jurisdictional conflicts. Control over water within the meaning of the British North America Act is divided in rather indefinite terms between the federal and provincial spheres, depending upon the use and purpose of the control. So, in parts of Eastern Canada, we have the problem of a commodity in short supply, destined for several conflicting uses, and subject to a divided control by federal, provincial and municipal governments. It should be the purpose of a national water-management policy to resolve these conflicts by way of a twofold co-ordination: co-ordination of the manifold uses of water and co-ordination among the three levels of government.

INTERNATIONAL JOINT COMMISSION

What do we have by way of water management in this country? We should be clear that a very considerable degree of management does prevail now and indeed has had a considerable history. There is today very active management of water on the Great Lakes and St. Lawrence River systems. Lake Superior and Lake Ontario are regulated within specific limits by the International Joint Commission, the body set up by Canada and the United States. The Ottawa River is regulated, and this regulation has a further bearing on Montreal harbour levels. The Prime Minister has recently announced that Canada believes that the possibility and benefit of increasing the level of regulation to the other lakes in the Great Lakes system should be investigated by the IJC. A draft reference has been sent to Ontario and Quebec for their comments with a view to sending it to the United States as a proposal for a joint reference to the IJC. It is our position that any steps taken to regulate and control water levels on the Great Lakes should be taken through the IJC. We do not intend to establish any new agency.

I think it is essential for the purposes of this seminar that we recognize some of the important factors with which the engineer must deal in considering the control of the Great Lakes and how these factors bear on the water levels of Montreal Harbour. The Great Lakes and St. Lawrence River system is unique and differs from other river systems because of the large surface area of the Great Lakes, about one-third of the total drainage area.

The *seasonal* variations in the water levels of the Great Lakes are due to phenomena that occur every year. The *long-term* variations in water levels are due to the large surface area and restricted outlet capacities of the Great Lakes, and these result in the accumulation over the years of the effects of persistent precipitation excesses or deficiencies. Such an accumulation means that the average levels can remain either above or below normal for many years and that the normal seasonal variations are superimposed on a higher or lower base. This type of variation is very different from the variations observed on ordinary river systems. It also explains why the Great Lakes can be low when neighbouring rivers and lakes are high or vice versa.

WATER STORAGE

Of the four Great Lakes, if we exclude Lake St. Clair and consider Lakes Michigan and Huron as one lake, two are completely controlled (Lakes Superior and Ontario) and two are not (Lakes Michigan-Huron and Erie). One of the basic principles used in the control of the lakes is to store water during periods of ample water supply for use during periods of deficient supply. There are several limitations on the amount of water which may be stored. Two of the more important of these are the amount of water available for storage and the storage space available. It is obvious on lakes the size of the Great Lakes that the storage available is greater than can be filled or emptied in a few months. For example, it has taken a series of three years of below normal precipitation to deplete the storage on the Great Lakes to the present levels. This has resulted in low levels and low outflows for the lakes which are not regulated. The lakes which are regulated have been held as high as possible under these drought conditions, and every opportunity to store additional water has been taken. However, since the regulated lakes have been subjected to low rainfall, and since their outflows have to be maintained to meet downstream requirements, their storages are also deficient. This is the situation with respect to Lake Ontario. There was opportunity this spring to store additional water on Lake Ontario, and the International St. Lawrence River Board of Control took advantage of this opportunity after consulting with the operating entities on the river. This storage will be used in the ensuing months since the depleted storage on Lakes Erie and Michigan-Huron will result in low water supplies for some months ahead.

TIME RELATIONS

Also of importance with respect to the storage, and consequently the levels, of the Great Lakes are the time relationships. It requires approximately three years for 50 per cent of a change in the outflow from Lake Superior to reach the St. Lawrence River. Why should this be so? Because a large volume of water is required to raise the water levels of Lakes Michigan-Huron and Erie in order to increase their outflows. For example, it would require almost one *million million* gallons of water to raise Lake Michigan-Huron sufficiently so that it could discharge an additional 2,000 cubic feet per second of water. This additional flow, if transferred to the St. Lawrence River, would raise Lake St. Louis and the Montreal harbour levels by about one inch. These are tremendous forces with which we are dealing, and changes in them persist in the system for many years.

The water levels in Montreal Harbour and on Lake St. Louis are not only subject to the storage problems and regulation effects of the Great Lakes, but are also affected by the regulation of the Ottawa River, winds, and local rainfall. In addition, Montreal harbour water levels are affected to some extent by tides. To give an idea of the importance of rainfall on the Great Lakes to Montreal harbour, we should note that it would require only one inch per year of additional rainfall running off from the entire basin, to provide sufficient flow to raise the harbour levels by an average of over one foot.

Now what can we suggest as possible lines of enquiries for prospective solutions to the water-level crisis? In pursuing these possibilities, I would like you to keep in mind the two points which I mentioned

(Continued on P. 4)