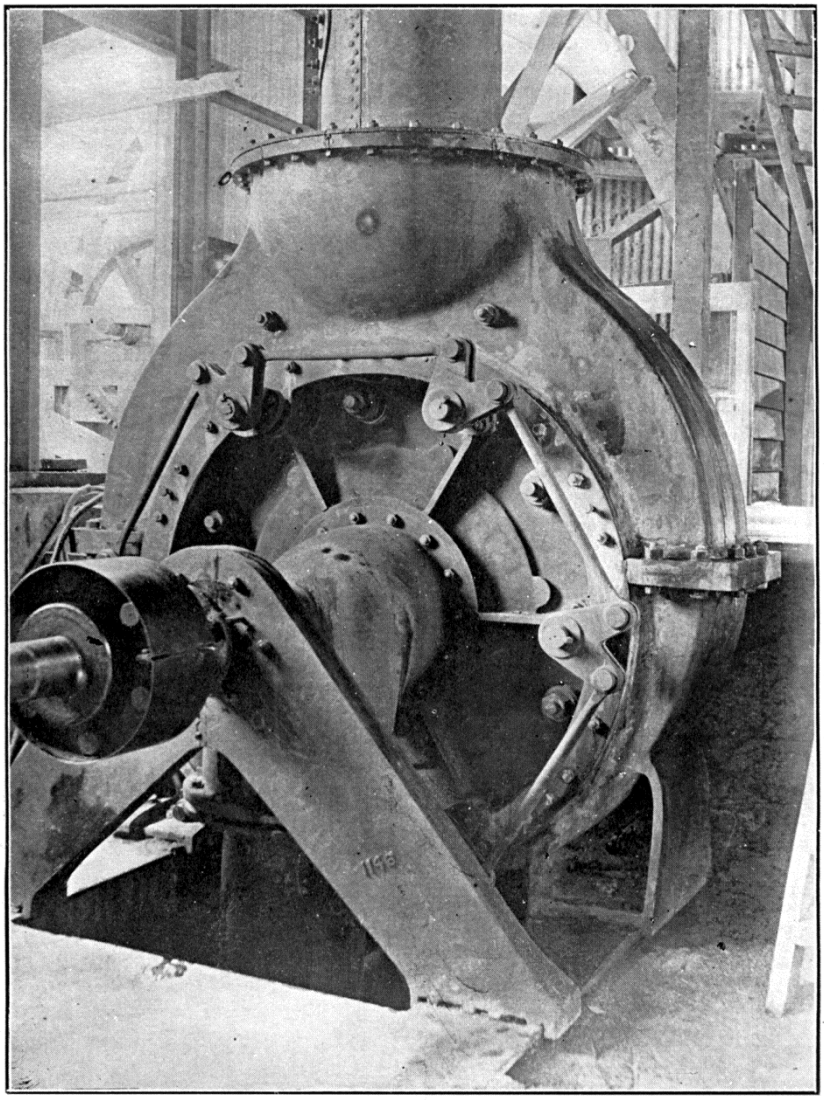
The elevated launder is in the background. We are looking south. This appears to be the eastern most of the two concrete elevator wheel foundations present today.

The caption says “group of four elevator wheels”. If this is accurate, then we can “see” two lower wheels in the smudges of the bottom of the image. And one at the top. “Three were brought into use when the Mill started on the 4th January, 1904” – as Barry reports in early 1904, for 1903.

If there are indeed to be four wheels in this installation, then it is soon added:

“The 4th elevator wheel has been brought into use for lifting the pulp from the Mill to the treatment plant, so that the sand pumps formerly used for that purpose have not since been required.” – Barry 1904.

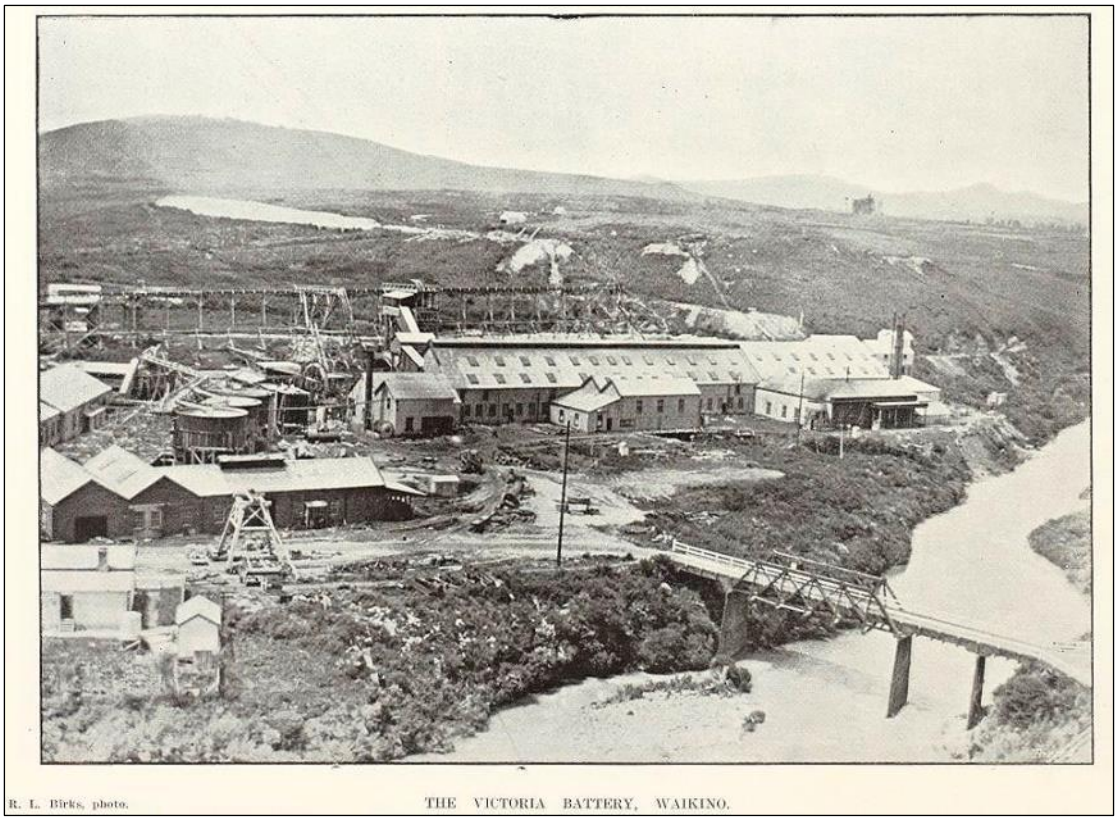
Papers and Reports Related to Minerals and Mining, 1904.



100-HORSE POWER TURBINE, WAIKINO BATTERY, WAIHI GOLD-MINING COMPANY.

This is the 100hp turbine that was repurposed from the main battery turbine pit. It was installed in the stone breaker/ore elevator area (?); the low pressure water race specialy extended, including a pressure pipe 24".

Papers and Reports Related to Minerals and Mining, 1904.



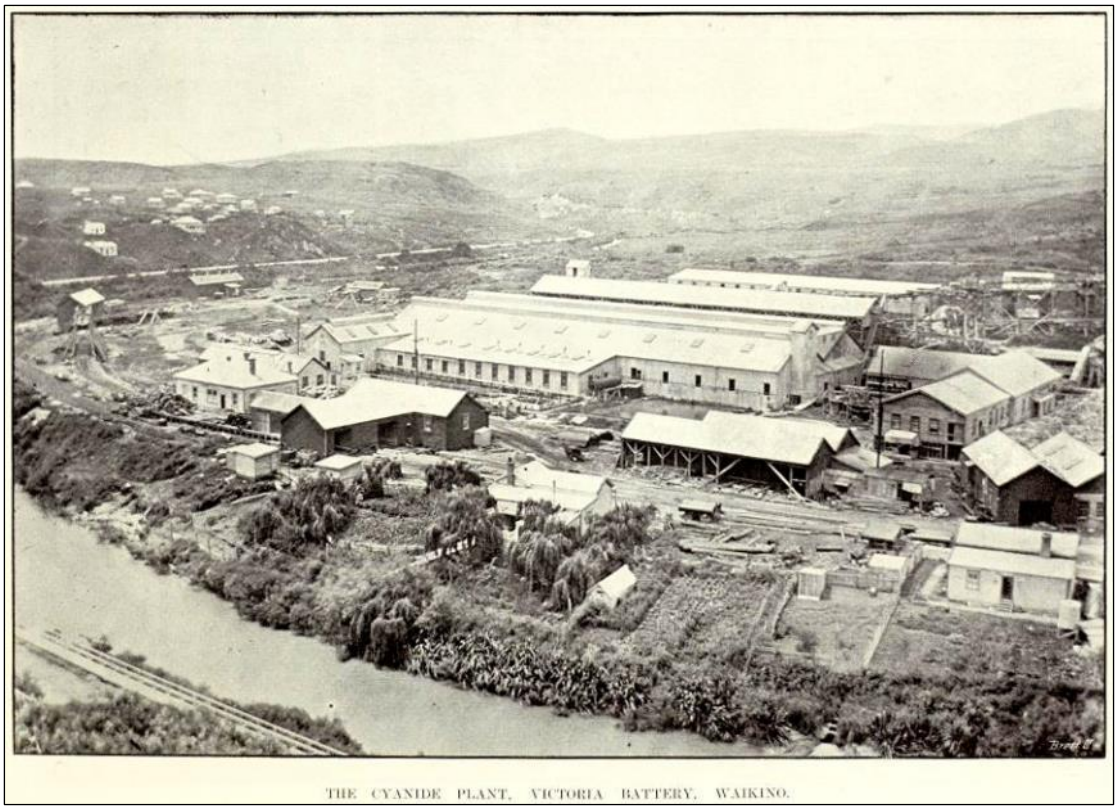
R. L. Birks, photo. THE VICTORIA BATTERY, WAIKINO.

This photograph and the next are effectively a panorama. They were published in the New Zealand Graphic, June, 1904. Although published in June, the images must be earlier, as no foundry building is visible. Its building was underway at the end of 1903. We can see the elevated launder elevator wheels (CC'DD').which were largely finished by the end of 1903. The elevated launder, to the right of the wheels, remains. It will be removed.

The small building with the roof and unfinnished walls (possibly the first experimental concentrates treatment plant), just to the right of the three large steel vats, of the 1903 panorama has gone; see page 82. In its place can be seen the group of tall tanks of the new concentrates treatment plant. The B elevator wheel has been erected. This, and the A wheel, elevate the pulp from the stampers to the bottom of the double lift wheels (CC'DD').

There is no sign of the distinctive "A" shaped structure which identifies this location in many later photographs. So this image must predate the tube mill image (1904).

RL Birks Photo. Auckland Libraries Heritage Collections NZG-19040618-29-2



THE CYANIDE PLANT, VICTORIA BATTERY, WAIKINO.

This photograph and the previous are effectively a panorama. They were published in the New Zealand Graphic, June, 1904.

Although published in June, the images must be earlier, as no foundry building is visible. Its building was underway at the end of 1903. It was a substantial building.

Not very visible here is the tailings discharge point from the slimes treatment plant. It shows as an accumulation of tailings at the river edge, bottom right. It shows better in a 1905 AWN image.

Auckland Libraries Heritage Collections NZG-19040618-23-2

1904

Superintendent HP Barry, in his Superintendent's Report for the year 1904:

> Soon after the commencement of the year a start was made to treat the Concentrates in the Plant erected for that purpose at the Victoria Mill, and within a few months the whole of the Concentrates produced at the three mills were sent to that Plant for treatment instead of shipping them to Smelting Works in Australia or England, as had previously been done…
>
> A total of 118,778 tons were passed over amalgamated copper plates and vanners before being cyanided, a further 141,200 tons were cyanided direct, making a total of 259,978 tons…
>
> During the whole year 30 stamps, with the necessary vanner plant, crushed a total of 21,724 tons of mineralised ore, which is included in the tonnage shown above.
>
> As it is now becoming increasingly difficult to keep separate the supply of oxidised and mineralised ore it will be necessary in the near future to extend the vanner plant so that a concentrate may be taken out of the whole of the output at this Mill; plans of this proposed extension of plant, embracing two tube mills, have been prepared…
>
> The work in connection with the Foundry which was in hand at the end of 1903 was completed, and the Foundry was brought into use early in the year since which time nearly the whole of the gun metal and iron castings required by the Company have been supplied from there.
>
> A third No. 5 Gates' Crusher has been ordered.
>
> The 4th elevator wheel has been brought into use for lifting the pulp from the Mill to the treatment plant, so that the sand pumps formerly used for that purpose have not since been required.

This must be the final wheel in the tandem double lift (CC' DD') installation?

The A, H (beside the turbine house) and B wheels must lift the pulp from the stampers to the CC' DD' (double lift) wheels, via launders. These launders are not obvious in any photographs. In 1908 another set of wheels, a triple lift, are installed beside the original double wheels. They are labelled K L M on the old map.

> Two additional sand treatment vats 33 feet diameter by 7 feet in depth have been added.
>
> A Breaking Down Saw and building have been added to the Saw Mill Plant, which supplies a considerable part of the sawn timber required by the Company.
>
> An addition has been made to the Engineer's Shop, and a shaping, machine and plate-bending rolls added.
>
> The sites of the Clerk's and Mill Foreman's Dwellings were required for the Government Paeroa-Waihi Railway; these buildings have consequently been moved.
>
> CONCENTRATES TREATMENT PLANT (Victoria Mill).
>
> The concentrates produced at the three Mills are forwarded for treatment at this plant.
>
> A total of 1,992.19 tons of Concentrates were treated during the year value, approximately, of £42 per ton…
>
> The tailings are being conserved.

The working arrangements of this plant have proved to be satisfactory. The Concentrates are ground in a Tube Mill and subsequently agitated by means of compressed air, with cyanide solution in ten 6 feet diameter vats.

The system of zinc fume precipitation is in use.

Prior to the Tube Mill being used for grinding Concentrates, experiments were carried out so as to see what increased output could be obtained from its use in connection with stamps for reducing the ore to the required fineness…

RAILWAY AND TRAMWAYS.

The erection of the Coal Hoppers at the Victoria Mill in connection with the Government Railway is nearing completion…

Areas containing a considerable quantity of kauri timber and other mining timber have also been secured in the Waitawheta Valley; the bush tramway connected with the sawmill at Victoria Mill has been extended between two and three miles, and a bridge over the Waitawheta river has been constructed; the final section of this line is in hand…

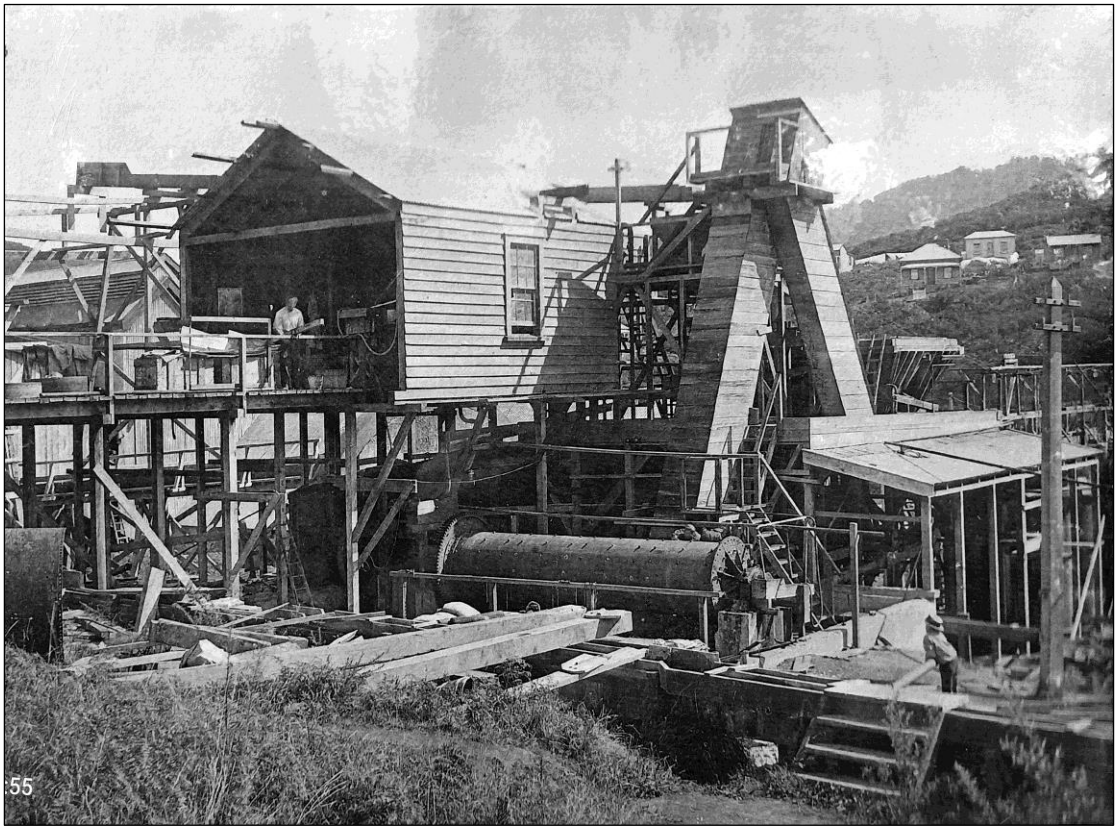
This bridge is beside Deam Road, in the vicinity of the junction with Franklin Road.

GENERAL.

The construction of the Government Railway from Paeroa as far as the Victoria Mill is nearing completion, and will probably be opened for goods traffic by the end of March. A substantial amount of the formation work between the Victoria Mill and Waihi has also been made, and there is nothing to prevent the line being completed to Waihi within a few months after it has been opened as far as the Victoria Mill at Waikino.[38]

[38] Superintendents Annual Report For 1904. Waihi, 25th January, 1905

1904 Images in chronological order (maybe).



The plant may still be under construction, but the tube mill is in place (and working?) The telegraph pole visible in an earlier image is prominent on the right of the image.

“The Tube Mill came to hand in October, and was erected, and the shafting for driving it and the air compressor and pumps was installed. A pressure tank was also installed. An order was placed for a second-hand Dehne Filter Press (1 ton capacity) for this plant at a satisfactory price. Work in connection with the whole plant has just been completed.” – Barry, 1904.

The distinctive “A” shaped structure identifies this location in many later photographs. What is it? A bucket belt elevator, part of the sizing circuit for the ground ore? “and the necessary V boxes were constructed” – Barry. V boxes classify the pulp, the fine particles overflowing and on to the agitation tanks, the coarser sands sinking to the bottom whence they are directed back into the tube mill for further grinding.

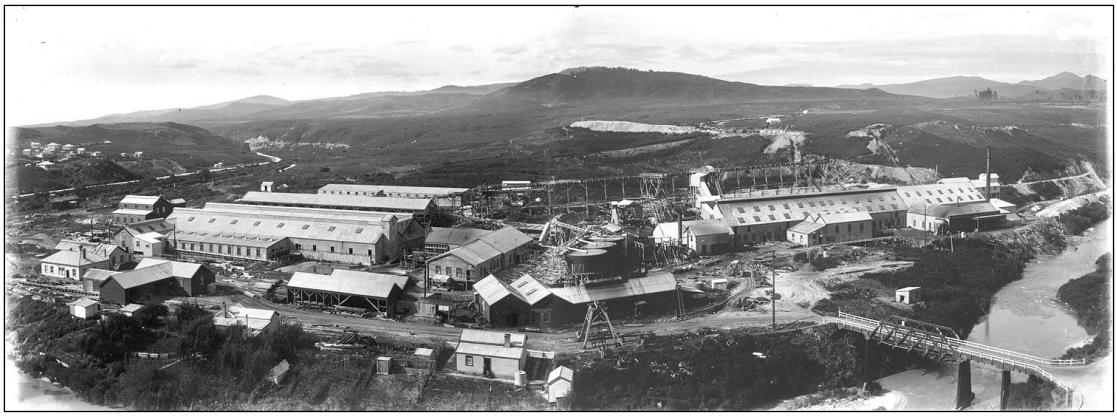
The agitation tanks are behind the tube mill, barely visible in the gloom. To the right of the A frame structure there appears to be a wooden V box.

The ventillated roof of the stamper building appears behind the structure of the concentrates plant, at the top left of the image.

Note the young tourist.

VBTS.

1904 **Wet Crushing**



The two images shown below have been joined as the photographer would have hoped.

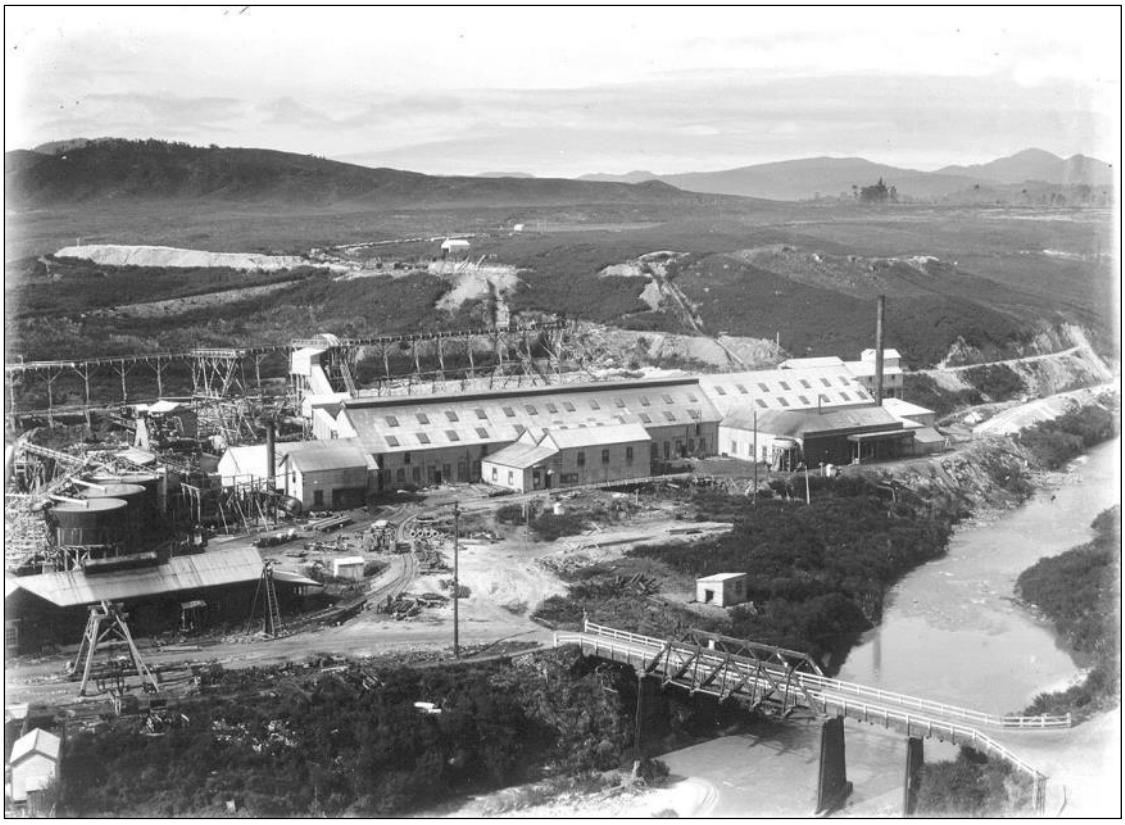
The foundry building is complete, top left with the two tier roof.

No Government railway yet, though there may be the beginnings of construction at far right.

See below for the separate photographs.

DoC Thames.

1904 **Wet Crushing**



It appears that some formation work may be underway on the railway, far right of image. In early 1905 Barry states: “The construction of the Government Railway from Paeroa as far as the Victoria Mill is nearing completion, and will probably be opened for goods traffic by the end of March”. So this image is still early 1904.

“Soon after the commencement of the year a start was made to treat the Concentrates in the Plant erected for that purpose at the Victoria Mill” – Barry. An addition to the CTP is under construction. The tailings of this plant will be conserved, but there is no sign of them yet. The distinctive “A” shaped structure can be seen.

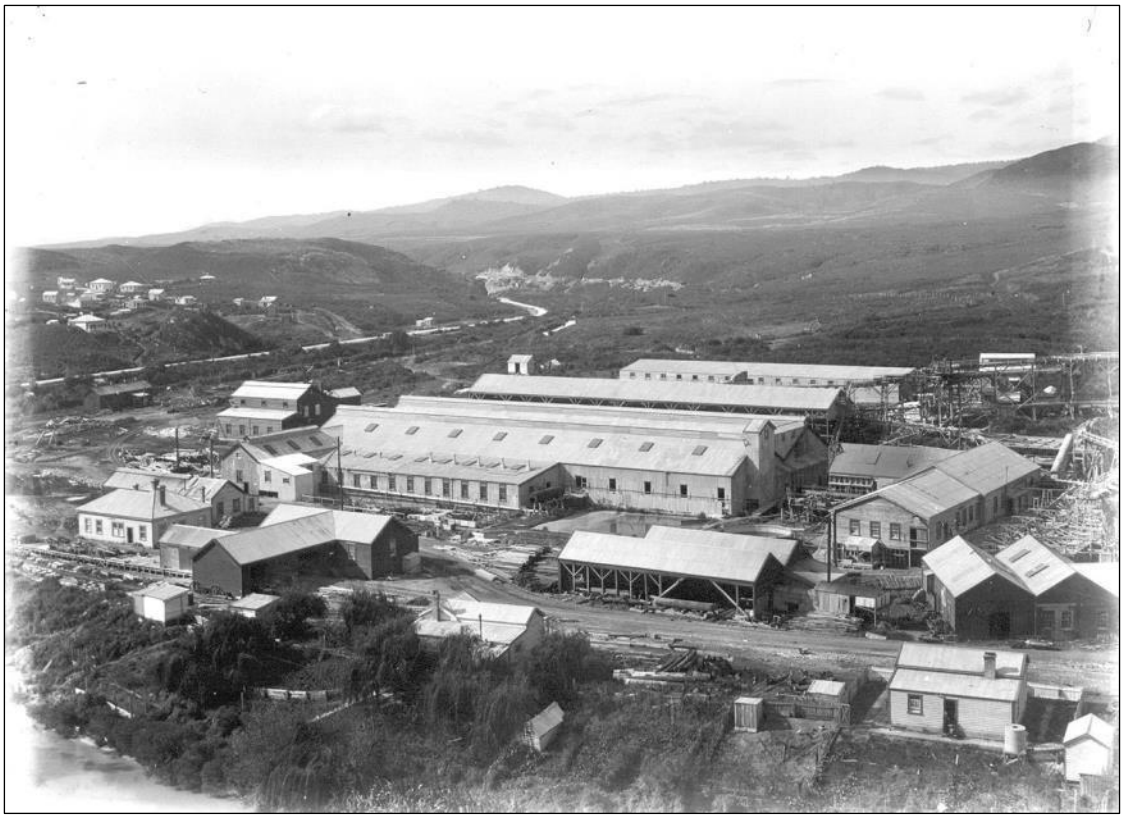
There may be ore carts and rails by the ore stockpile, behind and to the left of the kilns, and signs of ore removal. The incline in front of the kilns looks a little overgrown. Is the ore from the stockpile being transferred to the kilns? Barry mentions using the kilns to store ore.

Is timber (firewood?) still stacked along the timber tramway from the Waitawheta, beyond the kilns?

Two distinctive objects protruding at an angle from the kilns appear to be large timbers. For what purpose?

There is a man up a ladder in front of the fitting shop, at left.

DoC Thames.



The foundry building is complete, top left with the two tier roof.

A new extension (lighter coloured) has been added to the pricipitation buildings.

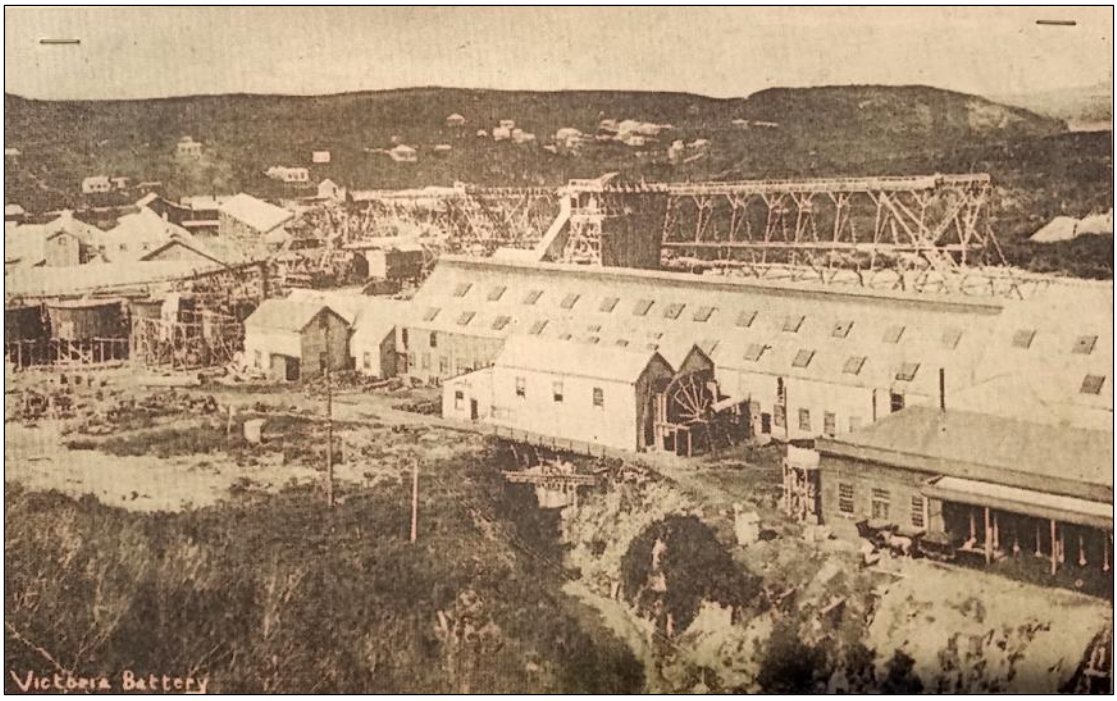
There is a small building behind the elevated launder, top right. Is this the first vanner/tube mill building?

Immediately behind the press house can be seen a set of V boxes. Where in the flow sheet do they belong?

The V boxes of the CTP can just be seen immediately in front of, and to the right of, the A frame structure. An extension to the front of the CTP appears to be under way. It will become a 2 storey building, from which the the concentrates tailings will exit on a trestled tramway. The tailings will be stacked and conserved.

Of the two dwellings on the riverbank, only the one on the right will remain after the Government railway is established. Two houses will be built beyond the buddle, and new vanner shed, during 1905.

DoC Thames.



The H elevator wheel can be seen against the wall of the turbine building. It does not protrude above the roof line, so is not visible in most of the images.

Presumably it collects pulp from some of the stampers, elevating it so that it can be laundered to the C D wheels. The concrete sump (Barry calls it a pit) of this wheel remains. A square hole on the eastern side of it allowed pulp to enter the sump, to be lifted by the wheel. Wear on several areas of the concrete sump attest to the abrassive nature of the pulp.

F Nuggent photograph. VBTS.

1905

Superintendent HP Barry, in his Superintendent's Report for the year 1905:

> During the whole year 30 of the stamps, with the necessary vanner plant, were at work on mineralised ore, crushing a total of 26,721 tons, which is included in the tonnage shown above.
>
> The third No. 5 Gates crusher, which was ordered during 1904, was erected and brought into use during the year under review.
>
> Until 1905 the single filter-press treatment was in use at this mill. It was decided to adopt the vacuum slimes process, and the necessary plant, consisting of rectangular iron vat, disintegrator, vacuum pump, hydraulic elevator, and traversing gear, was procured, erected, and brought into use.
>
> It was decided to add two tube mills, more especially with a view of improving the extraction at this mill. The necessary building has been erected.
>
> The two elevator wheels required in connection with this plant have been constructed and partly erected in position.

Are these the two wheels (one sump) immediately to the east of the tube mill floor? The E elevator wheels?

> To provide the power required for driving the tube mills, etc., one of the engines not in use has been transferred to this mill and overhauled and re-erected; an extra boiler, not required at one of the shafts, has also been erected in position, but further boiler power will still be required.

The chimney for this can be seen in the AWN DS Shaw photograph, 1906.

> The tube mills themselves are now coming to hand.
>
> The decision to extend the vanner plant, so as to embrace the product from the whole 200 stamps, has been given effect to, and the work has been in hand for several months past, and the large plant for this purpose is nearing completion and should be brought into use within a few weeks.
>
> This plant is in a different position from the small vanner plant now in use.
>
> A large two storey building has been erected, the necessary copper plate-tables, which are situated on the top floor, have been put in, and the "Wilfley" vanners, 25 in number, have been procured and erected on the ground floor.

This new building can be seen in the AWN image of 27.07.1905.

> The necessary iron tanks, launders, and elevator wheels required in connection with this plant have been constructed and erected in position, only the smaller details still remaining to be dealt with.

Another set of wheels? At northwest corner of vanner shed? The F wheels?

> The vanners will be driven by means of a steam engine which was not in use, and which has been transferred and re-erected in position.
>
> Alterations to the store, platforms, and lines have been carried out; large coal hoppers, connecting with the Government Railway, have been constructed and are now in use.
>
> A dwelling-house for unmarried members of the assay office staff, etc. has been erected.

In fact two dwellings have been constructed in the horse paddock to the southeast of the new vanner shed.

> The foundry has been in constant operation throughout the year, supplying the whole of the gun-metal and iron castings required in the various departments, including heavy castings such as mortar boxes, anvils for mortar boxes, dam doors and frames for the Mine, and parts in connection with balance weight for Mine pumps.
>
> The small truck repairing shop was damaged and partly destroyed by fire towards the end of the year and has been rebuilt.
>
> Concentrates Treatment Plant (Victoria Mill).
>
> As the tonnage of Concentrates produced at the three Mills and which is forwarded for treatment in this plant (situated at the Victoria Mill) has been increasing and will still further increase in the near future, it has been necessary to make some additions to the existing plant.
>
> Early in the year two more agitating vats 15 feet in height by 6 feet in diameter were added, and later on in the year a further seven vats of the same size have been erected.
>
> The treatment plant has been roofed in.
>
> A second tube mill obtained locally and fitted up at the Victoria Mill has been added to the plant and erected in position….
>
> CONCENTRATES TREATMENT PLANT.—
>
> All the concentrates produced at the three mills, with the exception of the small shipments previously referred to, have been forwarded for treatment at this plant.
>
> The tailings from this plant are still being conserved…
>
> RAILWAY AND TRAMWAYS.
>
> The main line between Waihi and Waikino has been maintained in good order.
>
> It was desirable to have a new locomotive of increased power for the transport of ore and general goods, in addition to the three locomotives which have been constantly in use. The new locomotive “Waikino” was received at the end of the year and has now been put together and tested, with satisfactory results…
>
> Additional rolling stock has been obtained.
>
> A short line connecting the Government Railway line with the Company's coal hoppers at the Victoria Mill has been constructed…
>
> Large quantities of mining timber, logs, etc., have been obtained, the logs being sawn up at the Company's saw mill at the Victoria Mill into the various sizes of building timber required…
>
> The construction of the Government Railway from Paeroa as far as the Victoria Mill, Waikino, was completed by the end of March, the first train of coal trucks reaching there on the 2nd April. The opening of the line to this point has lessened the difficulties attending the transport of the large quantity of coal and other goods required by the Company.
>
> The extension of the line to Waihi was completed a few months later and the line was opened for traffic on the 9th November.
>
> With a view to providing additional power to allow of the gradual expansion of the Company's Works which has been going on and is likely to continue, considering the very satisfactory manner in which the Mine has continued to develop, further examination has been made of the water power available in the neighbourhood; after careful inspection of various sources of

power, a scheme for transmission of power from the Waikato River was decided upon as being the most suitable; by the adoption of this scheme all the power likely to be required could be generated and transmitted to the Company's Works.

Application has been made to the Government for permission to carry out this scheme, and in the interests of the Company, the mining community, and the Colony itself, it is very much to be hoped that the necessary authorisation will be made.[39]

[39] Superintendents Annual Report For 1905. Waihi, 18th January, 1906.

1905 Images in chronological order (maybe).

This image a little earlier than the following image of Auckland Weekly News 27.07.1905.

The conserved tailings from the concentrates treatment plant are stacked where the air agitation tanks will go in a couple of years (centre of image). The new CTP can be seen top left with the trestled tramway delivering the tailings to the stack.

A new building has arrived between the press house and the three large vats. What is it? A part of the CTP?

The railway has been located on the riverbank, and bridged over the tailrace.

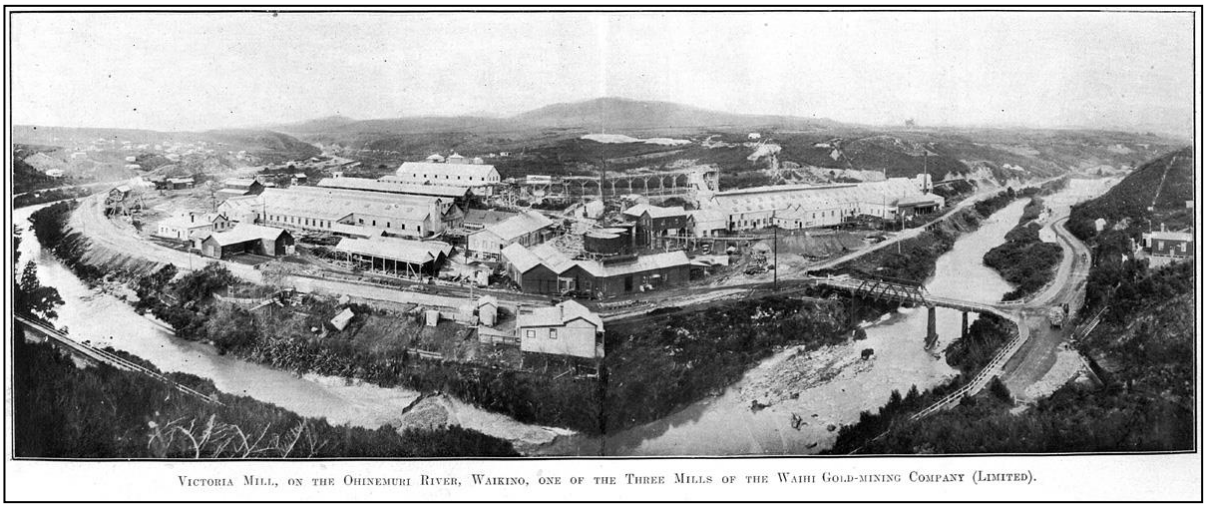
The house remaining on the riverbank is the same house, in the same position, but it has been turned so that the front verandah does not face the new railway.

The now unrequired section of the elevated launder has been removed.

The river is choked with tailings and debris, hardly flowing under the battery bridge. More water is added by the tailrace. Three people (children?) gaze forlornly at the devastation.

The incline in front of the kilns looks overgrown.

VBTS. Also MV20, WACMA.



Victoria Mill, on the Ohinemuri River, Waikino, one of the Three Mills of the Waihi Gold-mining Company (Limited).

This panorama taken from same spot as the previous, but a little later (more vegetation on some of the bare areas).

Government railway in foreground.

The now unrequired section of the elevated launder has been removed.

The two storey vanner shed has been constructed. There is a small building (early tube mill building?) where the large tube mill building will soon be built.

Two new dwellings can be seen in the horse paddock beyond the vanner shed roof.

Only one house remains on the river bank. It is the same house, in the same position, but it has been turned so that the front verandah does not face the new railway. A room has been added to the back (left side), and the little shed and water tank have been moved from right to left side. This is not mentioned in the literature.

The conserved tailings from the concentrates treatment plant are stacked where the air agitation tanks will go in a couple of years. The trestled tramway delivering these tailings to the stack can be seen. See crop below.

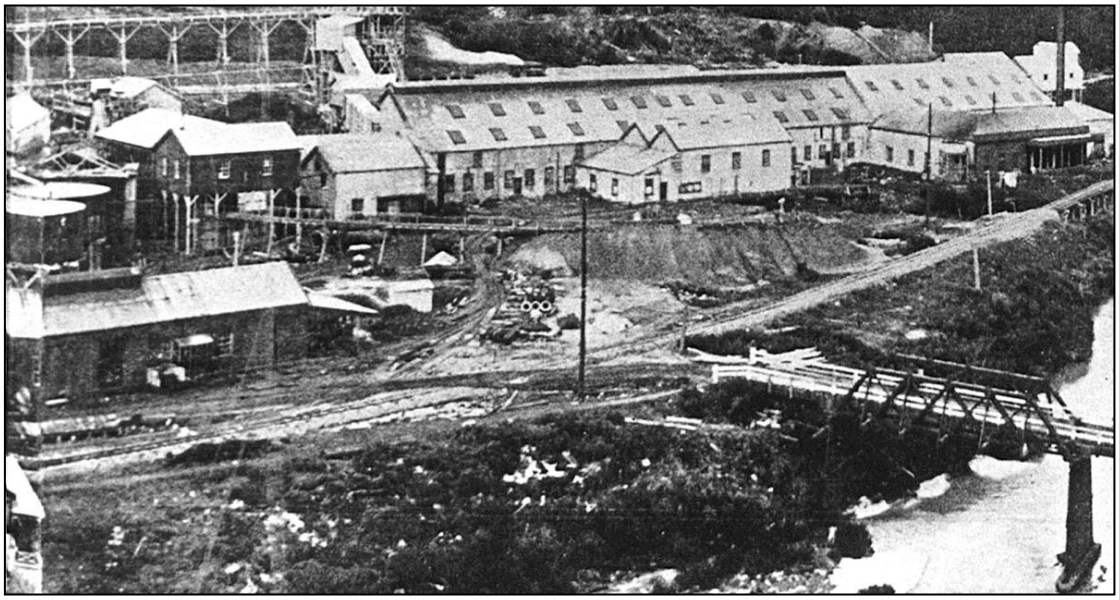
The river just to the left of the dwelling has a sand bar with an erosion scar. Just below the two outhouses is a trench. This must be the tailings discharge plumbing for the early slimes plant, which includes the press house (behind the gap between the saw mill and fitting shop). This can also be seen in a 1903 image. Once the vacuum slimes plant and tall air agitation tanks are established, the slimes tailings are discharged a little down stream from the site bridge. The CTP may discharge its tailings here later.

Victoria Mill, on the Ohinemuri River, Waikino. Auckland Weekly News 27.07.1905.

This image also appears in: AJHR 1907 SESSION I, C-03.

https://paperspast.natlib.govt.nz/parliamentary/AJHR1907-I.2.2.2.7

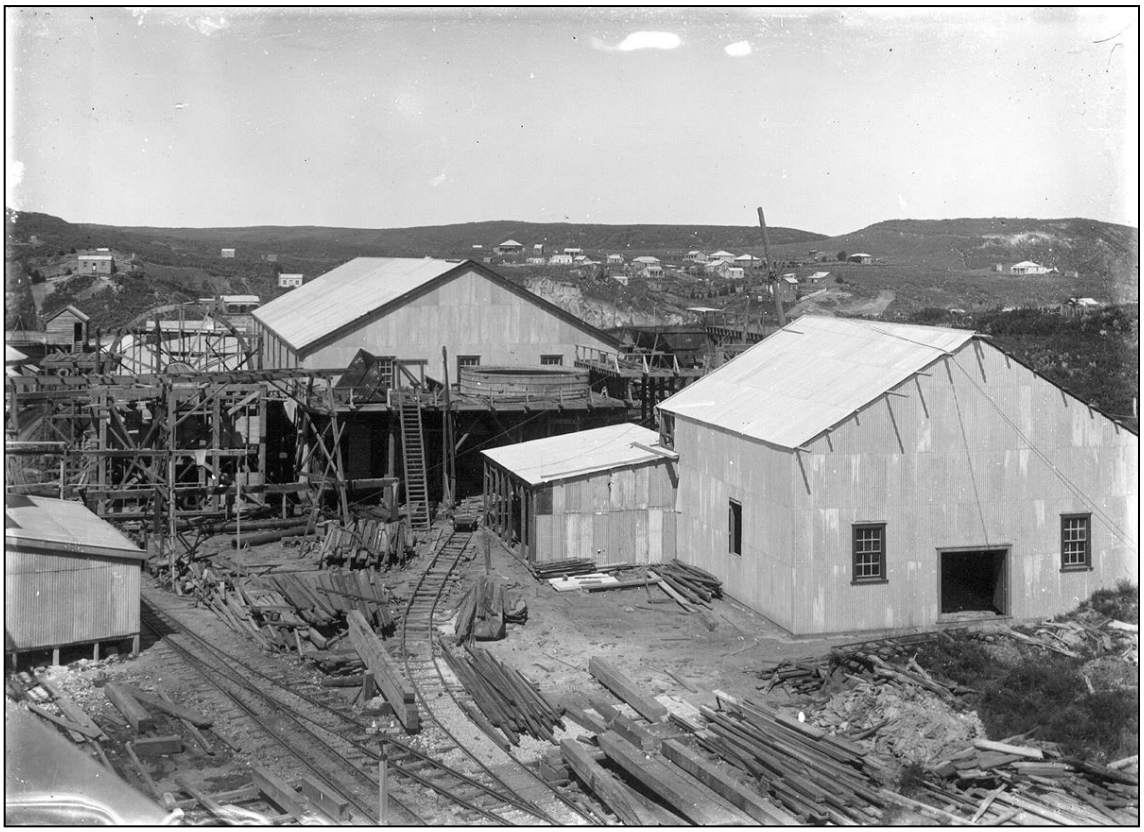
And Papers and Reports Relating to Minerals and Mining,1907.



Victoria Mill, on the Ohinemuri River, Waikino. Auckland Weekly News 27.07.1905.

The conserved tailings from the concentrates treatment plant are stacked where the air agitation tanks will go in a couple of years. The new CTP can be seen top left with the trestled tramway delivering the tailings to the stack.

1905 **Wet Crushing**



Looking east. Photograph taken from the elevated launder, or C D' elevator wheels?

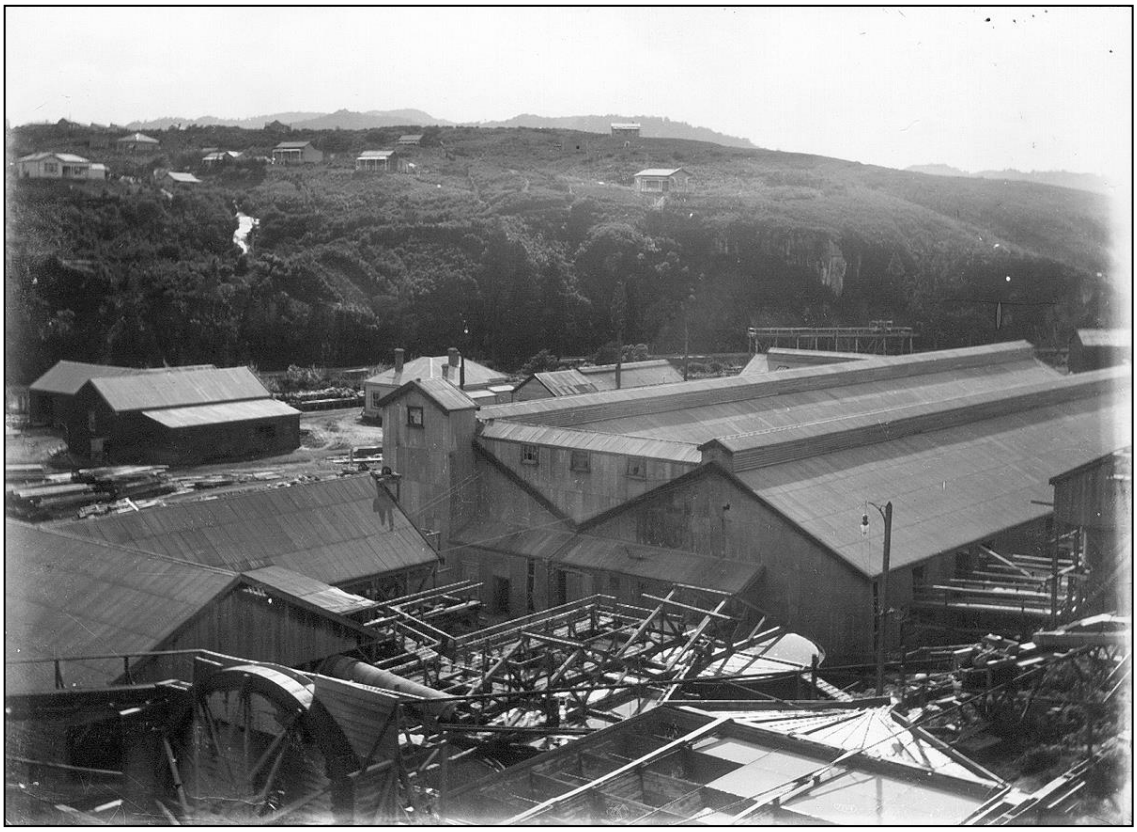
In the background is the new two storey vanner shed, to the left an elevator wheel under construction. This will be the double lift F elevator wheels. It is labelled on the old map as "3 wheels double elevator".The buddle plant must be directly behind the wheel.

Note the little shed with ladder, perched on the tank at top right. Barry describes a similar installation at the Waihi Battery, 1902: "A large steel vat has been erected for making up the necessary cyanide solutions, and a cyanide store erected immediately by this vat, the floor of which is level with the top of the vat". This would make up solution for use in the sand treatment vats. It is visible in subsequent images.

In the foreground is the early version of the tube mill building?

The building at left is the lime shed?

DoC Thames.



Looking north east from up on the elevated launder.

The large building to the right is the vat shed. The tall left hand structure, and the connection between the two gables, were for elevating and distributing the dry crushed ore. This is probably not in use now. The lower lean-to may have housed the pelton wheel that powered these elevators. To the right of the building are visible some of the short tramways used to deliver the sand from the intermediate sand vats (on the extreme right).

Bottom left shows the slimes elevator (the I wheel), and behind it the press house. In the foreground part of the V boxes, or classifiers.

In the background are from left the store, office, and gantry.

DoC Thames.

1906

Superintendent HP Barry, in his Superintendent's Report for the year 1906:

> WAIHI MILL (90 STAMPS).—
>
> The use of “Honeycomb” liners in these tube mills has been adopted, their use having proved an economy in the cost of repairs, and also in time required to line the mill in the first instance, and subsequently to effect the necessary repairs…
>
> As the mortar blocks under the stamps were beginning to show signs of decay and it became increasingly difficult to keep the mortar boxes bolted down snugly in position, it was decided to gradually instal heavy cast iron anvil blocks between the mortar boxes and mortar blocks; this work has been carried out as opportunity offered and the whole mill has been equipped in this way…
>
> VICTORIA MILL (200 STAMPS)—
>
> By the end of 1905 the re-arrangements and additional plant required for concentrating the whole of the product from the mills were well forward, two tube mills with the necessary engine and boiler power were also in process of erection. At the commencement of the year under review it was decided to add an additional boiler and consequently a large sized Lancashire boiler was obtained and installed…
>
> To provide room for additional machine tools which were obtained during the year, and to facilitate the large amount of work which is now carried out at the Victoria Mill, the fitting shop has been considerably extended; provision has also been made to enable the repairs to the locomotives to be carried out here which is more convenient than the former arrangement.
>
> Alterations to the stonebreaking department have been carried out. A large sized Heclon Breaker has been erected, and one of the No. 5 Gate’s Crushers taken down and forwarded to the Union Mill. One of the No.? Gates Crushers has been replaced by a newer one, the old one being removed to the quarry and erected there.
>
> A gantry has been erected to facilitate the transfer of heavy lifts of machinery, etc., from the Government line to the Company's trucks. Arrangements are being carried out for discharging coal direct from the Government trucks into the boiler house without the re-handling which is at present necessary.
>
> The foundry has been kept steadily at work and has supplied practically the whole of the iron and gun-metal castings required, including heavy pieces such as mortar boxes, anvil blocks, etc.
>
> PRODUCER GAS[40] AND TUBE MILL PLANT:—
>
> The Company's application for a license to generate power at the Hora Hora Rapids, on the Waikato River and transmit it by electricity to the works was refused by the Government.
>
> Under these circumstances the general scheme of increased power permitting of extensions at the various mills had to be modified, and the erection of a 1,000 horse-power producer Gas Plant was decided upon: the erection of which will primarily permit of a very considerable extension to the Tube Mill department, which it was very desirable to make.
>
> The first consignment of the "Crossley" Gas Plant and engines which have been ordered should reach here within a week or two, and in the meantime the work of additions to existing tube mill and treatment plant has been actively carried on.

[40] For detailed description see: https://patents.google.com/patent/US8480771B2/en

The extension to the tube mill building has been completed, and concrete foundations for an additional seven mills put in; a contract for the bodies of seven mills has been let, and the first of these has been received, fitted up at our own workshops and erected in position; the other bodies are now coming to hand, and will be fitted up here as they are received. The overhead main shafting, bearings and pulleys, etc., have been ordered from Home.

The most suitable position for the extension of the vacuum slimes plant and agitators required for the treatment of the increased product, which should amount to about 5,000 tons per month, was occupied by the concentrates tailings dump, consequently these have been removed.

A contract for 32 agitators, 12 feet diameter by 35 feet in height, has been let, and the erection of part of these is already well in hand, the concrete foundations and walls for a number of them having been completed.

Seagar Brothers[41] (Engineers, Boilermakers, Iron and Brass Founders, General Smith Workers) have the contract for installing the agitators. Auckland Star 17 November 1906:

"WANTED, 6 Labourers and 3 strong Rivet Boys.—Apply to Seagar Bros., at Waikino Battery, on Monday morning, 10th inst."[42]

Contracts have been let for the rectangular iron tanks and hydraulic elevators, etc., required in connection with the vacuum slimes department and extension of slimes thickening plant: the foundations have been completed and framework of building is in hand.

A contract has been let for three slimes settling vats, 32 feet diameter by 13 feet in depth.

The concrete foundations have been put in for the building to contain the three gas engines required to drive the tube mills, elevator wheels, and vanner plant.

So far as can be seen at present the whole of the additional power, crushing and treating plant now being added, should be completed soon after the middle of the year.

CONCENTRATES TREATMENT PLANT, VICTORIA MILL.—

The tonnage of concentrates handled at this plant shows a considerable increase over the preceding year.

The second tube mill, which had been erected, was brought into use during the year under review, and another filter press was also added to the Plant…

The benefit of the two tube mills and concentrating plant was only felt for from 7 to 8 months of the year, consequently it may reasonably be anticipated that the current year will show a still further improvement which will be further helped during the last few months of the year 1907, when the extension to the tube mill plant, referred to above, is completed.

Concentrates Treatment Plant, Victoria Mill.

All the concentrates produced at the three mills have been forwarded for treatment at this plant…

The tailings from this plant are still being conserved…

RAILWAY AND TRAMWAYS.

The main line between Waihi and the Victoria Mill, Waikino, has been maintained in good order, and a portion of the track has been re-laid with heavier sleepers.

[41] https://nzetc.victoria.ac.nz/tm/scholarly/tei-Cyc02Cycl-t1-body1-d1-d47-d28.html
[42] https://paperspast.natlib.govt.nz/newspapers/AS19061117.2.3.8
Auckland Star, Volume XXXVII, Issue 269, 17 November 1906, Page 1

> An extra siding has been put in at the coal hoppers and water tank half way between the two termini, and the three rail siding is being extended to the boiler shed.

Half way between the two termini means at the “halfway”. The three rail siding to boiler shed means the dual gauge line to the main boiler house for the big steam engine. Dual gauge means the Government waggons can be moved around the site.

> The new locomotive "Waikino" has been running regularly.
>
> The additional power which it has, has proved advantageous.
>
> One of the locomotives and several trucks were derailed during the year but the damage done was very slight.
>
> To cope with the increased tonnage which will be required at the Victoria Mill when the extension of the tube mill plant is completed, material for additional rolling stock has been ordered and will be constructed in the Victoria Mill Workshops.[43]

The concentrates tailings stacked at the battery were moved to beside the rakeline and river, upstream from the battery. A separate document explores this new tailings stack.

> Waihi Daily Telegraph, Volume VI, Issue 1675, 4 **July 1906**
>
> > WAIHI GOLD MINING CO., Ltd Tenders will be received up to noon on FRIDAY, 6th July, for the REMOVAL AND DEPOSITING of about 4000 yards of CONCENTRATES TAILINGS at the VICTORIA MILL, WAIKINO. Specifications to be seen at the Company's Offices, Waihi and Waikino. H, P. BARRY, Superintendent.[44]

WAIHI GOLD MINING CO., LTD

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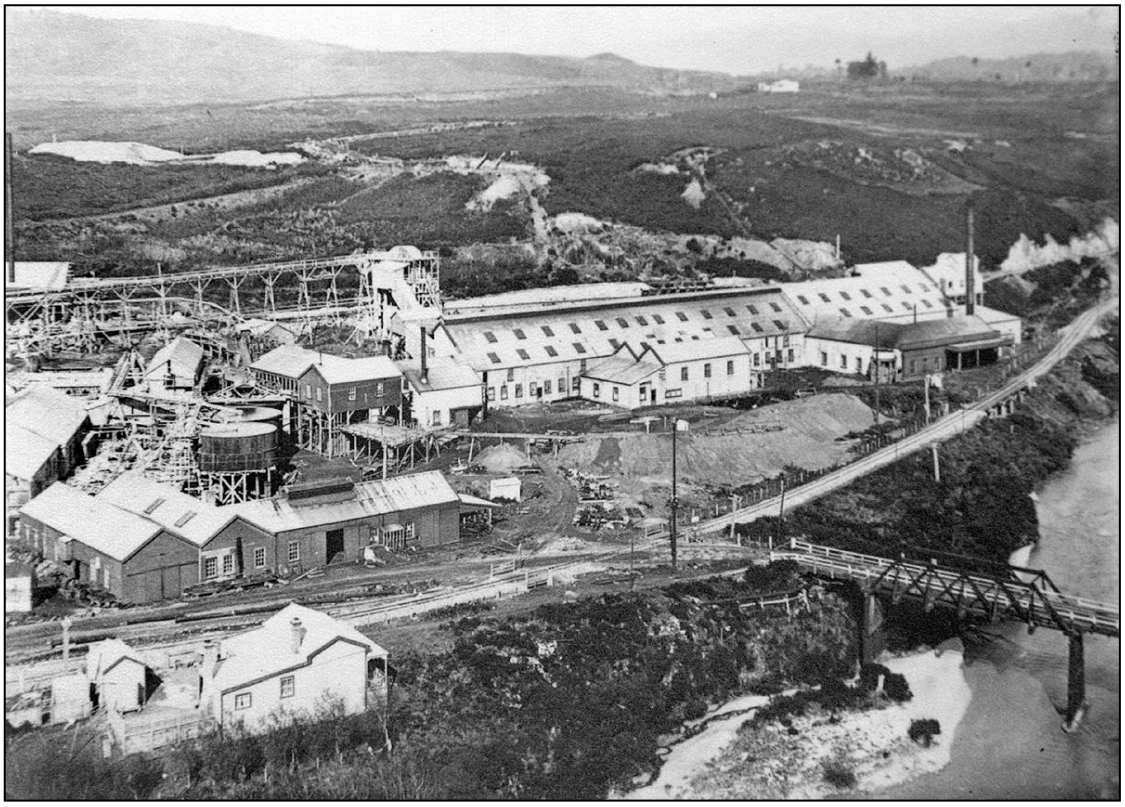
Specifications to be seen at the Company's Offices, Waihi and Waikino.

H. P. BARRY,
Superintendent.

[43] Superintendents Annual Report. For 1906. Waihi, 17th January, 1907.
[44] https://paperspast.natlib.govt.nz/newspapers/WHDT19060704.2.49.5
Waihi Daily Telegraph, Volume VI, Issue 1675, 4 July 1906, Page 3

1906 Images in chronological order (maybe).



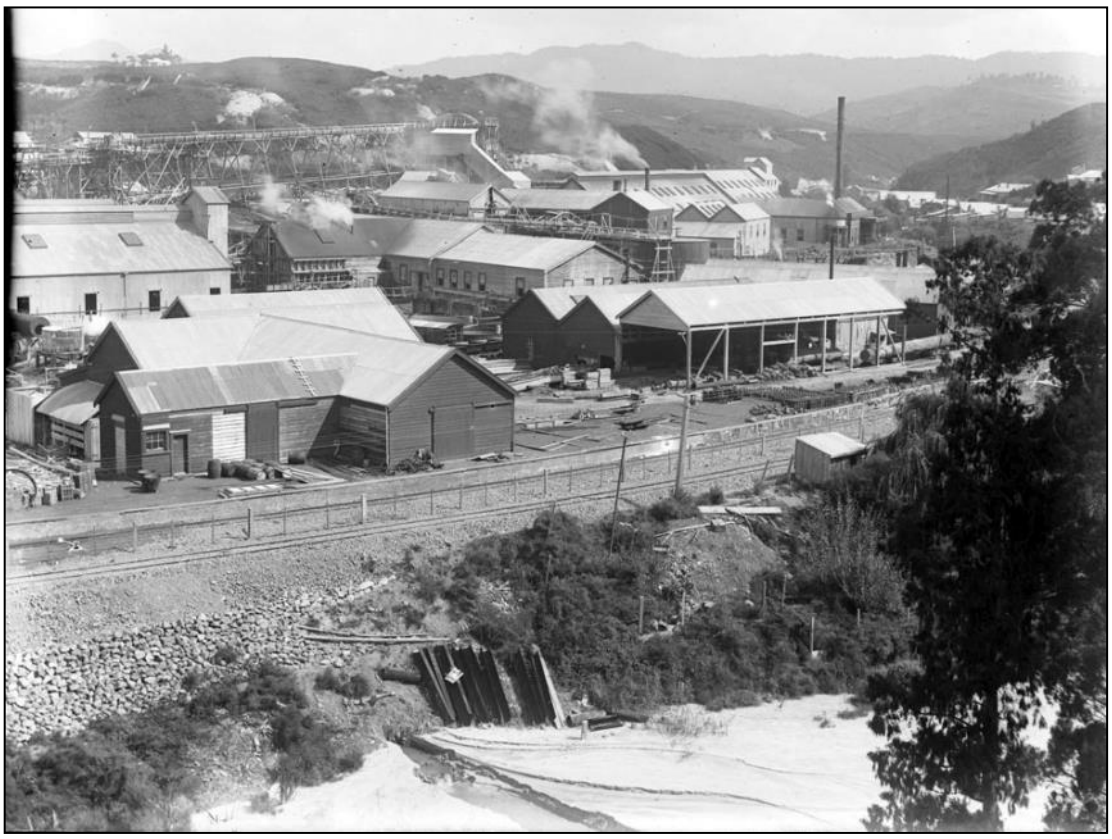
The concentrates tailings stack has grown, with a new lobe to the right.

The conserved tailings from the concentrates treatment plant are stacked where the air agitation tanks will go soon. The CTP can be seen middle left with the trestled tramway delivering the tailings to the stack. These tailings will be removed shortly after July 1906.

An AWN photograph published 03.05.1906 looks no different.

Stubbs.

1906 **Wet Crushing**



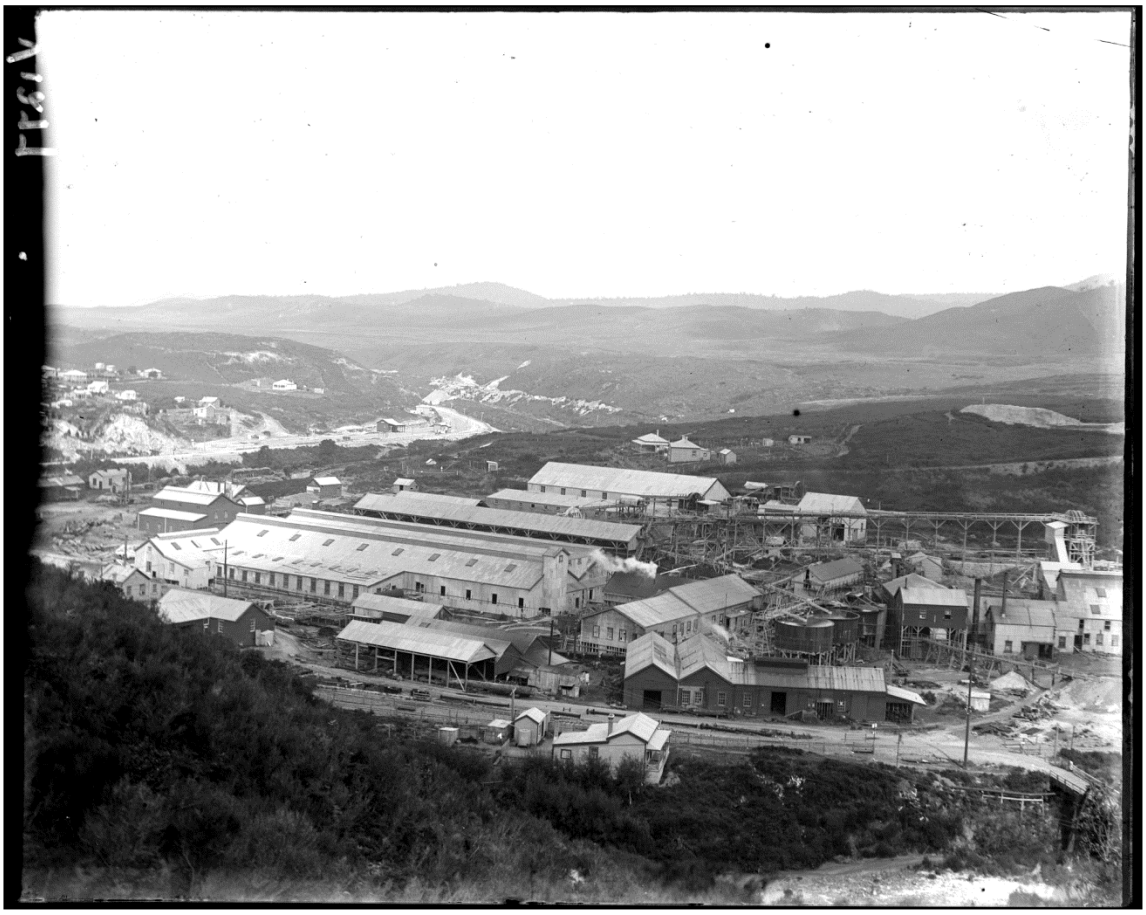
The sands tailings prominent, creating a beach in the river.

Railway in foreground, company tramway on other side of fence. Saw mill to right, store to left. No rail platform yet. End of sand vat shed above store roof.

The store still has only the eastern wing. The western wing arrives in 1908.

The vat shed still has the tall elevator housing at its western end. It will soon be gone.

HE Vaile, Auckland Library, 03.1906 V1280.

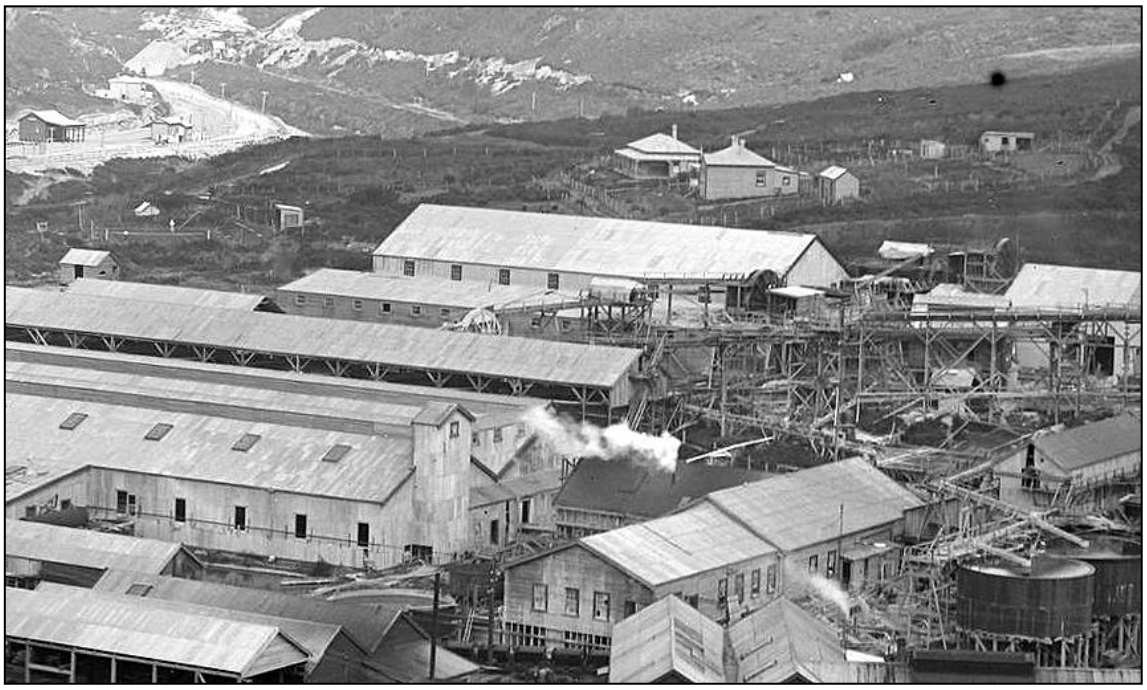


The new vanner shed is prominent at centre, with the two dwellings behind. A small version of the tube mill building is to the right of the vanner shed. The buddle shed in front of Vanner shed. It will be removed after 1907.

Bottom right corner of image shows a new pipe emerging from under the bridge. A new connection to the high pressure pipe? Cast iron pipes are laid out in front of the fitting shop, ready to be connected and buried? To power?

A large log protrudes from the saw mill. The same log as in the previous photograph.

HE Vaile, Auckland Library, 03.1906 V1277.



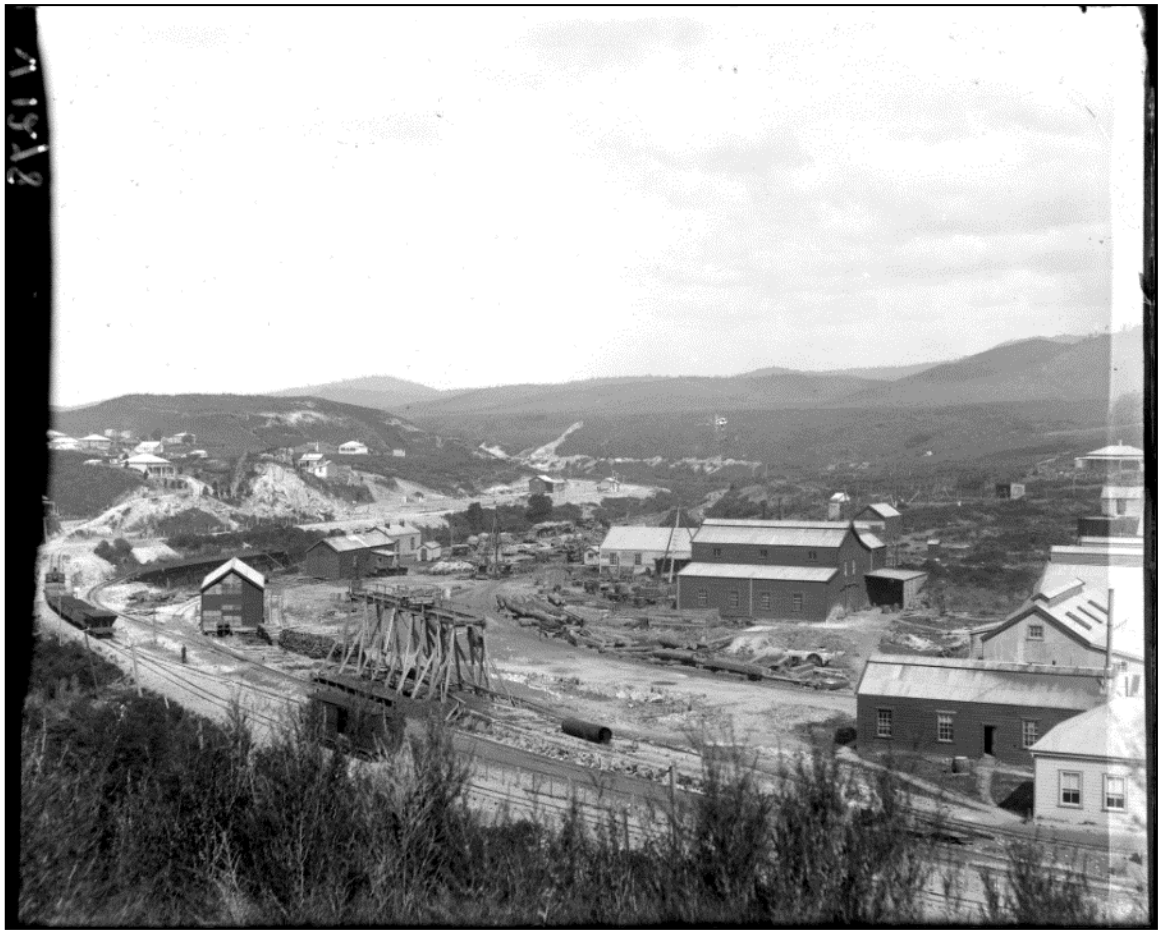
This is a crop from the previous image. It shows in particular the three elevator wheel installations.

At the end of the small tube mill building, middle right (the E wheel); at the vanner shed (F wheel); and at the intermediate sand vats (J wheel, centre of image). These remain for the life of the battery, and their foundations/sumps remain today, but not of the J wheel.

The roof with the steam plume is the engine house of the Press House.

Top left of image shows the new railway station. Beyond it across the river is a conical pile of spoil from the quarry. This pile remains today. The rake line is immediately behind this, angling towards the battery, and above that the scar of the water race channel. Between these two will be deposited the concentrates tailings towards the end of the year.

HE Vaile, Auckland Library, 03.1906 V1277.



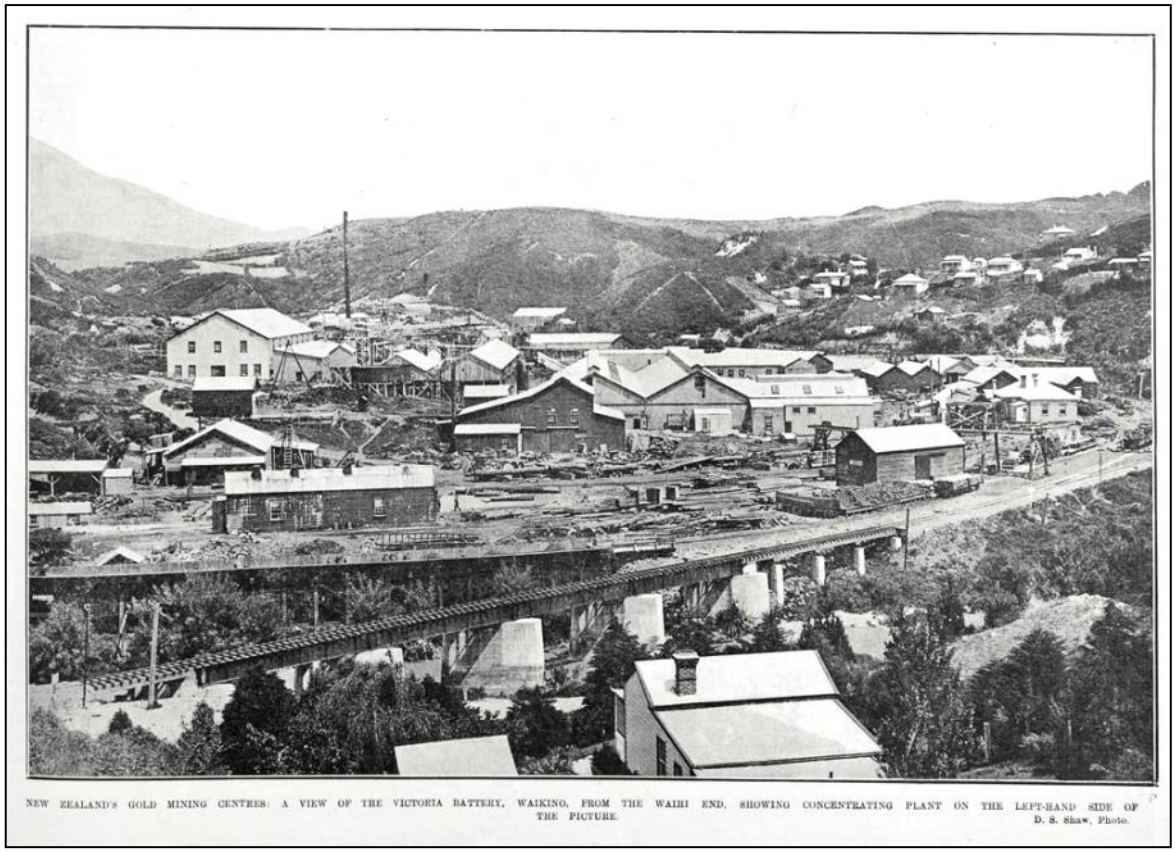
“A gantry has been erected to facilitate the transfer of heavy lifts of machinery, etc., from the Government line to the Company's trucks” – Barry.

Government railway in foreground. Coal hoppers behind what must be the cyanide store. Engine shed and loco shed beyond.

The NZR locomotive has dropped its guard’s van, and is now preparing to back the coal waggons on to the company line, from where the company will shunt it to the coal hoppers.

Foundry right of centre, work shop to its left.

HE Vaile, Auckland Library, 03.1906 V1278.



NEW ZEALAND'S GOLD MINING CENTRES: A VIEW OF THE VICTORIA BATTERY, WAIKINO, FROM THE WAIHI END, SHOWING CONCENTRATING PLANT ON THE LEFT-HAND SIDE OF THE PICTURE. D. S. Shaw, Photo.

Published in the Auckland Weekly News end November 1906.

Railway in foreground, crossing the Ohinemuri River. Coal hoppers visible above.

Engine shed above the hoppers, then workshop, coke shed, and vanner shed and buddle.

The vat shed tall elevator housing at its western end has gone.

Auckland Libraries Heritage Collections AWNS-1906.11.29-11-2.

1907

Superintendent HP Barry, in his Superintendent's Report for the year 1907:

> Victoria Mill (200 Stamps)—
>
> An addition has been made to the carpenters' and pattern-makers' shop and to the pattern store.
>
> The planing and moulding machine in stock has been erected in the old stable, a new stable being erected further away from the centre of the works.
>
> A room has been added to the office buildings, which is being fitted up to receive any person injured whilst at work.
>
> The precipitator room being now up to its utmost capacity is being enlarged.
>
> Producer Gas and Tube Mill Plants—
>
> The main portions of these plants have been completed.
>
> Everything in connection with the producers and gas engines is working satisfactorily.
>
> The cost of this power will be considerably lower than steam, the consumption of coal per h.p. being only about one-half.
>
> At present there are seven tube mills erected, which with the concentrating plant and elevator wheels, are driven by three 200-h.p. Crossley Gas Engines.
>
> The slimes plant has one unit out of the three completed, the balance to be finished early in the year.
>
> The 32 agitator tall tanks worked with compressed air are erected, pipe work is being completed. Eight are now finished and being filled with slimes.
>
> The necessary air compressors, vacuum pumps and solution pump are partly completed and some are running, the power being supplied by a 200 hp Crossley Gas Engine.
>
> To drive the motors on the overhead cranes a 35-h.p. gas engine is ? to run the generator, a 35-h.p. gas engine also driving the electric light dynamo.
>
> Another 35-h.p. gas engine is being erected to drive the blowers, mills, etc., in the foundry.
>
> A 200-h.p. gas engine is on the ground for driving the concentrates treatment plant, but we have had to delay its erection until the beginning of the year.
>
> Concentrates Treatment Plant—
>
> This has been increased by the addition of a standard size tube mill, six more agitator vats, and a 3 ft. 6 in. Martin filter press is being erected in place of the small central filled Dehne press…
>
> The gradual addition of tube mills at this battery has enabled us to grind finer with a consequent beneficial result on extraction.
>
> Concentrates Treatment Plant, Victoria Mill—
>
> All the concentrates produced at the three mills have been forwards treatment to this plant.
>
> A total of 5,581.14 tons were treated during the year of a value £29 7s. 6d. per ton…
>
> Owing to our available stacking ground being full, we have, since October, been unable to continue conserving the tailings, the actual cost of conveying them to the nearest site, about a mile distant, being prohibitive.

We have very little hope of ever being able to treat these tailings at a profit, but are making every endeavour so to increase the extraction on the concentrates, that this question of the value of the tailings will become of less importance.[45]

Waihi Daily Telegraph, Volume VII, Issue 2070, 16 October 1907, Page 2

At the invitation of Mr. Fieldwick, representative of Messrs. Crossley Bros., the contractors for installing the gas-producer plant at the Waikino battery, some forty people assembled this morning at Waikino, to see the initial run of the gas-producer and engines. After inspecting the whole plant which occupied some hours the party adjourned to the Victoria Hall, where they were entertained to a luncheon. Amongst those present were Mr. H. P. Barry, battery superintendent, R E. Williams, mine superintendent, J. McCombie, Mr. Stansfield, manager of the Talisman mine, T. Gilmour and other representatives. The trial run was eminently successful.[46]

Appendix to the Journals of the House of Representatives, 1908. For the year 1907.

Inspecting Engineer to 31 December 1907 C 3 P4

Waihi Goldmining Co.

…At the reduction-works there are installations of 330 stamps, the total average number running during the year being 316.5, with an average daily duty of 3.794 tons per stamp. In addition, there are twelve tube mills, eight of which are now driven by 3 units (of 200-horse power each) of Crossley gas-engines (a 1,000-horse-power plant of this type having been installed), which have already effected an economy of 50 per cent. in coal-consumption.

The tube mills are of the Davidson 22 ft. type, run at a speed of 27.5 revolutions per minute, and have proved most efficient in the reduction of the pyritic chalcedonic quartz of average hardness from this mine. Each mill is loaded with 5.5 tons of flints, the quantity consumed being 18 cwt. per mill per week. Barry's patent Honeycomb liners are used, and have proved most satisfactory, the life per set being from twelve to fifteen months, and the cost per ton milled being under one-sixth of that of the imported silex-boxes formerly in use. A paper on the subject of these liners has been courteously contributed by Mr. H. P. Barry, M.Inst.M.M., and this appears in Appendix E, attached to this report.

The daily tonnage of sands passing through the tube mills is about 77 tons per mill. After grinding in three tube mills, 70-87 per cent. of the slimes has been found to pass through a screen of 150 mesh. The cost of running the tube mills per ton of sand passed through them is 1s. 2d., and on the total mill tonnage 9.1d. per ton of ore crushed. The chief benefits derived from the use of tube mills at Waihi are—(1) Increased extraction, amounting to about one-sixth per ton on the whole of the ore crushed; (2) increased tonnage of fully 36 per cent.; (3) a saving of 75 per cent. on the cost of screens; (4) amalgamation improved by from 5 to 7 per cent.; (5) the slime, owing to the contained fine sand, is more easily treated.

The reduction of milling-cost due to the use of the tube mills is fully 6d. per ton on the total tonnage; this, together with one-sixth improved extraction, represents a total increased saving of 2s. per ton. After the tube-mill treatment the slimes are treated by agitation, and finally by vacuum filtering.

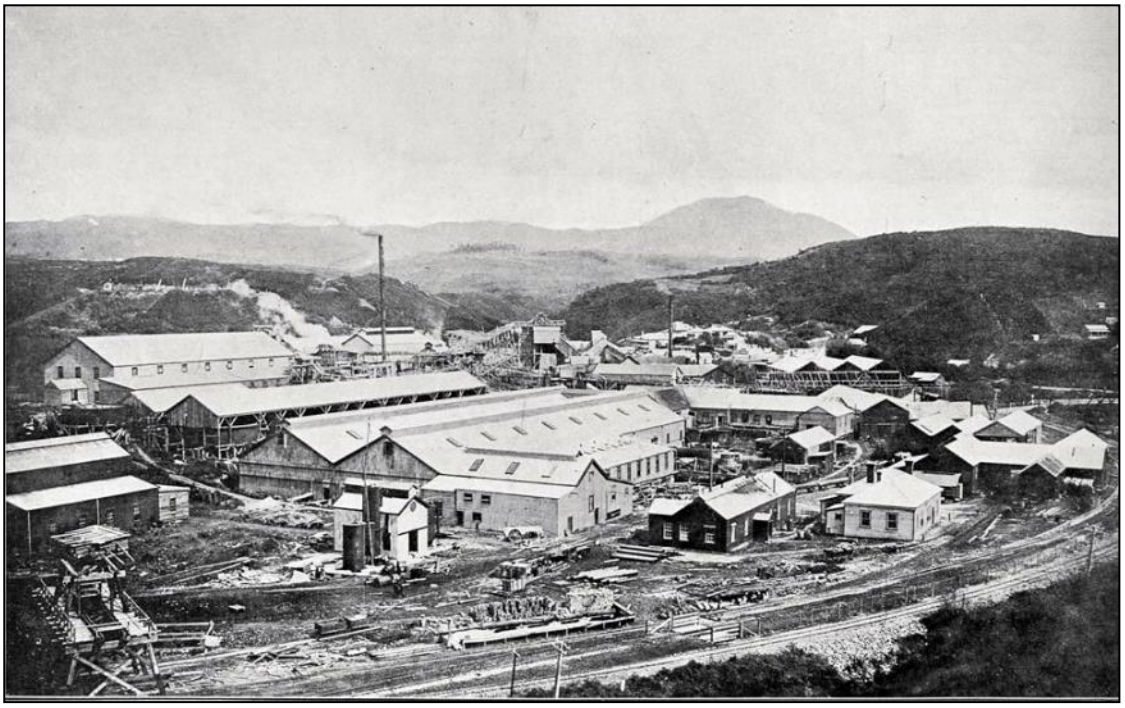
During the past year thirty-two tall agitator circulating tanks of B. and M. type have been installed, together with the necessary air-compressors, vacuum and solution pumps. This machine, which has given great satisfaction on the New Zealand and Mexican goldfields,

[45] Superintendents Annual Report. For 1907. Waihi, l3th February, 1908.
[46] https://paperspast.natlib.govt.nz/newspapers/WHDT19071016.2.7
Waihi Daily Telegraph, Volume VII, Issue 2070, 16 October 1907, Page 2

consists of a deep cylindrical-shaped vat, with a large pipe running up the centre, and it in by this means that agitation is carried out by the aid of air forced into the residues, no other power being required to operate it. This vacuum [compressed air], applied as it is, causes the whole of the charge to boil up, in appearance similar to the more active of the boiling-mud pools in the thermal districts of this Dominion. A specially written paper on this efficient agitator, kindly contributed by the inventor and patentee, Mr. F. G. Brown, superintendent of the Waihi Grand Junction Mine, appears in Appendix E. The total extraction obtained at the Waihi Mine was, according to assay, 89 per cent. of the gold and 70.3 per cent. of the silver contents… [47]

[47] https://paperspast.natlib.govt.nz/parliamentary/AJHR1908-I.2.2.2.5
THE GOLDFIELDS OF NEW ZEALAND. (REPORT ON), Appendix to the Journals of the House of Representatives, 1908 Session I, C-03

1907 Images in chronological order (maybe).



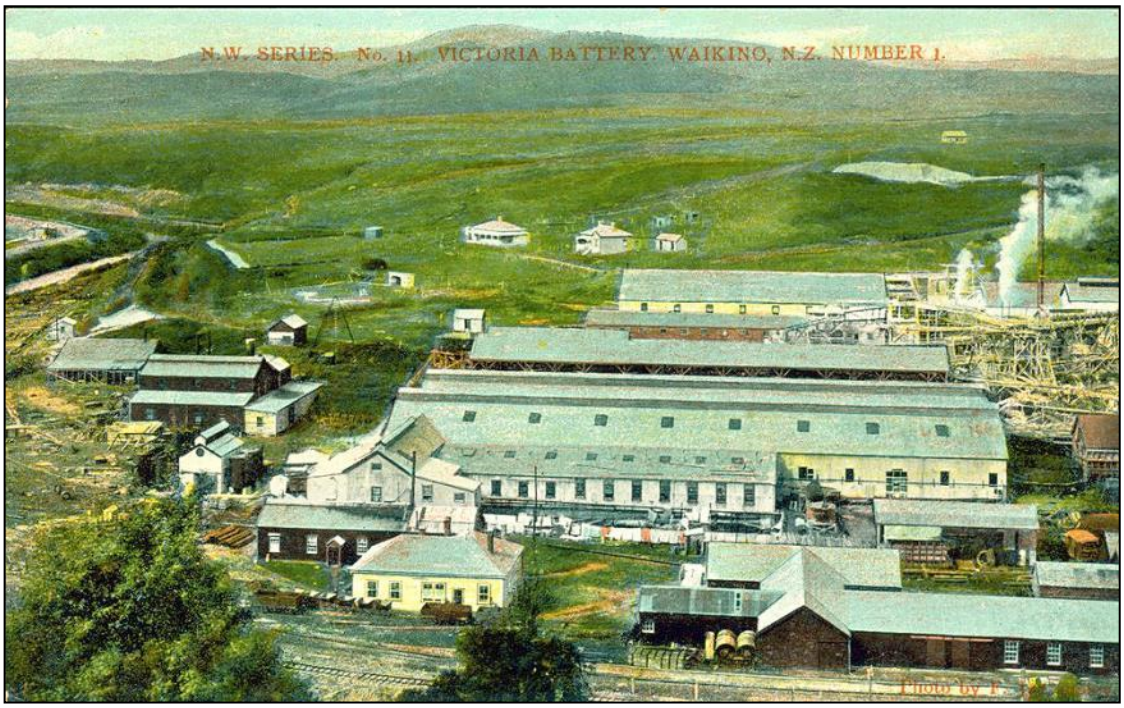
This photograph early 1907.

The producer gas plant is under construction, mid left foreground. Barry says that the main portion completed 1907. The building will get bigger.

The framework of the roof of the vacuum pump building (for the slimes plant) can be seen at right background.

Waikino AWNS 18.4.1907 Auckland Library.

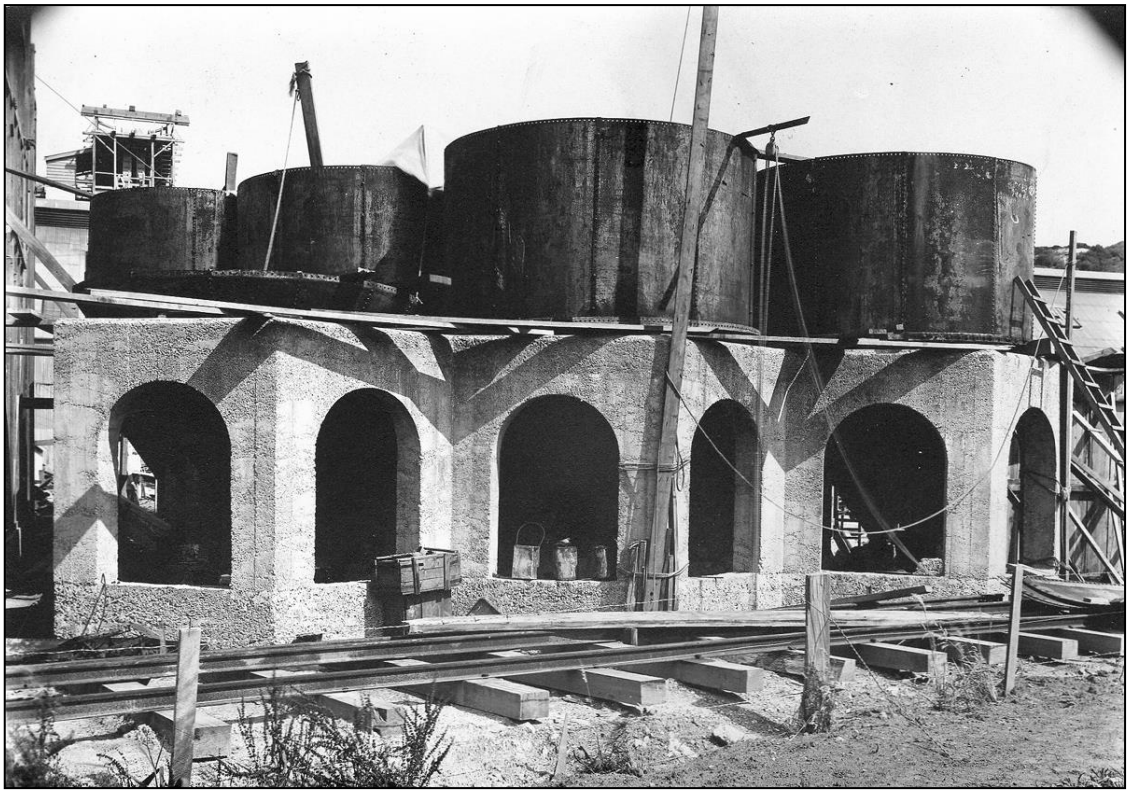
1907 **Wet Crushing**



The producer gas plant is under construction, mid left.

The store has had a large extension added to the right (west) of the building.

Victoria Battery, Waikino, NZ. No1 FJ Causley. VBTS.



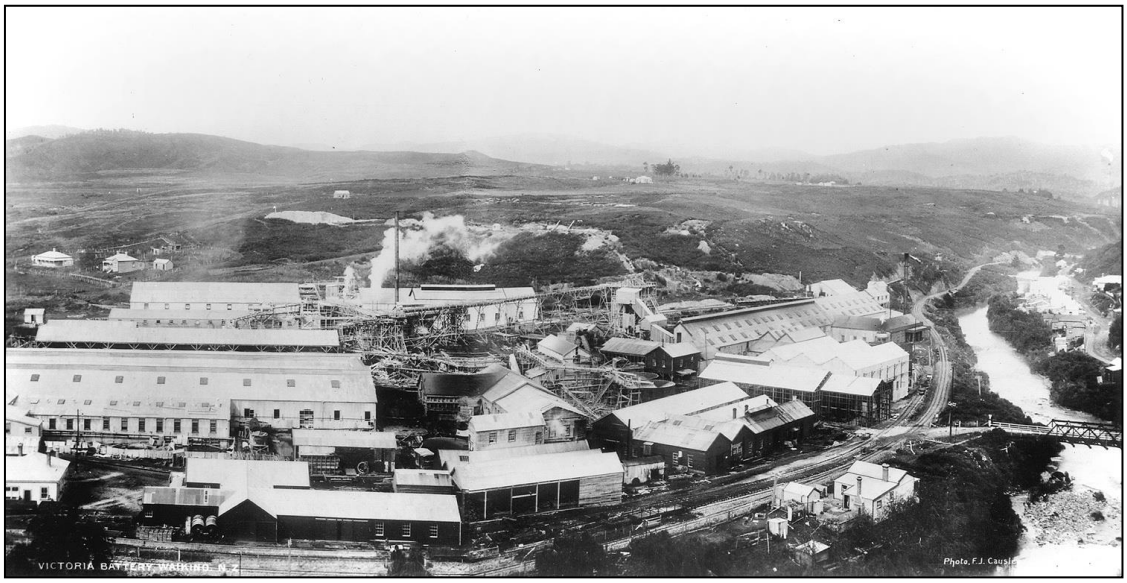
The first set of tall air agitation tanks being erected.

The side of the vacuum slimes plant building is at extreme left (unclad). The top of the double elevator wheels on the elevated launder beside that.

The recently laid rails allow materials to be brought to site. The tanks were fabricated in situ. One heck of a riveting job.

VBTS.

1907 **Wet Crushing**



This photograph is two images joined together.

The store has had a large extension added to the right (west) of the building. The fitting shop has had an addition also; a new roof to the rear, and a complete new building behind that..

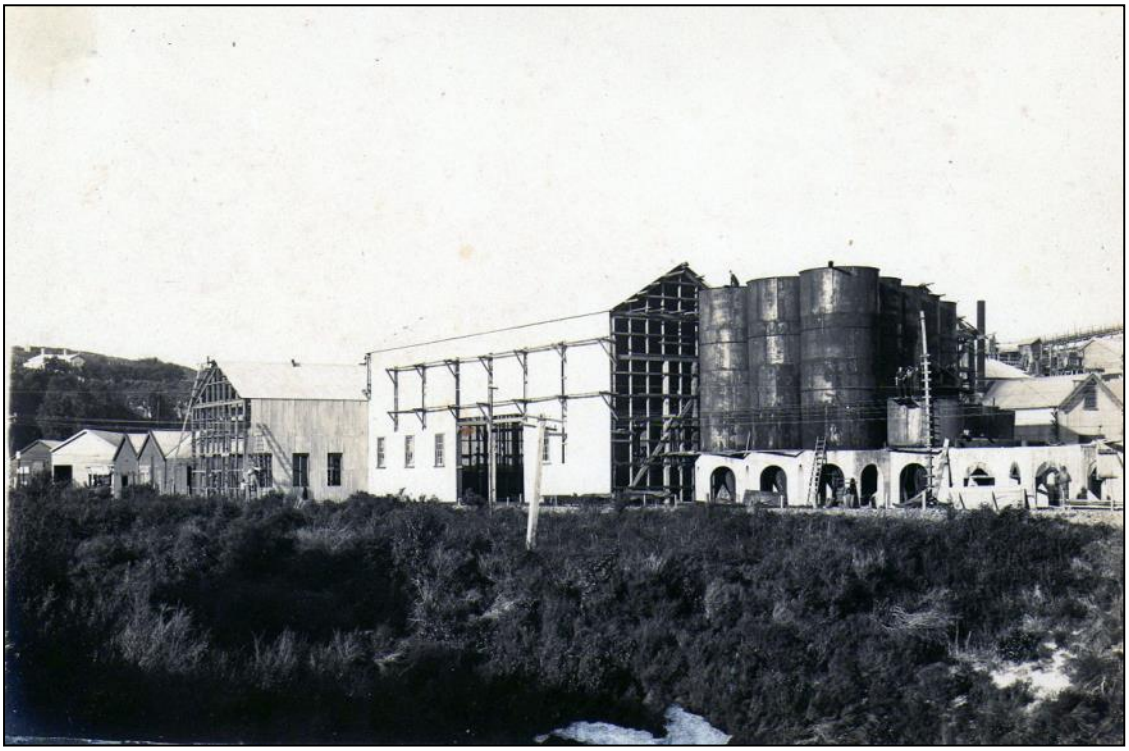
To the right of the image is the new vacuum slimes plant, and the vacuum pumps building, as yet without walls. Beyond the slimes plant can be made out the first of the tall air agitation tanks. Eight of the proposed 32 were finished in 1907.

The large tube mill building appears completed, with the engine house in front of it. The plume of steam, and the tall stack may indicate the power source, although producer gas engines take over during this year (1907).

It is wash day at the vat shed/sand vats, with filter cloths (?) hanging out to dry.

Victoria Battery, Waikino, NZ. Photo. FJ Causley. WACMA.

1907 **Wet Crushing**



The first of the air agitation tanks are erected, more being built. Barry says eight were operating by year's end (1907).

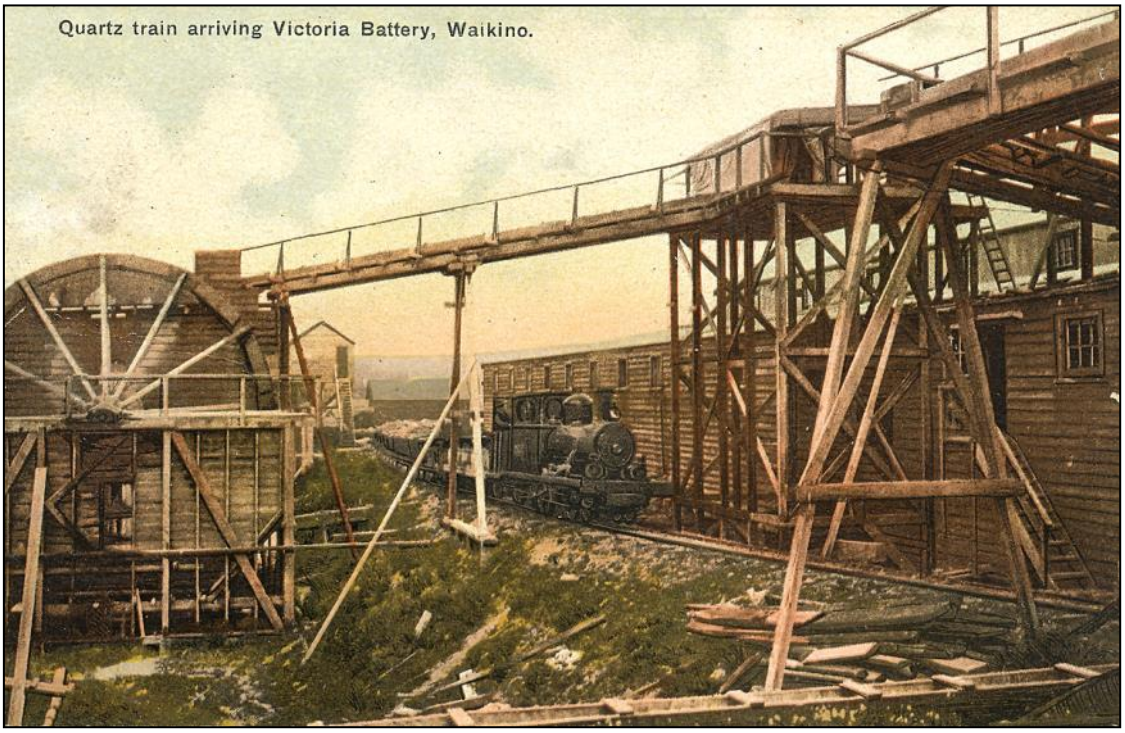
Construction of the buildings on going.

Two workmen at the ladder at the vacuum engines building, one on top of a tank, three atop the half-finished tank, and one or more working at concreting the support structures, extreme right (with a hint of the formers used to create the arches). Five ladders.

Centre of the photograph is a power or telegraphh pole, with numerous wires traversing the whole image.

VBTS.

1907 **Wet Crushing**



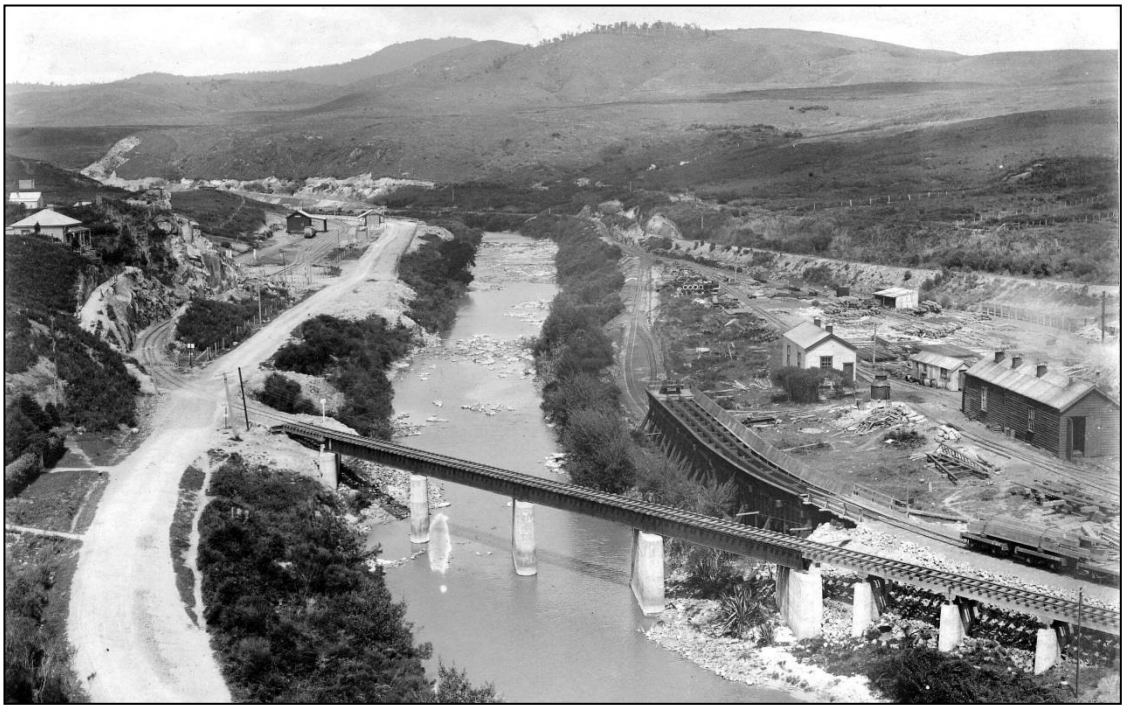
This is the loco Waikino (JAT Terry) arriving at the battery. The elevator wheel to the right is the wheel by the intermediate sand vats (J wheel), and the building to the right the buddle plant. This building is removed in 1908. Beyond it is the vanner shed.

It looks like the elevator wheel may not have had a concrete sump, or pit. This would explain why no remains can be seen today.

The little building with the ladder is perched above a round vat. We see it in many photographs post 1901-2. It may be where cyanide is added to the sand vats leaching solutions.

To the right of that is the coke shed or workshop.

JAT Terry.



This photograph clearly shows the coal hoppers, with its double gauge rail lines. The NZR coal waggons dropped coal from underneath into storage hoppers, or directly into company waggons beneath.

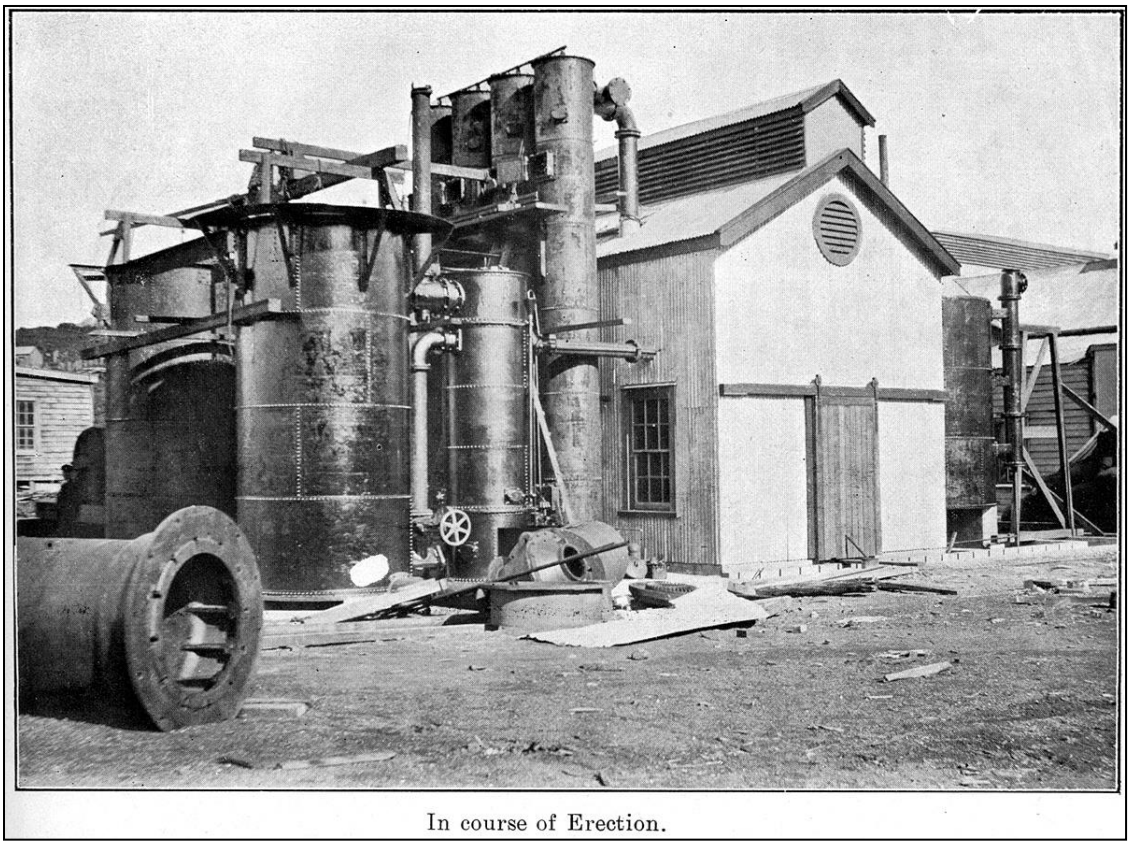
In the distance to the left, just above the station buildings, the concentrates tailings can be seen. They were moved from the battery area mid 1906; stopped October 1907. Close inspection suggests these tailings were tipped from a graded tramline on top of the tailings. There is even what appears to be a rake of six or seven waggons at the left hand end.

The scar in the distance is the quarry excavation.

In front of the loco shed is an upright cylinder that looks like a gas producer. What is it doing there?

A similar image was published 25 October 1906 AWN, so this image may be 1906.

Brittenden Collection, John Agnew Collection.



In course of Erection.

This is the producer gas plant under construction, viewed from the north east (front).

The large tanks on the left are the gas producers, only two were installed initially. To their right are saturators and coke scrubbers (the four tall tanks). Far right are sawdust scrubbers.

Presumably it was at first thought that much of the plant could remain in the open. The completed plant has been placed in the 1908 images.

Papers and Reports Relating to Minerals and Mining 1908.

1908

Superintendent HP Barry, in his Superintendent's Report for the year 1908:

> Victoria Mill (200 Stamps)—
>
> Some trouble and delays having been caused by the two main elevator wheels being overloaded, three new ones of ample capacity have been erected alongside the old ones. Improvements have been made in their construction and in the methods of driving them, which should considerably lessen the cost of maintenance.

These are the K L M wheels.

> The old ones will be left as a stand-by.
>
> The old buddle plant being of no further use has been pulled down, the material being used up as far as possible for other work.
>
> The precipitator room has been enlarged, 15 new precipitators having been put in and brought into use.
>
> A direct connection between the Government Railway and the boiler plant has been completed, enabling the trucks to be unloaded right in front of the boilers, and thus save one handling of the coal.
>
> The vacuum slimes plant for removing the gold-bearing solutions from the pulp is completed, the filter press plant now being stopped.
>
> The 32 tall agitator tanks are in use, and foundations for 10 more are being prepared.
>
> A vacuum plant for removing surplus water from the pulp before cyaniding is being erected.
>
> Producer Gas and Tube Mill Plants—
>
> The full number of 10 tube mills have been erected, of which we endeavour to keep eight running full time.
>
> These, with the vanner plant and three elevator wheels, are driven by three 200 h.p. Crossley Gas Engines. It was expected that each engine would drive three mills and possibly the fourth one also, but it has been found inadvisable to run more than three mills from each engine.

Three wheels: E, F and J?

> Some trouble has been caused by breakage of two engine crankshafts during the year. No satisfactory reason has been found to account for this, and more thorough and frequent examination for alignment must be made in the future.
>
> With this exception the Gas Plant and engines have been most satisfactory;
>
> Concentrates Treatment Plant—
>
> The gas engine of 200 h.p. for running this plant has been erected and brought into use.[48]

[48] Superintendents Annual Report. For 1908. Waihi, 10th February, 1909.

Gold-mining Progress at Waihi, 1908, NZ Mines Record

Gas-producer and steam plants.

Gas is rapidly superseding steam as motive power at the Waikino Mill. I was shown the complete gas plant and producers, which have been installed at a cost of over £50,000. The engines are Crossleys, and comprise, in all, five of 200-horse power, three of 35-horse power, one of 39-horse power, and one of 30-horse power. These engines are supplied with gas from a producer plant, consisting of two 500-horse-power units. A third unit of similar horse-power is now being installed, and the foundations are ready for a fourth. All the gas is generated as it is used, going directly into the mains and engines, and there are no gasometers or storage-tanks. The coal required is brought right into the works by the Government train and dumped into ground hoppers. (The company's coal-consumption, by the way, right throughout the mine and mills, averages 120 tons per day.) Gas-power has been found to be more economical and better in every way than steam. Not only is it more reliable, but it requires less attention. The cost is about one-third that of steam. The principal steam-power remaining is a 520-horse-power plant, which drives the 200 head of stampers. This engine and plant cost £10,000, and the company, therefore, does not contemplate substituting gas-power in its place, at any rate for the present. The fly-wheel is of the enormous diameter of 24ft., and weighs 18 tons. It carries thirteen cotton driving-ropes, and the engine gets its steam from five Babcock boilers. This plant is assisted in the driving of the stamps by two 200-horse-power and one 100-horse-power water-turbines. There is on the works also a complete electric-lighting power plant, driven by a 70-horse-power water-turbine, and a second dynamo for extra power in another shed.

A feature about the Waikino Mill is the foundry and adjacent machine-shop. On so large and complete a scale are these fitted up that the company is self-contained as far as repairs and the making of parts of machinery are concerned. From 35 tons to 50 tons of finished castings are being turned out here every month, all for use in the works and mine. The biggest casting made and machined to date weighed 6 tons.

Increasing the output at the battery.

The Waihi Company's trains bring to the Waikino Mill a daily supply of 900 tons of ore. Each train draws 35 trucks of 35 cwt. capacity. They run right in alongside the upper portion of the battery. The trucks containing ore of all grades mixed indiscriminately, are side-tipped into three stone-breakers, and from there the ore passes into two smaller stone-breakers for finer crushing. The quartz by this time is reduced to about 1½ in. metal. Elevators then carry it about 70 ft. into the battery-hoppers, whence it is fed automatically by ore-feeders into the stamper-boxes. Of the 200 stamps in operation 150 are running on 15-mesh screens (15 perforations to the running inch), and the other 50 on 35-mesh. At present the elevating system is a little limited, but a new system is being installed, by means of which, instead of 900 tons a day, the mill will, after Christmas, be putting through 1,100 tons a day. This increased output naturally means increased returns next year.

Mr. Fraser explained that when wet-crushing was instituted at Waikino the stamps were started on 40-mesh screens, and the first elevator-wheels were only designed to elevate 500 tons a day. (As a matter of fact, they are lifting 900 tons of sand, plus the necessary water.) Now the company is duplicating the elevators, and putting in bigger wheels, which will deal comfortably with 1,100 tons a day, as stated. It is also intended to run the stamps on coarser mesh—namely, 10 to the inch—which will have the effect of increasing the stamper output from 4½ tons per stamp per twenty-four hours to over 5 tons in the same working-period.

The vacuum sliming process

Whilst at Waihi Mr. H. P. Barry, the company's superintendent, informed me that an improved process for dealing with slimes had been worked out by the staff, and was now in use at Waikino. He explained that ever since wet-crushing was instituted the slimes had had to be separated from the sands. That was why wet-crushing was not in vogue before. It was impossible to percolate the mass. In the Waihi district the slimes have always been worth more than the sands, but the difficulty was in getting the gold-bearing solution out of the pulp. At first the company tried filter-presses, and for some time past these have been found effective, but expensive.

Now a vacuum process is relied upon. Mr. Fraser showed this process to me. In the first place, it has necessitated the erection of a plant (which has been going since January last), driven by a 200-horse-power Crossley engine, in connection with which there is a 35-horse-power electric generator. A 70-kilowatt engine, to give additional power, is now being installed. The motive power is gas. In connection with this plant are also an electric dynamo, two compressors, and nine horizontal, double-acting vacuum pumps, with 12 in. cylinders and 33 in. stroke, the latter and the two compressors all made on the works.

The principle of this vacuum process is that the slimes, after agitation in the B and M tanks (of which there are thirty-two now, and ten others being installed), until the gold is dissolved, are brought into what are called vacuum baskets. Of these there are three “bays”, consisting of six slimes-tanks and six wash, or filter, tanks. The gear consists of parallel rows of baskets, from which are suspended flat frames, about 1 in. thick, covered with canvas. These baskets are put into the slimes-pulp tanks, and when the vacuum is applied the material adheres to the baskets and frames in the form of a cake. When the frames are caked to a depth of 1 in. or more the whole thing is lifted by an electric travelling crane (there is one such to each "bay"), and lowered into the wash tank. Here the balance of the gold-solution remaining in the "cake" is removed. After a certain time allowed for washing, the baskets are again lifted by the crane over discharge-pits, and the “cake” drops off, and finds its way to the river. The solution with the extracted gold is meantime carried automatically to the precipitation-room and zinc-boxes.

Other sliming processes.

Another system of slimes-treatment that is being installed is a dehydrating plant for taking the water from the slimes before the treatment by cyanide. Four tanks are being completed in connection with this process. The slimes, as collected, will be pumped into these tanks, which will each contain "nests" of seventeen vacuum baskets in permanent position—not made for lifting, like the others described. The vacuum will be put on to these baskets until sufficient slimes are collected on the frames, after which it will be shut off; the "cake" will fall off the frames, and pass out through a siphon pipe at the bottom, as a thick product, into a disintegrator. There the material will be chopped up and mixed with cyanide-solution, and from thence elevated and put into the B and M tanks for treatment. Mr. Fraser stated that the vacuum process is cheaper than that of the filter presses, all of which, in a few weeks, will have been discarded in favour of it.

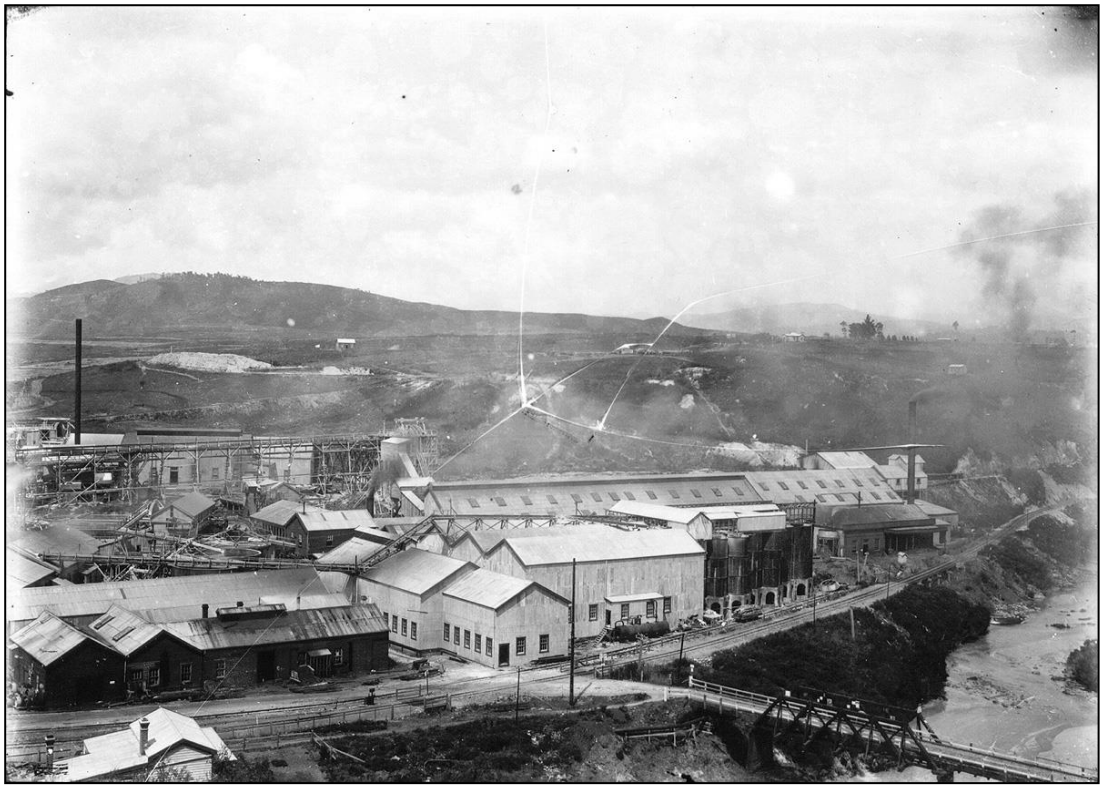
Tube mills, vanners, and percolation-vats.

The Victoria Mill contains, in addition to the other gold-saving and crushing plant mentioned, ten tube mills, driven by three 200-horse-power gas-engines; a tube-mill plant for the exclusive treatment of the sulphide concentrates, of which about 20 tons a day, worth anything from £50 to £75 per ton, are handled; twenty-five vanners, percolation-vats, and, in short, every modern device known for the saving of the precious metal. So thoroughly is the work carried out, and so-complete the extraction, that, as Mr. Fraser put it, the residue that is

allowed to find its way into the river from the mill at Waikino would not pay a Chinaman to work.[49]

[49] The New Zealand Mines Record. VOL. XII.]November 16, 1908 [No. 4.
Gold-Mining Progress At Waihi.

1908 Images in chronological order (maybe).



The air agitation tanks are in position, and the vacuum slimes plant looks complete.

The second set of elevator wheels, the KLM, are not yet evident. This will change quickly.

The tramway directly to the boilers is not yet.

Just to the right of the air agitation tank bases are two round partial cones. Are they the former plugs for casting the concrete bases?

There is a walkway and/or pipeline traversing roofs, and entering the top of the air agitation tanks. What is it? Images from 1909+ show that it comes from the roof of the sand vat building, but it may originate further afield. The 1948 flow sheet diagram (Page 158) shows that fine sands and slime are separated before the sands are finally delivered to the sand vats. These fine sands and slime are sent to the slimes settling boxes and on to the slimes plant. Is it an early version of this that we see here? If so, the above photograph, and subsequent, show the material delivered to the top of the tanks by launder, suggesting they were added that way. It appears the material was pumped up to the final launder to the tanks.

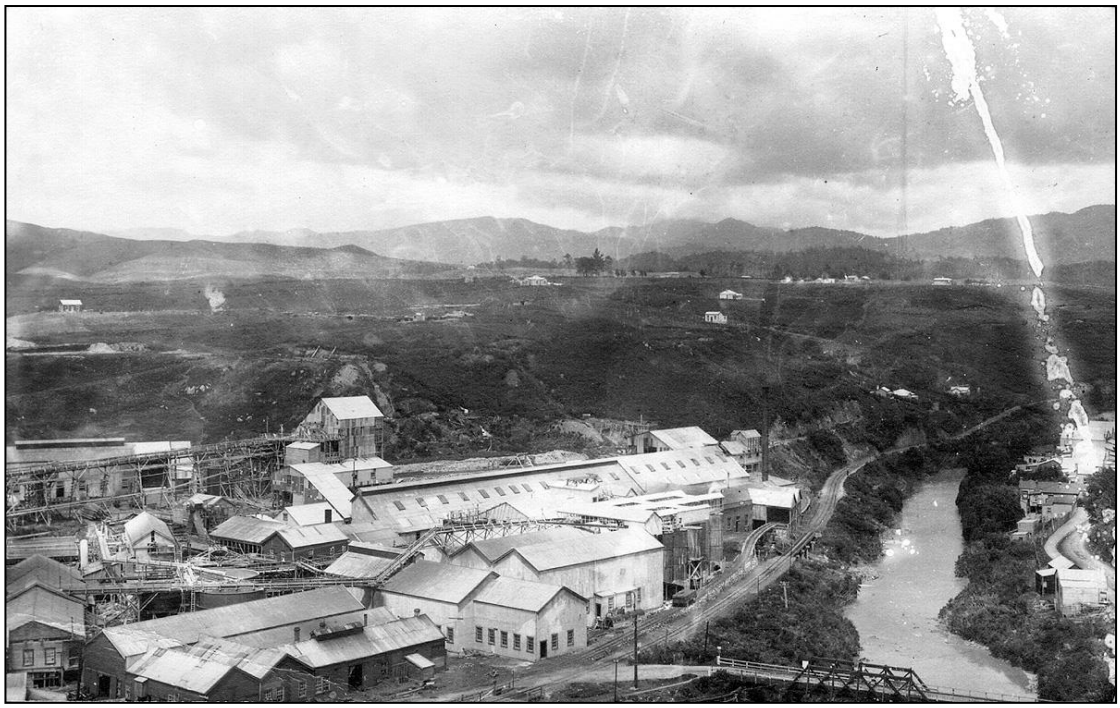
It is still there in a c.1916 photograph, but gone in a c.1929 photograph.

DoC, Thames.

The old wheel on the elevated launder is still showing in this image.

Note that tailings are still being discharged below the house. These are from the concentrates treatment plant (or at least the press house). Does this discharge point continue to the bitter end?

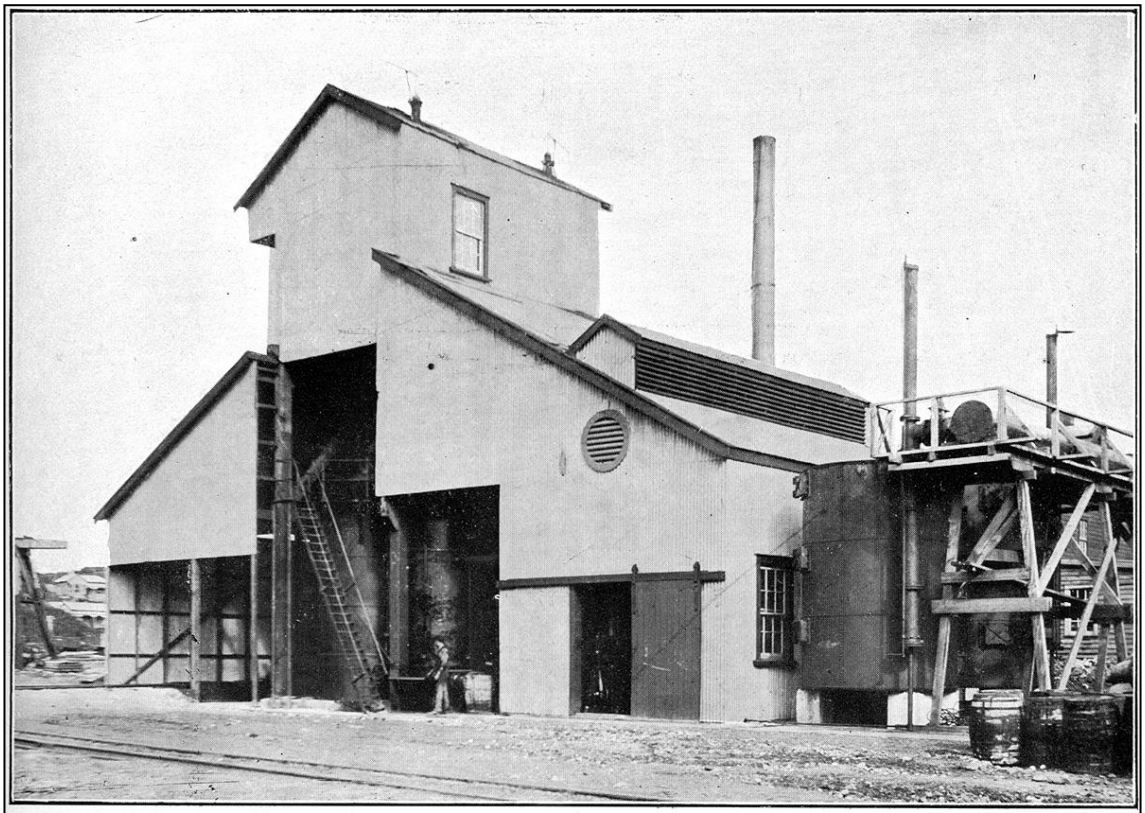
Staples Collection.



Big changes at the elevator wheels. Taller than the original wheels, the three wheel high KLM elevator is fully enclosed. They are the K, L and M wheels in the alphabetically named elevator wheel installations. The old wheels (C D') are still visible to the left of the new.

The new tramway to the boilers crosses the tail race. The boiler house has extensions to fascilitate the coal waggons. The tramway rises to a bridge on an embankment, faced with stone, which we see today.

Staples Collection.



Completed and working.

WAIHI GOLD-MINING COMPANY (LIMITED): 1,000-HORSE-POWER CROSSLEY PRODUCER-GAS PLANT.

This is the producer gas plant completed, viewed from the north west (front). A substantial building, much enlarged from the earlier photograph; note the figure standing near the ladder. The smaller original building, with the round luvred vent, has been extended to cover the producers and coal hopper.

The coal hopper is at the left of the building. Coal was elevated to the top of the building, then distributed to the producers.

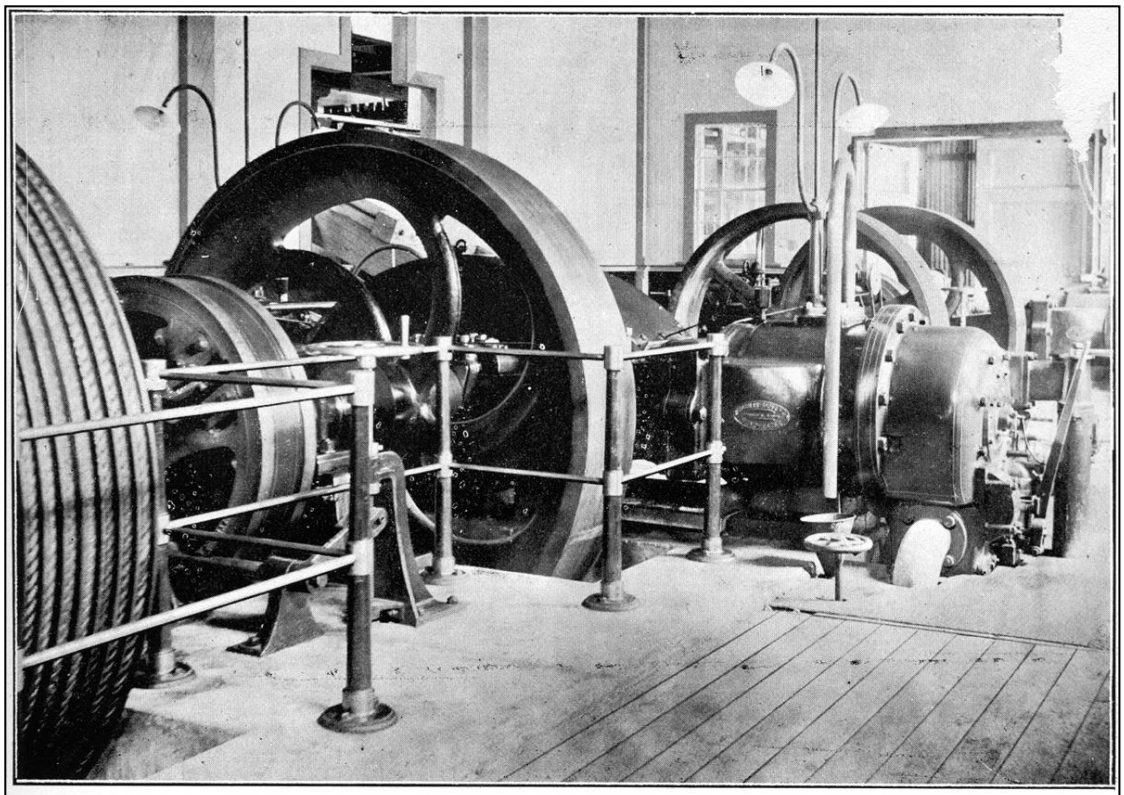
To the right of the building are two large sawdust scrubbers, standing on elevated concrete foundations. The trestle supports the pipes taking the gas away to the engines.

A third producer is added in 1909 (in front of the first two producers), and two more sawdust scrubbers.

The foundations of this plant are relatively well preserved today.

This plant became redundant circa 1913 with the electrification of the battery and mine. It appears that the building was repurposed to become a change house/shower room.

Papers and Reports Relating to Minerals and Mining 1908.



The Main Engine-room, containing three units of 200-horse-power each, two of which are here shown. All drive Tube Mills.

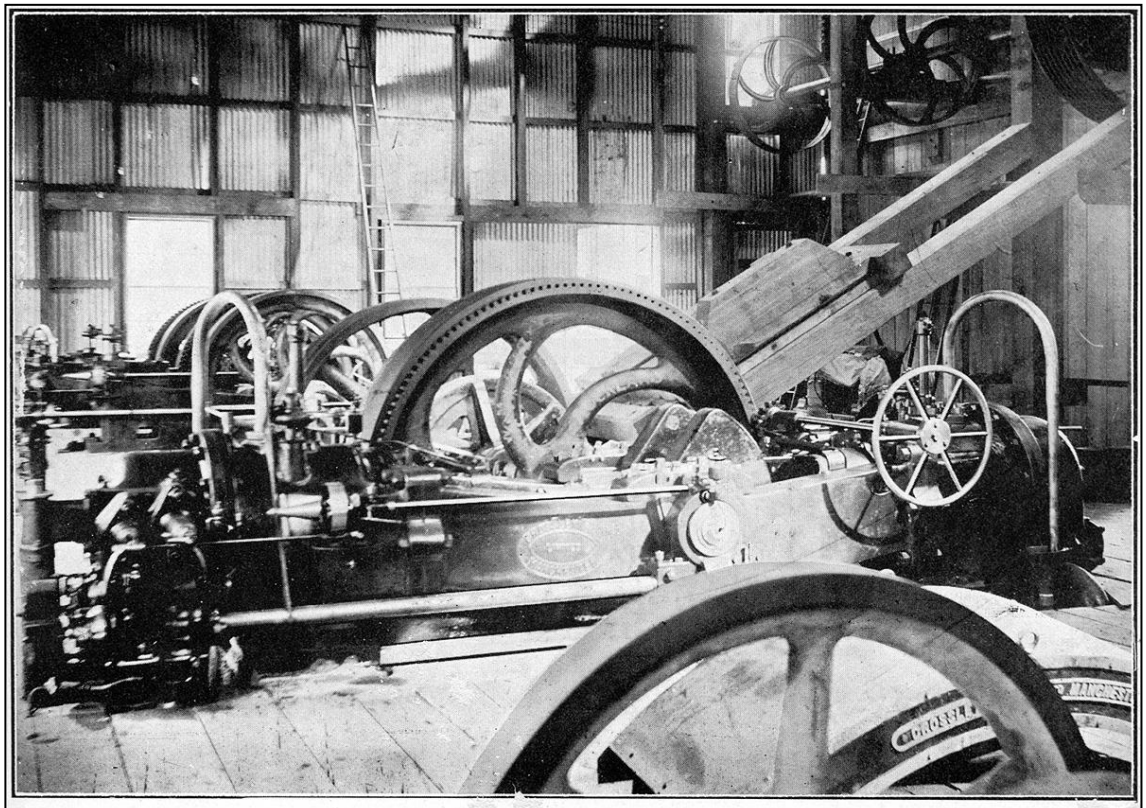
WAIHI GOLD-MINING COMPANY: 1,000-HORSE-POWER CROSSLEY PRODUCER-GAS PLANT.

These are the engines that drove the tube mills. The foundations for two engines are clearly identifiable in the massive concrete foundations to the north of the tube mill floor. The imprints of the hand rail mounts, and cast iron mounts, are still clearly visible.

These engines were horizontally opposed internal combustion engines, running on the gas from the producer gas plant.

A 250 HP tandem engine is installed (replacing a 200 HP engine?) in 1909, operational early 1910.

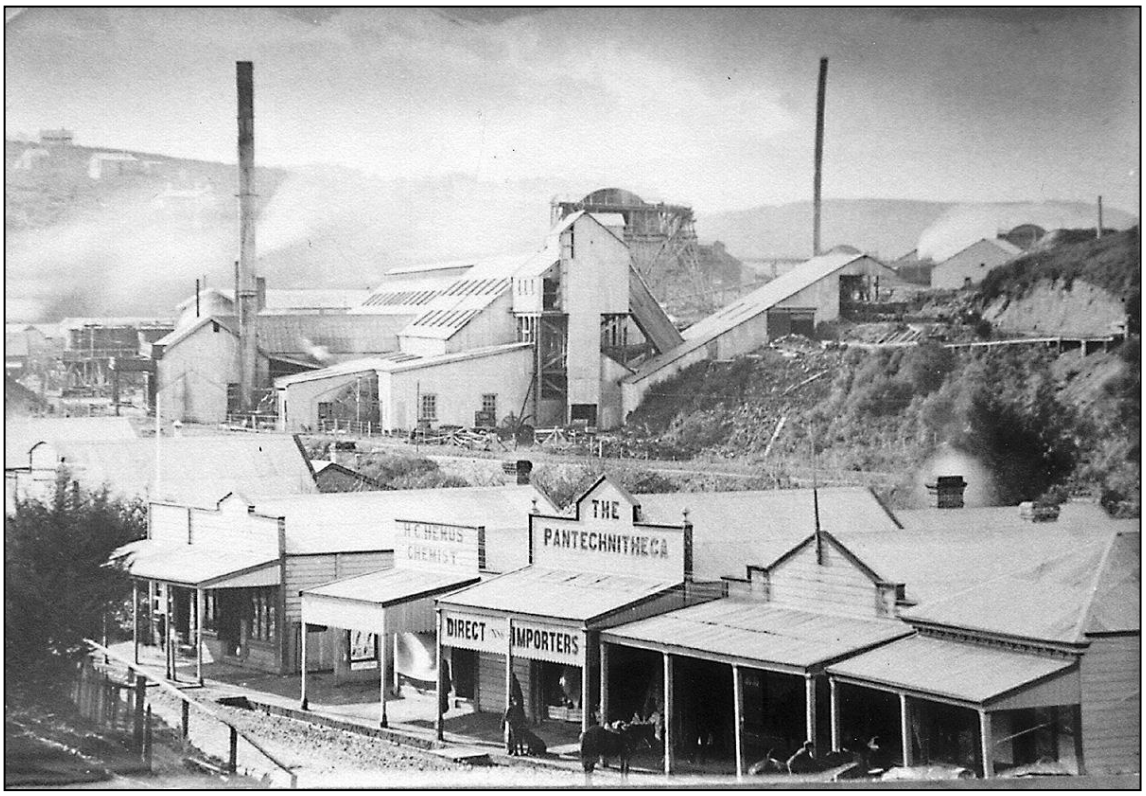
Papers and Reports Relating to Minerals and Mining 1908.



One Engine of 200-horse power, ar two of 40-horse power in the background.

These gas engines are probably in the vacuum slimes plant (and still under construction?).

Papers and Reports Relating to Minerals and Mining 1908.



Looking to the north east from the hotel balcony, across the river to stamper building. The large chimney to the left is for the 5 boilers and large steam engine. Slightly to the right of this chimney, against the wall of the low buildings with sloping roofs, might be the G elevator wheel. It is not mentioned in the literature, and its purpose is not clear. This is the best image known.

Stubbs.

1909

Superintendent HP Barry, in his Superintendent's Report for the year 1909:

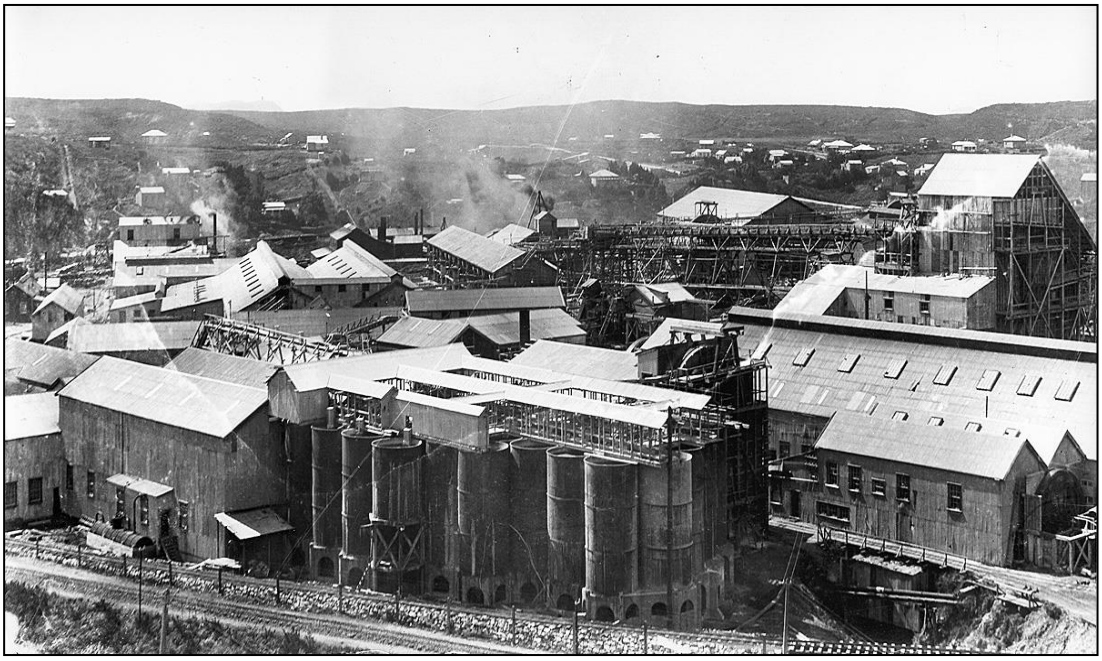
> Victoria Mill (200 Stamps and 10 Tube Mills).
>
> Ten more tall steel conical bottom agitator vats have been erected and brought into use.
>
> The vacuum plant for removing surplus water from the slimes before cyaniding has been erected and brought into use, enabling a reduction to be made in the amount of cyanide used in the slime treatment.
>
> A Pelton wheel has been erected to drive the vanner plant when water is available in the wet season.
>
> By using a mixture of scrap cast and wrought steel we are now casting stamp dies giving satisfactory results.
>
> Producer Gas and Tube Mill Plants.—This plant has run satisfactorily.
>
> A third producer unit has been erected and brought into use, and a 250 h.p. tandem engine is being erected at the tube mill plant with three more tube mills.
>
> A water scrubbing tower has been added to the producer plant to still further clean up the gas before it enters the mains.
>
> HYDRO ELECTRIC POWER.
>
> A License has been granted by the New Zealand Government to the Company to generate up to 10,000 horse power at the Hora Hora Rapids on the Waikato River, and to transmit the same to Waihi, a distance of 51 miles.
>
> Plans are being prepared so that work can be commenced as soon as possible.[50]

The vacuum plant for removing surplus water from the slimes, or slimes thickening plant (STP), was established after the vacuum slimes plant (VSP). The N and O elevator wheels were on the side of this building, elevating the thickened slimes to the top of the air agitation tanks. The implementation of these wheels are not mentioned in the literature.

Three more tube mills, so 13 in all. There are indeed 13 tube mill mounts visible today, the three new mills installed along an extension at the southern end of the building.

[50] Superintendents Annual Report For Year Ended 31st Dec, 1909. Waihi, 10th February, 1910.

1909 Images in chronological order (maybe).



The air agitation tanks and associated buildings are complete. Notice that the short tank fourth from the left is on trestle work rather than concrete base. Why? The nib wall for this trestle can be seen today.

Coal tramway to the boilers in the foreground. The tail race is obviously a simple ditch at this time; it will change when the additional 12 air agitation tanks are added in 1910.

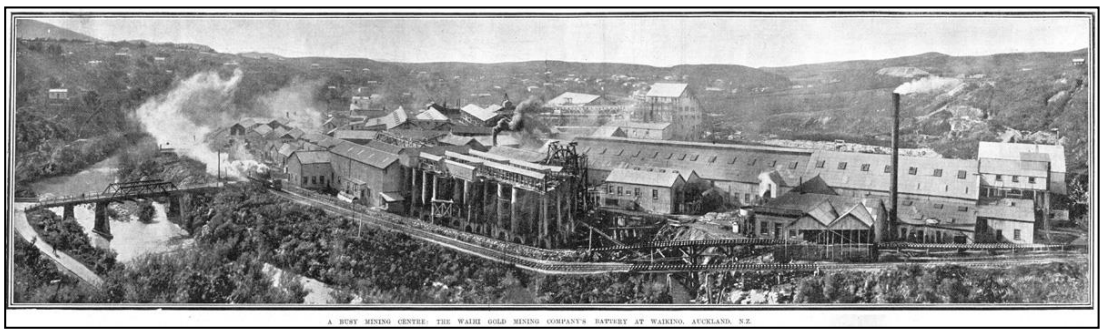
Directly behind the tanks is the elevator wheel group that elevated the thickened pulp 50 feet to the agitators. This looks like it must be a triple lift, but apparently only a double, N and O. The sump foundations remain.

At the right hand end of the turbine building is the H elevator wheel (bottom right of image). These sump foundations also remain.

The KLM elevator wheels are complete at top right.

The extension to the producer gas plant can be seen top left. It is lighter coloured (left hand window), and houses the third producer installed in 1909.

Staples Collection.



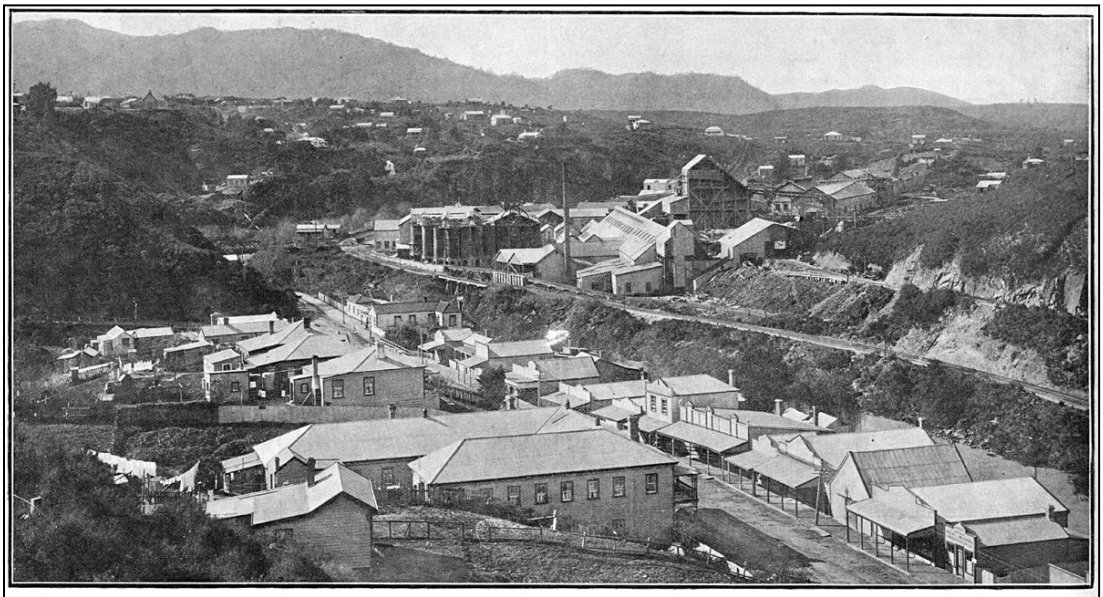
A BUSY MINING CENTRE: THE WAIHI GOLD MINING COMPANY'S BATTERY AT WAIKINO, AUCKLAND, N.Z.

This image, and the one below, was published in August 1909, but may actually be a little earlier than the preceeding image (but taken from the same position). The wheels associated with the air agitation tanks don't have the little building at the top as in the preceeding image.

This is a panorama: two images joined in the middle.

The tramway directly to the boilers extends right past the boilers to the right.

Auckland Weekly News, August 1909.



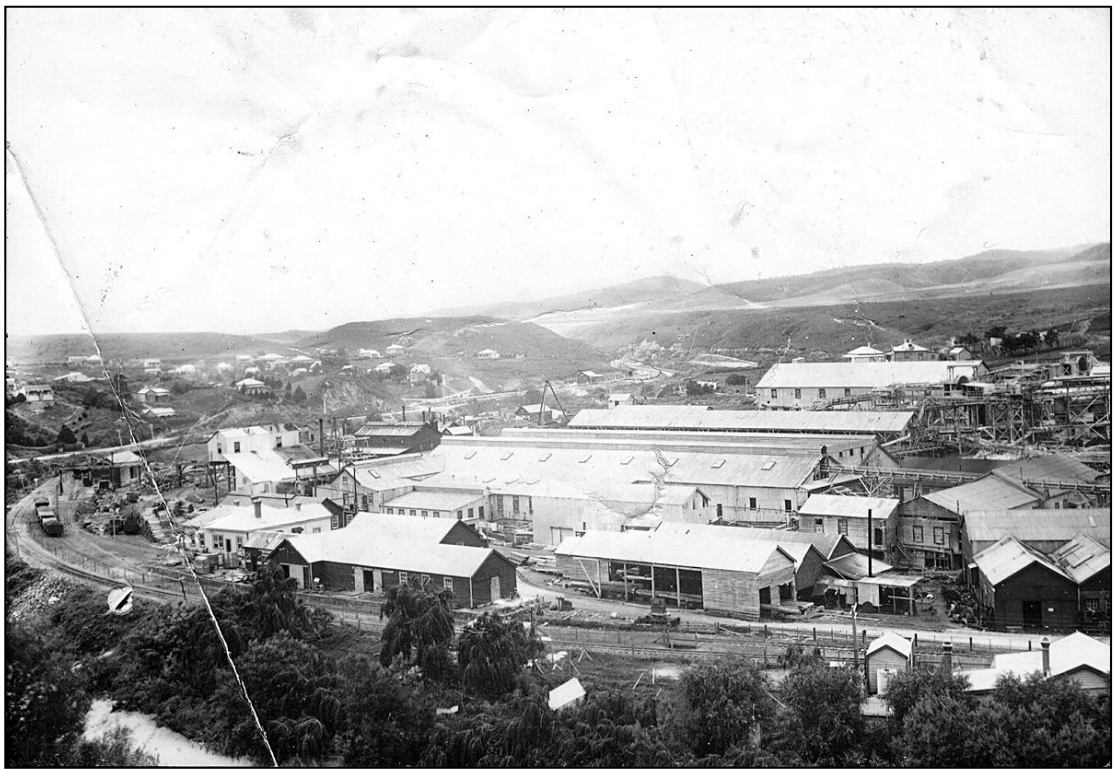
A BUSY CENTRE OF THE GOLDFIELDS: WAIKINO TOWNSHIP, SHOWING THE WAIHI GOLD MINING COMPANY'S BATTERY

Among the various modern devices employed at Waikino for reduction and gold refining are the dry crushing and cyanide treatment of tailings, the basket filter treatment for slimes, tube mills, B and M agitating tanks, vanners for concentrates, and the acid treatment. The Waikino mill contains 200 head of stampers, driven by a steam power plant developing 520 h.p.

Looking north east over the township of Waikino. The hotel centre foreground.

There are two levels of tramway through the stone breaker building.

Auckland Weekly News, August 1909.

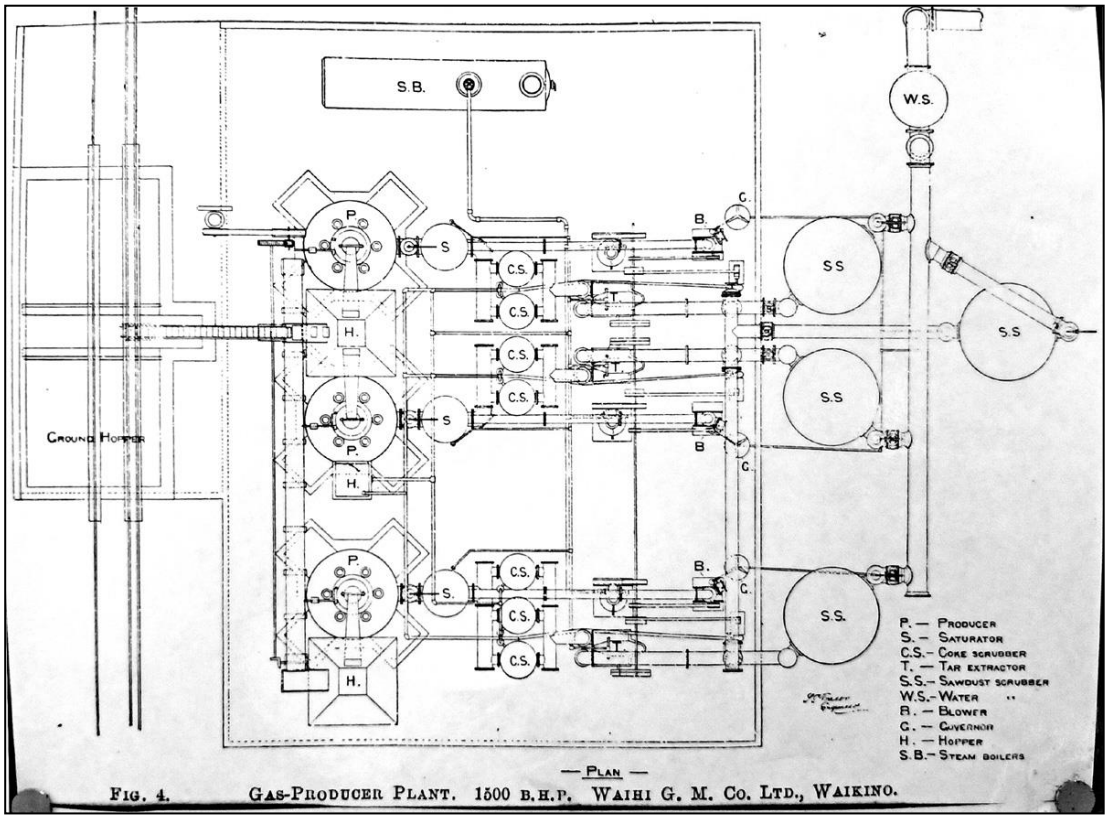


The producer gas plant at left, showing the extension added in 1909. The roof vent of the initial building remains.

The precipitator room has had an extension added, in front of the left hand end of the original: “The precipitator room has been enlarged, 15 new precipitators having been put in and brought into use”. – Barry 1908.

Note the trestle work exiting the sand vat roof on its way to the air agitation tanks.

Waikino Tavern.



Plan of the producer gas plant. It shows the final layout of the plant?

Two side elevations also exist.

Coal was delivered by rail directly into the ground hopper, from whence it was elevated by bucket elevator to high in the building. A conveyor then distributed coal to the hoppers above each producer.

Signed SE Fraser, Engineer. VBTS.

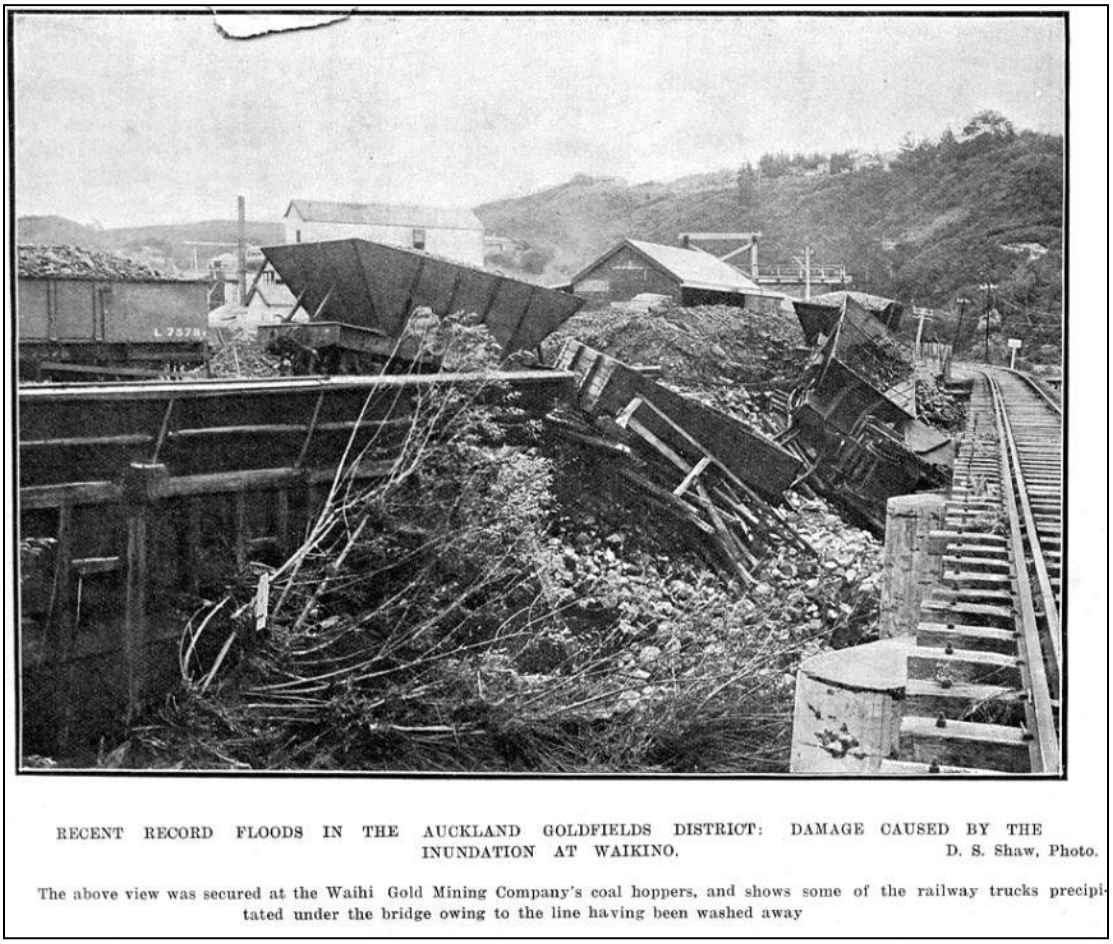
1910

Superintendent HP Barry, in his Superintendent's Report for the year 1910:

> Victoria Mill (200 stamps and 11 tube mills; the 11th mill started in August).
>
> This Mill ran 302⅔ days.
>
> The average duty per stamp per diem was 5.056, an increase of 0.386 tons as compared with 1909; the increase in the total of ore crushed amounted to 16738. The average number of stamps running was 190.139.
>
> A contract was let for the construction and erection of 12 more conical bottom agitator vats, 60 feet high by 13 feet diameter, placed on a concrete foundation over the tail race; in connection with this work it was found necessary to erect retaining walls of concrete to support the tail race embankments.
>
> The electric cranes in the Slimes Treatment Plant have been fitted with magnetic brakes; this has resulted in steadier running of the motors and fewer stoppages in the Plant.
>
> An additional 25 clearing boxes for mill water were put in.
>
> The heavy flood on March 29th caused a total stoppage of the Mill for 36 hours; the flood water rose to a height of 2 to 5 feet in the machine shops, gas plant, offices, etc., causing damage to machinery and carrying away a considerable quantity of coke, coal and timber from the yards. Several wash-outs occurred on the tramway, which were promptly repaired.
>
> The 8 h.p. portable engine at the quarry has been replaced by the 14 h.p. portable engine from the Saw Mill at Victoria Mill.
>
> A 20-ton weighbridge has been installed to check the weight of all stores, etc.
>
> With a view to improving the combustion on slack coal, the main boilers have been fitted with steam blowers.
>
> To avoid delay of the ore trains, the stonebreaker section has been improved; a Heclon breaker and an elevator were added and the plant split into two complete units.
>
> The Government railway line has been extended alongside the locomotive sheds to allow for extra storage of coal direct from the Government trucks.
>
> Producer Gas and Tube Mill Plants.—
>
> The 250 h.p. tandem gas engine was started in February and is a decided improvement on the opposed cylinder type. Considerable economy has been effected by the use of a proportion of slack coal in the producers.
>
> No. 11 tube mill was completed in August.[51]

[51] Superintendents Annual Report For Year Ended 31st Dec. 1910. Waihi, 17th February, 1911.

1910 Images in chronological order (maybe).



RECENT RECORD FLOODS IN THE AUCKLAND GOLDFIELDS DISTRICT: DAMAGE CAUSED BY THE INUNDATION AT WAIKINO. D. S. Shaw, Photo.

The above view was secured at the Waihi Gold Mining Company's coal hoppers, and shows some of the railway trucks precipitated under the bridge owing to the line having been washed away

Photograph taken from the rail bridge over the Ohinemuri River, looking north west toward the battery.

Auckland Weekly News, April 1910.

Date estimated at 1910 or 1911. No sign of power pylons (1912+) in the background.

1909 additions to the producer gas plant stand out clearly. The producers do not produce smoke, but the boiler at the back of the building certainly does at this time.

Coal piled up at left of image.

DoC Thames.

1911

Superintendent HP Barry, in his Superintendent's Report for the year 1911:

REDUCTION WORKS.

No additions of any extent have been made to these, with the exception of the 12 Tall Agitation Vats at Victoria Mill. The improved extractions obtained by their use have warranted the outlay.

Owing to the necessity of reducing our output, the Union Mill was stopped in February, and, after treating an accumulation of tailings, etc., the Mill was sold to an Auckland syndicate.

TREATMENT OF THE ORE.

Very close attention has been paid to the most economical treatment of the ore, resulting in a saving according to assay of over 89 per cent. of the value. This improvement in the extraction is partly owing to the increased time of treatment that it has been possible to allow, owing to the reduced tonnage and new agitators.

E. G. BANKS, Metallurgist.

METALLURGICAL REPORT FOR YEAR ENDED 31st DECEMBER, 1911.

Waihi, 20th February, 1912.

VICTORIA MILL. 200 Stamps, 11 Tube Mills.

The proportion of ore treated as sand was ... 18.63 % „ „ „ „ slime „ ... 80.09 % „ „ „ „. „ concentrate was 1.28 % -

All the concentrate was sent to the Concentrates Treatment Plant. Only about 35 per cent. of the ore pulp was sent over the plates, and vanners.

The staff on the plates was reduced early in the year, but the efficiency was not impaired; the percentage recovered by amalgamation was slightly higher than during the previous year.

The work of the concentration plant (Wilfley tables) has had special attention; the quantity percentage of concentrates has been decreased, but the value percentage (in spite of lower head assay) has increased. This was achieved by cutting out a low grade middling product which is returned to the tube mill plant. This has helped to reduce the general treatment cost, the lesser quantity of concentrate enabling us to reduce cost at concentrates treatment plant.

Owing to the smaller quantity of sand now being produced we have been able to economise cyanide by giving very prolonged treatment in the leaching vats, with weaker solutions.

The reduced tonnage now being milled has enabled us to close down the smaller of the vacuum slime thickening plants; at times this has caused some difficulty in thickening to the required consistency, with the result that the cyanide consumption increased slightly, but the increase would not justify our running both thickening plants.

In the vacuum filtration (washing) plant general costs have been reduced and crane repairs have been much less frequent.

A large quantity of pipe fittings have been removed from the old filter press plant for use in repair and construction work.

The main classifying boxes have been altered in order to allow a grade of 10 per cent. on the launders conveying sand to the tube mills, and they have been fitted with heavy cast iron goose necks in place of the lighter wrought iron fittings.

The 12 new slime agitation tanks were completed and put into operation during August period; they are 60 feet high by 13 feet diameter, conical bottomed, and the charge is air agitated without the use of a central uplift pipe; they were designed to give an extra two to three days agitation on a daily output of 800 tons.

The increased extraction resulting from the use of the new slime tanks is from 5 to 6 pence per ton of slime; this improvement, though not so large as was anticipated with the higher grade ore which was being treated at the time the new tanks were decided on, is still highly satisfactory, and, after making full allowance for the extra operating cost and for amortization of plant (spread over 5 years) shows a net profit of about £1,400 per annum on a daily slime output of 600 tons.

The above figures are based on a comparison of the average result obtained over 6½ four weekly periods prior to the new tanks coming into operation, and the average result obtained during 3½ four weekly periods after the tanks were in use; the general treatment conditions obtaining during the above comparative periods were alike and the increased extraction is entirely due to the extra time of agitation.

Many experiments made during previous years and confirmed during 1911, prove conclusively that prolonged agitation of the slime is necessary in order to secure a satisfactory silver extraction; in some tests (on a comparatively high silver assay) a profitable amount of silver was dissolved up to 7 days.

Experiments have also again been made, on a working scale, with a view to increasing the activity of the cyanide solutions; these included (a) increased protective alkali, (6) lead salts, (c) decreased and increased cyanide strength, (d) fresh versus stock solution.

The result of this work has shown that the solutions throughout the plants have been thoroughly active and that time is a most important factor in obtaining a high recovery of the silver.

This of course applies with more force when the ore runs over about 3 ozs. silver per ton, but our experience has been that it is unprofitable to at any time allow the agitation time to fall below 4 to 5 days.

ENGINEER'S REPORT—VICTORIA MILL—YEAR ENDED 31st DECEMBER, 1911.

WAIKINO, 31st January, 1912. S. E. FRASER, Superintendent Engineer.

I beg to submit my Report on Plant Construction and general condition of the Machinery at the “Victoria Mill” Waikino, for the year ending 31st December, 1911.

The expenditure on Plant Extensions was principally absorbed in the erection and completion of 12 Conical Bottom Agitating Vats, 60 feet high by 13 feet diameter, together with the necessary staging and gangways, pipe service, slimes pump and motive power, also for a special compressor (18 inches diameter cylinder by 33-inch stroke) for air agitation in these vats.

Ten of the 12 vats had to be built on a reinforced concrete platform with two arches, each 8 feet wide by 80 feet long, to carry the discharge water from the turbines. This platform was required to be built sufficiently strong to carry a load of 3,500 tons.

The foundations for the other two vats and slimes pumps were benched out of the solid and saved a certain amount of concrete. Some difficulty was experienced in getting the vats completed in rotation by the contractor owing to the shipments of the plates not coming to

hand as required. It was specified that each vat should be completed at a certain date in order to obtain the benefit of the extended slimes treatment as early as possible.

Unfortunately, the Contractors did not meet this clause, and the matter was settled by deductions on the contract payment.

Owing to the Slimes Pump in connection with these vats being placed within four feet of river level, it was considered advisable, in view of floods, to encase the pump in a water-tight concrete chamber, with walls sufficiently high to withstand a rise of 13 feet.

As motive power for the pump, a 4 feet diameter Pelton wheel was fitted direct on to the pinion shaft.

The Air Compressor—belt driven—was made at the Waikino Workshops, and added to those in the Vacuum Washing Plant, the power being obtained from the No. 6 Gas Engine.

The whole of this extension work was handed over to the Treatment Department in August, and is now in operation.

A Rope Haulage System was installed over the Battery Hoppers, to convey the broken ore from the Breaker Elevators to the Ore Bins, in June, at a cost of £415 9s. 0d., and is working very satisfactorily.

Other small plant additions, including Stonebreaker Plant, Oil and Waste recovery and sundry extensions amounting to £164 19s. 7d., were carried out during the year. This closed our Expenditure on Capital Account, leaving now only the Electric Motive Power to be dealt with during the coming year.

The drop in Stamp Duty over last year's work was due to utilizing the water power as far as possible, and curtailing the use of steam.

In June, the number of stamps running was reduced from 200 to 150. Advantage was taken of this to work on the water power as far as possible, and to minimise the reduction of tonnage the Stamp Screens were altered to 10 mesh.

With the advent of coarser crushing, the additional wear on the Battery Elevator wheels has been very considerable; so much so, that the life of the steel buckets in use has been reduced quite 50 per cent.

The buckets on the “K" wheel were increased from 1/8" to 3/16” plate, and with that we can only reckon on about eight months' life.

An experiment was carried out with a wooden bucket in place of steel, and the results were somewhat astonishing. Additional buckets of this type were put in the "A" and "B" wheels as a further experiment, made of different kinds of timber, and those of "Mirau" showed that after four months' running, very little wear was perceptible.

On these results we decided to renew the "A" and "B" wheels (35 feet diameter, taking the coarse pulp from the 200 head) with wooden buckets.

This confirms that the elevator wheels are assigned letters of the alphabet. The mystery of the KLM, or K L M, wheels may be solved. At the Waihi Battery the elevator wheels were given numbers.

This work was carried out during the annual overhaul. Apart from the increased life of the wheels, new buckets can be made and placed in position at about one-third of the cost of steel ones; and I anticipate that in future a good deal of the expense in maintenance of the wheels will, by the new arrangement, be eliminated.

The other wheels on the Plant will, as occasion arises, be similarly dealt with.

With the large amount of scrap steel accumulating at the works, and being unsaleable, we tried the effect of casting it into dies, in place of importing them. After a series of trials we were able to produce a die of good wearing quality, which, although not equal to the imported article, still showed a saving of 44 %.

As the result of an article appearing in the Mining and Scientific Press of July, 1911, an experiment to try and further reduce the cost of wear on the stamper dies, and at the same time increase the Stamp Duty, was carried out. The results, however, were not sufficient to warrant our departing from the present method.

Stamps.—The Machinery in this department is in good running condition.

Advantage was taken of the December stoppage to lift the Main Line of Shafting (599 feet), re-babbit the bearings, re-line the shafts, and overhaul the various clutch gear throughout the Mill.

The transverse logs carrying the stamper framing for the 200 head of stamps were cleaned out underneath, and concrete grouting put in to give greater solidity to the standards.

Tube Mill Plant.—The cost of lining for the Tube Mills during the year was heavy, owing to the alteration from the Honeycomb to the metal ribbed linings. To do this, the barrels of the mills had to be drilled to hold the liners in position.

The arrangement of driving the Pulp Distributor for the Tube Mills direct off the Main Line Shafting was not satisfactory, and an Electric Motor was installed to run the Distributor independently.

Treatment Plant.—The whole of the machinery in this Department is in good running order; and with the exception of a broken crank shaft to the 12 inch by 12 inch by 24 inch air compressor (for which a new steel was made and fitted in December), little work has had to be done during the annual overhaul.

The Main Shaft (6 inches diameter) in the Vacuum Washing Plant, taking the drive from the No. 6 Gas Engine, broke in the centre of the rope pulley boss.

This section was rather light for the work it had to perform, and when altering the speed of the No. 6 Engine, advantage was taken to replace it with a heavier one, 7 3/4 inches diameter. This necessitated boring out the rope pulley (9 feet 4 inches diameter) and putting in heavier oil ring bearings.

The drive previously was run with a single cotton rope and tightener pulley, but the life was comparatively short. This was altered to 8 single driving ropes and grids for steadying, as we found it to be more economical.

Power, Steam.—The Main Engine, cross compound 19 inch and 36 inch cylinders by 54 inch stroke (Yates & Thom) has been running continuously for the past 11 years; and the wear in the High Pressure Cylinder necessitated our having to bore it out, and fit new piston and rings. This work was done during the annual overhaul, and the engine is now in good condition.

The Fowler Engine, cross compound 12 inch and 21 inch cylinders by 24 inch stroke has also received a thorough overhaul. The crank shaft was taken out, and the crank pins and journals trued up in the lathe, and new brasses fitted throughout.

Gas.—This power is very satisfactory, and with the exception of a breakage on the No. 2 engine (200 B.H.P.) at the Tube Mill Plant, has been running continuously throughout the year.

The crank pin brasses to the "A" cylinder of this engine carried away, causing damage to the cylinder liner, piston and breach end; but having spare parts on hand no serious delay was occasioned.

The Tandem Gas Engine (260 B.H.P.) is doing good service, but after two years' work, the piston rod showed a considerable amount of wear. This was taken out during the Christmas stoppage and skimmed up in the lathe.

New metallic packings for the front cylinder were made to suit the altered size of the rod.

In other respects the engine is in good running order.

The exhaust drain from the Tube Mill engines was taken up where necessary and renewed. In addition to this, an extra escape pipe was put in to minimise the back pressure of the drain.

In adding the last new compressor to the drive of the No. 6 engine, it became necessary to speed the engine up without altering the speed of the main line of shafting, in order to obtain sufficient power, and to do this the existing rope pulley (7 feet 6 inch dia. 8 grooves) on the engine had to be replaced by one 5 feet 7½ inch dia. This we made at Waikino.

Water Power.—This showed a falling off in the latter part of the year, necessitating the use of steam. The peltons and turbines are all in good condition and required little attention in the way of repairs.

One of the 200 B.H.P. Vortex Turbines was opened up during the Christmas stoppage and the rotor taken out for inspection. This machine had been running continuously for the past 12 years, and considering the enormous quantity of tailings from the Waihi Mills which has passed through the wheel, it is in excellent condition.

The only wear noticeable has been in the bushings of the packing boxes and glands. A few of the vanes of the rotor showed a little slackness, but in every other respect the wheels are in good running order.

The No. 1 Turbine (200 H.P.) has been running for 15 years, and appears in about the same condition.

The No. 3 Turbine (100 H.P.) has been running 11 years, but does not require anything in the way of repairs.

It was thought that perhaps the pumice drift would cause wear on the Rotor vanes of the Turbines being installed at Hora Hora, but from the conditions of the Turbines at Waikino, there is little to fear in that respect.

Water Races.—The Low Pressure, Waitekauri, and Taieri Races have been supplying a fair percentage of the power used during the year; and their condition generally is good. One break in the Waitekauri section occurred in June, necessitating a deviation of about 3 chains of the race.

The country through which the Taieri Race passes is not at all reliable, and frequent small washouts occur.

Where too bad to puddle, it is secured with pipe fluming.

The wings of the Masonry Dam supplying the Low Pressure Race were carried up an additional six feet as a protection against high floods.

During the Christmas stoppage, the three races were thoroughly gone over from end to end, and all slips and overgrowth removed, and timber work in tunnels repaired.

Government Inspection of Machinery.—The Machinery and Plant was examined in September, and everything satisfactorily passed with the exception of the Locomotive "Ohinemuri."

After 15 years' service, corrosion became apparent inside the shell and around the fire-box. To repair it, the inside of the boiler required taking out, and the Boiler was shipped away to one of the local firms for the necessary work.

Foundry.—During the year 301 tons 10 cwt. of Iron Castings, 77 tons 2 cwt of Steel Castings were made, and 8,426 lbs. of gunmetal castings were made.

This department has, apart from the advantage of speedy repairs, effected a good economy in the working costs.

Tramways.—The Main Line between the Mine and Works is in good running order. Nothing beyond general maintenance has been necessary during the year. At the No. 1 Station Yard the lines were re-graded to suit the altered bend of the No. 1 hopper, and new rails laid down.

At the No. 6 Shaft the lines had to be lifted in places 2 feet owing to the settlement of the ground.

The branch line to the Union Mill was taken up and the material stocked.

With the decreased tonnage, one of the locomotives has been put out of service.

We are now running two on quartz and one on yard shunting and haulage of goods to Waihi.

Yours faithfully,

S. E. FRASER,

Superintendent Engineer. [52]

[52] ENGINEER'S REPORT—VICTORIA MILL—YEAR ENDED 31st DECEMBER, 1911

1911 Images in chronological order (maybe).

None known.

1912

REPORT OF THE DIRECTORS

NEW ZEALAND MANAGEMENT.—It is with deep regret the Directors have to report that for reasons of health it has become necessary for Mr. Barry to retire from the position of Superintendent of the Company at the end of the year. Mr. Barry has been connected with the Company for over 20 years, and during the time he has occupied the post of Superintendent, over £4,379,000 have been distributed in dividends to Shareholders. The Directors feel sure that the regrets they are now expressing will be widely shared by the Members of the Company, but they are glad to add that in the arrangements which are contemplated at the end of the year, it is hoped to retain Mr. Barry's services in an advisory capacity, where his experience will be of the greatest assistance to the Company, and less active work will be required.

SUPERINTENDENTS ANNUAL REPORT FOR YEAR ENDED 31st DEC., 1912.

Waihi, 14th February, 1913. HP Barry

The only additions to the Victoria Mill have been in connection with the Hydro-electric Power Scheme.

METALLURGICAL REPORT FOR YEAR ENDED 31st DECEMBER, 1912.

Waihi, l4th February, 1913. E. G. BANKS, Metallurgist.

VICTORIA MILL

200 stamps, 11 tube mills.

This mill ran 172 days : and the average number of stamps running was 126.021: the ore crushed amounted to 110,940 tons (dry weight) of 2,000 lbs. per ton, representing a daily average stamp duty of 5.118 tons. The standard screen used on the mortars was 10 mesh, and the average number of tube mills running was 6.7…

This mill was also closed down on May 14th, and re-started on October 4th [Waihi miners' strike].

All bullion-bearing solutions in the general plant and in the Concentrates Treatment Plant were run to the extractor boxes and the bullion recovered; the amalgamated plates were cleaned and rich concentrate was collected from various parts of the plant.

The usual repairs and renewals have been made, but there have been no additions to the plant.

REPORT on the HORA HORA HYDROELECTRIC WORKS

For Year ended 31st December, 1912. Waihi, 14th February, 1913. H. P. BARRY, Superintendent.

The transformer houses at Waikino and the Mine are now well in hand, work at these places having been much delayed by the strike.

HORA HORA HYDROELECTRIC WORKS

Chief Engineer's Report for year ended 31st December, 1912. Waihi, January 6th, 1913. W. P. GAUVAIN.

Hora Hora.—The plant at the power house consists of six 1,500 Brake Horse Power Turbines, operating under a head of from 24 to 26 feet of water.

Each turbine is direct coupled to a Three Phase Alternator generating current at 5,000 volts with a frequency of 50 cycles. The speed of these sets is 187 revolutions per minute.

Current is taken by two three core armoured cables from the Power House up to the Transformer House, which is situated on rising ground above the Power House, and is here transformed from 5,000 up to 50,000 volts.

The Transformer Plant consists of six Single Phase Transformers, the necessary Oil Switches and Lightning Arrestor gear.

The Transformer House is a ferro-concrete building with steel roof. Adjoining this building are the Workshops and Oil Boiling Shop.

Transmission Line.—From Hora Hora to Waiorongamai, a distance of about 32½ miles, the line runs for the greater part of the way along the roadside.

It consists of three copper wires carried on steel masts, which are spaced approximately eleven to the mile. In accordance with Government regulations, the lowest wire has to be kept 24 feet from the ground.

The telephone wires (metallic circuit) are carried on the same masts and below the power wires, and are transposed at every pole.

At Stanley Bridge, 23 miles from Hora Hora, a Halfway Station is to be erected containing disconnecting switches.

From Waiorongamai the line runs for a distance of about 5½ miles over the Te Aroha Ranges, rising to a height of 2,500 feet above sea level. The whole of this ground is of an extremely rough character. Special masts and insulators have been ordered for this portion of the route, the maximum spans being 1,200 feet.

The line then runs through rough country for a distance of 6½ miles to the Waikino Transformer Station.

Waikino.—The Waikino Transformer Station is practically a duplicate of that at Hora Hora, the current being transformed down from the line voltage (46,000) to 11,000 volts. At this latter pressure current is sent to the Waihi Mine, some 5½ miles distant.

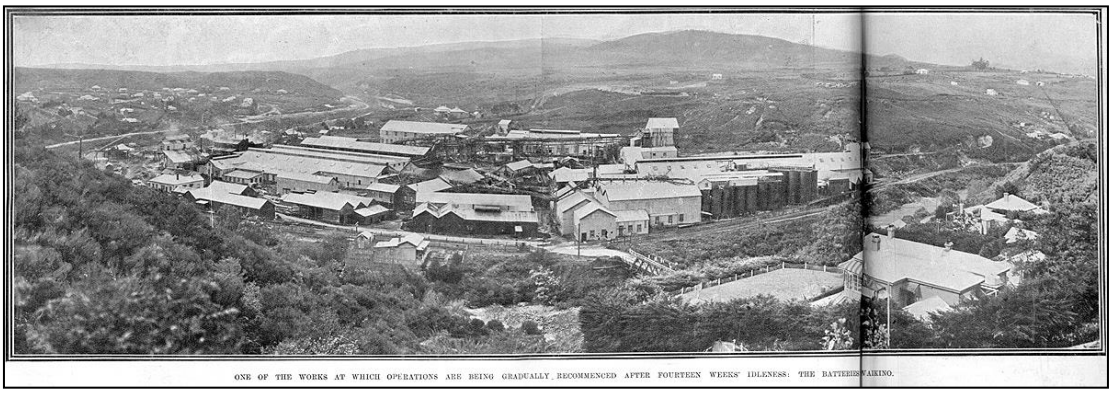
There are also in the Transformer House three Three Phase Transformers, receiving current at 11,000 and stepping down to 500 volts. Some twenty-five motors are being installed at this Mill, all of them being operated from the 500 volt circuit.

Waihi Mine.—The Mine Transformer Station contains four 500 K.W. Three Phase Transformers receiving current at a pressure of 11,000 volts and transforming down to 2,000 volts, at which latter pressure the motors receive current.

The motors installed here will be utilised for winding, pumping, air compressing, ventilation and lighting…

Waikino.—The ferro-concrete Transformer House is in course of erection, and several of the motor foundations are finished.

1912 Images in chronological order (maybe).



ONE OF THE WORKS AT WHICH OPERATIONS ARE BEING GRADUALLY RECOMMENCED AFTER FOURTEEN WEEKS' IDLENESS: THE BATTERIES TAKING.

Although published September 1912, this is an earlier photograph; no sign of the transformer house.

Auckland Weekly News, September 1912.

1913

HORA HORA HYDROELECTRIC WORKS, Report for year ended December 31st, 1913.

W. P. GAUVAIN, Assistant Superintendent.

Waikino.—The Transformer House and the whole of the transforming plant has been erected.

The main control board, distributing circuits, and the majority of the motors are erected.

1914

ENGINEER'S ANNUAL REPORTS FOR YEAR ENDED 31st DECEMBER, 1914.

Mill Work.—A considerable amount of work has been done on the Elevator Wheels during the year; one has been entirely rebuilt, a complete new centre fitted to another and several overhauled.

It has also been found necessary to renew a good deal of the timber work throughout the Mill.

Stonebreaking Plant.—A No. 7½ Gates Crusher was installed during the year, together with a new Belt Conveyor Plant. The broken quartz is distributed over the hoppers by means of a shuttle belt. The whole of this plant has worked satisfactorily and is effecting a good saving in this department.

Tramways.—Repairs were carried out to the Main Bridge over the Ohinemuri River during the Christmas stoppage, and various culverts overhauled…

Power.—The past year being an exceptionally dry one the amount of Power available from our races was small, and towards the end of the year almost negligible.

The water-race flumes and pipe lines have been kept in good order. Power was brought in from Hora Hora early in the year and the first motor started on February 4th.

By the end of February practically all the motors were in use. The following Motors are in commission :—

Alternating Current Motors, 20 ... 2,190 H.P.

Direct „ „ 7 98 ,.

Total 2,288

The whole of the Electrical Plant has been running very satisfactorily.

The Steam and Gas Plants are not in use now that we are receiving power from Hora Hora. These Plants are kept in good order and are available for use at any time.

Yours faithfully, W. P. GAUVAIN, Assist. Superintendent.

Steam engines and gas engines were retired as the battery was electrified. Mounts for electric motors were added, or older mounts were modified. This creates extra challenges for interpretation of remaining foundations.

1917

A new centre was fitted to the "M" Elevator Wheel, and the timber framing supporting the "N" and "O" Elevators was strengthened.

1918

A new type of wooden bucket has been fitted to several of the Elevator Wheels, and is giving very satisfactory results, besides being cheaper to instal.

On August 16th the Shaft, on the Vanner Elevator Wheel broke. The Tube Mill Elevator Wheel has been completely re-built.

Power Plant.—The whole of the Power for operating the Mill has been obtained from Hora Hora, with the addition of a small percentage of local Water Power.

1919

The Hora Hora Electric power plant has been purchased by the New Zealand Government, and we are now obtaining power from the Government; the new arrangement is working well…

The “E” Elevator Wheel has been completely re-built, new segments and buckets fitted to the "B" Wheel, new buckets and backs to the "M" Wheel, new shaft to the "F" Wheel, and new gearing to the “K" Wheel.

If K is the bottom wheel, then these may be the alterations to the mounts which can be seen on the concrete sump/pit. It looks like this bottom wheel (axle mounts) has been moved east a few centimetres.

Transport.—The locomotive "Waikino" was completely overhauled. The boiler tubes on the “Victoria" were removed so that a thorough inspection of the boiler could be made by the Government Inspector. Owing to shortage of labour in this department, the repairs to the rolling stock are behindhand.

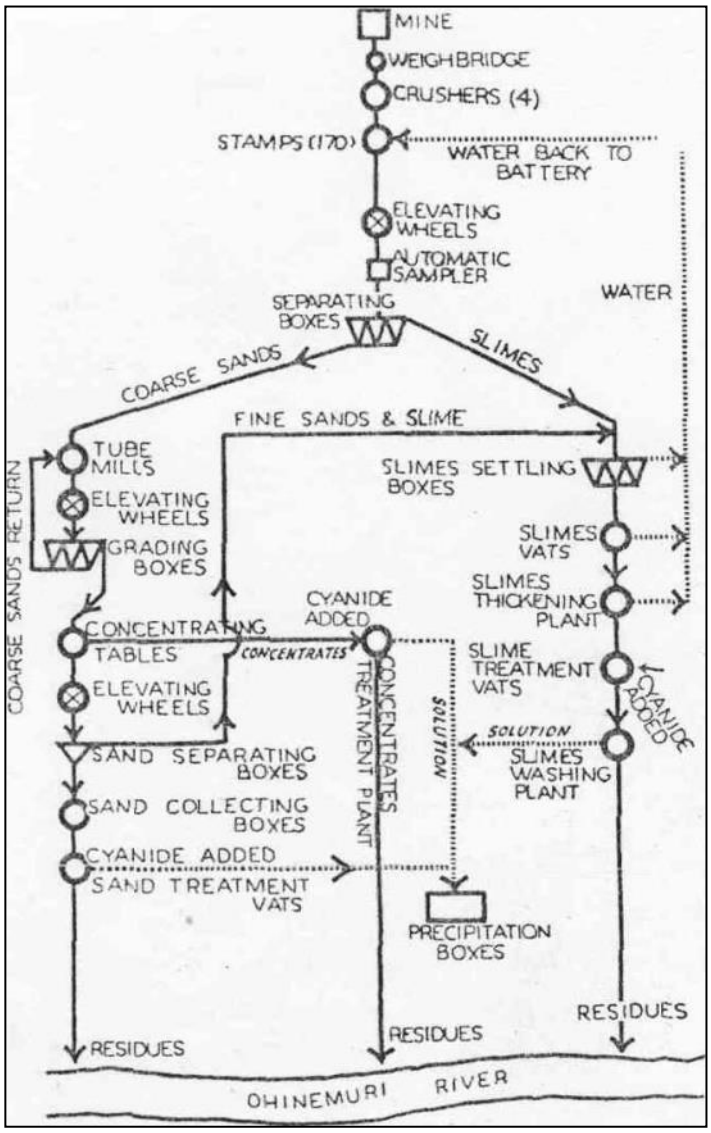
Water Races.—A good deal of work has been done on the Water Races, in order to obtain as much water power from these as possible. Shortage of labour, has, however, handicapped us, and it will be some little time before the necessary alterations are complete…

Power.—From November 1st we started obtaining power from the Government, the Public Works Department having taken over the Hora Hora undertaking. As we are taking power on the maximum demand system, every endeavour is being made to reduce our Peak Load. With this end in view we are using water power from our races during the day shift (when the heaviest load occurs), and conserving the water during afternoon and night shifts…

Timber.—Owing to the difficulty in obtaining timber in the district for mining and milling purposes, we have been compelled to acquire a "bush" at Mamaku, some 80 miles away. This necessitated a tramline from Mamaku Station to our bush, a distance of about 4½ miles, with the necessary sidings, loading platforms, etc.

The tramline has now been laid into the bush and timber is being-delivered. The work was handicapped owing to the New Zealand Government Railway restrictions, which came into force last July and continued until early in December.

Wet Crushing Flow Sheet



Chemical Engineering and Mining Review, January 10, 1948.

1900. HP Barry:

> Wet Crushing.—The process adopted has been, as already explained in last year's Annual Report, wet crushing with water, separation of the sands and slimes by means of spitzkasten, the sands passing to large vats where for the present, and until the dry crushing part of the Victoria Mill is converted to wet crashing, the treatment is completed.
>
> The slimes pass to collecting vats, thence to agitators and are finally dealt with by means of filter presses, three of which of a capacity of 6 tons per charge per press are in use. [53]

AUCKLAND STAR, VOLUME XXXI, ISSUE 33, 8 FEBRUARY 1900, PAGE 2

> The ore, on arriving from the mine, will be crushed with water, and the product will be elevated some 70 feet. Then it will be run with a launder to the treatment shed. About half-way there will be a series of separators for separating the sands from the slimes. The sands will pass into

[53] Superintendents Annual Report. Waihi, 19th February, 1901.

intermediate vats, five in number, with a capacity of 480 tons each. The slimes will pass on to receiving tanks, five in number, with a capacity of 480 tons. From these the slimes will pass into agitators, and the ore will be agitated for a time with cyanide, after which the slimes will be drawn off, passed through three filter presses, each holding 5 tons charges, pressed out and washed into the river. The gold is left on zinc shavings…

It is expected the new plant, will be started in June or July, and of this hundred stamps 20 will be used for the treatment of the mineralised ore already referred to. It will pass to the stamps over six Union Iron Works concentrators. The concentrates will be sent for further treatment, and the residue will pass on with the other ore for wet treatment. There is already on hand a thousand tons of this refractory ore ready for treatment, and it should add considerably to future returns. [54]

(Extract from An Outline Of Milling Operations At The Victoria Battery, Waikino 1898 – 1954. John Bacon, 1998)

Victoria Battery Flow Sheet

Treatment before 1912 - Grinding to 70% through 200 mesh, followed by plate amalgamation, then Wilfley table concentration. The Wilfley table concentrates were reground and cyanided in the concentrates treatment plant.

The Wilfley table tailings were then classified into –

(c) Sands - cyanided by a percolation method.

(d) Slimes - cyanided by an agitation method.

Treatment from 1912 to 1947 - Amalgamation practice ceased on 12th May 1912, and the flowsheet was continued as before to produce Wilfley table concentrates, sands and slimes for cyanide treatment in separate sections for each product.

Treatment from 1947 to 1952 - The sand treatment plant closed down in 1947 and the flow sheet changed to:

(c) Concentration on Wilfley tables.

(d) All sliming of Wilfley table tailings.

Treatment from 1952 to 1954 - The concentrate treatment plant was modified to cyanide the clean-up material recovered from the Battery cleanup.

Tonnages And Recovery - Victoria Battery

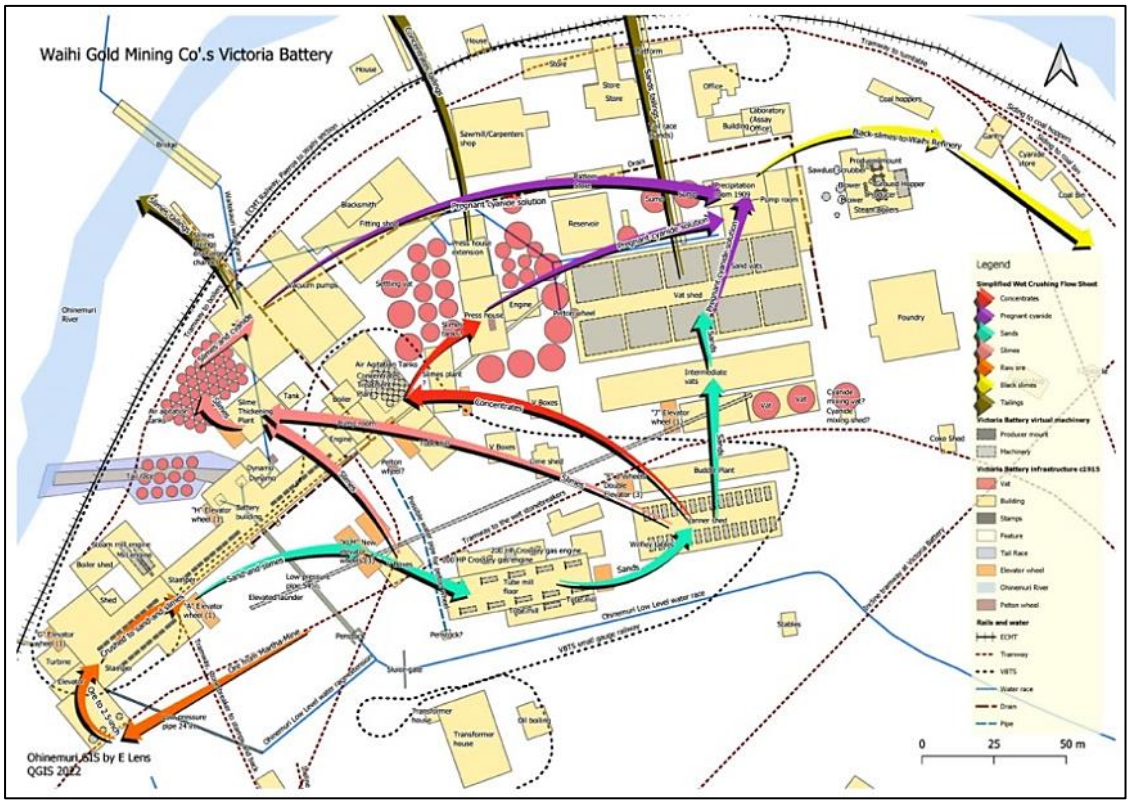
		Recovery	
	% of Total Tonnage	Gold %	Silver %
Concentrates	2	25	14
Sands	12	6	8
Slimes	86	69	78
	100	100	100

[55]

[54] https://paperspast.natlib.govt.nz/newspapers/AS19000208.2.7
Auckland Star, Volume XXXI, Issue 33, 8 February 1900, Page 2
[55] An Outline Of Milling Operations At The Victoria Battery, Waikino 1898 – 1954. John Bacon, 1998.

Wet Crushing Flow Sheet

GIS map showing stylized wet crushing flow sheet



Jock Hinton diagram? VBTS

Elevator Wheels

A B C D E F G H I J K L M N and O.

There are eleven elevator wheel installations at the battery, five with multiple wheels, one of which was a triple lift, with 20 wheels in total. Wheels were 25, 30, or 35 feet in diameter. The triple lift wheels achieved an 85 foot lift (26m)[56].

The wheel installations were named alphabetically, but confusion and doubt remains whether strictly in date sequence. Additionally some installations of multiple wheels were given a single letter, others for each wheel. The first wheel installed, the early slimes wheel, was not labelled A, but I.

The C and D wheels are labelled on the maps to suggest four wheels total (i.e. tandem double lift). The Papers and Reports Relating to Minerals and Mining. 1904 image has the caption: "Group of four elevator wheels, double lift". The reporter may have misunderstood? The literature does not make this clear, but it appears that this installation comprises two double lift wheels. The fourth wheel was added later in 1904.

The installation and usage of wheels A, B, G, H and N&O is not mentioned in the literature. The G wheel in particular remains a mystery. Not every wheel is labelled on every version of the early maps.

An attempt to organize these wheels is made in this table:-

Elevator wheel	Wheels	Date	Location	Size	Function
A	1	1903/4	Behind the masonry wall of the stamper building	35ft[57] (10.7m)	Primary wheel for lifting from the stamps
B	1	1903/4	Beside the concentrates treatment plant	35ft[58] (10.7m)	Primary wheel for lifting from the stamps
CC' DD'	4	1903/4	East of the later KLM wheels. Tandem double lift	35ft (10.7m) x 4? wheels[59]	Raising pulp to the elevated launder
E	2	1905	East of tube mill floor	?	Raising discharge from tube mills to V boxes then vanner shed
F	3	1905	North west corner vanner shed. Three wheels, double lift	?	Raising the tails (sand) from the vanners/wilfley tables
G	1	1905?	North west of stamper building	?	Nothing in the literature
H	1	1905?	South west of turbine building	?	Lifting from the stamps
I	1	1901	At early slimes plant	25ft[60] (7.6m)	Early slimes plant
J	1	1905?	South of intermediate vats	?	Raising the tails (sand)

[56] John Bacon
[57] SE Fraser 1912
[58] SE Fraser 1912
[59] Papers and Reports Relating to Minerals and Mining. 1904 image
[60] Superintendents Annual Report. Waihi,27th January, 1902

					from the vanners/wilfley tables?
K L M	3	1908	Between stamper building and tube mill floor. Triple lift	30, 30, 25ft[61]. Total 85ft (26m).	Raising pulp to the elevated launder
N&O	2	1908 or 1909?	South west of slimes thickening plant. Double lift	50ft[62] (15m) total lift	Raising thickened slimes to top of air agitation tanks
11	**20**				

From the literature:

Superintendents Annual Report. Waihi,27 th January, 1902

> An elevator wheel. 25 feet in diameter for lifting the slimes into the slimes tanks has been constructed at Waikino. [63]

The first mention of an elevator wheel. It appears to be the first wheel installed at the battery, but is labelled the I wheel

Superintendents Annual Report For 1903 Waihi, 21st January, 1904

> Owing to the wear and tear on the sand pumps used for raising the pulp from the mill to the distributing launders, and the heavy cost for keeping them in repair, it was decided to substitute four elevator wheels for this purpose.
>
> The greater part of the construction of these was carried out at the Mill, and three were brought into use when the Mill started on the 4th January, 1904. [64]

The elevator wheels constructed to move pulp from the stampers to the elevated launder are clearly visible on many photographs. Three in use on 4th January, 1904. The images show one sump. Although not abundantly clear, it appears that this installation comprises two double lift wheels. The fourth wheel was added later in 1904.

Superintendents Annual Report For 1904. Waihi, 25th January, 1905

> The 4th elevator wheel has been brought into use for lifting the pulp from the Mill to the treatment plant, so that the sand pumps formerly used for that purpose have not since been required. [65]

The maps label these wheels as D D' and C C'. The images published in Papers and Reports Related to Minerals and Mining, 1904, say "group of four elevator wheels".

If Barry is reporting on this installation alone, then there has been no mention of the A and B wheels. These must be required to deliver the pulp to the D D' and C C' wheels, and so must be built simultaneously, or already exist.

These wheels are first mentioned in 1912. Reporting on 1911, SE Fraser states: "we decided to renew the "A" and "B" wheels (35 feet diameter, taking the coarse pulp from the 200 head) with wooden

[61] Bacon
[62] Bacon
[63] Superintendents Annual Report. Waihi,27 th January, 1902
[64] Superintendents Annual Report For 1903 Waihi, 21st January, 1904
[65] Superintendents Annual Report For 1904. Waihi, 25th January, 1905

buckets". This suggests that these are the primary wheels for lifting from the stamps to the D D' and C C' wheels.

The A, B and H wheels must lift the pulp from the stampers to the CC' DD' (tandem double lift) wheels, via launders. These launders are not obvious in any photographs. In 1908 another set of wheels, a triple lift, are installed beside the original double wheels. They are labelled K L M on the old map.

Superintendents Annual Report For 1905. Waihi, 18th January, 1906.

> The two elevator wheels required in connection with this plant [tube mills] have been constructed and partly erected in position. [66]

Are these the two wheels (one sump) immediately to the east of the tube mill floor? The E elevator wheels?

> The necessary iron tanks, launders, and elevator wheels required in connection with this plant have been constructed and erected in position, only the smaller details still remaining to be dealt with. [67]

Another set of wheels? At northwest corner of vanner shed? The F wheels?

Superintendents Annual Report. For 1908. Waihi, 10th February, 1909

> Some trouble and delays having been caused by the two main elevator wheels being overloaded, three new ones of ample capacity have been erected alongside the old ones. Improvements have been made in their construction and in the methods of driving them, which should considerably lessen the cost of maintenance. [68]

These are the K L M wheels.

> The old ones will be left as a stand-by…
>
> These, with the vanner plant and three elevator wheels, are driven by three 200 h.p. Crossley Gas Engines. [69]

Three wheels: E, F and J?

The vacuum plant for removing surplus water from the slimes, or slimes thickening plant (STP), was established after the vacuum slimes plant (VSP). The N and O elevator wheels were on the side of this building, elevating the thickened slimes to the top of the air agitation tanks. The implementation of these wheels are not mentioned in the literature.

ENGINEER'S REPORT—VICTORIA MILL—YEAR ENDED 31st DECEMBER, 1911.

WAIKINO, 31st January, 1912. S. E. FRASER, Superintendent Engineer.

> With the advent of coarser crushing, the additional wear on the Battery Elevator wheels has been very considerable; so much so, that the life of the steel buckets in use has been reduced quite 50 per cent.
>
> The buckets on the "K" wheel were increased from 1/8" to 3/16" plate, and with that we can only reckon on about eight months' life.

[66] Superintendents Annual Report For 1905. Waihi, 18th January, 1906.
[67] Superintendents Annual Report For 1905. Waihi, 18th January, 1906.
[68] Superintendents Annual Report. For 1908. Waihi, 10th February, 1909.
[69] Superintendents Annual Report. For 1908. Waihi, 10th February, 1909.

Elevator Wheels

> An experiment was carried out with a wooden bucket in place of steel, and the results were somewhat astonishing. Additional buckets of this type were put in the "A" and "B" wheels as a further experiment, made of different kinds of timber, and those of "Mirau" showed that after four months' running, very little wear was perceptible.
>
> On these results we decided to renew the "A" and "B" wheels (35 feet diameter, taking the coarse pulp from the 200 head) with wooden buckets.[70]

This confirms that the elevator wheels are assigned letters of the alphabet. The mystery of the KLM, or K L M, wheels may be solved. At the Waihi Battery the elevator wheels were given numbers.

> This work was carried out during the annual overhaul. Apart from the increased life of the wheels, new buckets can be made and placed in position at about one-third of the cost of steel ones; and I anticipate that in future a good deal of the expense in maintenance of the wheels will, by the new arrangement, be eliminated.
>
> The other wheels on the Plant will, as occasion arises, be similarly dealt with. [71]

John Bacon on The Victoria Mill and Waikino. John Bacon, 1998

Elevator wheels

> By the time the crushed pulp had passed the stamper screens it had almost reached river level. This meant that the designers of the Waikino battery were confronted with the problem of moving the pulp some distance higher up the hill to the tube mills. Pumping was not a viable option because the abrasive nature of the sandy pulp would cause excessive wear on pump parts. The problem was solved by the use of a remarkable contrivance known as the elevator wheel. Five of these wheels were in use between the stampers and the tube mills and altogether eleven were installed at various points in the battery.
>
> The elevator wheel could be described as a cumbersome wooden contraption with a diameter of either 25, 30 or 35 feet. Each wheel was constructed from 12 long lengths of 8 inch by 8 inch timber arms (sweeps) bolted to a heavy cast iron boss at the centre of the wheel which in turn was keyed to an 8 inch diameter steel turning axle. The outer periphery of the wheel was made of arc shaped hardwood segments 2 inches thick, between which were nailed 2 inch boards that were 2 feet wide and set at an angle to act as buckets to carry the pulp. Wooden backs were nailed right around the wheel behind the buckets and protected from wear by scrapers made from 3/8 inch steel.
>
> The water-borne pulp was simply fed into the buckets on the inside of the revolving elevator wheel at its base and then carried up to discharge into a large crescent shaped receiving launder called a shoe, at the top of the wheel. Perhaps the elevator wheels at Waikino might have possessed some rustic charm for the viewer, like their cousins the ancient water wheels, except for the necessity to enclose them, almost out of sight, inside a weatherboard housing because of their sloppy habit of spilling pulp.
>
> The final stages of elevation before the pulp reached the tube mill was by means of the KLM wheels. The KLM consisted of three wheels set vertically one above the other to achieve a direct lift of 85 feet above ground level. The whole set of wheels and driving machinery, powered by a 110 horse-power electric motor, was enclosed by a timber structure covered with corrugated iron sheets. Access to each floor meant a steep climb using stairways. The whole KLM structure vibrated beneath the feet and swayed considerably at the top level. The

[70] ENGINEER'S REPORT—VICTORIA MILL—YEAR ENDED 31st DECEMBER, 1911
[71] ENGINEER'S REPORT—VICTORIA MILL—YEAR ENDED 31st DECEMBER, 1911

Elevator Wheels

three wheels creaked and groaned and this noise, together with the dim lighting and the flapping of loose iron sheets in the wind, created an eerie effect in the dark hours.

Despite their unwieldy style the elevator wheels at Waikino were efficient. They performed well over the years, requiring only minimum attention from the carpenters in the form of maintenance. The base of each wheel was surrounded by a concrete pit but the churning action of the wheel through the pulp spilling into the pit had a concentrating effect which trapped a considerable amount of values in the form of free gold and silver and enriched sulphides, in the elevator pit. In order to know the actual recovery of gold and silver achieved by the battery, it was necessary to dig out this material from certain elevator wheel pits every six months and to treat it…

Crushing and Grinding

Gyratory Crushers and California Stamp Battery:

The crushed battery sands were laundered to two 35’ diameter wooden elevator wheels [A and B?] which, in turn, delivered it to a series of 3 elevator wheels of 30’, 30’ and 25’ diameters placed one above the other so that the discharge from one wheel was picked up and elevated to the next, so that the top wheel delivered the pulp to a launder approximate 85 feet above ground level. This elevator unit was known as K.L.M. and was belt driven from an A.C. 110 H.P. motor.

Tube Mills

An attempt to organize the tube mills is made in this table:-

Location				**Date added**	**Function**
Concentrates treatment plant	Added	**Tube mill floor**	Added		
1	1			1903, erected October[72]	Finely grind concentrates
		2	2	1905[73]	Forerunner of the tube mill house?
2	1			1905 or 6[74] [75]	Finely grind concentrates
		7	5	1906[76]	Finely grind run of the stamps
3	1			1907[77]	Finely grind concentrates
		10	3	1908[78]	Finely grind run of the stamps
		13	3	1909 – 10 [79] [80]	Finely grind run of the stamps
3		**13**			

Although not often specified, it appears that most of the mills were 18ft internal length. The extant foundations reflect this. EG Banks reports that one of the mills in the concentrates treatment plant was one 19 ft. 6 in.

The north east corner of the vanner shed has concrete foundations that appear to have mounted a tube mill (drive end of a mill). No reference to this tube mill has been found, and it is not included in the above table. Why a tube mill in the vanner shed, and what was it for?

[72] Superintendents Annual Report For 1903 Waihi, 21st January, 1904
[73] Superintendents Annual Report For 1903 Waihi, 21st January, 1904
[74] Superintendents Annual Report. For 1906. Waihi, 17th January, 1907.
[75] Superintendents Annual Report For 1903 Waihi, 21st January, 1904
[76] Superintendents Annual Report. For 1906. Waihi, 17th January, 1907.
[77] Superintendents Annual Report. For 1907. Waihi, l3th February, 1908.
[78] Superintendents Annual Report. For 1908. Waihi, 10th February, 1909.
[79] Superintendents Annual Report For Year Ended 31st Dec, 1909. Waihi, 10th February, 1910.
[80] Superintendents Annual Report For Year Ended 31st Dec. 1910. Waihi, 17th February, 1911.

Air Agitation Tanks

An attempt to organize the air agitation tanks is made in this table:-

Air Agitation Tanks			**Date added**
CTP 6x15ft 9in tanks	**36x12ft tanks**	**60x13ft tanks**	
10			1903[81]
2 plus 7			1905[82]
	32		1906[83]
6			1907[84]
	10		1908[85]
		12	1911[86]
25	**42**	**12**	

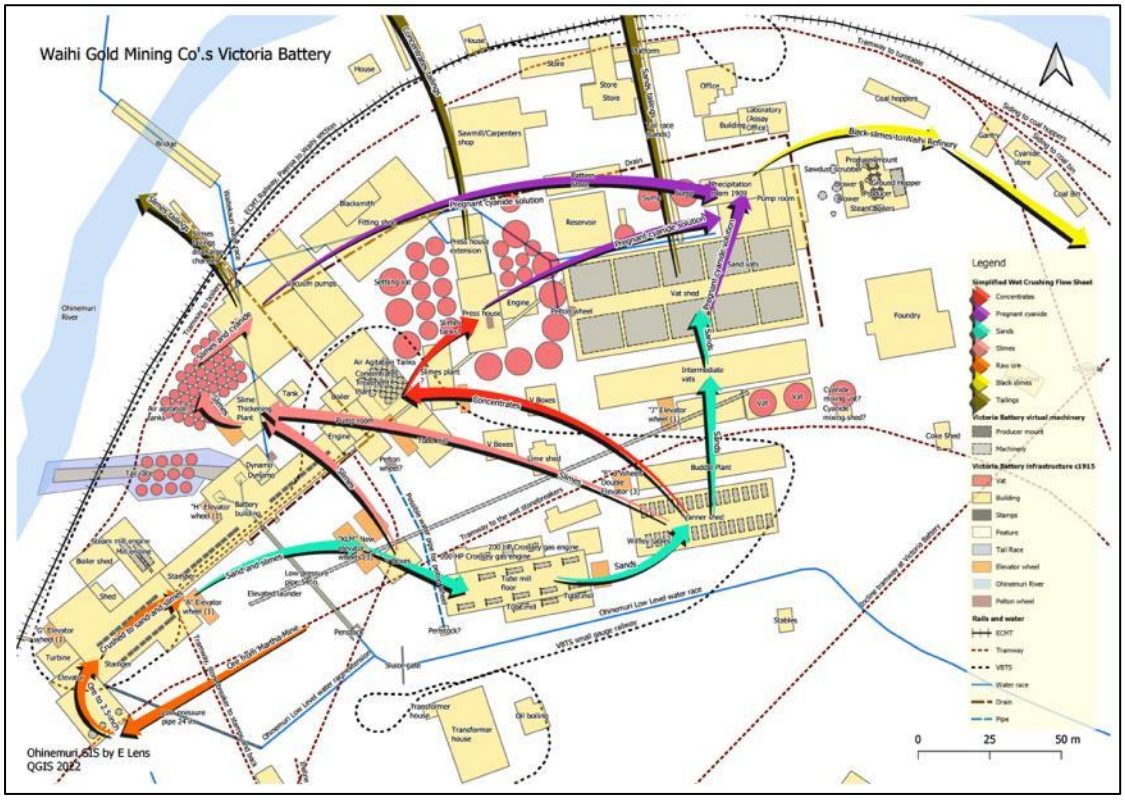
Barry's reports suggest that there were 25 air agitation tanks in the concentrates treatment plant (CPT), Bacon says 23. These tanks were operated in series.

The 42 36ft tanks were operated individually, the 60ft tanks in series.

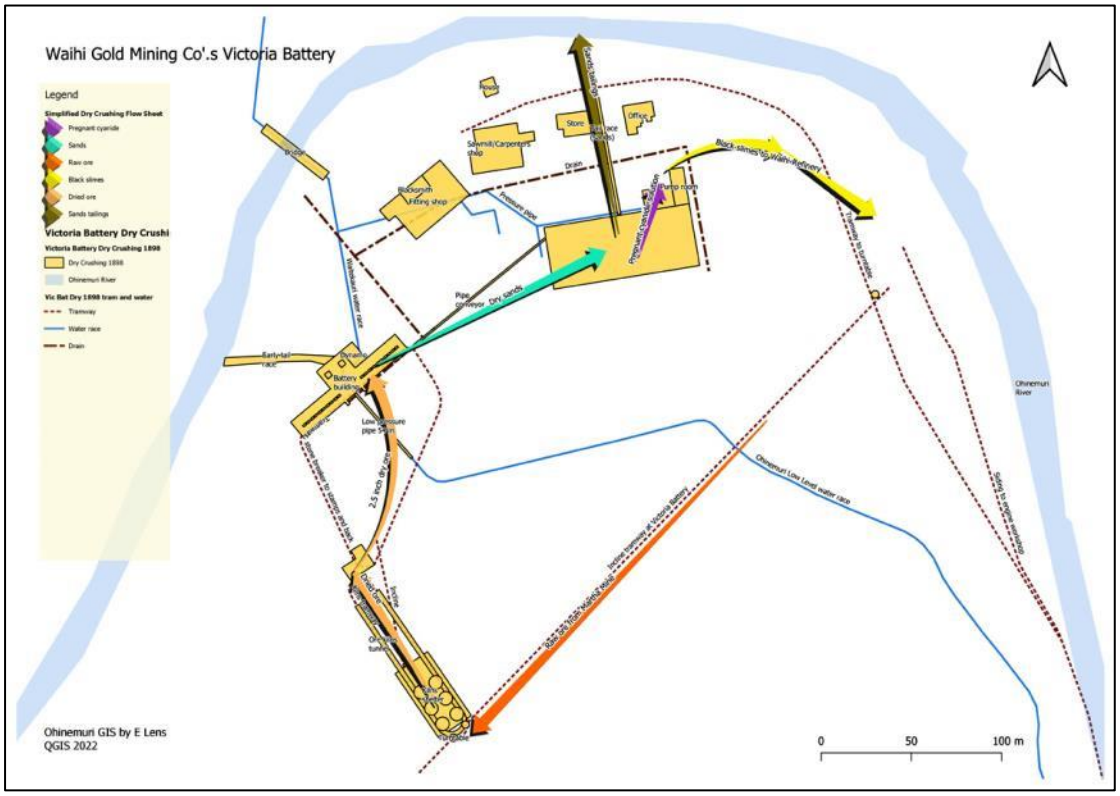
[81] Superintendents Annual Report For 1903 Waihi, 21st January, 1904
[82] Superintendents Annual Report For 1905. Waihi, 18th January, 1906.
[83] Superintendents Annual Report. For 1906. Waihi, 17th January, 1907.
[84] Superintendents Annual Report. For 1907. Waihi, l3th February, 1908.
[85] Superintendents Annual Report. For 1908. Waihi, 10th February, 1909.
[86] ENGINEER'S REPORT—VICTORIA MILL—YEAR ENDED 31st DECEMBER, 1911

Maps

GIS and historic maps are best viewed directly, or in the live GIS, and so are not reproduced here, with the exception of the stylized flow sheets.



Above is the stylized wet processing flow sheet, below the dry processing flow sheet.



Time Line

The table was intended to capture the detailed timing of the various structures and processes, and provide the data for the GIS. It is far from finished ☹.

The GIS has been largely updated with the information captured in this document. The databases which are part of each layer of the GIS have been exported to Microsoft spreadsheets, and are available in the folder: **GIS layers databases of features.** This is the information which appears when you click on, or touch, a feature in the GIS.

1898 Feb.	Victoria Battery starts dry crushing. Full 100 stamps on March 2nd. Six ore roasting kilns, sand vats shed with 10 concrete vats.
1899 May	In May a start was made to erect a further 100 stamps which were to be wet crushing. First 50 wet stamps started end September
1900	By mid January 1900 the 100 wet stampers were fully operational.
1900	550 H.P. Yates and Thom steam engine together with five Babcock and Wilcox boilers.
1901	New 100 stamps start wet crushing. Experimental Concentrates Treatment Plant (CPT) was established.
1902	The whole battery starts wet crushing early August.
1905	New CTP built, treating the concentrates from the whole 200 stampers at Victoria, and from the Waihi and Union batteries. The tailings are conserved.
1906	July onwards. The conserved concentrates tailings stored at the battery are removed to the tailings stack beside the tramway.
1907	October. The saving and deposit of concentrates tailings ceases.
1912/13	Horahora electricity arrives at battery. 46,000 volts reduced to 11,000 to send on to the mine. 500 volts for use at the battery
1940s	The 1942 aerial photograph shows possible activity at the concentrates tailings stack. Tailings taken for reprocessing?
1998	Keith Hay proposes extracting the tailings.
2012	Keith Hay and Alan Death propose another attempt.

Appendices

The Rise And Fall Of Dry Crushing On The Hauraki Goldfield.

BY PERCY MORGAN. 1903

TRANSACTIONS of the AUSTRALASIAN INSTITUTE OF MINING ENGINEERS,

VOL. IX. PART II. PAPER No. 128.

I.——HISTORICAL.

IN the early days of the Hauraki goldfield (1866 to 1889) almost the only system of ore treatment was wet crushing followed by copper plate amalgamation. A further saving of bullion was in most cases obtained from the tailings by means of pans or berdans. Though this system was not always as efficient as might have been desired, it answered fairly well for the bulk of the gold-bearing quartz of the Thames and Coromandel districts, where the gold occurs chiefly in the form of visible particles, and there is not a great deal of silver. It failed, however, with most of the ore found in the Upper Thames or Ohinemuri district, especially in the Karangahake and Waihi portions of the field. In those days the cyanide process was not, and the usual prescription of the mining “expert" was smelting. At Karangahake, many attempts were made to discover a payable method of treatment for the so-called " refractory " ore, but on the whole with very little success, and the district struggled along for a number of years without adding very materially to the production of gold in New Zealand. At Waihi, the Martha Co.'s stamp battery treated by wet crushing and copper plate amalgamation some 18,000 tons from the Martha Reef, worth probably at least £4 per ton, but the average return was considerably less than £1 per ton, a sum which barely paid working expenses, and consequently the shareholders were glad to part with a property containing millions, for what they considered the excellent price of £3000. The art of fire assaying, one need hardly state, was apparently quite unknown to the Martha Co.'s staff, and a curious sidelight is thrown on the usual mining methods of those days, when one reads that the manager estimated the stone to contain from 4 to 6 dwts. per ton only, while at the battery "they were losing very little, and they looked on their gold-saving appliances as being as good as any in the district."

About 1887 (the year in which McArthur and Forrest patented their cyanide process) the now famous Waihi Co. was organised, principally by aid of British capital, in order to take over the Union and Rosemont claims adjoining the Martha Co.'s ground, which also was presently to be absorbed by the British capitalist. It is necessary to dwell somewhat upon the history of the Waihi Co., for it was undoubtedly the great success of this corporation, especially after the introduction of the cyanide process, that led to the universal adoption of dry crushing in the Ohinemuri district. Profiting, it would seem, by the experience of the Martha Co., the Waihi Co. decided to adopt dry crushing succeeded by pan amalgamation, as their system of ore treatment. Thirty head of stamps, together with drying kilns, rock-breakers, Challenge ore feeders, combination pans, settlers, etc., were accordingly put up on a site adjacent to the Union Hill. About the year 1889 this plant, the first of its kind in New Zealand, was in full operation. In many respects it was a great improvement on any battery previously built on the Hauraki goldfield, but it is doubtful whether it would have paid its way had not the Waihi Co., through the shrewdness of Mr. T. H. Russell, then superintendent, acquired the ground held by the Martha Co. for a sum equal to about one hundredth part of the present annual profit therefrom.

At this time the Waihi Co. was by no means in a satisfactory financial position; but during the next few years, thanks to the abundant supply of good ore obtained from the Martha lode, and the up-to-date methods of battery treatment, the company found itself on a better footing. The average extraction resulting from the pan amalgamation system was much better than that obtained by the Martha Co. in their wet crushing and copper plate amalgamation battery, but was still moderate, being from 60 to 70

per cent. of the gold and 45 per cent. of the silver. One great drawback to the dry crushing was the clouds of dust generated thereby, but this was partially remedied by housing in the stamps as closely as possible. About 1892, thirty additional head of stamps were erected, and with these wet crushing was given a trial, but apparently without success, as dry crushing was soon resumed throughout the whole battery.

We now come to the introduction into New Zealand of the cyanide process, which was destined to play an important part in the development of dry crushing. About 1889, the Crown Co. erected at Karangahake a small dry crushing plant, consisting of a rock-breaker, a step or shelf kiln, and two Lamberton mills. In connection with this mill, one of the first, if not the very first, working cyanide plants in the world was built under the auspices of the Cassel Co. Though the crushing plant was anything but a success, the excellent results obtained by the cyanide process led to the construction of a twenty-head dry crushing battery, together with a complete cyanide plant. The Waihi Co., which now had 90 stamps at work, adopted the new process early in 1894. The striking success which immediately ensued gave a great impetus to the mining industry all over the Hauraki gold-field. In the Ohinemuri district in particular, Waihi practice was naturally followed as much as possible, and thus dry crushing, succeeded by cyanidation, became the leading process of ore treatment in this part of the Hauraki field. Existing wet crushing batteries were converted into dry crushing plants, whilst a number of new batteries were specially designed and built for the process. During 1896 and 1897 dry crushing was at its zenith; every battery in the Ohinemuri district, including the new 100 stamp battery built at Waikino by the Waihi Co., dry crushed its ore. The undisputed reign of the process, however, was short. During 1897 Mr. F. Daw, superintendent of the Crown Mine, introduced a wet crushing system at the Crown battery which proved successful. The new departure was speedily followed by the Komata, Waitekauri, Waihi-Silverton, Woodstock, and other companies. After making numerous experiments, the Waihi Co. also began to come into line, and built 100 head of stamps at Waikino specially for wet crushing. At the beginning of 1902, the older 100 head at this place were converted into wet crushing stamps, and finally, at the beginning of this year, [1903] the adaptation of the Waihi battery to the system in vogue at the Waikino mill brought the reign of dry crushing on the Hauraki goldfield to a close.

II.—GENERAL DESCRIPTION OF DRY CRUSHING PRACTICE IN THE OHINEMURI DISTRICT.

The first operation which the mine ore underwent was to be calcined, or partly calcined, so as to expel moisture, this being absolutely necessary as a preliminary to dry crushing. In most cases kilns, excavated in the ground (usually in solid rock) and holding from 60 to several hundred tons of ore, besides the necessary fuel (firewood), were used for this purpose. The shape of these kilns was that of an inverted dome or beehive. Generally they were lined with red brick, a step which resulted in a considerable economy of fuel. At the bottom was a brick and iron shoot, similar in principle to that used in mine passes, leading to a drive which ran to daylight, the kilns being always placed on a hillside, so as to allow of an adit being driven underneath. The kilns made by the Waihi Co. at Waihi were for the most part 20 feet wide and 37 feet deep; those at Waikino were considerably larger.

In charging an empty kiln the method employed was first to place a layer of firewood on the bottom of the kiln, building it up to some extent round the walls—then came a layer of ore of moderate thickness, with rough wooden chimneys through it, then more firewood and ore in alternate layers, and finally a thick layer of ore. The bottom layer of wood, either while charging was going on or after its completion, was fired, combustion being supported by the air which entered through the partly open shoot door. In the course of a week or more the firewood was burnt out, and the ore, after it had been allowed to cool somewhat, was in part withdrawn from the kiln. Hereafter kiln charging was carried on as an intermittent operation, about half the ore being withdrawn every few days, and fresh fuel and ore placed on top of the remaining quartz so as to fill the kiln. The wood was usually fired by the hot ore

below; now and then this did not take place, and the kiln men had to dig down through the ore to the wood before they could start the fire. The weight of ore calcined in the kilns by one ton of wood (40 cubic feet) varied from three to seven tons, the larger kilns, especially those that were bricked, being more economical than the smaller ones.

The cost of kiln drying varied from 10d. to 2/- per ton for fuel, and from 6d. to 8d. per ton for labour. In 1898 kiln drying cost the Waihi Co. 1/4¾ per ton of 2240 lbs.

At the old Talisman 20 stamp battery a rotary drying cylinder, which did good work, was used, and at the Crown battery a shelf furnace of special design dried the ore as it came from the rock-breaker with a consumption of one ton of wood to eight tons of ore. It seems rather surprising that rotary calcining cylinders were not more largely used; but the prevalence of the more expensive kiln calcining is probably to be explained by a spirit of imitation which led other mines to copy the Waihi practice rather than to attempt to improve upon it.

Besides fitting the ore for dry crushing, the calcination, partial though it was, had the effect of bricking the clay and hydrated oxide of iron present, thus very materially checking the formation of unleachable slimes. This was, in fact, a very important advantage of calcining, and explains to a great extent the adoption on this field of dry crushing in connection with the early cyanide process. During kiln calcining the larger lumps of ore, probably owing to internal steam pressure, often cracked with a loud report. The heat also had the effect of rendering the ore a little more brittle or friable, but not to any great extent.

With respect to kiln drying, a point which I believe has hitherto escaped notice deserves mention, namely, that the alkaline wood ashes which mingled with the ore were beneficial during cyanidation in correcting any acidity. On the other hand some unconsumed charcoal was occasionally left in the ore, and this had, of course, a more or less deleterious effect in cyaniding. If the ore contained sulphides, half the sulphur perhaps would remain, principally in the form of sulphates, most of which would act as cyanicides.

From the kilns the ore, generally still hot, was trucked to rock-breakers of the Blake Marsden or Gates' type, which reduced the lumps to two inch cube or less. From the breakers the stone gravitated or was trucked into bins supplying the stamps through the medium of Challenge ore feeders. As far as possible, the ore was fed to the stamps in a warm, or even hot condition, cold ore not forming a good wave in the mortar box, and being apt to clog the screens. The dust as it came through the screens was very perceptibly warmer than the fed-in ore, as might be anticipated by those acquainted with physical laws. At times it reached the cyanide vats quite warm, a circumstance which no doubt had a tendency to improve the extraction.

The usual weight of stamp employed in dry crushing was from 900 to 1050 lbs. Taking a 1000 lb. stamp as the basis, the average duty was about 1.7 tons, or a little more, of hard quartz per 24 hours crushed through a 40 mesh screen. The great bulk of the pulverised ore, however, was fine enough to pass a 100 mesh sieve. The stamp duty varied very considerably, not only with the weight of stamp and nature of ore, but also according to the state of the dies and shoes, depth of discharge, order and height of drop, number of blows per minute, and skill of attendant.

When new, the dies were about two inches below the discharge line of the screen, but the depth of discharge, of course, increased as the dies wore away, though it was sometimes regulated to a certain extent by placing liners under half worn dies.

After many years experience the Waihi Co. found that the best order of drop for rapid crushing was 1.5.2.4.3. This order, though rather hard on the screens, gave a good wave in the mortar box, and prevented the ore from accumulating under the end stamps, as it did with some other orders, e.g., 1.3.5.4.2. At one time the usual drop was 6 to 6½ inches, with about 96 blows per minute, but the drop was increased by the Waihi Co. to eight inches, and the speed to 102 blows per minute for stamps

weighing 900 to 960 lbs. Had heavier stamps been used, it would not have been possible to work quite up to this speed without excessive breakages. For instance, in wet crushing with 1250 lb. stamps, the highest desirable speed with an eight inch drop was found to be 98 blows per minute. At these speeds, one need hardly say, stamps require attention and careful regulation of the drop in order to prevent "camming."

The high speed mentioned above led to a considerable increase in the output of the stamps in the Waihi battery. In 1890, soon after dry crushing first began, the duty per 900 lb. stamp was stated to be 1.16 tons per diem with 60 mesh screen. Even this was probably overstated, for in 1893 it was only 0.93 ton per diem, and in 1894 when most of the ore was crushed through 40 mesh, it was still as low as 1.14 tons. By reducing lost time to a minimum, improving the order of drop, and increasing the speed, the duty of the same stamps with some screens was, during 1901, raised to 1.7 tons per diem, which may be taken as representing very nearly the greatest possible duty for the hard Waihi quartz, which requires, be it remembered, very fine crushing. The wet crushing duty of the same stamps is, at the present time, between 2.3 and 2.4 tons per twenty-four hours, using 40 mesh screens.

The life of the steel shoes employed varied from six weeks to three or four months, depending on weight of stamp, hardness of ore, method of feeding the stamps, and degree to which it was considered advisable to allow them to be worn away. The dies were generally of cast iron, this wearing better than steel, though only lasting half the time. Their life, when of cast iron, varied from three weeks to as many months. The short life of some of the dies is to be explained by the uneven wearing of their surface, which caused them to be discarded before they were half worn down. The Waihi Co. found that taking the average of a year, cast iron dies lasted 41 days with stamps weighing 900 to 960 lbs. Leaving out of account the unworn portion of shoes and dies, the total consumption of iron (and steel) was about 2¼ lbs. per ton of pulverised ore.

The mortars used were of the ordinary single discharge type. In several instances double discharge mortars were given a trial, but in no case did the results come up to anticipation. About 1892, the Waihi Co. fitted half their stamps with back and front discharge mortars; but it was found that they crushed no more than the single discharge mortar. A few years later, the first 100 head of stamps erected in the Victoria mill at Waikino, were also given double discharge mortars, which were made somewhat wider than the single discharge mortars; but the experiment was eminently unsuccessful. The back screens were continually breaking owing to lumps of ore being dashed against them, although in order to obviate this they were placed further from the dies than the front screens. This had the effect of lessening the amount of pulp that passed through them very seriously. Again, the increased width of the mortar box and the consequent larger body of half pulverised ore contained in it, resulted in a very poor wave, thus lessening the discharge through the front screen. Much time was lost in extra repairs to the back screen, and it was soon decided to block up the backs of the mortars, with the result that the duty of the stamps, instead of being lessened, was actually increased. Probably only in exceptional cases will the double discharge mortar be found suitable for dry crushing. They may perhaps succeed when the stamps are fed with ore broken to a small size, say three-quarter inch cube or less, as this would admit of a fairly narrow width of mortar, but they did not answer for the ore of the Upper Thames district, which consisted of hard quartz, broken to a moderate size only, and requiring fine pulverising in order to extract the values during the subsequent cyanidation.

The screens used were wire cloth, generally 40 mesh, sometimes 30 mesh. They lasted with a turning end for end and upside down, about a fortnight. As was previously mentioned, the bulk of the dust passing through the screens was very fine, much finer than the holes in the screen. In consequence many thought that the product was finer than was absolutely necessary, and that a great waste of stamping power was taking place. Experiment showed that there was not very much in this idea. More than once coarse screens were fitted to the mortars, the product sifted through finer shaking sieves (40 mesh) and the coarse material returned to the stamps. In no case was the result encouraging, for although the stamp duty was increased, or apparently increased, the percentage of extraction invariably

fell off, generally very seriously, owing to the extra amount of fine gold locked up in the comparatively coarse particles that just passed the 40 mesh.

From the stamps, Archimedean screw conveyors running in wooden troughs and bucket elevators of flourmill type took the ore to bins, or in some cases direct to the leaching vats. In the former case the ore was discharged through short canvas shoots fitted on to doors opened or shut by a lever into half ton iron trucks. In order to allow the trucks to be emptied into any desired vat or any part of a vat, they were run on to bridges or travellers, which ran over the vats on rails and could be moved by means of gearing backwards or forwards. In order to break the fall of the ore and prevent packing, cross bars were placed under the traveller. This device, which was probably of little use, helped to raise dust. After the proper number of trucks had been emptied into a vat, the surface of the ore was nicely levelled by means of a wooden rake. The charge was now ready for cyanide treatment, and here it must be left, since to enter into details of treatment would be outside the scope of the present paper.

In order to give some idea of the cost of dry crushing with gravity stamps, it may be mentioned that during 1898 the average cost of dry crushing in the Waihi Co.'s mills was 4/4¾per ton, exclusive of kiln drying, which, as mentioned, cost during the same year 1/4¾ per ton.

Though during, as well as before and after, the regime of dry crushing, the gravity stamp was the chief pulverising medium, various other machines were used to a certain extent. At Kuaotunu the Kapai-Vermont Co. crushed their ore, which was fairly soft, with the aid of an Otis ball mill. The Waihi Co. also gave the Otis a trial, but their ore was too hard for the machine, and the results were very unsatisfactory. Krupp ball mills were used by the Waitekauri and Talisman Companies for some time. Provided the feed was not too coarse, these mills crushed fairly well for a time, but deteriorated as the working parts began to wear. Another disadvantage was that the product, though 60 mesh screens were used, was not fine enough to enable a good extraction to be obtained by the cyanide treatment. It is probable, however, that these mills would compare favourably with stamps when crushing ore of medium hardness. On the Upper Thames goldfield, principally on account of the hardness of the quartz, they proved inferior to stamps as pulverising machines. Krom rolls were tried by the Waihi Co., but were given up after a time, as their product, even after screening, was not fine enough at any time, and, moreover, soon decreased, owing to the surfaces of the tires wearing unevenly.

DUST AND ITS PREVENTION.—The evils arising from the presence of dust in dry crushing batteries on the Hauraki field were so serious as to require special mention. They came under three heads, of which the third was the most important, namely:—

1. Loss of ore.

2. Injury to machinery.

3. Injury to health of workmen.

1. Loss Of Ore—Unfortunately no data are available as to the amount of ore that floated away in the form of fine dust, but it was by no means inconsiderable, and would probably in every case have repaid the cost of collection. Some of this dust settled in places where it could be scooped up from time to time, but a great part floated out of the battery, or was otherwise lost. This float dust, strange to say, was worth considerably more, both in gold and silver (though especially the latter) than the ore whence it was derived. The Waihi Co. saved a certain amount of this fine dust by connecting the housing in front of the mortar boxes with exhaust fans, which discharged into dust chambers. The primary object being merely to keep the battery free from dust, and thus prevent injury to the health of the employees, the chambers were not arranged to catch all the dust that entered, much of which therefore escaped into the outer atmosphere—still the saving was noteworthy. This arrangement, it is evident, also obviated to a great extent the other evils connected with the presence of dust in the battery.

2. Injury To Machinery.—The presence of dust in the battery caused a certain amount of extra wear and tear with the machinery, and made cam shaft and other main bearings more liable to heat than in wet crushing batteries, but no serious trouble ever arose from this cause. The entry of dust into adjoining rooms containing steam engines or other delicate machinery was at times the source of much annoyance.

3. Injury To Workmen.—This was by far the most serious phase of the dust evil. It was experienced not only at the stamps, but also at the rock-breakers, in the kiln drives, and in the treatment plant.

In order to prevent the dust from injuring the battery employees, numerous expedients were tried, but none was altogether successful. It is, however, to be regretted that for a number of years the subject of dust prevention was taken up somewhat half-heartedly by the managers of most of the companies, probably from a failure to realise the serious nature of the case. After the matter had been dealt with by an Act of Parliament, which enjoined the use of adequate dust prevention appliances, a marked improvement took place.

From time to time the following means, amongst others, of lessening the dust nuisance were given a trial:—

1. The stamps, conveyors, etc., were closely housed in. Sheepskin with the wool on was found, very effective for closing cracks and other small openings, such as those in the top of the housing round the stamp stems. However well and carefully the work was done, it was not perfect and soon deteriorated, so that housing alone proved a comparative failure.

2. Natural ventilation was used as much as possible in order to carry off the dust from the places of origin. The various buildings were made as open as possible, and provided with louvered roofs. As in mines, so in batteries, natural ventilation was not always a success.

3. The housing of the stamps was connected with iron pipes or wooden boxes, leading to exhaust fans which discharged into dust chambers. This method proved very successful, and when properly carried out, in conjunction with close housing, kept the neighbourhood of the stamps almost perfectly free from dust. Exhaust fans were used by the Waihi Co. in order to purify the air in the neighbourhood of the rock-breakers, and also, I believe, for ventilating the kiln drives at Waikino.

4. In order to lessen the clouds of dust that arose when filling the vats a method of damping the ore (I have been informed) by means of steam was tried, but the damping caused the ore to pack in the vats, and percolation of the cyanide solutions was so seriously checked that the experiment was abandoned. It seems a pity that damping the ore was not given a further trial, for in ordinary vat chlorination the ore is damped without greatly interfering with the subsequent leaching. It is possible that the use of cyanide solution to dampen or even wet the ore as it came from the stamps would have given good results in more than one way.

5. In the Waihi Co.'s Victoria Mill, Waikino, where the vats were automatically filled, the ore being brought by conveyors and elevators high above the vats, and run into them through long canvas shoots, dust was at first very much in evidence in the vat shed. After trying various devices, Mr. S. E. Fraser, the superintendent, found that the attachment of a covered conical sheet-iron spreader to the bottom of the canvas shoot broke the fall of the pulp, and greatly lessened the dust.

6. Various patent respirators were tried, and at times their use enforced on the workmen, but none was successful to any extent. They all quickly clogged with dust, and impeded breathing to too great an extent. On the whole, the best plan was the tying of a silk handkerchief over the mouth and nostrils and breathing strictly through the nose. For some time the Waihi Co. issued liberal supplies of silk squares to their battery employees, but it was found that many of them used the silk for other purposes, and in consequence cambric was substituted for the more expensive material.

Though dry crushing was superseded by wet processes before the problem of dust prevention had been entirely solved, sufficient experience was gained to show that it is quite possible, with proper appliances and precautions, to carry on dry crushing without material injury to the health of the employees, at any rate in the case of clean quartzose ores.

III.—ADVANTAGES AND DISADVANTAGES OF DRY CRUSHING.

The chief advantages of the dry crushing system practised on the Hauraki field were as follows:—

1. There was no loss of ore during treatment, except the small (though not inappreciable) one caused by float dust. The losses caused by sliming and " float" gold in the old wet crushing process were entirely done away with.

2. The product was in such a condition that it could be leached by potassium cyanide solution, in one stage, without separation into sands and slimes. It was, therefore, well adapted as a preliminary to the cyaniding of the clean quartzose ores of the upper levels.

3. Even with ores containing much clay or hydrated oxide of iron the bricking of these substances protected them to some extent from being pounded into unleachable slimes.

4. The method lent itself to the fine crushing, which was absolutely necessary for obtaining a good extraction of the values by pan amalgamation or by cyanidation.

The chief disadvantages were:—

1. Cost of kiln or furnace drying.

2. Loss of ore in form of dust.

3. Low stamp duty, as compared with wet crushing.

4. Injury to machinery from dust.

5. Injury to health of workmen, necessitating also a higher scale of wages than that customary in wet crushing batteries.

6. Lowered efficiency of labour, caused by unpleasant conditions under which employees worked.

7. The depth of ore which could be satisfactorily leached in a vat, even with the use of vacuum pumps, was limited to from 20 to 30 inches. Very rarely did it reach 36 inches.

8. Practical impossibility, or at any rate, difficulty, of concentrating the ore, or of separating it into sands and slimes. It is true that pneumatic separators and concentrators have been invented, but it is by no means certain that any of these contrivances would have suited the ore of the Upper Thames field. It follows, therefore, that the dry crushing process does not lend itself to a complex system of ore treatment, and hence was not suitable for the mineralized ore which appeared in the lower levels.

The last of these disadvantages was the one that had most influence in causing the abandonment of dry crushing in New Zealand; but there is no doubt that it was well adapted as a preliminary to the cyanidation of the clean quartzose ore found in the upper levels of the Waihi and other Ohinemuri mines. It was, and perhaps still is, the best commercial method of dealing with such material. Yet, had the metallurgical knowledge and experience of to-day been available ten or twelve years ago, one can hardly doubt that the class of ore referred to could, and would, have been successfully treated by some modification of the wet crushing process now in use in the same district for ore, much of which is not materially different from that dry crushed in the past.

Useful though it undoubtedly was in its day, dry crushing was responsible for no little suffering and loss of life, and its replacement on the Hauraki goldfield by wet crushing processes is not a matter of regret, either to mine shareholders or employees. Though on certain mining fields, especially those with a scanty rainfall, dry crushing of auriferous ores may be preferred to the wet process, the writer's

experience leads him to recommend mining engineers to adopt wet crushing as much as possible. The modern improvements in concentration, and the introduction of hydraulic separators and of the practice of pumping the separated water back to the stamps, together with more perfect methods of slime treatment, have practically eliminated the losses caused by fine particles of ore being carried away by the battery water, so that in this respect, formerly its chief recommendation, dry crushing has no longer any advantage over the wet process, which, in most other respects, is immeasurably its superior.

Milling and Treatment at the Waihi Mine, New Zealand.

By E. G. Banks. Paper No. 221

Paper presented at the Australasian Institute of Mining Engineers, Thames New Zealand 1911.

In presenting a description of milling and treatment methods at the Waihi mine, it is advisable to first traverse a good deal of the past history of the mine, and show the various steps which have led up to present-day practice.

The record of the company is one of steady, solid advancement, both in metallurgical and financial results. This is illustrated by the following figures, dating back from 1897:-

Year	Tons Treated	Stamp duty	Extraction Gold %	Extraction Silver %	Gross revenue. £	Total Profit. £	Total expenditure per ton (N.Z. & London), inclusive of mine development.
1897	40,767	1.315	86.6	48.7	144,346	82,322	£1 10s. 5d.
1898	77,929	1.520	88.2	57.6	257,697	155,850	1 6 3
1899	102,381	1.790	88.4	57.4	305,596	166,686	1 7 2
1900	112,012	1.888	88.2	52.7	319,872	168,511	1 7 3
1901	159,325	1.960	88.1	56.1	464,811	232,480	1 9 2
1902	179,485	2.118	88.2	61.6	525,174	273,737	1 8 0
1903	231,323	2.406	87.5	65.1	661,754	364,944	1 5 8
1904	259,978	2.667	87.1	63.6	688,146	370,154	1 4 5
1905	298,531	3.124	87.3	64.8	733,561	416,593	1 1 3
1906	328,866	3.504	88.5	66.1	847,197	502,073	1 0 11
1907	356,974	3.794	89.0	70.3	888,585	530,911	1 0 0
1908	393,214	4.167	90.4	73.3	939,534	558,142	0 19 5
1909	416,813	4.492	91.2	73.9	970,034	606,182	0 17 5

Note:- To end of 1904 all calculations are on long tons (2240 lb.)

From 1905 all calculations are on short tons (2000lb.)

In every department of milling and treatment no expense has been spared in making experiments which might result in lower working cost, increased output, or improved extraction. Many small improvements have been introduced which, though perhaps of little account to a mine operating only on a small scale, have had an important bearing on the results achieved at Waihi.

The Waihi lodes, from the surface down to about 400 ft., contain a large proportion of hard chalcedonic quartz, which adversely affects the crushing. For about 400 ft. from the surface practically no base sulphides were met with, and a small percentage only of metallic oxides. The gold exists in an exceedingly fine state, combined with a variable proportion of silver. Very fine crushing is necessary in order to obtain a good extraction.

With increased depth, sulphides of iron, copper, zinc, and lead were met with, and the proportion of silver (in the form of argentite) increased. Even in the lowest levels the base sulphides do not amount, on the average, to more than about 4%.

Appendices

Approximate analysis of ore (dry crushed mill sample) from surface to about 400 ft. :-

	%
Moisture	.15
Loss on ignition	.73
Silica	95.97
Iron (oxide)	.93
Iron (sulphide)	trace.
Manganese	.24
Lime	.25
Alumina	1.62
Magnesia	trace.
Undetermined	.11
Total	100.00

Approximate analysis of ore (wet-crushed mill sample), from about 400 ft. to 850 ft.

	%
Loss on ignition	1.39
Silica	90.80
Iron (oxide)	.82
Iron (sulphide)	2.48
Manganese	.43
Lime	.69
Alumina	2.89
Copper, lead, & zinc	traces
Undetermined	.35
Total	100.00

Three separate mills are in operation – Waihi, 90 stamps; Union, 40 stamps; Victoria, 200 stamps. The Waihi and Union mills are situated at Waihi, being respectively about half and three-quarters of a mile from the mine, and the Victoria mill is at Waikino, about 5½ miles from the mine. The mills and mine are connected with each other by rail.

The Waihi mill was the first built, and was intended for the treatment of ores from the Union mine; but the supply of ore from this source proving insufficient, the company bought the mine now known as the "Waihi" in 1889.

The first method of crushing was by Globe mills . The ore, after being dried by wood fuel in kilns excavated in the hillside, was broken by a Blake crusher and passed to the Globe mills. No records are available of the work done by these mills, but they evidently proved unsatisfactory, for 30 stamps, crushing dry, were soon erected to replace them.

By March, 1892 , an additional 30 stamps had been erected, and arrangements were made to employ 40 stamps dry crushing and 20 stamps wet crushing. The wet-crushed pulp was settled in a series of large hoppers with V-shaped bottoms, fitted with discharge doors for drawing off the settled sand and slime.

Although crushing wet gave a higher stamp duty than the dry method, the experiment was soon abandoned, mainly owing to the lower extraction obtained; the reason of this being that the ore was not crushed so fine as by the dry method, although the same screen was used. Also, the cost for screens and labour was higher than with dry crushing.

A further 30 stamps were added and running by May, 1895. About this time a trial was made with an Otis ball mill, but results were most unsatisfactory. The flinty portion of the ore simply cut to pieces the hardest balls obtainable, the result being that wear and tear was excessive and the output of the machine very low.

Krom rolls were experimented with, but proved a failure. Two methods of using the rolls were tried-by crushing direct from the rock-breakers and also in conjunction with the stamps, a coarse screen being used on the latter, and the coarse sand, separated by a Mumford and Moody separator, sent to the rolls. Neither method was successful, as was too coarse to permit of a satisfactory bullion extraction.

Experience with Waihi ore has always shown that, to ensure a good extraction, the ore must be crushed exceedingly fine, and, until the advent of tube-mills, stamps crushing through a fine screen proved the only suitable pulverizers for this ore.

By February, 1898, 100 dry-crushing stamps were running at the Victoria mill, 50 more to crush wet were added by September, 1900, and by the end of January, 1901. An additional 50 were crushing wet, thus making 100 stamps crushing wet and 100 dry at the Victoria mill. The Union mill of 40 stamps started crushing for the Waihi Co. in September, 1902, bringing the total number of stamps to 330.

So long as the ore was free from base sulphides, dry crushing-first through 60 mesh screens for pan amalgamation, and later through 40 mesh for cyaniding-was very satisfactory. Compared with later practice, the stamp duty-about 1.4 tons with 60 mesh-was low; but it must be remembered that very fine crushing was an absolute necessity, and that the ore contained a large proportion of hard, flinty quartz.

Before the Waihi Co. bought the present mine , a large quantity of ore was taken from near the surface and treated by wet stamping and plate amalgamation. No exact records are obtainable of the quantity or value of ore treated at that time, but it is known that the extraction was only about 25%.

By the dry-crushing and hot pan-amalgamation process adopted by the Waihi Co., the recovery was 60 to 66% of the gold and 35 to 40% of the silver. No grinding was done in the pans. This result could have been improved to 75% of the gold and 50% of the silver by very fine grinding, but the increased extraction would not have balanced the extra cost.

About July, 1892 , the Refractory Ores Reduction Co. erected a plant to cyanide 10 tons per day, but it was an utter failure. The method was as follows:- The dry crushed ore was charged into a vertical iron cylinder, 10 ft. long and 4ft. 6in. diameter, supported on trunnions so as to be reversible. Each end of the cylinder had a removable cover, held in place by bolts. Inside these covers was fixed a filter cloth, backed by a strong wooden grating. After filling the cylinder with ore, the cover was tightly bolted in place and cyanide solution forced through a 2 inch pipe in the bottom cover into the cylinder and out through a 2 inch pipe in the top cover. When the upper cloth became choked, the cylinder was reversed, and so the solution would be pumped alternately in and out of each end. It was found that the solution channelled up the sides of the cylinder instead of passing through the body of the ore, and for this and other minor reasons the plant was shut down.

The McArthur-Forrest cyanide process was introduced in August, 1893, and was an immediate success; the average extraction for a number of years being 88 to 92% gold and 50% silver. By May, 1894, the cyanide plant at the Waihi mill was completed, and pan-amalgamation stopped.

The dry-crushed ore was conveyed by screw and pipe conveyor to storage hoppers, and was trucked from the hoppers to the treatment vats. At the Victoria mill the crushed ore was conveyed direct to the vats by a system of pipe conveyors. At the Waihi mill the leaching vats were 22.5 ft. diameter and 3.5 ft. deep, constructed of wood, and holding 30 tons each; and at the Victoria mill they were 40 ft. by 50ft. deep, and 4 ft deep, holding 150 tons, and constructed of concrete.

The most suitable depth of ore was 2ft. to 2.5ft., and the solution was run in below the filter cloth until it showed on top of the charge; the remainder of the solution was then run on top. About 1 ton of solution (.35% to .5% KCy) to 3 of ore was used, and was allowed to remain in contact with the ore for 5 to 6 days, being then drawn off by a vacuum pump. Washes of weak sump solution and water were drawn through, and the residue discharged by sluicing through side discharge doors. A grading analysis of the ore from 40 mesh screens was as follows:-

	%
+ 60 ..	4.52
- 60 + 80 ..	9.60
- 80 + 100	20.10
-100 +120	8.90
-120 +150	17.50
-150	39.38

This treatment was very satisfactory for such time as the ore was practically free from base sulphides; but as soon as these appeared trouble was experienced, owing to the formation of soluble sulphates while the ore was in the drying kilns.

At this time a great deal of experimental work was done on the sulphide ore.

Dry crushing, roasting dead, and cyaniding gave an average extraction over a number of 30 ton tests of 88 to 91% of the gold and 20 to 30% of the silver. A 3% salt roast showed about the same extraction of the gold, but the silver extraction increased to 72%. The fuel used was wood , and the consumption was half a ton (by stack measurement) per ton of ore. The cyanide consumption was 2.7 to 3.5lb. per ton of ore.

Crushing in cyanide solution was tried, with promising results, but was not considered a suitable method where there was a probability of the nature of the ore changing at any time. It was also considered that the liability to loss of bullion, through leaks or theft, with large quantities of rich solution in circulation, was great.

The most promising results were obtained by wet crushing, plate amalgamation, concentration, and cyanide. In the first experiments the sand and slime were treated together in an agitator, the solution being separated by decantation; but later experience showed that it was more profitable to treat sand and slime separately.

By September, 1900, 50 stamps were crushing wet at Victoria mill through 40 mesh screens. The ore crushed by these stamps was only lightly mineralized, and the pulp was not passed over amalgamation tables or concentrators, but was separated into sand and slime, the sand being collected in large steel tanks, in which it was given a preliminary wash with weak solution, then transferred to the large concrete tanks (40ft. by 50ft. by 4ft.) for final treatment. The slime was collected and thickened in

14ft. deep steel tanks, and from these was drawn into agitators and cyanided for 24 to 30 hours and then filter-pressed.

Towards the end of 1900 considerable experimental work was done with vacuum filtration of slimes at the Victoria mill.

The machine first used was a revolving cast-iron cylinder, 6ft. in diameter and 5ft. long. The periphery was formed of perforated iron plates covered with strong carpet or matting and an outer cover of canvas. Vacuum applied through the trunnion caused a layer of slime to adhere to the canvas as it dipped into a trough of slime. Wash water or weak solution was sprayed on to the slime to displace the gold solution, and the treated slime cake was taken off with scrapers just before again entering the slime trough. This machine worked well, and the capacity was large when the filter cloth was new, but fell off rapidly as the slime worked into and choked the cloth.

Soon after this the Eureka slimes machine (an Australian invention) was tried, but proved unsatisfactory. Filter-pressing results were so satisfactory that vacuum filtration experiments were for the time abandoned.

In January, 1901, a further 50 stamps were crushing wet, and in August, 1902, the 200 stamps comprising the Victoria mill were wet-crushing. Early in this year (1901) 20 stamps at the Victoria mill were set apart for dealing with the more heavily mineralized ore, the pulp being passed over amalgamated plates and six Union vanners, and then joining the pulp from the stamps on lightly mineralized ore.

By the end of 1901, 30 stamps and 8 Union vanners were running on sulphide ore. The concentrates produced were shipped to smelters in England and Australia.

During the latter part of 1902 the alteration of the Waihi 90-stamp mill from dry to wet-crushing was proceeded with without hindrance to the running of the mill, and in January, 1903, the alterations were completed without the loss of any milling time. The amalgamation and concentration sections were not completed until the end of May, and only lightly mineralized ore was crushed for the first few months.

In April, 1904, the question of vacuum filtration was again taken up, and a small experimental filter, to treat about ½-cwt. Charges, was constructed at the Waihi mill. Results were so good that a plant to handle 1 ton at a time was erected. This proving satisfactory on a working-scale, the method was adopted to replace 2 filter-presses used for dewatering slime at Waihi mill, and a plant was installed to assist the filter-presses in handling the large increase of slime due to increased output following the introduction of tube mills in May, 1905.

By May, 1907, the vacuum plant was extended to entirely replace the filter-pressing at the Waihi mill. The process is similar to the Moore, which was installed, but did not prove very successful, at the Mercur mine, Utah, U. S. A., in 1903; but the filter frame invented at Waihi was much superior to that first used in the Moore process. A detailed description of the process will be given under the heading "Cyanidation of Slime."

During 1907 it was decided to erect a vacuum plant to deal with all the slime at the Victoria mill, and a section of this plant was completed and at work by the end of the year.

One of the biggest advances in the milling of Waihi ores was the introduction of tube mills . One was erected at Victoria mill in 1903, and three were installed at the Waihi mill by May, 1905, and results were so successful that another two were soon erected at the Victoria mill, and arrangements made to put in six more. By the end of 1907, 8 were working at Victoria mill and 4 at Waihi mill, and to-day there are 5 at Waihi 90-stamp mill, 11 at Victoria 200-stamp mill, and 1 at Union 40-stamp mill.

Owing to the fact that the Waihi Co. operates three separate mills, the methods in all three being, in the main alike, it is not considered advisable in this paper to minutely describe each mill. To do so

would result in a great deal of repetition; therefore, the mills will be treated as a whole, and only the most representative practice will be described under the various divisions.

The Waihi mill consists of 90 stamps and 5 tube mills (4 running and 1 stand-by), and the daily output is 420 tons.

The Victoria mill consists of 200 stamps and 11 tube mills (10 running and 1 stand-by), and the daily output is 970 tons.

The Union mill, consists of 40 stamps and 1 tube mill, and the daily output is 110 tons.

The ore is weighed before passing the rock crushers, and samples taken daily for moisture estimation as the broken ore passes to the ore bins. The moisture varies from 4% to 6%.

Sampling.- The mill head sample is taken after stamping and tube-milling. Plate tail and vanner tail samples are taken, also sand and slime head and tail. Daily assays are made on all these samples. All sampling is done by hand, and check samples are put on from time to time.

Rock-breaking.- Gates and Heclon breakers are in use. The ore first passes a grizzly, spaced 1½inch coarse, to a No. 5 Gates or "S" Heclon, delivering to a second grizzly, the oversize falling into a No. 3 Gates. The ore is reduced to a 2-in. ring size. A continuous oil feed is supplied to the inner and outer sleeves of the breaker, and the oil is pumped through a small filter-press before returning to the breakers. By means of an exhaust fan all dust is drawn from the breakers and passes to a settling chamber.

From the breakers the ore is elevated by either a belt or a chain bucket elevator, and distributed to the bins by belt conveyors or by trucking.

Stamping:- The running weight of the stamps varies from 900 to 1250 lb.; blows per minute, 102 to 105; drop, 7 to 8 in. The screen mostly used is 10 mesh (aperture, 1.78 mm.), resulting in a daily stamp duty of about 5.6 tons, which grades as follows:-

	%
+ 20 ..	16.67
-20 + 40 ..	12.50
- 40 + 60 ..	9.76
-60 + 80 ..	8.47
-80 + 100 ..	4.03
-100 + 120 ..	3.30
-120 + 200 ..	6.70
-200 ..	38.57

(Note.- I.M.M. standard screens to No. 120; aperture of 200 mesh = .072 mm.).

The average life of a screen is 7 days.

From 7 to 9 tons of water are used per ton of ore, and this is returned to the stamps after being cleared of sand and slime. The water is kept alkaline by the lime which is added to accelerate slime settlement.

The mortar boxes are 4ft. 3in. long, 3ft. 9 in. deep, and 10½ in. wide on bottom (inside measurements), and height of discharge varies from 2 to 5 in.

The screen frame is made of cast iron, and is constructed so as to divide the screen into three separate pieces, each 15 by 17 in. This frame is found very economical, resulting in a reduced screen

consumption and saving of time in changing screens. When a section of the screen bursts it can be removed and a new piece put in position in 2 or 3 minutes without removing the frame.

Locally cast steel dies and imported steel shoes give best results. The local dies show an economy of 50% over imported. No liners are used in the boxes. The ore feeders are of the revolving plate type. The pulp from the stamps is conveyed in wooden launders with a fall of at least 7%. These launders (and all others conveying coarsely crushed ore) wear out rather rapidly, and it would be preferable to use concrete launders. If the wear is found excessive at any particular place, a lining of old rubber belt is found useful.

All leakage from launders, elevator wheels, &c., finds its way to a large collecting sump, which is emptied from time to time. This sump is large enough to contain all pulp in circulation, much of which might otherwise be lost in the event of a sudden stoppage of the mill.

With the combination of stamps and tube mills it is found more economical to obtain the required tonnage from each mill by crushing with a reduced number of stamps through the coarsest screen that will keep the tube mills working to the best advantage. At present it is found that 20 stamps on 10 mesh screen (aperture, 1.78 mm.) can keep one tube mill fully supplied.

Recent experiments indicate that it may be possible to stamp somewhat coarser and still obtain a final product from the tube mills sufficiently fine for satisfactory bullion extraction, but it is usually safer not to run any risk of overloading the tube mill plant.

The stamp product is elevated by wheel elevators to sizing boxes. These are 4ft. by 4ft. by 4ft. deep, and two are necessary to deal with the output from each 20 stamps. They are placed one behind the other, so that any coarse sand escaping over No. 1 has an opportunity of settling in No. 2. No. 1 discharges through a 1 3/8 inch nozzle, and No. 2 through a 1 in. The cutting effect of the coarse sand from these nozzles is very great, and a useful method of overcoming this is by arranging that the discharge is caught in a box lined with bricks. All sand from the sizing boxes enters a distributing pan designed to supply equal feed to whatever number of tube mills is running.

Tube Milling.- Tube mills have proved by far the most efficient and economical grinding machines for Waihi ore. Those in use at the Waihi mills are 18 ft. long, 4 ft. 9 in. in diameter (inside shell measurement). Various methods of lining the mills have been tried, and the most satisfactory is a cast iron ribbed liner. The ribs are 4 in. wide, spaced 15 in. centres, and, when new, standing 3¼ in. above the body of the liner. When the lifting side of the rib becomes much rounded the liner is reversed. The body of the liner is 1½ in. thick. These liners promise a life of at least 18 months, and represent a cost of .52d. per ton of stamp output. They are bolted to the mill, and can be taken out and a new set put in by two men in 16 hours. The pulp discharges through the trunnion. This is covered inside the mill by a cast-iron grating. The mills run at 25 to 26 revolutions, and require about 55 h. p. when loaded with flints to about 2 in. above centre of the trunnion. This height of flints gives the best grinding, and represents a flint load of about 5.5 tons. Flints are put into each mill daily in order to keep the load (and therefore the grinding) as even as possible. The consumption of flints is 2.6 lb. per ton of stamp output, representing a cost of .86d. per ton.

The pulp from the distributing pan is thickened in a V box at the head of each mill. This box is 3 ft. by 3 ft. by 3 ft. 4 in. deep, and discharges through a 13/8 in. pipe into a 4 in. cast-iron bend, the outlet end of which passes into the trunnion. Flints are fed through this bend while the mill is running, thus avoiding any loss of running time.

The proportion of water to ore in the mill is kept about 1 to 1. About 110 to 120 tons of stamp output (10 mesh) per day is at present the maximum work of a mill. The total amount of sand passing through a mill in 24 hours is 280 to 340 tons, owing to the large amount returned from the sizing boxes. The discharge from the mills joins the pulp from the stamps on its way to the sizing boxes.

The overflow from the sizing boxes passes to a V-shaped distributing tank and thence to the plates. It grades as follows:-

	%
+ 60 ..	0.2
-60 + 80 ..	1.79
- 80 +100	2.62
-100 + 120	7.58
-120 + 200..	8.63
-200 ..	79.36

(Note.- I. M. M. standard screens to No. 120; aperture of 200 mesh = .072 mm.)

The average cost of tube-mill grinding, including labour, power, lighting, stores, and sundry, is 8.83d. per ton of battery output.

Amalgamation.- The plates are contained in a building which is reserved solely for amalgamation work, and to which only the amalgamators have access, unless by special permit. The plates are 12 ft. by 6 ft. muntz-metal sheets, set at a fall of 1½ in 12. They are kept fairly "hard," and about once a month are steamed and scaled, the upper 2 ft. or 3 ft. having quite 1/16 in. scale of hard amalgam. All of which is readily removed by a steel scraper after 20 minutes' steaming.

Muntz-metal is preferred to copper, because the amalgam scale does not adhere so firmly, and after the plate has been scaled it quickly works into good condition again. Very perfect amalgamation is not aimed at, as any fine free gold escaping the plates is easily accounted for by the cyanide plant. The average recovery by amalgamation is – gold, 29%; silver, 5%.

The pulp is distributed to the plates from a V-shaped tank fitted with as many 2-in. discharge pipes as there are plates; each plate can deal with about 30 tons of ore per day. The plates are rubbed up twice each shift, and the amalgam removed every 8 hours. When the pulp-flow is cut off from a plate it is run into a return launder back to the main elevator wheels, and so distributed evenly over all the other plates. A Berdan pan is used for cleaning the amalgam and grinding the product from the traps. A centrifugal machine is used to separate the excess mercury; it works well, and leaves the amalgam in a powdery condition. The total cost of operating the amalgamating plant is slightly over 1d. per ton of ore.

It is sometimes said that it would be more profitable to cut out amalgamation and rely on the cyanide plant to save the gold. No doubt the cyanide plant would do so; but with the necessary amalgamation plant in existence, and operating at such a low cost, it is considered better to continue amalgamation and avoid the accumulation of very rich concentrate in all wheel pits and launders.

Concentration and Cyanidation of Concentrate. Union vanners and Wilfley tables are both used. The former give a lower tail value (especially in the silver), but the latter have a much greater capacity, and, as close concentration is not required, they are preferable, being cheaper in first cost and more economical to run.

Concentration after tube mill grinding is not usually considered good practice; but with the Waihi ore it is found that, provided the coarser portion of the sulphides is separated by the vanners, it does not matter if the very fine sulphides escape to the cyanide plant.

The average percentage of concentrates produced is 1.5, and an analysis shows as follows:-

	%

Sulphur	35.00
Iron	32.43
Copper	.05
Arsenic	.10
Lead	.32
Zinc	2.05
Manganese	1.02
Lime	.85
Magnesia	trace
Silica	27.65
Loss, &c.	.55
Total	100.00

The concentrate from each mill is sent to the concentrate treatment plant daily. It is shovelled from the collecting boxes into tubs holding about 600 lb. weight (wet), and kept under water until delivered at the treatment plant.

The tubs are made from two oil barrels strengthened with iron bands, which terminate in two lugs for convenience in handling. One vanner-man per shift attends to 30 Union vanners or Wilfley tables, and there is also a foreman on the day shift who attends to most of the repair work.

The average recovery by concentration is – gold, 22%; silver, 28%.

The concentrate from the three mills is treated together, and a rough valuation of the output from each mill is obtained by bore sampling each tub. This valuation is required in order to allocate to each mill its proportion of the bullion recovered.

The concentrate treatment plant is situated at Victoria mill. On arrival at the plant the output of each mill is weighed. The monthly total is about 500 tons.

The grinding is accomplished in two tube mills- one 18 ft. by 4 ft. 9 in., and one 19 ft. 6 in. by 4 ft.- and the concentrate is sluiced from tubs into the head boxes of the mills, slaked lime being added into the proportion of 10 lb. per ton. From the mills the pulp is elevated to a V sizing box, 3 ft. 2 in. x 3 ft. 2 in. x 6 ft. deep, the sides being vertical for the first 2 ft. 6 in. The coarse delivers through a 7/8 in. nozzle and returns to the mills, and the fine overflow passes to the thickening boxes, by which the moisture is reduced to .7 water to 1 of dry concentrate. The concentrate is given from 8 to 10 days' air agitation in 23 conical-bottom tanks 16 ft. by 6 ft., which are worked in series. The solution is kept at an average strength of .4% KCy. The sodium salt is used, the average consumption being 16 lb. per ton, which represents .25 lb. per ton of original ore.

The solution is separated by filter-pressing. The number of men required to work the plant is 3 each shift, and the cost, inclusive of labour, repairs and renewals, power, transport, cyanide, zinc, flints, and sundry, is about 25s. per ton. This represents about 5d. per ton of original ore. The bullion is precipitated by the zinc filament method, no trouble being ever experienced in obtaining good precipitation.

Prior to 1904 the concentrate was bagged and shipped to smelters in England and Australia. The charges, all told amounted to about £8 per ton. Local treatment has given uniformly good results, as shown by the following figures:-

Year	Tons	Gold	Silver	Extraction.

Appendices

		Per ton Ounces	Per ton Ounces	Gold %	Silver %
1904	1992	7.65	98.25	95.1	92.0
1905	3719	6.65	96.35	95.5	93.3
1906	4692	5.68	81.00	95.6	94.7
1907	5581	5.40	66.75	95.7	94.3
1908	6061	5.44	66.00	96.3	93.0
1909	6339	5.60	63.30	96.3	93.5

A somewhat higher extraction can be obtained by finer grinding and the use of stronger solution, but the increased recovery would not cover the extra cost.

Cyanidation of Sand:- From the vanners the pulp is elevated to spitzluten for preparation of sand and slime. The sand amounts to about 20% and grades as under (I.M.M. screens):-

	%
+ 60 …	.43
60 + 80 …	15.57
80 + 100 …	11.63
100 + 120 …	11.33
120 …..	61.04

At the Waihi and Union mills the sand runs direct to the treatment vats, which are filled by a revolving distributer. They hold, some 40, and others 80 tons, and are filled with water before charging. Most of the slime that comes along with the sand overflows into an annular launder and returns to the main slime separating cone.

At the Victoria mill intermediate collecting vats are used, and the sand is trucked from these (no preliminary treatment) to the treatment vats, which hold 275 tons. After draining off water, a sump wash (.04% KCy,) is run on, and is followed by the working solution at a strength of .3% KCy, which circulates by means of a small air lift, for from 9 to 12 days. It is then drained off and displaced by weak sump solution and water washes, the total treatment time being about 13 days. The residue is sluiced away through side discharge doors. Assay results of the different grades of sand residue show that the economic limit of grinding has possibly not yet been reached, and that it may be profitable to extend tube mill grinding until all 120-mesh sand – amounting to about 7% of the output- is eliminated.

The consumption of sodium cyanide is 2.20 lb. per ton of sand, and the extraction is- gold 81%; silver, 69%, representing a residue value of 5s. 7d. per ton.

Cyanidation of Slime:- The overflow from the separating cone runs to a nest of V thickening boxes, being mixed on the way with milk of lime in the proportion of 2 to 3 lb. lime per ton of ore, representing a cost of .5d. per ton. The lime is freshly slaked and fed into a grinding pan, the overflow passing to the slime launder. The thickening boxes are 5 ft. x 5 ft. by 5 ft. deep, and each box can deal with about 10 tons (dry weight) of slime per day.

The overflow from the last row of boxes is clear, and returns to the stamps or battery water reservoir. The thickened slim flows from the apex of the box to collecting or settling tanks. These are built of steel, 32 ft. diameter by 14 ft. deep, one being required for each 100 tons of slime per day. By means of overhead gear a stirring arm is rotated slowly for a few minutes every hour; the clear water overflowing passes to the reservoir. The thickened slime is drawn from the settlers at intervals and sent

to the vacuum thickening plant, where the moisture is reduced to about 30%. Two methods of working the vacuum thickening process are in use. In one case the frames are lifted from the loading tank and discharged over a disintegrator, and in the other the frames are stationary, the slim cake being dropped off into the pulp in the loading tank, which has a V bottom, terminating in a goose-neck discharge pipe 24 inches in diameter. When sufficient thick slime has accumulated in the tank a valve is opened, and the slime, under a head of about 14 ft., is forced into a disintegrator. The latter method is somewhat the cheaper to operate. In either case one man per shift can attend to an output of at least 300 tons per day. The filter frames are constructed of light, closely corrugated sheet-iron attached to a wooden head-piece, and are 16 ft. long by 4 ft. 6 inches deep. A ¾-in. pipe-slotted to receive the lower edge of the corrugated sheet-is fitted round the ends and bottom. One end is closed and the other passes through the wooden head-piece, and is coupled to a flexible hose attached to a 3-in. pipe common to all the frames. The frames are covered with canvas, which is caulked to the head-piece. Any frame can be cut out of action by closing a cock on the suction pipe. A sight-glass is fitted to the suction pipe on each frame, by means of which the workman can see if the suction is coming through clear. From 10 to 12 frames are coupled to two "H" iron girders to form a "basket."

The loading or pulp tanks are designed to give easy clearance to the basket, and to prevent fine sand accumulating on the bottom the slime is kept agitated by compressed air during the time the basket is out of the tank. With a vacuum of 20 inches to 24 inches a slime cake 1½ in. to 2 in. thick is formed in about 90 minutes. The basket is lifted from the loading tank and carried to the disintegrator by either hydraulic or electric power, and 80% of the slime cake falls off the filters as soon as the vacuum is broken, the remainder being easily detached by hand.

Cyanide solution is run into the disintegrator in such proportion that the mixture contains 1 of dry slime to 1.3 or 1.5 of solution showing .12% KCy. The pulp is agitated for 5 days, and the most economical agitators in use are tall conical-bottom tanks with air agitation. The most recent are constructed of ferro-concrete, . 55 feet high and 13 feet inside diameter. The cost of these is about £240, and is less than for similar-sized steel tanks. No centre pipe is used, slightly better results having been obtained without it. The air is introduced through a small pipe at the bottom of the cone. About 7 h.p. per tank is absorbed in agitating and circulating the pulp from one tank to another. The extraction of the gold is practically complete in 24 to 30 hours, but a profitable amount of silver is extracted up to 5 days. The consumption of sodium cyanide is 1.66 lb. per ton of slime.

From the agitators the slime flows to the vacuum washing plant, in which the filters are similar to those previously described. The loading time is 45 to 60 minutes, and with a vacuum of 20 to 24 inches a 1½ inch cake is formed. The basket is then transferred to the wash tank, and displacement of dissolved values is usually complete in the same time as was occupied in forming the cake. The residue assays- gold, 13 to 14 gr.; silver, 12 to 14 dwt., representing an extraction of – gold, 89%; silver, 71%. In the washing plant each filter frame can deal with 6 tons (dry weight) in 24 hours; this represents about 83 dry lb. per square foot of filtering area. The total time occupied in forming a cake, transferring to wash tank, washing, transferring to discharge hopper, discharging and returning to pulp tank, is about 2½ hours. When the vacuum is broken the slime falls from the cloths quite readily unless the cloths are very old. An ordinary life for a cloth is 6 to 9 months on the washing plant; they then go to the thickening plant for a further period of 3 to 6 months. Every 3 or 4 months it is necessary to wash the cloths in a weak solution of hydrochloric acid to remove the lime deposit, which gradually chokes the canvas. A double-ended vacuum pump is used, one end operating each basket of frames. The solution and washes pass through the pump to a clarifying and then to a storage tank, for delivery to the precipitators.

The power required for a plant to handle 800 tons a day is as follows:-

5 vacuum pumps at 11 h.p. ….. 55 h.p.

1 air compressor …. 40 h.p.

3 cranes (electric) at 5 h.p. .. 15 h.p.

2 solution pumps at 3 h.p. … 6 h.p.

The total cost of vacuum washing filtration with an 800 tons a day plant is:-

Labour ….. 2.43d. per ton

Power ….. 1.16d. " "

Stores (including lighting, filter cloth, oil,

waste, belting, packing, hose, caulking rope,

and sundry) .67d. per ton

Total …….. 4.26d. per ton.

Labour is paid at from 8s. to 10s. per shift of 8 hours. Power (gas) is calculated at £10 per b.h.p. per annum. About 80% of the ore is treated as slime.

Precipitation and Melting:- The zinc filament method is used, and the precipitation boxes have 8 compartments, each 17 inches x 17 inches x 26 inches.

The precipitation room is floored with concrete and surrounded with a concrete wall 18 inches high, so that, in the event of a fire, the gold slime would not escape beyond the room. A clean-up is made each week at each mill, and all new zinc is dipped into lead acetate solution. No difficulty is ever experienced in obtaining good precipitate, provided the solution entering the boxes is kept free from ore slime.

The bullion slime from each mill is brought to one melt-house. This is situated at the Waihi mill, and the melt-house staff carry out the clean-up at each mill. The coarsest of the zinc slime is treated with sulphuric acid.

Surplus moisture is taken out on a vacuum vat, and the wet slime is mixed with 20% to 25% of borax glass and 10% soda ash. A small set of rolls is used to mix the flux and slime, which is then transferred to light iron trays holding about 100 lb., and these are put into a drying oven. The slime cakes dry firmly and is roughly broken to a convenient size for melting, which is done in No. 200 plumbago crucibles (gas fired) or on a cupellation test. For the last 18 months all melting has been done on the cupellation tests with coal fuel, but at present experiments are being made with pot melting by gas fuel, which promises considerable economy. Great difficulty was found in making tests that would stand, first, the corrosive action of the slag during melting, and next, the action of the litharge during cupellation. A concrete shell with mabor filling gave the best results. The gas for pot melting is conveyed from the mine producer-gas plant in a 3 inch pipe, and the cost at the melt-house is about 2d. per burner-hour (1000 cub ft.) Two burners are necessary for each No. 200 crucible, and the slime can be melted at the rate of 40 lb. per hour. The slag is ladled from time to time, and the bullion is finally poured into 1000 oz. bars, which run about 940 fine in bullion. These bars are cupelled down to about 1% base- mostly copper- and cast into slabs 8 in. x 10 in. x ½in., which are weighed, sampled, and sent to the refinery department. About 13,000 lb. of bullion slime is handled each month, producing about 125,000 oz., the average value being about 12s. per ounce. The bars from the amalgam are refined with the cyanide bullion. The output of each mill and the concentrate treatment plant is kept separate until sent to the refinery. All slags, litharge, and dross are run down in a 20 inch round water-jacketed blast furnace, the lead bars being used for cupelling the next month's bullion, and the slag is crushed and passed over a Union vanner for recovery of metallics. The final tail usually assays from 15s. to 30s. per ton.

The gasses from the cupels and blast furnace pass through long settling flues, and finally to condensing chambers, before escaping.

The total cost of clean-up of precipitators, melting, and cupelling, is .8454d. per ounce of bullion. This represents about 3d. per ton of ore.

Doré Refining:¬- For several years the sulphuric acid process was in use but was discarded two years ago in favour of the present electrolytic method. The slabs as received from the melting department weigh about 200 ounces, and run approximately – gold, 12%; silver, 87%. The stationary cathode type of cell is used, and the output of the 30 cells in use is 5,000 to 6,000 ounces in two shifts (16 hours). The current is supplied by a 17.5 kw. generator. Each cell requires 90 amp. at 3 to 4 volts. The gold sludge from the cells is boiled for from 2 to 3 hours in a cast-iron kettle with strong sulphuric acid, and when washed and melted runs 996 to 999 fine. The silver crystals are simply washed free of acid and melted without drying in No. 200 plumbago crucibles; the bars run 997 to 998 fine. Both the gold and silver are melted in oil-fired furnaces.

Waihi bullion contains up to .5% selenium, and special precautions have to be taken to free the gold from selenium, also to remove every trace of lead from the refined gold. Less than 1 part of lead in 10,000 of gold will render the gold too brittle for coinage. The brittleness only becomes noticeable after alloying with copper. The cost of refining is about .36d. per ounce of doré.

Summary.

At present the ore averages- gold 9 dwt., silver, 3½ ounces per ton, and the average residue assay is – gold 20gr., silver 17.5 dwt. per ton, representing a recovery of –gold 91.2%, silver 75%.

This extraction can be improved slightly, chiefly in the direction of finer grinding, but it is necessary to proceed very carefully as it is an easy matter to overstep the economic limit of grinding and so obtain extraction at a sacrifice of cost. The main desideratum in the successful treatment of Waihi ore is fine grinding.

The total milling and treatment cost (average of last 6 months) is as follows:-

	s. (shillings)	d. (pence)	
Breaking, elevating and distributing to binns	0.	5.340	per ton
Stamping.	0	10.660	" "
Tube Milling	0	4.620	" "
Extraction	2	8.000	" "
Concentrates treatment	0	4.974	" "
Power.	0	11.380	" "
8.974 per ton			
Assaying, clean up and melting and cupelling	0	4.916	" "
General: including concentrates and slag marketing			
and proportion of salaries, postages, cables, &c.	0	2.250	" "
total	6	4.140	per ton

The average consumption of sodium cyanide is 1.913 lb. per ton, and represents a cost of 1s. 5.87d. per ton.

The average consumption of zinc is .513 lb. per ton, and represents a cost of 1.632d. per ton.

Power to operate the mils is supplied by water, steam, and producer gas. Steam power costs about £18 to £20, and gas power about £10 per b.h.p. per annum. A grand total of about 2800 b.h.p. is absorbed by the three mills and treatment plants, not including the large amount used at the mine for pumping, air compressing, and winding, the demands for which are increasing very rapidly with depth.

A hydro-electric power scheme to deliver 6,000 b.h.p. is now being installed. The generating station is situated 51 miles from Waihi, and when completed the mills will be operated entirely by water and electric power. All repairs and renewals and foundry work required for the company's operations are turned out in the Waihi and Victoria mill workshops.

Discussion.

Dr. Bell said he had one question to ask Mr. Banks. He would like to know if in the treatment of the ore he had noticed any increase or decrease in the amount of selenium present in the oxidised and in the sulphide ore and also whether it was present in any particular kind of vein-stone ? Near the surface in Waihi the prevailing gangue was a quartzose one, whereas in depth the gangue contains much manganiferous calcite or the quartzose replacement of that mineral.

Mr. H. W. Gepp said tube mills had been running at Broken Hill for some years, but in order to avoid sliming the mill had been shortened considerably until the standard size was now 10 feet long by 5 feet diameter. Most of the Broken Hill mills were running on rollers, whereas at Waihi they were on trunnions.

Now that he had seen both types in operation, he was strongly of the opinion that the trunnion mill was a very much better mill than the mill on rollers. He noticed particularly the large heavy tailings wheels which were in use in this field. In Broken Hill nothing was used for this purpose except bucket elevators, and he was inclined to think that they were better than the wheels, as the cost of the upkeep and power was smaller, and the cost of construction was much lower than for the tailings wheels. He proposed to send the cost of construction, upkeep, and capacity of standard wet elevators at Broken Hill to the Managers at Waihi, and probably to those in other fields as well, and he felt sure they would reciprocate, and that they would thus finally get exact information as to what was really the cheapest and most efficient means of elevating the large quantity of material handled in the mills. An idea he had noticed at Waihi was the lining of wooden launders with old belting in order to take the scour of the sand, it was a very good one, and worthy of adoption in other places, especially where the only timber available was oregon which was very soft. Some mines in Broken Hill lately adopted steel launders which require no further description than can be gathered from the accompanying drawings (Figs. 1, 2, 3 and 4) These drawings are supplied by Mr. T. H. Palmer, General Manager of the Broken Hill Junction North Silver Mining Co., No Liability. Mr. Palmer was the first one to use this particular type in Broken Hill as far as he (the speaker) knew.

Mr Sidney Fry said that Mr. Banks stated "Concentration after tube-mill grinding was not usually considered good practice; but with the Waihi ore it was found that, provided the coarse portion of the sulphides is separated by the vanners, it did not matter if the very fine sulphides escaped to the cyanide plant." Also, "The extraction of gold was practically complete in twenty-four to thirty hours, but a profitable amount of silver is extracted up to five days." He (Mr. Fry) would like to ask the following question.- "Was the aforesaid profitable amount of silver contained in the siliceous particles of the slime or was it to a large extent, or altogether, contained in the galena which formed part of the fine sulphides referred to ?" If the latter were the case there seemed to be an opportunity for a greater saving. In such a case the modification that he would suggest would be to agitate the slime for the twenty-four or thirty hours necessary to extract the gold values, and then, after the filtration and washing was complete, sluice the slime residues over fixed cement tables and thus save the argentiferous concentrate. Cement tables were probably the best slime concentrators known, and that

treatment would only cost about 2d. per ton. Seeing that the consumption of cyanide at the mills was 1.913 lb. per ton at the Waihi Co's works and that the extra amount of NaCN was probably altogether due to the extra time of treatment, viz.: - 5 days, as compared with less than 1 day at the Grand Junction, the saving of 8.5d. in cyanide at the cost of 2d. per ton of ore would make a net saving of 6½d. per ton, which would represent a saving of £11,288 per annum, reckoned on the output for 1909, viz.:- 416,813 tons.

Mr. Banks in reply said, with reference to Dr. Bell's question he would state that they had found an increase in recent years in the amount of selenium in the bullion, evidently due to sulphide ore. From year to year they had been treating a larger proportion of sulphide ore. With regard to the question as to how they got rid of the last trace of lead; at present they used chlorine, giving twenty minutes to one hour's treatment. The lead was in very minute traces. They were prepared to say it was certainly not one in 10,000 and he was personally inclined to think it was more likely one in 20,000. The gold as it was sent out could be perfectly tough against any test, but when it was alloyed with copper for coinage at the mint the result was a brittle mass if traces of lead or selenium were present. They were not absolutely certain yet that lead was the chief culprit. They tested all their gold after melting. If it showed brittleness when tested they treated it with chlorine gas, therefore they did not like using it to any great extent, but in order to get rid of the last traces of brittleness it seemed the only satisfactory method at present. Brittleness can be overcome by treating the molten gold with copper oxide, but this method of course reduces the fineness of the gold. He was not quite clear about Mr. Fry's questions. He understood Mr. Fry to ask "Why do we cyanide slimes for five days if the silver can be got out by concentration ?" They had done a great deal of experimental work with a view to cutting down time of treatment. They had tried well known methods and a few perhaps not well known. Most of the silver in the slime was in the form of very finely divided sulphide; close concentration on canvas and concrete tables had been tried but neither that nor any other method of concentration left the silver value of the slime low enough to obviate cyanide treatment. Even if a satisfactory result could be obtained by concentration, there would still be the treatment of the concentrate to be considered, the cost of which, added to the cost of concentration, would certainly be higher than that of three or four days agitation. The higher consumption of cyanide at the Waihi Co's mills as compared with that of the Grand Junction Co's. was largely due to the fact that the Waihi Co. was treating a good deal of partly oxidised ore; also, the higher silver content of the Waihi Co's. ore necessitated the use of stronger solution and longer time of agitation.

McAra. Gold Mining at Waihi. 1878-1952

Extract from **Gold Mining at Waihi**, 1878-1952, JB McAra. Pages 212 to 224 and 226 to 235.

ORE TREATMENT & GOLD RECOVERY AT WAIKINO

THE evolution of the ore-treatment methods, including the cyanide process, used at Waihi and Waikino for the recovery of gold and silver has already been described. This chapter is concerned with the *general method eventually established and operated over the greater part of the life of the mine*…

The gold and silver extraction-process started at Waikino with the tipping of the trucks of ore into the primary crushers and ended at the refinery at Waihi with the checking and numbering of the bars of gold and silver before shipment to the bank at Auckland.

These were the main operations: ore crushing, stamp hopper ore-distribution, stamper pulverising, water transportation of crushed ore, pulp elevation, automatic sampling, primary sizing, tube-mill feed distribution, tube-milling, tube-mill product sizing, concentration, sand and slime separation, concentrate treatment, sand treatment, slime settlement, slime thickening, slime cyanidation, precipitation, smelting and refining (at Waihi).

Ore Crushing. On arrival at Waikino, the rake was shunted into position on the tipping line and the loco picked up the empty waiting rake and returned to the mine. The tippers, two of whom worked together, drew the first trucks along with their winch until they were vertically above the grizzlies leading to the four primary gyratory crushers. To tip a truck the two men each seized an end and, after lifting the tipping latch, with a skilful rocking motion they overturned the heavy truck body; a third man attended to the removal of sticky material using a chisel-pointed pick or bar. The gyratory crusher could be choke-fed so there was little delay on that score. When one rake was disposed of there was usually another waiting and the work went on.

The fine material passed through the grizzly bars directly on to the conveyor-belt to the secondary crushers, while the remainder of the ore went into the gyratory crushers; boulders too large for the crushers had to be spalled, and some difficulty was experienced in maintaining the supply of ore from the mine at minus-twelve-inch ring size. The ore was reduced to approximately five-inch ring in the primary crushers and then passed on a rubber conveyor-belt to the secondary crushers, which reduced it to two-and-a-half-inch ring for the stamper-mill feed. I believe some of these crushers were made by Hadfield & Jack, some were Heclon crushers and others were Gates; some of these last had corrugated bell liners.

Stamp Hopper Ore-Distribution. From the secondary crushers the ore was conveyed by specially-designed rubber-belt distributing conveyors to the numerous stamp hoppers, which were situated immediately above the stamp mortar-boxes and held something like a thousand tons of ore, sufficient to keep the battery going for twenty-four hours. The distributing-conveyors worked by traversing on rails along the top of the hoppers and discharging at any desired point; they were operated by electric-motors so very little effort was required to keep the hoppers evenly filled. The system worked admirably for many years.

The ore was fed from the stamp hoppers into the stamp mortar-boxes at a predetermined rate, by Challenge ore-feeders adjusted to give the required feed (generally five or six tons a day). These feeders, almost universally used with stamp mills, were simple and efficient. They consisted of a circular, inclined, iron plate, about an inch thick, mounted in the feed-chute and revolved in short jerks by a ratchet attached to a rod, which was actuated by being struck by a stamp tappet once in each revolution of the camshaft. The gyratory crusher, which later proved such a boon in its more highly-developed form of the cone crusher, gave wonderful service at Waikino, although breakages of both the drive-shaft and the crusher-shaft were frequent and demanded rush repairs to keep the plant operating at capacity. Sometimes the repair gangs worked a full twenty-four hours at a time to get the job done.

In these crushers the vertical shaft which carried the crushing bell was suspended from the top supports, and its bottom end was swung in a circle; this end was eccentrically mounted in a horizontal bevelled pinion, thus continuously squeezing and releasing the rock as it passed between the bell and the crusher liners. This imparted a shearing force to the fragments of rock, breaking them with a minimum consumption of power, and with virtually no vibration being imparted to the machine foundations.

Stamper Pulverising. The stamps were of the conventional gravity type and were gradually adapted over the years until they fitted the special requirements of the Waihi ore. The process was in a state of evolution until about 1908 or later, when the installation of the tube-mills was completed, but eventually the Waihi Company settled for stamps of 1250 pounds, crushing wet through ten-mesh screens. The stamper-blocks on which the three-ton mortar-boxes stood were of eighteen-foot-long kauri, of thirty-by-sixty-inch size, or sometimes of two thirty-by-thirty-inch pieces bolted together. They were usually embedded in the ground for about twelve feet. Most of them came from the Company's own bush at Waitawheta. The Company's quarry, on the Waihi tramway a mile or so from the battery, supplied masonry blocks for the walls of the foundations, and masonry was also used for the dam at the head of the low-pressure Ohinemuri water-race.

The mortar-boxes were eventually cast at the Company's Waikino foundry, and as was usual carried five head in each — that is there were two mortar-boxes each four feet three inches long to each set of ten head of stamps, which were contained in their own frame and represented a more-or-less complete crushing unit. In all there were two hundred head installed at Waikino and all these, together with ninety at the Waihi battery and forty at the Union battery, Waihi, were operated until 1910, after which only about a hundred and fifty of the Waikino stamps were in continuous operation. The output stabilised at eight hundred tons a day and remained at this figure for about forty years. (E. G. Banks in his paper, No. 221, to the Australian Institute of Mining Engineers in 1912, when he occupied the position of metallurgist for the Company, gives an admirable description of the process at that time. He later became the Company's New Zealand representative and was eventually head of the Australian Mining Trust.)

As time went on more and more of the replacements were made locally and stamper shoes and dies, of a special hard-wearing type of cast-iron, were made at Waikino. Liners were not used in the mortar-boxes. The screens were made up in sections in frames that normally lasted a week and could be changed in a few minutes. The stamps worked at a hundred and two to a hundred and five drops, of seven to eight inches, a minute, and the height of the discharge above the dies was from two to five inches. Seven to nine tons of water to the ton of ore was used in the stamping process and thirty-eight per cent of the ore was reduced to minus-200-mesh to the linear inch in this phase of the reduction process (equivalent to an aperture of .072 mm). The stamp stems, about fourteen feet long, were tapered at both ends and either end could be wedged in the heavy boss, into the bottom of which the shoe, also tapered, was tightened by wooden wedges. The dies, on to which the ore fell and was pounded by the rising and falling 1250-pound stamp in a stream of water, were replaced when there was about an inch of metal remaining on the top. Wear of iron from the stamps was said to be in the vicinity of half a pound per ton of ore crushed. Working the stamps required about five horsepower per head. At Waikino the stamp-mill was driven mainly from a long continuous shafting, which had disengaging clutches at various points to allow use of a variety of alternative drives, such as the two 200-horsepower water-turbines operated from the low-level water-race, and the 500-horsepower Corliss steam-engine. After 1913, when hydro-electric power was available from Hora Hora, the steam- and gas-engines were no longer required and energy costs were substantially reduced.

Water Transportation of Crushed Ore. The minus-ten-mesh pulverised ore and water from the stamps (then called pulp) flowed into a large, common, wooden launder with a minimum gradient of seven per cent, and to the large set of wooden elevator-wheels which raised it to the highest point of the

circuit; from there it gravitated to the ten grinding-mills of the tube-milling section and to other parts of the plant.

Pulp Elevation. The wooden elevator-wheels were like water-wheels working in reverse. They were approximately thirty-five feet in diameter, and were mounted one above the other so that the discharge from the lower one was picked up by the top one and carried to the discharge point near the top, about fifty feet above the ground. The system was made necessary by the extremely abrasive nature of the pulp, which was too severe for the pumps available at the time, and by the need to maintain a reliable flow of pulp. Davey pumps had been tried earlier but had proved a failure. The construction was a triumph of local engineering and carpentry skills, plus unlimited supplies of first-grade kauri timber in long lengths. With occasional repairs the wheels gave reliable service throughout the life of the mine. They were driven by electric-motors through heavy pinion-gearings, and although their power requirement was high, this was of little significance at the low cost of electricity.

Automatic Sampling. After being elevated, before tube-milling, the pulp was sampled by an automatic sampler, a mechanical device actuated by the periodic filling and discharge of a water-bucket, which caused a sampling vessel with a narrow opening to cut across the stream of pulp at roughly fifteen-minute intervals, providing a sample which was collected and assayed daily.

Primary Sizing. Beyond the sampler the pulp flowed into a set of inverted, pyramid-shaped, hydraulic classifiers or "sizing boxes", equipped with overflow launders round the top and underflow nozzles at the bottom so that, as the stream of pulp flowed across the tops of these boxes, the heavier and coarser particles sank swiftly and flowed out through the nozzles underneath to the mill feed distributors. The finer and lighter material remained suspended and overflowed the end sets of the boxes into a launder leading to a large, twelve-foot diameter, counter-current, diaphram classifier, to be more accurately separated into sands and slime and passed on to the appropriate process.

Tube-milling. The great bulk of the plus-200-mesh pulp was directed into the ten grinding-mills via the distributors and mill-head thickening-boxes, and remained in the tube-mill circuit until it was ground fine enough to pass over the top of the fourteen "return boxes", the underflow of which returned to the mills.

In dealing with quartz that is hard enough to cut glass and cannot be scratched with an ordinary file, there was an enormous amount of wear through abrasion and a great deal of thought was given to overcoming this. The large launders were often lined with old conveyor-belts, and the best device for the smaller ones was to line them with concrete made from crushed chalk flints, worn too small for use in the grinding mills and discharged through the mill gratings; these flints were even harder than the quartz.

The plant comprised ten tube-mills (4ft 9 ins diameter by 18 ft long), loaded two inches above intake trunnion centre with five and a half tons of roughly two-and-a-half-inch-diameter chalk flints and revolving at twenty-five r.p.m. A pulp density of one of ore to one of water was considered desirable. Fifty-five horsepower per mill was needed and the plant was driven by two 475-horsepower synchronous motors through cotton-rope drives to a countershaft mounted in the roof of the building. In 1910 capacity was estimated at ninety tons per mill per day, to eighty per cent minus-200-mesh. Flint consumption was 2.6 pounds per ton of ore (stamp output) and cost was then estimated at .86d per ton.

The replacement of tube mill liners was an important aspect of grinding and eventually the liners were made of hard cast iron in the foundry at Waikino. The liner plates were one-and-a-half-inches thick and the lifting ribs, arranged longitudinally on the plate joints fifteen inches apart were four inches wide and three-and-a-quarter-inches thick when new. Liners were renewed at approximately eighteen-month intervals at an estimated cost (1910) of .52d per ton of ore.

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Tube-Mill Product Sizing. Because much of the gold in the ore was in an extremely fine state of division, grinding of the ore to expose these very fine particles to the solvent action of the sodium cyanide solution was essential, and the economic limit to which grinding could be carried was carefully calculated. The general standard of eighty per cent minus-200-mesh (.072 mm) was normally maintained. This gave a recovery of about ninety-one per cent from the slime and eighty-two per cent from the sands; the concentrates (about two per cent of the ore) were reground into the finest practicable size, retained about seven pennyweights of gold and silver per ton in the tailing, and were stored for possible later treatment.

The size of the tube-mill product was determined by the overflow of the "return" sizing-boxes, of which there were a set of fourteen, fitted with underflow nozzles of about an inch-and-a-half-diameter. The pulp first entered the mill-head thickening-box, the overflow going from this box to the tube-mill-elevator and so to the return boxes, while the course underflow entered the grinding-mill through a nozzle which passed through the mill trunnion. The material slowly made its way through the mass of revolving flints to the discharge trunnion where it passed through a cast-iron grating, which retained the flints in the mill, and went on to the elevator pit and return-boxes. It was estimated that the pulp had to pass close to three times through the mills before it was reduced to the required size. Like most of the treatment plant the tube-mills operated continuously from midnight on Sunday to midnight on Saturday, with one attendant on each shift and a maintenance team on day shift.

Concentration. From the overflow of the mill return-boxes the ore went to the Wilfley concentrating tables via a distributor which regulated the flow of pulp to the twenty-nine large shaking tables installed in what was known as the vanner room, because the Union vanners had originally been there.

For many years there was an amalgamating room on the floor above the Wilfley room but it was eventually done away with; its main purpose seems to have been to remove the free gold from the circuit at as early a stage as possible — a desirable security measure. The room contained about thirty, twelve-by-six-foot wide, Muntz-metal, amalgamating tables which were coated with mercury and over which the finely-ground ore was distributed from two-inch-diameter pipes, one to each table. The gold and silver amalgam was removed from the plates every eight hours and the plates were rubbed up twice a shift. There were two mercury traps to each plate and a Berdan pan was used for cleaning the amalgam. Excess mercury was efficiently removed by a centrifugal machine. Twenty-nine per cent of the gold content and five per cent of the silver was recovered by amalgamation. The plates were scaled at monthly intervals. The ground pulp from the tube-mills on its way to the Wilfley tables was distributed from the old amalgamating floor to the Wilfley tables on the ground floor by small, open, wooden launders and fed on to the tables with the required quantity of water.

The tables were about fifteen feet long by about six feet wide, made with a true surface. They were covered with heavy linoleum, on which thin tapering riffles made from narrow strips of wood about six inches apart were fastened lengthwise. The table' had a variable tilt towards the discharge side and the pulp entered the distribution trough at the high side, flowing across the table in a thin layer, while a longitudinal reciprocating movement was imparted to the table by the pitman toggle mechanism at the intake end. This motion, at the rate of about two hundred a minute, was a comparatively slow forward thrust with a sharp spring-operated return which caused the heavy particles of iron pyrites and other metallic sulphides, which sank and lodged against the riffles, to move along towards the far end of the table with each jerk, while an evenly-distributed flow of water washed away the lighter materials before the concentrate was discharged into the tub at the end of the table. As can be imagined, it was a very large building to house nearly thirty tables. It was floored with concrete so that any spillage could be recovered by hosing down to the pumps. The table-operating-mechanisms were driven by two long shaftings running the length of the building on either side; they had plain bearings and flat belts were used for transmission. Belts often broke, and it was not uncommon for bearings to heat up, so lubrication was quite a problem.

The concentrates were dug out of the wooden boxes at the end of the tables into large drums, twice a shift, by the single operator. Each morning the day's production, about twenty tons, was loaded on to flat-topped rail-waggons and hauled by the locomotive to the concentrate treatment plant.

Sand & Slime Separation. The lighter material, which was washed across the tables as the concentrates were taken out, gravitated to a pumping pit where it was raised by sand-pumps about thirty feet to the large spitzluten classifier apparatus, for separation of the slime (generally classified as minus-200-mesh) and sands (plus-200-mesh) which represented about twenty per cent of the total. The device consisted of a large steel cone about twelve feet in diameter with a launder running round the top. The material to be separated entered on top at the centre and a carefully regulated current of water entered at the bottom of the cone. There was a diaphram in the centre of the cone so that as the particles began to sink they were evenly distributed against the rising current of water; only the coarser particles sank against this rising current, and were washed out the bottom of the cone into the intermediate sand tanks, while the fine particles of slime were carried up over the top of the cone and into the launder leading to the vee-boxes.

Sand Treatment. Sometimes, owing to variations in the ore, dirty water and other factors, some slime might escape with the sand and this would make impermeable layers in the bed of sand, which prevented the cyanide solution from percolating through and caused losses. For this reason a set of intermediate sand tanks was used and a contract party had the job of digging the sand from these tanks and spreading it in the great, square, concrete, sand-leaching-vats in the huge vat room.

The sand was first treated with a wash of .04% KCN-equivalent, followed by the working solution of .3% KCN which was circulated by means of a small airlift for nine to twelve days. After this was drained off the remainder was displaced by weak sump solution and water washes, total treatment time being about thirteen days. Consumption of sodium cyanide was over two pounds for each ton of sand and extraction was in the vicinity of eighty per cent of the value.

Slime Settlement. The fine slime from the annular launder of the sand-separation-cone flowed over a large area of vee-boxes, which were inverted pyramids, five feet square on top and tapering to a point five feet deep, installed close together so that they formed one large tank, over which the slime and water flowed. The bottoms of the boxes were fitted with small nozzles which drew off the slime as it settled, producing a downward current that further encouraged settlement; by the time the slime had reached the far side of the vee-boxes the water was clear and was returned to the battery circuit. Two or three pounds of freshly slaked lime per ton of ore was added by a worm-drive belt-feeder to assist settlement by flocculation.

The underflow from the nozzles at the bottom of the vee-boxes passed to large settling-tanks, thirty-two feet in diameter and fourteen feet deep. One of these was needed for every hundred tons of slime treated. The clear water was siphoned off as the slime settled and the remaining slime pumped through to the vacuum thickeners.

Slime Thickening. To reduce the volume of material, solution and cyanide handled in the cyanidation process, it was necessary to thicken the slime to about thirty per cent, so that the ratio was a ton and a half of .12% cyanide solution to each ton of dry slime. This was done by vacuum thickening, a process very similar to vacuum filtration. The thickeners were "baskets" made up of about twelve canvas-covered frames (16 ft long by 4 ft 6 ins deep by about 1½ ins thick), inside which was a vacuum of twenty-four inches of mercury. When the frames were immersed in the thickening vats, into which the settled slime had been pumped, the suction inside the frames caused a "cake" of slime up to two inches thick to build up on the canvas during a period of ninety minutes. The frames were suspended under two H-beams, which held the baskets together and to which was attached the lifting-gear, operated by 15-horsepower D.C. motors. After being immersed in the thickening vat for the right time the loaded basket was lifted into the discharge vat and the vacuum released, allowing the cake to fall off and to be puddled up into a liquid for cyanide treatment in the fifty-feet-high "tall tanks", where it was agitated

with compressed-air in the cyanide solution. One man could deal with about three hundred tons of slime each day in this manner.

Vacuum Filtration. After agitation with cyanide solution for five days in the "tall tanks" — also known as the conical tanks because of their conical bottoms, or Brown agitators — practically all the accessible gold and silver was in solution and the next step was to extract this solution from the slime.

The slime was run off by gravity into the vacuum washing plant vats — the V.W.P., as it was generally known. These vats were equipped with filter baskets almost the same as those used to thicken the slime, only this time the objective was the moisture associated with the slime. The basket was loaded with cake in the same way as the thickeners had been, the solution which passed through the canvas frame being saved and pumped to the precipitation room. The basket was then lifted into the "wash" vat and a weaker solution was drawn through the cake to remove the last vestiges of precious metals. After this the basket was lifted and placed over the discharge-hopper and the vacuum was released, allowing the cake, with some help from a long thin wooden scraper, to fall into the hopper and be washed out to the Ohinemuri River, which was an officially designated "sludge channel".

Precipitation. All the pregnant cyanide solutions, including those from the sand vats, the concentrate filter-presses and the slime vacuum-washing-plant, were pumped to the precipitation room where they circulated through zinc boxes, depositing their gold content on the zinc shavings which were spread on metal-screen shelves. The precipitation boxes were wooden tubs about twelve feet long, eighteen inches wide and two feet deep; they were divided into a number of compartments by baffles which forced the solution to travel up and down through the zinc shavings. The gold and silver in the cyanide solution were precipitated on the fine zinc, which was gradually consumed and fell to the bottom of the box as a heavy black slime that was collected periodically and sent to the refinery at Waihi for smelting. The black slimes contained fifty-six per cent of bullion and were placed in trays in a special truck for transport under guard to the refinery. Only the best of kauri timber was used in box construction, boards being the full width of sides and bottom. Just as the dissolving of gold and silver was helped by oxygen from the compressed-air introduced into the conical tanks for agitation purpose, so precipitation was assisted by the low level of oxygen produced when the pregnant solution passed through the vacuum process. The theory behind this underlay the later patenting by an overseas firm of the Merrill-Crowe cyanide process.

The rich nature of the zinc slimes made security measures necessary and the windows of the precipitation room were fitted with iron bars. The attendant remained inside until relieved and had a small panel in the door for communication. Only one or two attempts at theft are known to have occurred; one man, a plumber, took home a quantity of zinc slimes in his tea-billy each day from a supply tapped from a solution pipe…

ANCILLARY SERVICES AT WAIKINO

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A great assortment of services and the skills for operating them were necessary to establish and maintain the ore-treatment process at Waikino. Over the years they were developed to a high level of efficiency and contributed substantially to the long life of the industry. They included such ancillary operations as the provision of power and electrical maintenance, assaying and metallurgical control, mechanical services from the fitting shop and blacksmith's shop, locomotive and rolling-stock maintenance, carpentry and building and woodwork maintenance, provision of stores and supplies, engineering design and drafting and pattern-making, foundry work, administration and accounting, transport, maintenance of tramways and water-races, besides such general work as plumbing and tinsmithing, pipe-fitting, servicing rope drives, belts and rigging, renewing filter cloth, zinc-cutting, and much else.

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Electric-Power Supplies & Maintenance

When the site of the Waikino battery was first selected it was hoped that water from the Waitekauri and Ohinemuri rivers would meet most of the power requirements of the ore-treatment process but rapid developments in metallurgical methods, including the introduction of tube-mills, concentrators and vacuum filtration, substantially increased the power demand and supplies soon had to be supplemented, first with steam, then by gas-engines, and eventually by hydro-electricity from the Company's Hora Hora scheme which could supply 6000 horsepower, ample for all foreseeable needs at the mine and mill.

There were several water-turbines, a number of Pelton wheels (some large), one 500-horsepower steam-engine (with 25-ft-diameter flywheel), and various other steam-engines. Later there was a producer-gas plant, of approximately 1000-horsepower-capacity, feeding several gas-engines. At about this time there were said to be seventy-five engine-drivers employed.

When hydro-electric power was installed, the capacity of the connected motors was 2350 brake-horsepower and there were about a thousand lighting points. The Waikino substation transformed the 50,000-volt supply to 11,000 volts and from 11,000 volts to 500 volts.

When hydro-electric power came to Waikino electricity was a rarity in everyday life, most towns and cities being lit by coal gas. There were practically no such things as electrical home-appliances. The interiors of buildings were whitewashed to help the lighting as much as possible and skylights in the roof were essential. At Waikino an advanced system of reticulating benzine through a tiny copper tube to lights distributed about the plant was used very successfully. To most people electricity was a new, unfamiliar and awe-inspiring concept. Electricity could not be seen, and no one at that time really knew what it was. It could kill at a touch, and perform what appeared to be miracles. It was regarded with wonder by those making its first acquaintance and one can imagine the sensation that was created when the thousand electric lamps of the battery lit the whole landscape in a blaze of light — a sight to talk about as a modern marvel, and for many years unique to this part of the country. The skull-and-crossbones on the enamelled steel plate mounted on the transmission towers added to the mysterious image of electricity, which tended also to cast its aura over the acolytes who attended to its wires and switches and humming motors. It was not until the 'twenties that a public supply became available — at a price: tenpence a unit for lighting and threepence a unit for other power.

I am indebted for the following information to Claudelle Clarke and my brother J. L. McAra, both of whom worked in the electrical department at Waikino.

The first electrical installation at Waikino was made at a very early date, possibly about 1902. There were two 220-volt direct-current sets, each of about fifty kilowatts, driven by impulse water-turbines[87]. These machines were replaced by two, synchronous, motor-driven, direct-current generators, of about a hundred kilowatts each, when hydro-electric power from Hora Hora became available. A main switchboard for the distribution of 220-volt direct-current for lighting was also a very early installation. Four panels were used and four machines supplied into a common bus bar, one pole being connected to a common bus; spider switches, of laminated copper, were operated by rotating them, and could be lifted out if necessary while being rotated. Knife switches did not come into use until later.

Among the first motors were direct-current dipole machines which had previously been used elsewhere as generators. Some were connected in differential to give a nearly constant speed with increasing load. The high torque possessed by D.C. motors, as opposed to the drooping characteristic and rapid loss of power with loss of speed of the ordinary motor, was made good use of in operating the machines in the battery, for which high starting torque and slow speed were essential.

[87] An impulse water-turbine is a Pelton wheel

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While the very early electrical installations were on a small scale, those responsible took a great deal of pride in them. The work was meticulously carried out and equipment presented as showpieces, being sometimes mounted on marble and surrounded by polished kauri woodwork and tiles, a suitable setting, no doubt, for this wonderful new power medium. The wires were generally sheathed in grooved wooden channels, joints being soldered and insulated, unlike the present loop-in system.

It has been estimated that at one stage (probably before the installation of the two 200-horsepower turbines) there were a seventy-horsepower turbine on the low-pressure race driving two generators, two twenty-five kilowatt generators driven by steam-engines, and a Bruce Peebles direct-current generator, of about seventy kilowatts, driven by a Pelton wheel from the high-pressure race, whose purpose was to supply the three fifteen-horsepower D.C. series motors for the V.W.P. cranes. There was also an eighteen-foot-diameter Pelton wheel, with large buckets, near the turbines, which was probably used on the high-pressure race supply to drive the first fifty head of stamps[88]. The high-pressure race provided an operating pressure of seventy pounds to the square inch and was available for fire-fighting.

The Taiere race, sometimes known as the Waitawheta, was capable of driving twenty-five head of stamps and gave a pressure of forty-five pounds at the Pelton wheel. A water-operated hammer connected to the high-pressure race was used for heavy welding work in the blacksmith shop. There were other Pelton wheels throughout the plant, one of which operated the elevator at the tube-mills to prevent the pit from being filled with silt in the event of a power failure.

The installation, about 1908, of a producer-gas plant and gas-engines to drive the tube-mills and other machinery was an attempt to find a cheaper source of power than steam — which cost £18 per brake-horsepower per year, compared with an estimated £10 for gas — and at the same time to provide enough power for the tube-mills, which were essential for maintaining a large output and a high ratio of recovery.

The mills were driven direct from the gas-engines and worked very well; in fact, when the electric-motors were later installed, practically no alteration to the drives was necessary. Some of the gas-engines had a generator in the middle, with one cylinder on each side, an ideal arrangement.

The first small electrical installation was under the charge of Tracy Knight, who was also a joiner and appears to have been a very versatile individual. He had his workshop just above the switchboard and the water-turbines driving the stamp-mill[89], so that he could keep an eye on the loading and adjust the various sources of power transmitting to the main drive-shaft and the power being transmitted from it. Although the system might appear to have been an involved one it was very flexible and worked well over a long period. Knight looked after the electrical plant until 1910 when MacAndrews took over as chief electrician until 1913. Neil McLeod was then appointed electrical engineer.

Later McLeod was appointed the first engineer to the Thames Valley Electric Power Board. When electrical gear was being installed in preparation for the advent of hydro-electric power Jack Herd was sent out from Britain to supervise the work on behalf of Siemens Bros who supplied most of the equipment and specially designed some of the plant. A remarkably good job resulted and most of the machines were still operating satisfactorily when the mine closed.

Once the installation was completed the work of maintenance fell mainly on the electrician and his helpers, including one or two cadets, some of whom later filled important posts both in New Zealand and overseas. One who returned recently to retire here was Claudelle Clarke, who became a life member of the American Institution of Electrical Engineers and was well known in his profession in a dozen countries, particularly in the United States and in South America. J. L. McAra was another cadet, of a later generation, who remained for many years in charge of the electrical workshop and afterwards

[88] There is no other reference to such a large wheel in any literature. It would be an enormous wheel, and Barry would surely have commented on it.
[89] See images 1903.

worked on the installation and maintenance of the huge electrical machines installed at the Tasman Mill at Kawerau.

As the mine and battery were so isolated from specialised engineering services, the Company had to be virtually self-supporting and undertook jobs which would have taxed the technical resources of many of the larger firms in the country. Even the biggest and most complicated electric motors were re-wound on the job whilst almost any casting required could be made at the foundry.

Assaying & Metallurgical Control

As the economics of the industry required constant recovery of a sufficient quantity of gold and silver to meet all the costs of production plus a reasonable profit on the money invested, it was always necessary to keep detailed records of costs in each department and make accurate assessments of the value of the ore going into the battery and the amount of gold being lost in the tailings discharged into the Ohinemuri River.

The accounts department kept a close watch on costs and the job of assessing the values was that of the metallurgist and assayer. First the "head value" had to be determined. This was done by taking a head sample, usually by an automatic sampler, of the pulverised ore going into the plant, at certain set intervals, possibly every half-hour. Samples were required also at various points throughout treatment to ensure that each stage was working properly. Most important, the tailings being discharged into the river had to be sampled to see that only the very minimum quantity of gold remained in them.

Cyanide solutions had also to be tested to make sure they were up to strength, and alkalinity had to be maintained at the correct level in the plant water.

The sampler made regular rounds about the plant collecting samples and on his return to the assay office prepared them for the fire-assay. The method of assaying usually began with pulverising the sample to about the fineness of flour; this was done in a pulveriser, a machine with one stationary and one revolving-disk, between which the sample passed into a collecting drawer underneath. Four hundred grains of this would be weighed out and would then be mixed with the fluxes, sometimes borax, litharge and soda, possibly with sand; if sulphide was used an iron nail might be added. This mixture was placed in a crucible of about half-pint size and melted in an oil-fired furnace. Usually batches of a dozen or more samples would be assayed at one time. The melted sample would be removed from the furnace with a pair of tongs and poured into an iron mould. The litharge would have been converted into a lead button, about half an inch in diameter, and would carry down with it the precious metals in the charge, and the quartz and other gangue materials would have formed a glassy slag which was removed from the lead. The button was hammered into a rough cube and placed in a mabor or bone ash cupel, about the size of an egg-cup, with a bottom about an inch thick. The cupel was placed in a cupel furnace under a carefully regulated heat until all the lead and base metals were absorbed into the cupel or vaporised, leaving a small bead of gold and silver.

This bead was weighed, and after being hammered flat was placed in a small crucible of nitric acid and heated on a hotplate to dissolve the silver. The solution was then poured off and the remaining gold, after being dried (it then had the appearance of a brownish powder), was weighed on the extremely sensitive gold balance, the difference between the previously taken weight of the bead and the gold giving the weight of silver in the sample; the values would be recorded in pennyweights and grains per ton.

There was usually little variation in the head values, which ranged round five or six pennyweights of gold. The unavoidable loss in the tailings averaged about fifteen grains to the ton.

Fitting Shop & Blacksmithing.

Most of the engineering jobs required at the Victoria battery, except boilermaking work, were carried out on the site, including repairs to locomotives, crushers, stamps, tube-mills, vacuum-pumps, air-

compressors, and other plant. Most of these jobs were done in the combined fitting and blacksmith's shop but there were also workshops at the loco sheds, the transport repair depot and the foundry. New truck bodies and new chassis were fitted at the transport workshop, the wheels and housing being cast at the foundry and the axles, bearings and wheel-hubs turned in the fitting shop. Running repairs were carried out by an engine fitter and his mate in the loco workshop. The fitting shop, where my father worked as foreman for about forty years, was equipped with a variety of machines, including large lathes capable of handling the heaviest work, milling, cutting, screwing and shaping machines. Fourteen men and apprentices were employed there. The blacksmith's shop carried out some very heavy welding work, with the aid of a power hammer; it included the welding and straightening of stamp stems, as electric and gas welding had not come into general use at the time.

Running maintenance of locomotives consisted mainly in replacing broken springs, worn bearings, leaking glands, boiler tubes, and so on. For larger jobs, like renewing or turning up axles or fitting new tyres, the work would be done in the fitting shop. The two locos engaged in hauling ore from the mine had to be serviced and cleaned each night, and steam raised ready for the engines to go out at seven each morning. This work was done by a loco cleaner, who had to clean the boiler tubes (which tended to choke with clinker and ash), clean the exterior and interior (giving particular attention to the rods and metalwork), lubricate the axle-boxes with pure castor-oil, and fill the boiler and water tanks.

Plant Woodwork & Building Maintenance.

A great deal of timber was used in the construction of plant and buildings, mainly because some of the best kauri was available from the Company's bush nearby at Waitawheta. I can remember seeing and hearing from my house on the hill to the north of the battery the huge, almost perfectly circular, baulks of kauri descending, to the accompaniment of squealing brakes, the self-acting incline from the end of the bush-tramway on the hill south of the battery. Some of the trees were six and eight feet in diameter. Building beams used to carry cranes and other machinery were often twenty-four by twelve inches in long lengths, and wide clean boards of up to four feet in width were used for big launders and the like. Even tanks were made of wood — twenty-one feet in diameter and constructed of three-by-three-inch vertical kauri slats. A gang of carpenters was constantly at work on a wide variety of jobs, including the renewal and repair of a great length of launders erected throughout the plant, the repair of the wooden vee-boxes and classifiers, the maintenance of the wooden elevator-wheels which were subject to severe abrasion, the maintenance of flumes, and extensive bridges on roads and tramways, and the maintenance of buildings.

Stores & Supplies.

The isolated situation of the mine and battery and the almost unique nature of many of its needs meant that huge stocks of consumable goods and spare permanent equipment had to be kept in stock — even including such things as electric-motors, twenty-four-inch-wide leather belting, and large quantities of sodium cyanide, coal and steel. The store was built with the government railway siding running through it so that waggons could be unloaded at the most convenient place. The Company's own line was close by. The staff of two or three, like many others in various parts of the battery, stuck to their jobs for many years and became most efficient. Everything was meticulously recorded and charged to its appropriate department.

Mechanical Design & Engineering.

Most of the variations in design of plant and buildings were worked out by the mechanical engineer in consultation with those concerned but once the whole process had become stabilised, after the introduction of hydro-electric power, there was very little to do in this field. At one stage, when oil flotation was being used successfully overseas, tests were carried out to obtain more economic extraction but the method in use was found to be superior under local circumstances. Most thought was given to making economies wherever possible. Nevertheless, there was an appreciable amount of

drafting and design work to be done, and new patterns to be made up constantly. A fully qualified pattern-maker was employed. This man had to be a very skilful artisan and worked with the very best of heart-kauri timber; many examples of his work were beautiful in their precision and finish.

The Foundry.

A team of several trained workers under a foreman operated the foundry, which was a short distance from the rest of the plant. Both ingots and scrap were used, also various copper alloys including phosphor-bronze. Some very large castings of pinions, rope-pulleys, stamp mortar-boxes and tube-mill trunnions were made, as well as smaller items such as bearings of great variety, stamp shoes and dies and tube-mill liners.

General Transport.

The battery railway-siding was used as a receiving depot for materials for the mine as well as the battery, because the railhead at Waihi was remote from the mine and it was more economical to transfer such things as timber, coal, and steel to the Company's waggons and take them with the loco to the place at the mine where they were to be used. Generally there would be sufficient material for a special rake to be run at regular intervals.

For short hauls about the plant a horse was used, in addition to a spare locomotive, and the arrangement was both convenient and economical. While most of the materials arrived by rail at the battery, some were transported by steamer to Paeroa and then by horse or motor lorry to Waikino. For the transport of ore from the mine two locomotives were used, running opposite ways, with a spare loco held in reserve.

Rail Track Maintenance.

A team of surfacemen left the battery in an open carriage attached to the loco every morning to maintain the five-and-a-half-mile tramway to Waihi and the lines in and about the surface of the mine and the battery, including ballasting, laying rails, renewing sleepers and cleaning culverts, as well as many other incidental jobs. Their work was well done because only on the rarest of occasions did a derailment occur. It must have been very difficult to maintain the tramway foundations in such a high rainfall region where the top layer of soil generally consisted of light volcanic ash. The continually subsiding surface near No. 6 shaft also posed problems.

Water-Race Maintenance.

The many miles of water-races with their tunnels, pipes and flumes were normally maintained by two or three men who patrolled them constantly, clearing the weeds and growth from the banks and the aquatic weed and rubbish from below the water level. From time to time major repair jobs became necessary, such as repair of an arch carrying one of the flumes or the retimbering of a tunnel after a fall of ground, and carpenters or miners were detailed to do the work.

Administration & Accounts.

The main office was centrally situated close to the stores and assay office and housed, as well as the battery superintendent and other supervisory staff, an accountant's office and a clerk's office. Accounts were kept on a fortnightly basis, fortnightly pay periods being adopted and fortnightly returns made to the Company's Auckland office, which supplied a fortnightly report of mining operations, with details of production and returns, to the financial section of the New Zealand Herald. Detailed records of every form of expenditure were kept, and an almost traditional ritual for the issue of stores grew up over the years; departure from this without good and sufficient reason was quite unthinkable. By such careful supervision, production costs were kept at a low level and consequently the life of the mine was prolonged, for there is in nearly every mine a considerable quantity of marginal ore which would have to be left behind if costs rose too high.

There were many other lesser but necessary services required, among them plumbing and tinsmithing, pipe-fitting, rigging, rope-drive and belt-drive maintenance, filter-cloth maintenance, security and fire-prevention. Besides employment of plumbers, pipe-fitters and riggers, they included a night watchman[90] and a sailmaker, to sew the various canvas cloths needed for vacuum-filters and filter-presses and other purposes.

[90] Occupied a house alongside the battery. McAra page 241. This is the house beside the river, turned 90 deg. in 1905.

John Bacon

(Extract from **An Outline Of Milling Operations At The Victoria Battery, Waikino 1898 – 1954. John Bacon, 1998**)

Victoria Battery Flow Sheet

Treatment before 1912 - Grinding to 70% through 200 mesh, followed by plate amalgamation, then Wilfley table concentration. The Wilfley table concentrates were reground and cyanided in the concentrates treatment plant.

The Wilfley table tailings were then classified into –

(e) Sands - cyanided by a percolation method.

(f) Slimes - cyanided by an agitation method.

Treatment from 1912 to 1947 - Amalgamation practice ceased on 12th May 1912, and the flowsheet was continued as before to produce Wilfley table concentrates, sands and slimes for cyanide treatment in separate sections for each product.

Treatment from 1947 to 1952 - The sand treatment plant closed down in 1947 and the flow sheet changed to:

(e) Concentration on Wilfley tables.

(f) All sliming of Wilfley table tailings.

Treatment from 1952 to 1954 - The concentrate treatment plant was modified to cyanide the clean-up material recovered from the Battery cleanup.

Tonnages And Recovery - Victoria Battery

		Recovery	
	% of Total Tonnage	Gold %	Silver %
Concentrates	2	25	14
Sands	12	6	8
Slimes	86	69	78
	100	100	100

Modern Gas Power Practice, SE Fraser, 1912

[A snippet from Fraser's paper, describing the gas installation at Victoria Battery. The whole document is in the folder: Producer Gas Plant, as is the whole volume from Google Books]

So far, the writer has only dealt with the development of the gas engine itself; but its rapid progress is due entirely to the introduction of the gas producers.

In the case of the suction producer its field of usefulness, up till a couple of years back, was limited to the use of anthracite, coke, or charcoal, for, owing to the high percentage of volatile carbons in bituminous and lignite coals, these could not be used.

Now, however, suction plants are manufactured which enable this class of fuel to be satisfactorily used.

With the advent of the pressure producer it became possible to make gas of good quality from low-grade bituminous slack, and to supply large units of power.

As this type of producer works slightly above atmospheric pressure, it is not incumbent upon the suction stroke of the gas engine to assist in drawing its charge of gas through the producer.

This excess of pressure is utilized in forcing the gas through suitable arrangements for cleaning the tarry matters out of the gas.

A plant of this type has been in continuous operation at the Waihi Company's Victoria Mill, Waikino, under the writer's supervision for the past 3½ years, and may be said to be a complete success.

A description of this plant may not be out of place here: it is illustrated in Figs. 4, 5, and 6.

The plant consists of three units of the pressure type, supplied by Crossley Ltd., of Manchester, each unit being rated at 500 b.h.p.

The producer consists of a wrought-iron, brick-lined cylinder, 7 ft. 6 in. in diam. by 18 ft. high, with the usual water lutes[91] at the bottom to facilitate the removal of ashes and clinker while working.

The rotary grate supplied by the makers was not, in the case under review, altogether successful, as it was found by experience that the horizontal blast pipes connecting the tuyere[92] caused the clinker to build on the walls immediately over them, which was with difficulty removed.

The air-supply pipe was altered so as to enter the grate from underneath. This left a clear passageway all round the tuyere, and gave better facilities for barring down. Since then very little trouble has been experienced with clinkering.

The charging hopper is of the usual type, the height of the coal in the producer being regulated by an internal container.

Ball-socket poking holes are conveniently arranged on the covering plate to bar down the clinker adhering to the wall.

After leaving the producer the gas passes through a saturator, which not only cools the gas and deposits the heavier portions of dust and tarry residues, but acts as a vaporizer and pre-heats the air supply to the grate.

This saturator consists of a cylindrical shell with top and bottom chambers, which are connected with a number of 4-in. diam. tubes.

The gas passes down the tubes, and through a water lute to the coke scrubbers.

[91] Any form of airtight joint formed by the agency of water; a water-seal or air-trap. https://www.wordnik.com/words/water-lute
[92] A nozzle through which air is forced into a smelter, furnace, or forge. https://www.merriam-webster.com/dictionary/tuyere

With the large amount of tar and dust passing through these tubes it was found, when working on a full load, that they rapidly became blocked, and caused a back pressure in the grates. To overcome this, the nest of tubes was removed, and replaced by a single pipe 17 in. in diam.

Although the heating surface was considerably reduced, the reduction was more than compensated for in continuous running and ease in cleaning.

After leaving the saturator the gas passes through coke scrubbers, which catch a large proportion of tar and dirt, and cool down the gas to atmosphere temperature.

It was found necessary to renew the coke about every four months. In place of this, checkered brick-work was substituted in the towers, with very satisfactory results. By steaming the towers at regular intervals there was no difficulty in keeping them clean, and they were in every way as effective as coke.

From the coke scrubbers the gas passes through a centrifugal tar extractor. This machine is illustrated in Fig. 4, and the principle of its operation can be seen at a glance.

To ensure good washing, it was found necessary to inject a fair quantity of water direct on to the revolving vanes, and close to the hub of the fan. This carries the tar out to the periphery, where it strikes the walls of the casing, and finally drains into the tar sump.

The gas next passes into the sawdust scrubbers, which consist of three compartments each 9 ft. in diam., with a depth of 20 in. of sawdust in each compartment.

Finally, the cleaned gas leaves these scrubbers and passes direct into the main, from which the various engines draw the supplies of gas.

In this plant the necessity of a gasometer for storage of gas is dispensed with, as the production of the gas is controlled by a simple arrangement of Crossley's, which regulates the quantity of air to the producer, according to the gas pressure in the main.

Connected to this main are five 200 b.h.p. engines of the opposed-cylinder type, with cylinders 18½ in. in diam. by 27-in. stroke, running at 176 r.p.m.; one tandem engine of 260 bh.p., with cylinders 21 in. in diam. by 30-in, stroke, running at 150 r.p.m., also three engines of 35 b.h.p. each, and one of 39 b.h.p.

The largest engines are all rope drive, with a friction clutch between the crank shaft and extension shaft.

Compressed air at 60 lb. pressure, which is drawn from one of the compressors on the plant, is used for starting.

It is of advantage, where a number of engines are drawing their gas supply in close proximity to each other, to place a receiver between the engines and the main. This has the effect of equalizing the gas pressure, and allows the engines to perform more uniform work.

An instance of this was observed in the tube-mill engine-room at Waikino, which contains three 200 b.h.p. engines of the opposed-cylinder type, and where the cylinders were fed off two mains, each reducing from 10 to 6 in. When all three engines were working in parallel, No. 3 engine, owing to an insufficient supply of gas, invariably fired in the exhaust.

Gas bags were tried, and they improved matters, but finally the trouble was overcome by the introduction of a receiver, 5 ft. in diam. by 28 ft. long (an old Cornish boiler with flue removed), to which each cylinder was independently connected.

The installation generally (with the exception of the incidental troubles due to the starting of the plant) has been a decided advance on steam power.

The engines have been running continuously night and day (Sundays excepted) for the past 3½ years, and show a saving of about 45 % over our steam plant.

The writer has taken the running costs of both the steam and the gas powers at Waikino for 1909, which show that the gas power stood at £9 19s. 8.6d. per b.h.p. per annum (of 303 days), and the steam power at £18 15s. 4.51d. For comparison the gas power is placed at a disadvantage in this instance in having the engines scattered about the plant and requiring the attention of additional drivers, for in centralizing the power the labour costs can be materially reduced.[93]

[93] Transactions of the Australasian Institute of Mining Engineers, Vol. 16, 1912

Appendices

The Waihi Borough Diamond Jubilee,1902 - 1962

RECENT MINING ACTIVITIES IN THE OHINEMURI DISTRICT

By A. M. ISDALE, B.A.

(Secretary, Thames-Hauraki Historical Society).

Following the winding-up of the Martha Gold-Mining Coy., in July 9th, 1955, the Martha Mine area was made a wildlife sanctuary and the Victoria Battery site at Waikino was taken over Mr I. Gerrand for cleaning up scrap metal and gold and silver residues. He also disposed of most of the buildings. From 1955 to 1960 Messrs Frewin Bros. carried out cleaning up operations for gold and silver residues on the old Martha refinery site at Waihi.

Towards the end of 1959 Mr Gerrand's interests at Waikino were purchased by a Canadian company, South Pacific Mines Ltd., which during 1959-60 also acquired rights to tailing on the banks of the Ohinemuri River between Mackaytown and Paeroa, and between Waikino and Waihi. Union Hill at Waihi was likewise taken up, together with Martha Hill, which was gazetted available for mining again. Two prospecting licences were pegged at Maratoto.

During 1960 and 1961-62 further cleaning up of gold and silver residues was carried on at Waikino on a pilot-plant basis, it being intended to erect a large plant at Waikino to treat sand tailings from the banks of the Ohinemuri River in conjunction with Waikino battery residues and some better grade surface ore left standing at the old Martha Mine.

During 1960 Pacific Western Alloys Inc., a Californian company managed by the officials of South Pacific Mines, took up prospecting licences in the Maratoto-Komata-Waitekauri area and carried out preliminary prospecting.

During 1960 an assay office was set up by South Pacific at Waikino, in addition to the one at Thames, the Waikino office later that year taking over all assay work for company operations in the Thames, Te Aroha and Ohinemuri districts.

1961 a small cyanide plant was added at Waikino, under the supervision of the Mill Superintendent, Mr D. M. Haszard of Waihi. Also a change-over was made from sending Waikino gold-bearing concentrates overseas, gold-silver bullion being melted and cast into bars on the spot.

During 1962 pilot-plant operations at Waikino were completed and at the time of writing the chief activity at Waikino, pending erection of the projected large sands-treatment plant, is the assaying of samples from Te Aroha.

In addition to the above, during 1959-62, several other companies, some with headquarters overseas, took up large areas in the Ohinemuri district, and areas were also pegged by individuals. 1961-62 New Zealand Mines Ltd., a company registered in U.S.A. carried out "diamond drilling in the Waihi area following geophysical and geochemical surveys." One bore was at the western entrance to Waihi.

The direct quotation just above is from one of the Government Mines Statements, to which considerable acknowledgement is due.

THE INTRODUCTION OF THE CYANIDE TREATMENT IN THE WAIHI GOLDFIELD

By G. H. WORTH

Almost the last chapter in the Company's history was the shovelling up and delivering to the Waikino Mill of the two paddocks of tailings that had lain overgrown with vegetation of all kinds for 60 to 70 years.

Appendices

Newspapers

A good contemporary description of the battery and process:-

https://paperspast.natlib.govt.nz/newspapers/NZH19081029.2.88

New Zealand Herald, Volume XLV, Issue 13893, 29 October 1908, Page 6

It turns up in: **The New Zealand Mines Record** vol. XII.]November 16, 1908 [No. 4.

GOLD-MINING PROGRESS AT WAIHI.