

essential to the growth and development of the country on both sides of the line, and invaluable to the people in the carrying on of their industries and other pursuits."

One of the first acts of the International Joint Commission in conducting the Lake of the Woods investigation, was to appoint Arthur V. White, of Toronto, and Adolph F. Meyer, of Minneapolis, as consulting engineers to report fully upon all the engineering and scientific phases of the problem.

After many months of field and office work, these consulting engineers made a preliminary report in three volumes. The introduction to this report, containing a review of all the causes that led up to the investigation, was summarized in last week's issue of *The Canadian Engineer*.

After explaining in clear detail the need for physical data, and the field operations which were undertaken to supply same, the report gives the complete results of those operations and an analysis of same. Voluminous evidence is presented regarding observed water levels, and outflows and run-offs from the various lakes and watersheds in the district. The engineering features of the problems, as based upon this data, are then discussed under the general headings of "Reservoir Control in General," "Regulation of Outflow from Rainy Lake," "Regulation of Levels and Outflow, Lake of the Woods," "Outflow Capacity Required Under Various Methods of Regulation, Lake of the Woods," and "Desirability and Practicability of Regulating Levels and Outflows, Lake of the Woods."

Following is a summary of the chapters regarding reservoir control in general and regulation of outflow from Rainy Lake:—

Reservoir Control in General.—Whenever the natural outflow from lakes is subjected to control by human agency, the natural regimen of outflow from such lakes is at once superseded, and a new regimen of lake levels is established.

The extent to which levels prevailing under a state of control differ from those which, in a state of nature, would have prevailed at the various seasons of the year, and also the effect of the new regimen of levels upon the riparian land, depends largely upon the character and extent of the control which is being exercised over the outflow from the lake. However, any control of outflow, whatsoever, results in higher than natural lake levels at all seasons of the year, unless the discharge capacity of the outlet is increased over what it was in a state of nature.

Control of the outflow from any lake, with a view to its equalization, presupposes the storage of flood water. Such a lake, then, acting as a storage reservoir, will frequently become filled at a time when the rate of inflow is high. The frequency with which this condition will recur will depend upon the extent to which the outflow can be equalized by the available storage, i.e.,

the filling will recur more frequently with a reservoir of relatively small storage capacity than with one of relatively large capacity. The extent to which flood water can economically be utilized in the equalization of stream flow depends upon the cost of flowage rights, and the cost of impounding and other works required for the utilization of the stored water, as compared with the benefits accruing to the various interests utilizing this water.

In the operation of all storage reservoirs whose capacity is insufficient to completely equalize the outflow over a long period of years,—and in principle this means essentially all of them—a time will come, if the ordinary high level is not to be exceeded, when the discharge of water, even under the most intelligent operation, must be substantially greater than the maximum outflow in a state of nature. The maximum rate of outflow to be expected under a state of control will equal the maximum rate of inflow which may occur at any time while the reservoir is full to its ordinary high level, unless special provision has been made for reserve storage capacity which is not permitted to be utilized except in years

of extraordinary floods, and at times when excessive precipitation, such as 5 or 6 inches, falling on the lake and on the adjoining watershed in a few days, will raise the level of the lake at least an equal amount. If reserve storage capacity has been provided, the high rate of inflow can be absorbed, partly by increased outflow and partly by increased storage on the lake, exactly as in a state of nature.

In the case of lakes in their natural condition, a rising stage and an increasing rate of inflow results both in an increasing rate of outflow and further storage. It follows, then, that in a state of control, when a reservoir is permitted to fill in other years besides the one year of maximum flood, occurring perhaps once in twenty-five or fifty years, the discharge capacity of the reservoir must be very substantially larger than the greatest natural discharge capacity, or else the lake will, sooner or later, rise above its ordinary high level and above its extreme natural high-

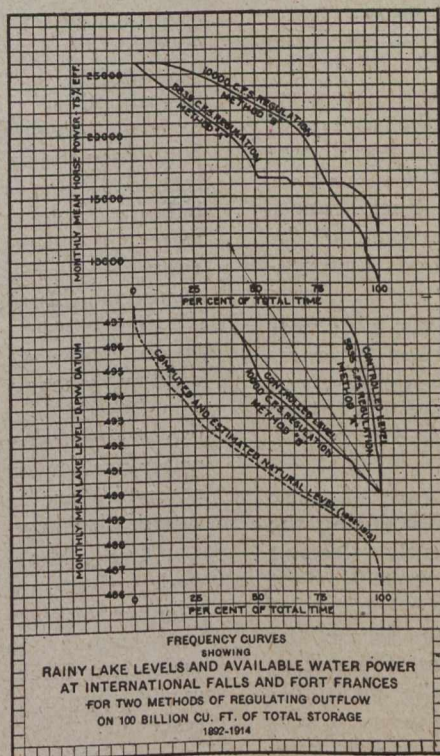


Fig. 1.



Panoramic View of Rainy River at International Falls and Fort Frances After Construction of Power Dam.