

CANADIAN HYDROLOGY SYMPOSIUM (CHS:88)  
 ASSOCIATE COMMITTEE ON HYDROLOGY  
 NATIONAL RESEARCH COUNCIL OF CANADA  
 MAY 9-11, 1988  
 BANFF, ALBERTA

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 COMITÉ ASSOCIÉ D'HYDROLOGIE  
 CONSEIL NATIONAL DE RECHERCHES CANADA  
 LES 9-11 MAI 1988  
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### Canadian Research Basins - in review

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**ABSTRACT** The Canadian Hydrology Symposium, CHS-88, held at Banff, Alberta, in May 1988, provided a forum for discussion of the findings, failures and the future of the Canadian research basin program. Fifty three oral or poster papers were presented and are published in its proceedings. Their authors addressed several specific questions with respect to the reasons for, and the findings of, basin research programs. These presentations provide useful information and guidelines for water managers, water program administrators and water resources researchers for the establishment, interpretation and evaluation of research basins.

Reductions in funding and support have made it relatively evident that water managers and administrators are somewhat disillusioned with research basin programs. We see this lack of support as symptomatic of two causes; unrealistic expectations on the part of many administrators and inadequate application of hydrologic knowledge by scientists to the solution of problems.

The focus of many early research basin projects was apparently not on problems, but on data. More recent efforts have focused interdisciplinary teams on the resolution of problems. These later efforts appear to be having a greater impact on water resources management.

One of the primary benefits of the Canadian research basin program has undoubtedly been the education of numerous students and scientists, which would not have occurred in its absence. We recommend that this educational aspect be formalized and strengthened. We have also listed a number of recommendations for the establishment and operation of both educational and research basin programs, that we feel would make future programs more effective if followed.

The Canadian research basin program has provided a wealth of hydrologic data and numerous scientific publications. However, it will not be seen as a success unless future basin programs result in a more integrated approach to research, that leans heavily on the confirmation and testing of existing understanding of hydrologic processes, and the application of findings to solve water related problems. Unfortunately, basins are still being established that do not meet these fundamental requirements.

**RÉSUMÉ** Le Symposium Canadien d'Hydrologie, SCH-88, tenu à Banff, Alberta en mai 1988, a servi de forum où se sont discutés les succès, les échecs et le futur du programme canadien de bassins de recherche. Le compte-rendu contient le texte des 53 communications écrites ou orales qui y ont été présentées. Les auteurs ont abordé plusieurs points spécifiques touchant les

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raisons-d'être et les résultats de programmes de recherche sur bassin. L'information et les directives contenues dans ces textes peuvent servir aux gestionnaires et aux chercheurs dans la mise en place, l'interprétation et l'évaluation de bassins de recherche.

Les réductions en supports financier et autres font bien voir le désappointement des gestionnaires et administrateurs de la ressource hydrique face au programme des bassins de recherche. Nous croyons que ce fléchissement de support a deux sources: les attentes non-réalistes, de la part de plusieurs administrateurs, et la faible utilisation des connaissances hydrologiques par les scientifiques pour solutionner des problèmes.

Plusieurs des programmes initiaux ont porté leur attention non pas sur un problème, mais sur l'acquisition de données. Les programmes plus récents ont souvent concentré un effort multidisciplinaire sur un problème spécifique. Ces derniers projets semblent avoir un plus grand impact sur la gestion de l'eau.

Un des bénéfices directs du programme canadien de bassins de recherche a sans doute été la formation de nombreux étudiants et scientifiques, ce qui ne se serait pas produit sans le programme. Nous recommandons que cet aspect éducationnel soit formalisé et reconnu. Nous avons aussi inclus une liste de recommandations pour la mise en place et l'opération de programmes avec bassin pour fins éducative ou de recherche. Nous croyons que ces recommandations rendraient de tels programmes plus efficaces.

Le programme canadien de bassins de recherche a généré des données hydrologiques et des publications de grande valeur. Cependant, le programme ne sera perçu comme étant un succès que si les programmes à venir entraînent une approche plus intégrée de la recherche, basée sur la validation des connaissances sur les processus hydrologiques, et sur l'application des résultats dans la résolution de problèmes se rapportant à l'eau. Malheureusement, on met encore sur pied des programmes qui ne répondent pas encore à ces exigences.

## INTRODUCTION

Research basins have been a focus for hydrological activities in Canada for more than 25 years. Many basins have been established. Some have quietly disappeared without published record of objectives or observations. Others have seen continual and expanding activity leading to a multitude of results and recommendations.

The purpose of Canadian Hydrology Symposium - 88 was to provide a forum for discussion of findings, failures and the future of hydrological research programs. A stated intent was that the published proceedings would provide useful information - perhaps even some guidelines - for water managers, water program administrators and water resources researchers for the establishment, interpretation and evaluation of research basins. Much food for thought is contained in the 53 papers assembled from the oral and poster presentations, as they have addressed the following pertinent questions.

- (a) What prompted the original research?
- (b) Why was the research basins approach chosen; and why the particular basin(s)?
- (c) What topics have been researched in the basin(s)?
- (d) Where studies have been completed, how have the results impacted the understanding or management of water resources in Canada?
- (e) Are significant research findings available or being used by other researchers and water resources managers? If not, why not?

- (f) Should the research basin approach be used again, or should things be done differently (What? How?), if the same problems were to arise?

It is neither possible nor appropriate to provide a comprehensive summary of all the symposium material. As we have listened to the answers to the questions and viewed the poster presentations, we have sought to gain an insight into the worth of research basin programs. With this in mind, we present a summary of the answers to the specific questions, a discussion of some problems that were implied but not expressly stated, and our recommendations for future basin programs.

## SPECIFIC ANSWERS TO THE QUESTIONS

### What prompted the research?

The papers presented and the discussion of them revealed that a large majority of Canadian research basin studies, and virtually all of such studies initiated before 1980 (including the IHD basin program), were prompted by a desire for hydrologic knowledge and data. Basin after basin was established to obtain a data set for and learn about a representative regime e.g. the Maritimes, Ontario and Quebec, the Prairies, the West Coast, and the Arctic; wetlands, drylands, glaciers, virgin areas, forested regions, and agricultural lands. So-called experimental watersheds were also initiated to monitor impacts of either urbanization or timber harvesting primarily on water yield. And although these watersheds were established in response to concerns about man's influence on the hydrologic system, the driving force was one of learning about that system.

The original intent of the early basin studies was to collect data, and for the most part, new hydrologic knowledge was expected to follow automatically from those data. A few basins were set up to explore the extrapolation of results through spatial scales, or to develop and investigate the implications of watershed models.

More recently, since the mid 1970's, perhaps having had a chance to learn about the local hydrological system from earlier studies and/or having to operate in a much tighter economic climate, hydrologic managers and researchers have established basin projects to solve problems. Whether these relate to soil erosion, nonpoint source pollution, phosphorus and pesticide transport, acid rain, or flooding and other water management issues, such problems and the need for their solutions provided the justification for basin studies. It is interesting to note that the problem-prompted research basin studies have almost unanimously been of shorter duration and have involved more researchers on a wider range of topics than the basin studies driven by curiosity.

One or two studies identified educational needs as being fundamental to the establishment of a research basin, and one noted public relations or visibility. The apparent lack of attention initially given to these areas is particularly curious in light of the program impacts and suggestions regarding future basin research discussed later.

### Why the basin approach - and why these basins?

In most of the basin projects it would appear that it was deemed unnecessary to develop a rationale for taking a research basin approach. Some of the papers have suggested that "basins had been useful in the U.S.", watershed projects "were in vogue", and research basins represented a "state-of-the-art approach" or "the approach of the time". However, a number of researchers

have identified the watershed as a fundamental hydrologic and geomorphic unit, one which integrates many important processes and effects and one from which it is possible to extrapolate results. The watershed is also quite desirable because of the zero flux boundary condition, almost always realized with regard to surface flows (an exception being some of the Arctic basins), and often realized (although usually assumed rather than validated) with regard to subsurface flows.

The reasons offered for the selection of specific research watersheds perhaps reflect most clearly those criteria considered to be most important for basin selection.

- (a) The watershed was representative of the hydrologic regime of interest and of the problem(s) being addressed (where such had been identified).
- (b) The watershed was accessible, convenient and available.
- (c) The chances of land use changes and/or physical and biological disturbances were considered to be minimal in time and over the area, or the basin's researchers had control over changes or were closely in touch with change agents.
- (d) There were already some valuable background data available for the watershed.
- (e) The watershed was reasonably safe from vandalism.
- (f) The watershed had good definition (i.e. the watershed divide was clearly definable).
- (g) Stable gauging sites were available and easily instrumented and monitored.
- (h) There was considerable local interest in the area.

#### Topics explored

The range of topics explored in Canadian research basins is extensive and is only summarized here. The evolution of the topics over the some 30 years of studies and the approaches taken to explore the topics are noteworthy.

In the research basins established in the 1960s, when the principal interest was gathering some data and learning about some of the hydrologic regimes, topics focused on the basic water quantity components of the hydrologic cycle (i.e. precipitation, streamflow, evapotranspiration). Where a concern such as urbanization or timber harvesting existed, particular attention was also given to the land use patterns. Moving into the 1970s, the spatial variability of a number of the variables and processes (most notably, precipitation and soil moisture storage) received more attention; and water quality began to be of interest, particularly as it involved soil erosion and sediment yield. Later in the 1970s and on through the 1980s, water quality, environmental and ecological topics were more in vogue, as basin settings were seen to be prime locations to resolve environmental issues relating to amounts, sources, and transport paths of many contaminants.

Although the initial approach taken to most research basins was essentially one of collecting data and of focusing on watershed scale studies, increasingly the basins became outdoor laboratories for a host of studies ranging from the microscale through plot and hillslope scales to the watershed

scale. In fact some of the most significant results have been achieved when studies from the various scales have been integrated, a modelling approach usually providing a framework for that integration.

#### Problems!

Perhaps one of the most significant outputs from the Canadian research basin experience is a list of the problems cited! Certainly, this is a valuable reference for researchers and research managers to ponder when contemplating the establishment of a research watershed. The most-cited problems have been grouped below in four classes:

##### Technical and Practical Problems:

- (a) Instrument breakdowns (more prevalent in the earlier years with older designs).
- (b) Insufficient sampling to ascertain temporal variations.
- (c) Practical problems associated with instrument installation.
- (d) Requirement for and difficulties with road construction and maintenance.
- (e) Inclement and extreme weather conditions (affecting or even incapacitating instruments; making measurements difficult or impossible).
- (f) Unstable gauge locations.
- (g) Vandalism.
- (h) Insufficient servicing of instruments (due to weather conditions or remoteness).

##### Data Management and Analysis Matters:

- (a) Lack of continuous data (due to instrument and/or human failures).
- (b) Lack of a central data repository (data for different variables and studies residing with different agencies and persons).
- (c) Lack of quality control.
- (d) Too much time on data collection and not enough time on analysis.
- (e) Too much time on detailed studies and not enough time on integration of results.
- (f) Too much time on setting up and "playing" with models and not enough time on interpretation and extrapolation of results.

##### Financial and Personnel Resource Problems:

- (a) Lack of sufficient funds and a commitment for ongoing funding (often caused by a lack of awareness of the real costs, resulting

in too short a study or the waste of time and energy striving for more funds).

- (b) Lack of a full-time coordinator (deemed by many in hind sight to be a necessity).

#### Management Issues:

- (a) Lack of a long-range plan which is focused yet flexible (leading to a lack of direction, the collection of unusable or un-needed data, and the failure to collect necessary data).
- (b) Lack of ongoing commitment to the project, with shifting agency priorities (affecting the allocation and commitment of funds and personnel).
- (c) Lack of ongoing coordination (staff turnovers leading to a lack of continuity and commitment).
- (d) Lack of awareness of issues being addressed and problems being encountered.

#### Impact of Results

Despite the many problems encountered in the research basins, there have been substantial results and their impact has been varied, extensive and often of a different nature than originally anticipated. Scientific results were anticipated, and there is little doubt that the understanding of hydrologic regimes both particular to Canada and more widespread has been expanded as a result of basin studies and the subsequent publication of innumerable papers and reports. There is also no question that Canadian research basins have played a major educational role, despite the fact that in most cases education was not initially identified as a prime objective. A great number of graduate and undergraduate university and college students have benefited from the opportunity to conduct research studies in the basins, make use of basin data, and use the basins as outdoor learning laboratories.

Perhaps more particularly, the research results from the more recently established research basin projects, which have focused on environmental issues, have begun to have an impact on the establishment of water resources management policy and guidelines and on their implementation. This impact has been the result of, and has led to, increased and improved cooperation amongst not only hydrologic researchers but also government agencies and the university community. There has also been an increased awareness of the significance of hydrology on the part of agencies and lay persons, perhaps due in large part to the informal transfer of information and results among groups of individuals. The knowledge gained about how to organize and run research basins in order to maximize their impact may have been as useful as the advances in scientific knowledge.

#### Would you do it again?

A large majority of the symposium participants endorsed the research basin approach to acquire hydrological knowledge, to resolve environmental issues, and to educate students, water resource managers and the laity. However, a number of bad experiences have discouraged some researchers from being supportive of further basin projects. For example, it has been stated that the basin research is too costly for what is achieved; we simply don't need

basin-type data any more; and unless water and other resource managers are sufficiently committed to the research exercise, the likelihood of results being used for management decisions is minimal.

#### IMPLIED PROBLEMS WITH RESEARCH BASINS

As we listened to the oral presentations and viewed the posters it became obvious to us that there were some underlying concerns that were not being addressed directly in the papers. These are discussed briefly below.

#### Research basins have been used as an excuse to avoid action.

Traditionally research basin programs have been established to study within a particular discipline or land area over a time period of 15 to 25 years or more. In some cases the solution to the prompting problem or a conclusion to the stated hypothesis already existed. For instance, many studies have demonstrated that most erosion and sedimentation problems associated with timber harvest are a result of poor road construction, particularly near stream crossings. The reason often offered for establishing a research basin to study this problem, rather than an action plan to resolve it was; "it has not been done in [this place], therefore we don't know if it will work here". It seems remarkable that many scientists and managers are unwilling to attempt to interpret or integrate research results from other places to solve local problems!

Some of the papers in these proceedings report the use of the HSPF hydrologic model or of the WRENS procedure as aids in instrumenting and interpreting the results from research basins. Those doing so are to be commended. However, research basins are still being established, apparently without even an attempt to use the available tools first. This problem may be alleviated if we provide easier to use models and techniques to interpret and extrapolate hydrologic knowledge, but better models are not of much use to those who refuse to try them, or who do not have an adequate scientific background to apply them!

#### The results have not been communicated in a way that receives the attention of managers.

Most of the IHD basin projects generated a long list of scientific publications, which is commendable. While these publications may be of use to other researchers, they are often ignored or not understood by managers. The scientific results are not usually presented in a form or format that is useful to the hydrologic manager. More effort must be put into interpretation and extension of results so that the managers can see their usefulness in the solution of local hydrologic problems.

#### The research was done primarily in response to scientific curiosity, rather than to a hydrologic problem.

Most research basin projects need a defined application goal in order to maintain continuing support by water managers and research administrators. Scientists, on the other hand, often wish to develop research projects to satisfy their curiosity. Some curiosity-driven research is necessary if the science of hydrology, as opposed to the applied art of hydrology, is to be furthered. However, rightly or wrongly, curiosity driven research must, at present, be conducted as a side line within projects with well defined and accepted application goals.

The solution to a problem found through research basin efforts does not coincide with nor justify current operations.

In some cases, those managers originally supporting a particular piece of research really wanted a "blessing" of their present management rather than an answer to the problem. When the results did not coincide with this expectation, they were ignored. There is not much that those establishing a research basin program can do about this problem except to get a firm commitment by users prior to initiating the research to resolve the problem, even if it might require a change in their operations.

Research efforts should not be stifled by preconceived and unrealistic time tables.

The time scale for the variations in climate that any research basin undergoes is a fair estimate of the time needed to properly conduct an experiment that involves the hydrological characteristics of a basin. If the basin is to elucidate processes within the hydrologic system, then the desired range of climatic variation that affects the processes ought to be allowed to occur. For example, it would be ludicrous to establish a research basin with a goal to investigate the effect of climatic change on streamflow, and then to curtail data collection before the climatic change occurs.

Likewise, experimental techniques should be used that are appropriate to the solution of the problem in mind, or to the research objective. A research basin approach will not always be the appropriate tool to solve a given hydrological problem. Unfortunately, the IHD research basin program may have inadvertently focused research on "interesting" scientific problems within research basins, simply because they were convenient and existed, rather than on the solution of the true hydrologic problem that the research was supposed to address.

#### DISCUSSION

In light of a reluctance among both scientists and managers to interpret and use research findings, how are we to make progress in the application of hydrologic information to the solution of current and local problems? Are research basins the best approach? Must each new situation spawn a research project that almost always delays implementation of remedial measures, often past the point where they can be taken?

The papers presented at this symposium shed some light on these questions. It is rather clear that the educational benefit of research basins far exceeds that of textbooks and publications. Some of the researchers who have worked in research basins have become disenchanted with research basins although most now view them from a different perspective than the rather simplistic viewpoint as a source of hydrologic data. This educational process could not have occurred in the absence of the Canadian basin program. Research basins have thus established themselves as a most necessary part of any hydrologic program.

Is the price that Canada has paid for such an education too high? Not if it results in better management and understanding of our water resource. What must follow from Canada's research basin program is a more integrated program of research and application. We see this already beginning to happen where a pressing environmental issue, acid rain, has forced researchers to use their best tools and joint knowledge to find a way to solve, or at least to mitigate the effects of, this problem. Similar integrated and joint efforts

will probably have to be mounted with respect to soil salinity, agricultural and forestry chemicals, and climate change, to mention just a few of the current issues facing Canadian hydrologists.

The most depressing aspect of this symposium was to find that there are still researchers who have not learned from their experience. Although the hydrologic cycle is complex, it is not incomprehensible. Those who seek simplistic solutions to hydrologic problems are doomed for defeat and disappointment. Surely it should be obvious by now that although individual watersheds are unique, the hydrologic processes that occur on any watershed are common to all watersheds!

If research basins continue to be established simply to "determine if [some action] causes a change in [quantity, quality, regime] of streamflow", then Canada's program over the past 25 years must be viewed as a failure! Research basins are much too costly and time is too valuable to be wasted in this manner. They must be used as places to test and/or verify our understanding of the hydrologic system, to increase our ability to integrate the action and interaction of various hydrologic processes, and to predict the hydrologic consequences of human or climatic perturbations of those processes wherever they are encountered. If those of us who have been fortunate enough to participate in Canada's research basin program refuse to use the scientific tools at our disposal to answer scientific questions, then how can we expect those further from the science (i.e. managers) to ever use these tools?

#### RECOMMENDATIONS

Whether the research basin approach was endorsed or attacked, there have been numerous recommendations offered for those contemplating future basin projects. The educational benefit cited by almost all leads us to recommend that a category of educational-research basins be established with teaching and student involvement as their primary reason for being. There should be a number of these and at least one should be located sufficiently close to each university so that appropriate faculty members at each Canadian university would be able to use both the data and facility in a routine manner. The following list, combined with that generated on problems, forms a set of guidelines for research (R) and educational (E) basins:

- (a) All research basin programs should incorporate a multidisciplinary approach, including extensive monitoring of both water quantity and water quality variables. (E,R)
- (b) An integrated study approach should be used, the plan taking advantage of individual but coordinated studies at the microscale, on plots, and over the watershed. (E,R)
- (c) Until the present political and economic climate changes, research basins should be planned to be concentrated projects in 3 to 5 year blocks of time. (R)
- (d) Regardless of time constraints, any proposal for a new research basin intended to supply information to solve a local water management problem (as opposed to a basin that is to be used primarily for educational purposes), should be scrutinized for evidence that existing hydrologic understanding and/or models have been tested and found to be deficient for proposing solutions to that problem. These deficiencies should be thoroughly examined to ascertain what information the basin's program must supply in

order to correct them and to expedite a solution to the problem.  
(R)

- (e) Research or educational projects should be planned and carried out within an existing basin wherever possible in order to make maximum use of available data. (E,R)
- (f) Research basin plans should include public involvement and high visibility programs e.g. demonstrations, workshops, update meetings, etc., to raise the awareness and the profile of the research, and to maximize information exchange and the likelihood of use of results. (E,R)
- (g) Management/operation of a research basin should include a cooperative and highly involved team. (E,R)
- (h) In cases where a number of agencies are involved, it is imperative that financial and jurisdictional commitments be clarified at the outset, that a lead agency be identified, and that a full-time coordinator be appointed. (E,R)
- (i) It is vital that a research basin program be coordinated with affiliated research, management and education programs. (E,R)
- (j) The most up-to-date sensing and recording instruments, security systems, and quality control facilities should be used. (E,R)
- (k) A data archiving and compilation system must be established at the outset and all data processed and verified as soon as it is received. (E,R)
- (l) A permanent and secure field camp should be established. (E,R)



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CANADIAN HYDROLOGY SYMPOSIUM No 17 - 1988

*Canadian Research Basins:  
Successes, Failures and Future*

COMPTES RENDUS DU  
SYMPOSIUM CANADIEN D'HYDROLOGIE No 17 - 1988

*Les Bassins de Recherche canadiens:  
Succès, Echecs et Futur*

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Banff, Alberta  
May 9-11 Mai 1988