(Paper No. 2833.)

(Abstract.)

“The New Westminster Waterworks.”

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NEW WESTMINSTER, the population of which is 8,000, is situated on the Fraser River, about 15 miles from its mouth, in British Columbia. It is served by a branch of the Canadian Pacific Railway, and is connected by an electric tramway with Vancouver. Its wharves are accessible to sea-going ships of heavy tonnage. The assessed value of property in the town is £1,550,000, and the municipal debt at the end of 1893 was about £186,600, of which £114,200 was invested in property yielding revenue.

In 1885 a scheme was prepared for the water-supply of Vancouver and New Westminster jointly, utilizing the Coquitlam Lake as a source of supply. This was to have been carried out as a private enterprise, but it was found impossible to raise the capital for it, and a rival company, holding a charter for Vancouver alone, constructed works of supply for that city at a cost of £50,000, thereby rendering it a more burdensome task to secure an efficient supply for New Westminster. The project became financially practicable only by the adoption of a riveted-plate pipe for the supply-main. In June 1889, the city acquired certain rights of the private company referred to, and decided to carry out the works. A special Board of Water Commissioners was established, to which the Author was appointed engineer, with instructions to prepare plans and specifications of works to meet both the existing and the prospective needs of the rapidly growing city.

The source of the supply is the Coquitlam Lake—a body of water of unexceptionable quality—about 7 miles long and between $\frac{1}{2}$ mile and $\frac{3}{4}$ mile wide. The depth has not been measured, but is known to be considerable. The lake is surrounded by lofty mountains, which guard it from contamination, and is fed from snow-fields. The lowest level of the lake is 435·8 feet above high-water mark; it is subject to sudden rises of 9 or 10 feet, which, however, never impair the purity of the water. The nearest part of the lake is 71,581 feet from the reservoir at New Westminster, by the pipeline. The supply is practically unlimited in quantity.

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There are two in-flow pipes, so as to guard against the results of an accident happening to one of them. These pipes deliver the water into a screen-chamber, 3 feet in diameter and 18 feet high. This consists of eight castings, one of which is a heavy bed-plate, the rest being cylinders of 1-inch metal with spigot joints, and having suitable branches for connecting with the mains. The chamber contains vertical channel-iron guides for the screen-frames. The screens are of copper-wire, seven and fourteen wires to the inch, in wooden frames about 34 inches square. A small wooden building above the screen-chamber accommodates the caretaker or patrolman. The ground along the pipe-line was cleared to a width of 33 feet. For a considerable distance from the town the line follows a previously existing public road, and for the remainder of the distance a wagon road has been made and declared public. Along the old road the ground is of easy slope, but after leaving it the line is generally along steep hill-sides and across bluffs, with occasional stretches of swamp. There are numerous streams, some of which were underrun and others bridged. On side-hill ground a bench was cut for the roadway, and the pipe-trench cut on the inner side of it.

Except at one point, where the line was carried over a high bluff to reduce the length, it was kept below an imaginary line of uniform gradient, drawn from the source to a certain point in the city. At any future time, therefore, by laying a link round the bluff in question, the pipe-line could be made available for supplying, at its full capacity, an additional reservoir at any point that might be chosen in the city. In locating the pipe-line, it was purposely carried over a number of points of considerable elevation and almost precipitous slope, thus dividing the line into a series of sections, any one of which could be discharged for repairs without emptying the others, without the shock and strain arising from the use of stop-valves on the main. In streets the pipes were laid at a mean depth of 5 feet, on highways at about the same depth, in heavily-timbered forest land at 5 feet to 6 feet, in light timber at 4 feet to 5 feet, and on steep hill-sides at 7 feet to 10 feet. The gradients vary between 1 inch in 100 feet, and 87 feet in 100 feet. Angles of less than 4° were passed without special pipes. For larger angles cast-iron bends were used, and changes of gradient were made to coincide with changes of direction as far as possible, so as to economise in the number of bends used. The main is 14 inches in diameter throughout. The steel plate, of which the main was constructed, was manufactured under a specification requiring a tensile-strength of 65,000 lbs. per square

inch, and an elastic limit of 39,000 lbs. per square inch, with an extension of 20 per cent. on 10 inches. The plates and other material were supplied from Glasgow, and put together by the contractor at shops established for the purpose in New Westminster. Each plate was bent in rolls, and lap-riveted with two rows of rivets. The circular joints were also lap-riveted with single riveting, the plates being sheared to such a size as to make an exact fit between the smaller and larger pipes. Four of the larger and three of the smaller pipes were riveted together to form a 25-foot length. Each length was then tested by hydraulic pressure, cleaned and coated, and taken to the ground for laying. A thimble made from 5-inch strips, of the same thickness as the pipe, was riveted on the inside of one end of each length, projecting to fit into the end of the next length. A sleeve made from 5-inch $\times$ $\frac{3}{8}$ -inch iron was passed over the joint and set up with lead in the usual way. The pipes were of four classes, the thickness varying according to the pressure to which the pipe might be exposed. The four thicknesses were B. W. G. Nos. 9, 10 and 11 and 12 (or 0.148, 0.134, 0.120 and 0.109 inch). The hydraulic tests with these plates corresponded to heads of 675, 625, 525 and 425 feet respectively. The corresponding rivets were $\frac{21}{64}$, $\frac{19}{64}$, $\frac{17}{64}$ and $\frac{15}{64}$ inch in diameter at a pitch of $1\frac{3}{4}$, $1\frac{6}{8}$, $\frac{63}{64}$ and $\frac{53}{64}$ inch respectively. Tight joints were obtained throughout the work. Trenching for the main was commenced about the 1st December, 1891, and laying about the 14th December. The water was turned into it on the 8th August, 1892.

The reservoir is on a ridge about a mile from the city, from which it is separated by a deep ravine. It is in good clay which formed excellent material for the banks. The reservoir was made by day-labour under the Author's direction, and the castings, valves, &c., were obtained from the Albion Ironworks, Victoria. The reservoir is rectangular, measuring 150 feet by 80 feet on the bottom, and with a depth of 15 feet the capacity is about 280,000 cubic feet. The water-level is 400 feet above the city datum (404 feet above high-water mark). The out-flow main from the reservoir is 22 inches in diameter, of steel plate, B. W. G. Nos. 9, 10 and 11, jointed and laid in the same way as the 14-inch main. A gate-chamber, 6 feet by 8 feet inside, was formed over the valve at the outflow, built of 4-inch cedar plank. It also contains a 6-inch open-topped pipe which serves instead of an air-valve. There is a 6-inch waste-pipe, from an overflow tank, delivering to a surface drain.

The 22-inch main has seven bends, five of which were of 90°,

and constructed for convenience in two lengths. There are four 4-inch air-valves, a 6-inch relief, and two 10-inch blow-off valves, supplied by the Glenfield Company, Kilmarnock. The 22-inch main connects with the two 14-inch steel-plate mains of the distribution system. On one of these is a relief-tank 20 feet in diameter and 6 feet deep, of brick laid in Portland-cement mortar, rendered with half an inch of neat cement. By means of this tank the pressure in the lower parts of the city is reduced, only the upper parts carrying the direct head of the reservoir; this was necessitated by the difference of level, amounting to 300 feet, between the upper and lower districts. In case of fire in the lower district, the full reservoir head can be made available, the two districts being cut off from each other by two 14-inch and four 6-inch valves. The service mains are chiefly of 6 inches diameter, of which size 89,936 feet have been laid. Seventy-three hydrants of the Galvin pattern have been established. The pipes were laid, as a rule, 15 feet from the street boundary, with a stop-valve 4 feet from each street intersection. Every summit and dead-end is provided with an air-valve; there are eleven 6-inch relief-valves on the system. Care was taken to have no avoidable summits between intersections. The house-connections are partly of lead and partly of ungalvanized wrought-iron pipe.

The trenches were 2.95 feet wide, on the average, at the top, and 3.82 feet deep. The cost to the city for trenching and laying was 11.4*d.* per foot run for 6-inch pipe, and 10.7*d.* for 4-inch pipe. In the course of a dispute as to the allowance to a contractor for waste of lead in pipe-laying, a careful examination was made of the subject, and it was found that in the use of 30 tons of lead, almost exactly the quantity theoretically necessary for the joints had been used, so that the waste was inappreciable.

The condition of the works since opening has been satisfactory. During the winter of 1892-3 a trying ordeal of flood and frost was experienced without any interruption of the water-supply. When the temperature of the air was 12° F. below zero, that of the water in the reservoir was 37.5° F. The 14-inch supply-main, where exposed for about a thousand feet, was carefully watched and was always found to liquefy snow placed upon it. The Coquitlam Lake remained unfrozen for some distance above the outlet during the coldest winter on record, and the velocity of the water in its flow appears to be great enough to prevent the danger of the supply being interrupted by anchor ice.

The capacity of the supply-main at the mean head is about 110,000 cubic feet per day. The capacity of the 22-inch main

below the reservoir is sufficient to meet a fire draught of 200 cubic feet per minute, besides the ordinary domestic wants of a population of 22,000. In consequence of the efficiency of the supply, insurance rates have been reduced in the city.

The following Table gives an abstract of the cost of the works, up to December 1892 :—

	\$
Franchise	22,033·27
Land, buildings, and materials in stock	23,169·12
Works :	\$
Screen-chamber	1,148·61
Patrol-house	620·99
Supply-main (including clearing)	184,023·14
Service-reservoir	17,921·29
City mains	44,370·36
Relief-tank	2,325·55
Distribution system	110,614·16
House service	5,490·18
Extensions not included in original designs }	3,340·57
	<hr/> 369,854·85
Total	<hr/> \$415,057·24

Equivalent to about £85,140.

In this abstract the cost of interest, engineering, law expenses, &c., has been distributed *pro rata* over the various items. The cost of engineering and surveys was 4·24 per cent. of the total, and general charges 1·68 per cent.

The Paper is accompanied by ten drawings, five printed specifications, and a copy of regulations dated 1892.