

THE CANADIAN IHD PROGRAM 1/

By

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Introduction

Hydrology as a technical science is only now emerging from its chrysalis of empiricism. This transformation is not, in Canada, a result of concerted effort by hydrologists to gain a more complete understanding of the inter-relationship between the parameters involved in this scientific field, but is due unfortunately, to a large extent, to the demands of the public for improved recreational facilities coupled with the increasing uses of water in industry and agriculture. Today more than ever, water is a key resource in Canada's development, continually opening up new fields for industrial and agricultural growth, providing renewable energy and ready means of access to materials.

If we consider Canada as a whole, we have no shortage of water. Our problem seems to be not one of supply but one of distribution both in time and in space. The solution to this problem depends on knowledge of how much water will be available, -where - and when. At present we do not have this knowledge to a sufficient extent. In the past, pressing water problems have been solved but we may yet have to pay the consequences for inefficient programs. Hydrology has not received sufficient attention to keep knowledge abreast of the accelerating demand for improved efficiency in the management of water resources and relatively little money or effort has been spent in the advancement of this scientific field.

Many scientists today are working on the fringes of hydrology as this is an interdisciplinary science. Some aspects of hydrology are of interest to sanitary, hydraulic, irrigation, power or flood control engineers, aquatic biologists, chemists, geologists, oceanographers, meteorologists, mathematicians, statisticians and economists to name a few yet the full spectrum of this science is not within any one of these professions. Because of a lack of continuity between the varied professions involved, few academic institutions offer degree curricula in hydrology at either the under-graduate or graduate levels. Consequently, skilled hydrologists and technicians are in very short supply in Canada. Those in the field are such by personal choice and have become hydrologists only through on-the-job training and experience.

This recent stimulation of interest in hydrology in Canada is being duplicated throughout the world, particularly in developing countries which visualize an understanding of this science as the first step in attainment of financial independence by significantly increasing agricultural production, due to the existence of the International Hydrologic Decade (1965-1974) which is an assault by 80 Member States of UNESCO on the science of hydrology.

Although the International Hydrologic Decade program commenced in January 1965, with UNESCO providing central coordination and guidance, negotiations for this undertaking commenced as early as 1961. Canadian representatives have actively supported and participated in the development of this outstanding example of international cooperation since its inception by way of the National Research Council's Subcommittee on Hydrology.

Canadian participation in an undertaking of this nature may be surprising to some in view of estimates that we possess approximately one-third of the world's fresh water supplies. However, even though Canada is in a very enviable position with respect to fresh water reserves; sharing the 7,400 cubic miles of water in the Great Lakes with the United States; having such a vast number of smaller lakes that no one has undertaken the formidable problem of trying to count them; and having a total river flow estimated at about 2.5 million cubic feet per second or about 6 per cent of the world's total river flow, water problems are arising with accelerating frequency with respect to pollution, severe

1/ Presented at the Western Snow Conference, Seattle, Washington, April 19 - 21, 1966.

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droughts and severe floods. Technical experts, in reporting on these seemingly unnecessary inconsistencies, have emphasized that a greater understanding of hydrology would permit more efficient water management and thereby minimize the severity of these quirks of nature.

In Canada, therefore, the Decade has sharpened our awareness of the need for more knowledge in order to conserve and manage our water resources more efficiently. Although our environment ranges from humid to semi-arid and arctic to temperate, it was acknowledged that hydrologic research within the confines of a single country can never lead to a full understanding of the circulation of water on the earth as a whole. It was also realized, that there is need for more than international exchange of scientific information. There must be active cooperation, including common effort on the more important scientific problems.

Endorsement of a principle is however a far cry from realization of a dynamic program designed to bring specific ideas to fruition.

Constitutional Limitations

Under our constitution, the administration and control of water resources within provincial boundaries are the responsibility of the provincial authorities, except in certain specific matters, over which the federal parliament has over-riding control. Detailed examinations of the jurisdictional and administrative aspects of water management in Canada have been made by Laskin (1961) and Patterson (1961). Water science and management is therefore the business of, or is of interest to, a number of federal and provincial government agencies in addition to educational and research institutions. As a result of our constitution, therefore, any comprehensive study of water resources must involve those agencies, actively interested in the technical aspects of water management projects, and universities, which are primarily interested in research aspects.

Aggravation of this problem results from our geography and population, for the vastness of our land mass together with the concentration of population in a relatively narrow band across the south of the country creates major problems for the administration of the nation's water resources. The significant differences in the physical, economic and social backgrounds of the various parts of the country have resulted in a wide variety of approaches to water management. The situation is complicated further by the non-coincidence of political and natural boundaries for some of our most important rivers and lakes are traversed by both inter-provincial and international boundaries.

Composition of the Canadian National Committee

In view of the jurisdictional considerations, endorsement of an international research program by the Federal Government imposes no obligation on provincial agencies to participate. In addition, it was acknowledged that although this program was to be largely of a scientific nature the support of senior administrators of water management agencies was essential if financial assistance was to be gained from the various agencies. A national survey, by the Sub-committee on Hydrology, of the interest of water use agencies indicated a strong endorsement for, and a desire to actively participate in, this scientific program. Provinces were desirous of active participation as they appreciated that this undertaking would provide, not only a means of accelerating research and expanding knowledge of a province's water resources, but also the opportunity of building up an experienced staff of specialists.

Having assessed national interest, architects of the Decade program in Canada invited as members of the National Committee those who could appreciate its aims and contribute to their attainment. In addition to a three-man permanent Secretariat, which provides continuity and handles day-to-day administration of the national program, the Canadian National Committee is composed of: senior representatives of provincial water authorities from nine of the provinces; technical specialists in hydrology or related professions from six of Canada's leading universities, to provide scientific perspective and advice on educational aspects; senior executives from the three major data collecting agencies of the federal government; a representative from the National Research Council, which not only sponsors the National Committee but also coordinates all research in Canada; the Secretary-General of the Canadian Council of Resource Ministers, to provide liaison with this political body; and the Secretary-General of the Canadian National

Commission for UNESCO. The National Committee, which meets annually, has adopted the terms of reference given in Table 1.

To facilitate general administration of Committee activities, a 7-member Executive Committee, 3 members of which rotate annually, meets twice yearly or at the discretion of the National Chairman. Hydrologic research projects offered for inclusion in the Canadian program are assessed by the Executive Committee in conjunction with a 7-member Technical Subcommittee. This latter group is composed of specialists drawn from the National Committee and the National Research Council's Subcommittee on Hydrology. The criteria used by the Technical Subcommittee and the Executive Committee in assessing projects for inclusion in the Canadian program, in addition to those recommended in Section II of UNESCO Document NS/188, are given in Table 2.

In view of the dearth of qualified professional and technical workers in hydrology in Canada, it was realized that a completely new research program could not be generated overnight, even if financial resources were available. For this reason many existing studies were designated as Decade projects. However, interest to participate in this undertaking is ironically causing administrative problems.

Program Administration

As in all countries, the competition for research funds in Canada is annually increasing with the number of contestants. The Canadian National Committee is attempting to coordinate federal and provincial agencies' and universities' programs in each province in order to make the most use of available finances and manpower. Queries have been received on the ability of the National Committee and its Subcommittee to accurately assess the value of a proposed project to the science of hydrology, and to evaluate the adequacy of research facilities in Canada, as particular interests of participants have at times, of necessity, been deferred or rejected. These differences of opinion are expected in circumstances of this nature as it was realized that the Decade program would constitute a strong temptation for the promotion of local water development and conservation activities. However, there always has been and there always will be active competition for available funds and some form of priority must be established by those responsible for assessment and apportionment of research funds.

To ensure that proposals are adequately formulated, the National Committee requests extensive information on all proposed studies. The information requested includes: project title, location, objectives and principal contributor; a brief description of the procedures to be followed in attainment of the objectives; preliminary estimates of the instrumentation required; and the expected duration and total cost of the project, including expenses of cooperating agencies. In this way the Committee is acting in the best interests of all sponsoring agencies by insuring that projects, which are recommended for inclusion in the Canadian program, are sufficiently positive to expect support from the Awards Section of the National Research Council or from executive personnel of other agencies.

Present Status of the Canadian Research Program

Lack of data coupled with lack of knowledge constitute one of the most serious problems facing the world in the near future. To participate effectively in an international program, to say nothing of managing our own resources, a great deal of effort must therefore go into expanding the hydrometeorological observing stations in all parts of the country, but particularly in those vast areas where no observations at all are being taken. In carrying out this expansion, particularly over the next five years, the programs of the federal agencies will not lose sight of the fact that the provinces are vested with the responsibility of control and development of the waters within their boundaries but rather will complement provincial studies by emphasizing research. Understanding the environment in which water occurs is the purpose of research. Also, research provides the tools for collecting basic data and the knowledge for interpreting them in terms of water management needs.

As suggested by the Decade Coordinating Council, the Canadian program includes studies in each of the 5 categories: basic data; inventories and water balance; research; exchange of information; and education and training. In each of these divisions Canada

will be able to contribute significantly to both national knowledge and to international efforts at global inventories. The Canadian program is designed to develop as much information of immediate value to water resource planners as possible. It is a program of research, intended to fill the gaps in present knowledge so that future water planning will be more effective. The bulk of Canada's participation is logically in those fields in which she is particularly fitted to make significant contributions because of climate and geography.

Currently, the Canadian program includes 185 projects being voluntarily sponsored by interested agencies across Canada. The diversity of these studies is too great for complete description at this time, and therefore a generalized description of the Canadian program will be given in very broad terms under the headings of: basin studies; ground-water studies; lake studies; studies of the influence of man's activities; snow, ice and glacier studies; and programs being instituted to insure exchange of information. Details of Decade projects which are emphasizing meteorological aspects of hydrology have previously been reported by Bruce (1966).

Basin Studies - One of the major centres of activity in Canada in Hydrology during the Decade will deal with representative and experimental basins. These areas have been chosen for particular emphasis as they represent the nearest thing to a discrete hydrologic unit. Basin studies with related investigations of forest cover, land use, evaporation, transpiration, soil erosion and river processes, and including the development of pertinent instrumentation, are being undertaken on selected watersheds from British Columbia to Nova Scotia and as far north as Baffin Island. By emphasizing measurement of all of the pertinent variables in the hydrologic cycle for each of these 69 projects, it is hoped that relationships may be developed that will permit accurate prediction of the basin characteristics of ungauged areas in similar climatic regions. These studies will emphasize the evaluation of network densities (e.g. rain gauges, soil moisture probes, snow course surveys, groundwater piezometers, etc.) required to achieve common levels of accuracy in measurement of the various hydrologic parameters. Some of these basins will, eventually of course, form part of the hydrometeorological network which is being established throughout the world for the collection of data which will permit development of a world water budget.

To assist the sponsors of basin projects to plan, organize and implement research investigations, the Canadian National Committee has published "Guide Lines for Research Basin Studies". This forty-four page report, which summarizes the proceedings of a national seminar on this subject, outlines the minimum instrumentation and study programs which it is felt should evolve over the initial years of any Decade project falling into the category of representative or experimental basins.

Two of the more important functions of these projects, in the opinion of the National Committee, is the use being made of these watersheds for the education and training of university students and also the opportunity presented for the close association of representatives from the great variety of disciplines interested in water use and development.

Groundwater Studies - This component is currently the greatest unknown in the hydrologic system and insight is required into methods of expediting the world's tremendous groundwater reserves. Preliminary to this, of course, is the development of geophysical techniques and equipment (seismic, gravimetric and resistivity for both land and air-borne operations) for mapping the location and volume of aquifers. Further studies will investigate flow systems, including recharge and discharge, relative to a variety of geologic materials. Running concurrently with these investigations is a national inventory of the quality of surface and groundwaters. This data will provide a common datum for correlation of the 47 projects in this group.

Lake Studies - Canada is a land of lakes; possessing such numbers that no one has undertaken the formidable task of even counting them. Yet our understanding of the water balance and circulation in lakes and reservoirs is pitifully meager in view of the increasing utilization of many lakes and reservoirs for multiple purposes and the introduction of problems by competing uses. Increased knowledge of the thermal regime, water budget, atmospheric budget and volume of our countless lakes is being sought, as the objectives of 11 separate projects, to accurately determine our national water budget and as an eventual means of developing more efficient regulation programs, extension of shipping seasons, and increasing the accuracy of storm prediction for the benefits of leeward communities.

The greatest obstacle to the solution of these problems is the accurate measurement of the amount of rain and snow which falls onto, and the amount of water which evaporates from, large water surfaces. The possible increased usefulness of weather satellite data to determine cloud formation, ice cover of lakes, and snow cover of basins will be evaluated in this regard. A direct attack on the accumulation of water surface temperature data for use in evaporation studies will be made using infra-red radiation thermometers, which sense the radiating temperature of a remote surface, to overcome the impractical physical problem of measuring water temperatures on a representative number of our lakes by means of conventional thermometers.

An exciting project in this category, which will be of particular interest both nationally and internationally, and, which is being investigated by our National Committee is a joint study by Canada and the United States of one of the Great Lakes by means of an international study year. This suggestion, proposed by Canada, has been enthusiastically received by the U. S. National Committee and efforts are currently being made to establish an 8-man Steering Committee, with 4 representatives from each country, to plan, coordinate, and supervise the implementation of such a program. The primary objectives of the project would be the detailed study of the atmospheric water budget, surface water budget, energy balance and circulation of one of the Great Lakes. Concurrent studies of related research activities, by universities, research institutions, and scientists from other countries, would be encouraged to take advantage of the major data collection programs of the primary projects.

Influence of Man's Activities - As water management and conservation projects increase in their scope and complexity, there is a pressing need to know the effects of population expansion and economic development on the climate and hydrologic potential of not simply watersheds but whole regions. Changes in land use cause changes in micro-climate. These micro-climatic effects may, in turn, produce marked changes in basin runoff. Thirty-six projects are being undertaken which are designed to provide answers to such items as the effects on consumptive use, phreatophyte growth, water table changes, temperature variations and storm path modification resulting from such activities as urban and rural development, tile drainage of agricultural areas, development of large scale reservoirs and irrigation projects, and recharge of aquifers by warm-water return flows.

Snow, Ice and Glacier Studies - In addition to the use of snow course surveys, which are included in virtually all the previous groups mentioned, detailed studies of snow, ice and glaciers are underway. These 12 projects are of particular interest and concern to Canadians, and to this gathering, as they form a necessary pre-requisite to the establishment of efficient flood-warning systems. Information is being sought on the fundamentals of surface and frazil ice formation and break-up (employing both ground and weather satellite equipment) and on improved methods for computing discharge under ice covers as a means to improving operating procedures for regulation projects. Further, results from projects investigating the effects of variable reservoir releases on ice formation and break-up will be coupled with the foregoing studies to complete the utilitarian aspects of these programs.

Investigations into the composition and extent of Canadian ice fields are also of international interest when it is realized that many specialists considered glacier growth and recession to be one of the most accurate climatic indexes available. In addition, to their potential use for the accurate extension of runoff records, however, glaciers represent convenient storehouses of fresh water and the results obtained from these studies may prove useful in the eventual regulation of these reserves.

A project which will assist significantly in the interpretation of snow and glacier survey data is the establishment of mountain transects on which temperature, humidity, and precipitation will be measured at intervals of 1,000 or 2,000 feet. These stations will be located on both the windward and leeward sides of typical mountain ranges, from the coastal range to the interior, to assess the effects of elevation, aspect, and exposure on climatic factors.

Plot and basin studies of the time distribution of snowmelt and subsequent stream-flow, in addition to infiltration characteristics of frozen soil and soil moisture migration in a freeze-thaw cycle under shallow snow packs, have also commenced and will provide insight into the relative effects of these parameters on winter and spring runoff.

A general picture of the hydrologic coverage of Canada already underway at the end of Year 1 of the program is illustrated in Figure 1. (Not printed, Ed.)

Exchange of Information - As a primary objective of the Decade program is to increase our knowledge of all aspects of the hydrologic cycle, the completion of research projects are in themselves only the first step towards this goal. The data collected and the theories proposed as a result of the various studies undertaken must be shared with all interested researchers. As shown in Table 1, one of the requirements of projects accepted for inclusion in the Canadian program is that all data collected must be maintained in open files. To assist workers in all parts of the country to know what studies are being undertaken and what data is being collected which may be pertinent to their specific studies, a "News Bulletin" highlighting Canadian Decade activities is published semi-annually and distributed free of charge to over 1400 addressees, and a schedule for familiarization and workshop seminars has been established.

Familiarization Seminars, of approximately 3-week duration and scheduled for the fall of 1966 and 1967, will provide an opportunity for workers trained in diverse disciplines related to hydrology to gain a common understanding of the science of hydrology. Workshop Seminars, of 2 or 3-days duration, will be held every spring and fall during the Decade period and will in turn deal with each of the major components of the hydrologic cycle. These latter sessions, by bringing together scientists with common interests, will permit the free exchange of views on problems encountered and resolved, the instruments being utilized, the methodology being employed in the analysis of the basic data, and future project plans. The first workshop seminars in this series are being held this month in Toronto and Calgary.

In addition to meeting national needs for communication of data and ideas, Canada is cooperating internationally with the UNESCO Secretariat; as a member of the Coordinating Council; in the provision of technical data on all national representative and experimental basins, and sediment programs; and in the monthly measurement of the tritium content of seven of our largest rivers. Further, the National Film Board of Canada in cooperation with UNESCO has prepared a documentary film on water entitled "Element 3" for distribution to Member States participating in this program.

Conclusion

From the growth of the Canadian program and the interest which is being demonstrated by all participants, one is able to appreciate the seriousness with which Canadians are viewing this undertaking. The work to be done in Canada will add immeasurably to the knowledge of our water resources - a knowledge which is essential for their best development. Also, there will be distinct benefits as a result of the increased number of Canadians who will receive training in hydrology during the Decade. The National Committee is and will continue to do its utmost to insure that the diversified projects now underway are carried through to fruitful scientific conclusions, and will thereby provide technical insight into the hydrological processes which will be of extensive value not only to Canada but hopefully to all Member States of UNESCO.

REFERENCES

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- T. M. Patterson (1961), Administrative Framework for Water Management, Resources for Tomorrow, Queen's Printer, Ottawa.
- J. P. Bruce (1966), Weather and Water, Canadian Geographical Journal, Vol. LXXII, No. 1.
- Canadian National Committee for the International Hydrologic Decade (1966), Guide Lines for Research Basin Studies.

TABLE I

Terms of Reference for the
Canadian National Committee

1. To develop and guide the national program for the Decade.
The Canadian National Committee will give whatever assistance is possible in endorsing approved research projects for financial support; in soliciting the loan of specialist technical equipment from other agencies; and in promoting, for cooperative projects, the active participation of pertinent agencies.
2. To ensure the collection and dissemination of data obtained from observations during the Decade.
Since trends in, or further understanding of, the hydrologic processes may be detected only by repeated analysis of the collected data, sponsoring agencies should ensure that all technical field information collected during the period of a research study is maintained in open files in tabular form. Data which is peculiar to a particular study should be made available through existing technical publications or through open files.
3. To coordinate the location, situation and education of specialized staff and scientific apparatus.
In view of the pressing need in Canada for specialists in the field of hydrology, the Committee will encourage the development of hydrologic courses at universities and technical colleges and will publicize the opportunities available in this calling in line with the activities being undertaken across the country.
4. To indicate what regional or international action Canada could take.
With respect to international action, the Committee will, in addition to encouraging international studies of national interest, support the development of international projects of global interest and assist in the nomination or selection of hydrologic specialists for foreign assignment.
5. To provide liaison with UNESCO's Coordinating Council of the Decade.

TABLE II

Criteria for Assessment of
Canadian IHD Projects

1. The project should be of broad scientific, or educational value and not to be directed only towards solution of a problem applicable to a specific water development program.
2. The project should be concerned with hydrology on land areas of the globe; that is, attention should be given to oceanic waters only in relation to specific problems in land areas, and to only those aspects of meteorology closely related to the land phase of the hydrologic cycle.
3. Studies of human consumption of water in industry, municipalities, etc., should only be undertaken if needed to complete more general hydrologic investigations.
4. Research on economic use and political aspects of water should not be included.
5. Investigations of the chemistry of natural waters should form part of the program although studies of sewage treatment processes and similar aspects of pollution should be excluded.