

through a tunnel excavated well down in the rock beneath the river bed. Borings are now being made to determine the nature and depth of the rock strata underlying the river. From the west bank of the river the line will be extended to McPhillips Street reservoir, probably as a 4-ft. cast iron main laid under the streets of Winnipeg.

A pumping plant will be located at a future date at the Red River tunnel, and from this point future lines can be extended when the capacity of the gravity supply beyond this point shall have been exceeded. By this arrangement the pumping plant will be located near the centre of gravity of the District.

It may be mentioned here that the location of the reservoir is some two miles further east than contemplated in the Consulting Engineers' original layout, due to the location of the final aqueduct line. For this reason the 5-ft. steel pipe would not be sufficient to carry by gravity 25,000,000 gallons into McPhillips Street, but would require to be 5 ft. 3 ins. in diameter.

General Features of Construction.—The right-of-way, 300 ft. in width (except for the easterly 12 miles which is 500 ft. in width), was cleared by contract in the winter and early spring of 1914.

A standard gauge railroad was constructed 40 ft. from the south boundary of the right-of-way during the season of 1914 at a total cost of \$1,325,000. The construction of the railroad presented no unusual difficulties, and was carried out with such dispatch that trains were operating over the whole of it in January, 1915. The present equipment consists of four 60-ton Mogul locomotives, forty 20-yard air dump steel cars, twenty-five 16-yard air dump steel cars (now under contract), twenty flat cars, ten box cars, three cabooses and two passenger coaches. Additional equipment is being purchased.

Methods of Aqueduct Construction.—There is considerable variation in the methods of handling the work. On contract No. 30 the excavation is carried out with teams and scrapers and by means of a walking dredge, the cut on this section being comparatively shallow and on the open prairie. The final trimming of the bottom of the trench is done by hand immediately before the invert concrete is placed. This hand trimming is required on all contracts and is done to prevent any possibility of the soil drying out and cracking, and thus forming a spongy bed for the foundation. The walking dredge is a heavy timber trussed structure spanning the trench and provided with a forward dumping dipper excavator. It is provided with six timber pads, one on each corner and one intermediate pad on each side. By means of chains and winches the weight is shifted from the corners to the centre pads and the whole structure is pushed forward by chains working on the legs of these pads. The dredge is driven by a gasoline engine operating, through clutches and belts, the various movements. The concrete plant on contract No. 30 is placed on a flat car operated on a track built alongside the trench. Materials are fed to the mixer from the storage piles alongside the District track by means of a travelling, stiff-legged derrick operating on a track midway between the railroad and the aqueduct trench.

A somewhat similar method of mixing and placing concrete is carried out on contract No. 31, but the excavation in this case is being done partly by stationmen and partly by Thew steam shovels, mounted on trucks, and specially built to work in the narrow trench, and to deposit the excavated material on the side.

The excavation on contracts Nos. 32, 33 and 34, most of which is in clay overlaid with muskeg material, is carried out by means of specially designed drag line ex-

cavators. These excavators are provided with superheaters in order that full economy may be obtained from the coal. The drag lines stand at the end of the trench and work backwards, the bucket being dragged towards the machines and then swung out to the side of the trench. They dump the material along the south side in most cases to form an embankment upon which a narrow-gauge construction track is placed for carrying trains of cars containing mixed concrete to the work. The draglines are supported on the bogs by means of plank platforms made in sections each 8 ft. 0 in. x 20 ft. 0 in. Concrete mixing plants in the case of contracts Nos. 32, 33 and 34 are located adjacent to the contractors' storage platforms on the District railway. Narrow-gauge tracks are built from the mixing plants along the aqueduct trench on the spoil bank left by the dragline for a distance of about one-half mile in each direction. Concrete is conveyed to the work by small dump cars drawn by gasoline-driven locomotives. Chutes deliver concrete from the cars on the construction track to the forms in the trench.

Progress of Work.—The progress accomplished during the year 1915 has fallen a little behind that anticipated. Eighteen per cent. of completed aqueduct was required and about fourteen per cent. was completed. This failure to make the necessary progress was mainly due to a very wet season and to delay in getting a proper start. The schedule of future progress required by contract is as follows: 50 per cent. up to December 1st, 1916; 85 per cent. up to December 1st, 1917; 100 per cent. up to September 1st, 1918.

Engineering Organization.—For carrying out the engineering direction of the aqueduct, five division headquarters' camps, one for each contract, have been established, each with a division engineer in charge, having under him, an assistant who is responsible for the lines and grades, an office man to look after field records and sketches, an instrument party, a stenographer and senior and junior inspectors. These inspectors in order that they may be present at all times on the work, live in tents at each point where work is in progress.

Each division engineer is provided with a light gasoline-operated track speeder, and each party with a large speeder capable of carrying six men with instruments, so that even on contract 30, which extends over a distance of twenty miles, the work is handled with expedition, and by means of a comparatively small staff of men.

The active co-operation and support given to the engineering project by the commissioners, Messrs. S. H. Reynolds, M.Can.Soc.C.E., and James H. Ashdown, has been a great factor in the successful prosecution of the work to date, and much of the success is due their untiring energy and business acumen. The engineering work is under the direction of Mr. James H. Fuertes, M.Am.Soc.C.E., of New York, consulting engineer, and W. G. Chace, chief engineer. M. V. Sauer is assistant chief engineer in charge of designs, and next in authority to Mr. Chace. The division engineers in charge of construction under the different contracts are: C. J. Bruce, contract 30; R. T. Sailman, A.M.Can.Soc.C.E., contract 31; G. F. Richan, A.M.Can.Soc.C.E., contract 32; W. R. Davis, contract 33; A. C. D. Blanchard, M.Can.Soc.C.E., contract 34. Messrs. D. L. McLean and F. G. Haven, both A.M.Can.Soc.C.E., are assistants to the chief engineer, the former having charge of all studies relating to concrete aggregates and cement tests. These engineers have all been employed by the District since the beginning of the work, and carried out the original surveys, construction of the telephone line and final location of the aqueduct.