



GB  
13995  
.B8  
K74  
1976

# **studies in hydrometric network planning and data analysis in british columbia**

**W. L. Kreuder**

**Water Survey of Canada  
Planning and Studies Section  
Vancouver, B.C.**

**December 1976**

GB  
1399.5  
B8  
K74  
1976

Studies in hydrometric network  
planning and data analysis in  
British Columbia.

GB  
1399.5  
B8  
K74  
1976

Studies in hydrometric network  
planning and data analysis in  
British Columbia.

LIBRARY  
ENVIRONMENT CANADA  
PACIFIC REGION

## CONTENTS

	Page
1. The Objective	1
2. The Analysis of Basic Data	2
2.1. Evaluation of Existing Data	2
2.2. Improvements in the Collection of Hydrometric Data	3
2.3. Extension of Records	3
2.4. Analysis of Extreme Events	4
3. Hydrometric Network Planning	5
3.1. Creation of the Data Bank	6
3.2. The Existing Network	7
3.3. The Proposed Network	8
4. Publication of Specific Data	9
4.1. Basic Data	9
4.2. Processed Data	10
4.3. <del>Lay-Reader</del> Reports	12
References	15

## STUDIES IN HYDROMETRIC NETWORK PLANNING AND DATA ANALYSIS IN B.C.

### 1. The Objective

The purpose of the Planning and Studies Section is to present data in the form required by the Data User, i.e. to provide hydrologic information. With the growing awareness of the value of British Columbia's water resources, the Data Users - designers, planners, and impact appraisors of water control and water related facilities - are demanding greater service from the Water Survey of Canada in providing hydrologic information of a kind and versatility beyond anything now being gathered. These demands, being made at a time when funding of the data collection program is being curtailed, have necessitated a redirection and strengthening of our efforts into studies which supplement the traditional field program.

The Planning and Studies Section is meeting these growing demands by utilizing the expertise unique to the Section, that is an awareness of the accuracy limitations of the raw data and hence its relative usefulness for analysis and a knowledge of what kind of data the Users want.

Specifically, our efforts are directed into three functions:

1. ANALYSIS - the extension of the usefulness of the basic data base through synthesis, simulation, interpolation and correlation studies,
2. NETWORK PLANNING - the improvement of the usable data base through a systematic assessment and design of the data collection system,
3. PUBLICATION - the dissemination of specific data to potential users and to make known the kinds of data which are available.

## 2. The Analysis of Basic Data

The primary purpose of the studies under this heading is to extend the usefulness of hydrometric stations, in particular the usefulness of project-oriented stations. Project-oriented stations are those that were established for a specific purpose, e.g. requiring point data at a specified location on the stream. Part of the analysis efforts is concentrated in assessing the value of the streamflow data in obtaining information on a day-to-day basis for the management of water, for the assessment of current water availability, for the control of water quality, for the forecast of flow extremes, and for the surveillance necessary for legal requirements. These studies are divided into four groups:

2.1. Evaluation of Existing Data

2.2. Improvements in the Collection of Hydrometric Data

2.3. Extension of Records, and

2.4. Analysis of Extreme Events

### 2.1. Evaluation of Existing Data

Streamflow information may be obtained directly from a streamflow record or may be derived from base data by analytical methods. In either case, accuracy goals for the information obtained are needed to test the adequacy of the information. The accuracy of streamflow characteristics corresponding to stipulated lengths of record can be determined. A streamflow characteristic is anything that describes the flow to be expected at a given site. The 50-year peak flow, 20-year low flow, mean annual flow, mean monthly flow, and the standard deviation of the

annual and monthly flows are examples of such characteristics.

There is a need to evaluate the adequacy of data being gathered in British Columbia by computing the accuracies of streamflow characteristics being obtained. This is particularly important at project-oriented stations. The analysis will aid the User in determining how long a station should be operated.

### 2.2. Improvements in the Collection of Hydrometric Data

An awareness of the accuracy limitations of the raw data leads to studies of methods for improving the collection of hydrometric data. In British Columbia inaccessibility of terrain is one of the major difficulties to be overcome in the operation and maintenance of many stations in our network. Some of the stations are located on reaches where no cross-section can be found that is suitable for taking discharge measurements using standard direct techniques.

### 2.3. Extension of Records

In British Columbia the diversity of climatic and physiographic conditions causes large variations in runoff, which make it necessary to increase the amount of data that must be collected. Unfortunately, existing streamflow records at many sites are not sufficiently extensive to allow the Data User to evaluate adequately proposed water system designs. The extension of records can be accomplished by correlation with the flow of a nearby long-term base station, by correlation with precipitation records in the drainage basin, by sequential generation of hydrologic information (synthesis), by interpolation between gauged points on the same stream channel, or by regression methods between two or more stations in a homogeneous region.

#### 2.4. Analysis of Extreme Events

Data collection is most difficult during times of flood flow. In British Columbia adverse weather conditions and problems of logistics often contribute to the failure in obtaining a direct measurement. The analysis of events surrounding a flood has a two-fold purpose: to make a reasonable estimate of the magnitude of flood peak and to analyze the antecedent conditions causing the flood. Knowledge of these will lead the designer and planner of flood control works to better estimates of a design flood.

It is the responsibility of the Water Survey of Canada to report on extreme flood occurrences and to disseminate the information to the Data User by publishing the reports.

### 3. Hydrometric Network Planning

The purpose of the studies in this group is the systematic and continual analysis, assessment and design of the data collection program in the direction of more efficient production of the information required by the Data Users. In hydrometric network planning our concern is with the controlled and systematic development of a water resources gauging system through the concept of regionalizing the relationship between hydrograph characteristics and physiographic and climatic parameters.

While studies mentioned in the previous section are usually of short duration, studies concerned with hydrometric network planning tend to be of an evolving nature, since the network is a dynamic entity requiring continual modification. The mechanism for providing planning and design information should be a continued cyclic process of data collection, data analysis, and design of the gauging network in the direction of more efficient and more effective production of the required information. The type of information that is required may change in time, accuracy requirements may change, and the state of the art of hydrologic analysis is changing. All these factors require periodic reappraisal of the gauging system. In British Columbia the Planning and Studies Section is primarily engaged in the evaluation of the data base and the capability of the existing hydrometric network to provide the information required by the Data Users. This knowledge will lead to recommendations in the improvement of the data base through network design. The studies in hydrometric network



planning are described under three headings:

3.1. Creation of the Data Bank

3.2. The Existing Network

3.3. The Proposed Network

3.1. Creation of the Data Bank

In hydrometric network planning the procedure used in the analysis and assessment of the existing data collection program is a correlation technique for relating hydro-meteorologic parameters to physiographic characteristics of a basin. Given the stochastic nature of hydro-meteorologic phenomena, designers and planners of water control and water-related facilities require that the observed time series of events be described in terms of statistical parameters. Among the hydrograph characteristics that will be estimated are the mean annual discharge, mean annual flood, mean monthly discharge, mean annual drought and mean seasonal drought. Meteorologic parameters that may significantly affect these hydrograph characteristics and which should be included in the analysis are average values of precipitation and temperature and some estimate of evaporation losses. Discharge estimates can also be made from measurable and unchanging parameters such as physiographic basin averages. The Shawinigan Engineering Co. Ltd. in the report "Hydrometric Network Planning Study for Western and Northern Canada" created a data bank of 26 physiographic factors, using a square grid of 10 x 10 kilometres which is printed on the Universal Transverse Mercator Projection maps of scale 1:250,00.

### 3.2. The Existing Network

The existing network must be assessed in order to determine if the network needs to be improved to satisfy the requirements of the Data User. A first step in this assessment is an examination of the quality of the data being gathered at a station and the cost of obtaining the data at the station. The completed evaluation will permit cost comparison studies with adjacent stations which may lead to a revision of operating schedules.

The evaluation of the existing network makes use of the following:

- results of the examination of the quality of the record at the station; for example, if the quality of the low flow data is not good the data should not be included in an evaluation of the network regarding low flow information.
- data bank of hydrograph characteristics.
- data bank of meteorological parameters.
- data bank of physiographic parameters.
- some method of data transfer.

For natural streams the transfer of streamflow information may be accomplished by regression methods by relating flow characteristics to the environmental factors that have an effect on streamflow. For streams in which the natural flow has been materially modified, hydrologic modelling of each individual basin may be required. One product of a multiple-regression analysis is the standard error of estimate, which is a general index of the predictive ability of the multiple-regression equation when applied to ungauged areas. In the evaluation of the

existing network based on multiple-regression studies the standard errors of estimate are compared to the accuracies required for planning and design purposes. If accuracy goals are met for some streamflow characteristics but not for others, the nature of the gauging effort may be changed so as to concentrate more efficiently on the types of information still unsatisfactorily defined.

### 3.3. The Proposed Network

The results of the evaluation of the existing hydrometric network will show whether the objective of the streamflow data program is being met, that is, to provide information on flow characteristics at any point on any stream in British Columbia.

Gaps in the network coverage will have to be filled by establishing new stations, while redundant records may lead to a discontinuation of existing stations. The design of the proposed network cannot be done by formula. It must be done by those who are familiar with the hydrology of the region, the needs for information, the information presently available, and the methods of hydrologic analysis. The results of a network evaluation however, will provide a firm basis for planning the future program. Decisions on number, location and length of operation of continuous stations and partial-record stations can be based on these results. Less productive elements can be weeded out and the effort can be devoted to important areas of streamflow information that are now receiving little attention. The overall plan for the proposed network should provide for a continuous interaction between data collection and analysis not only to gain a better understanding of the hydrologic system, but also to guide the future data collection program.

#### 4. Publication of Specific Data

The most important function of publications is to inform. The Water Survey of Canada in British Columbia and the Yukon Territory has gathered a great deal of data which is not being made available to the people in a form most useful to the Data User. An agency which gathers a great deal of data and then buries it in its files is an agency of little value to anyone. Through the means of publication it is possible for the agency to distribute specific data to potential users and also to make known the kinds of data which are available. Through publications the agency can also become well known and enhance its reputation. The subject of publications is treated in the following sections under three headings:

- 4.1. Basic Data
- 4.2. Processed Data
- 4.3. Lay-Reader Reports

##### 4.1. Basic Data

The Surface Water Data volume which is published every year provides information for a station on a stream for only one year, that is the year of the publication. Most Data Users when interested in data for a specific station are interested in reviewing the available data on that station for the entire period of record. Originally it was necessary for a person to look at forty volumes in order to see the data for a forty year period of record. The Planning and Studies Section, with the approval of the Data Control Headquarters Unit, undertook the preparation of a number of volumes giving summary data

for stations for the entire period of record. This has become increasingly important with the growing demand for statistical information as required by planners, designers and impact appraisors of water control and other water-related facilities.

#### 4.1.1. Publications

The Planning and Studies Section with winter works and summer student assistance has extracted arrays of annual mean daily peak flows, seasonal 7-day average low flows, annual 7-day average low flows and mean annual discharge values for all the stations in British Columbia, where this information is available. The peak flow and seasonal drought data have been processed into publications. There are also data on water temperatures and miscellaneous measurements which now lie dormant in our files and which we may be requested to produce.

#### 4.2. Processed Data

If we may assume that the Survey takes an active role in tailoring the publications it produces to the needs of the Data Users, we must then look at the processing of the data in addition to its publication. It is not sufficient to publish tables of arrays of hydrograph characteristics, when we know that the Data Users, in all their variety, must still develop individual techniques and programs to analyze this information in order to get it into a form useful for design, operation, administration, and so on. It is generally acknowledged that the Water Survey would be the preferable agency to undertake this type of analysis, because the Survey is best aware of the accuracy limitations of the raw data and hence its relative usefulness for analysis, and because it is

the logical agency to make available as required both the basic data and the processed information on rivers.

#### 4.2.1. Publications

The following compilations can be classified as publications of processed data:

- peak annual mean daily flows to 1971 at 354 stream gauging locations in British Columbia, arrayed in tables, plotted on Gumbel extremal probability paper, distributionless, published as "Magnitude of Floods in British Columbia", 100 copies printed, now out of print, to be updated.
- peak annual mean daily flows to 1972 at 35 stream gauging locations in the Yukon Territory, arrayed in tables, plotted on Gumbel extremal probability paper, mean line and upper confidence limit drawn by fitting the two-parameter gamma probability distribution by the Method of Maximum Likelihood, published as "Magnitude of Floods in the Yukon Territory", 25 copies printed.
- seasonal drought (7-day average low flows between June 1 and September 30) to 1972 at 707 stream gauging locations in British Columbia, arrayed in tables, plotted and mean line drawn by fitting the log Pearson Type III distribution by the Method of Moments, published as "Low Flows in British Columbia, June-September Averages", 50 copies printed.
- annual drought (7-day average low flows for the whole year) to 1972 at 427 stream gauging locations in British Columbia, arrayed

in tables, plotted and mean line drawn by fitting the log Pearson Type III probability distribution by the Method of Moments, published as "Low Flows in British Columbia, Annual 7-day Averages", 50 copies printed.

- annual drought (7-day average low flows for the whole year) to 1973 at 31 stream gauging locations in the Yukon Territory, arrayed in tables, plotted and mean line drawn by fitting the log Pearson Type III probability distribution by the Method of Moments, published as "Low Flows Yukon Territory, Annual 7-day Averages", 25 copies printed.
- water temperature data, data lies dormant in our files.
- miscellaneous measurements, some data have been extracted from the files.
- area-elevation curves, utilizing the grid square file of elevation values, curves have been drawn for some 100 basins in British Columbia.
- annual runoff maps, completed for several years and distributed to the Provincial Water Investigations Branch and to Ottawa headquarters, extraction of data for 1976 will start as soon as data become available.

#### 4.3. Lay-Reader Reports

While the contents of the basic data and the processed data publications are tailored to satisfy the requirements of the technical Data User, the lay-reader report is aimed at the general public. It is intended to

educate the nontechnical reader and make the lay public increasingly aware of the functions and services of the data collection agency. It is to be presented in a format which is easily understood by the public, that is, using nontechnical words with many graphical illustrations. In the report entitled "A New Look at the Inland Waters Program - Western Region, April 1973" the Regional Director has proposed a series of reports intended for the public:

1. Basin Booklet Series "..... to educate and inform people concerning environmental management ....."
2. Hydrologic Report Series " ..... would contain all environmental baseline data in an illustrative format easily understood by the public and yet also useful for cursory assessments of environmental problems by management ....."
3. Hydrologic Atlas " .....would be an effective aid in communicating ideas and concepts to the administrative and political decision makers ....."

The series appear to be of value in a region where there is a scarcity of water and where people are very concerned with water yields, consumptive uses of water, droughts, irrigation return flows, evaporation losses and flow duration curves. It is suggested that for the present our efforts in publications should be concentrated on improving the production of basic data and processed data. If the need for lay-reader reports becomes apparent, it is suggested that a User survey be conducted to identify the audience, their data needs and desires. There is one type of compilation which may be called a lay-reader report. It is a summary report of



hydrologic information available in specified areas. Recently the Water Survey of Canada, B.C. District had been requested to produce a summary report on hydrologic data on estuarine rivers. The finished compilation contained a short introduction on the history of stream gauging in each estuary, a list of stations near the estuary and maps showing the station locations.

## REFERENCES

### 1. The Objective

Anon. 1973. A Plan for Environment Canada. Draft of Internal Working Document.

Chin, W.Q. 1971. Progress Report on Implementation of Consultants' Recommendations. Water Survey of Canada. Presented at the Annual District Engineers' Meeting, 1971.

Durrant, E.F. 1968. The Water Survey of Canada - Its Role and Objectives. Internal Manuscript.

Meyboom, P. 1972. National Networks, Environmental Monitoring, Surveys and Surveillance - a Discussion of Principles and Six Issues. Internal Document.

Hydrometric Network Planning and Forecasting Section, Ottawa. Minutes of the Studies Engineers' Meetings, 1972.

### 2. The Analysis of Basic Data

Clent, G.W. 1972. Operational Problems - Exactel Hydrogauge. Water Survey of Canada.

Fiering, M.B., B.B. Jackson. 1971. Synthetic Streams. American Geophysical Union Water Resources Monograph 1.

Hardison, C.H. 1969. Accuracy of Streamflow Characteristics. Preliminary Draft. U.S. Geological Survey.

Langbein, W.B. 1960. Hydrologic Data Networks and Methods of Extrapolating or Extending Available Hydrologic Data. W.M.O. Flood Control Series No. 15.

Leith, R.M. 1972. An Examination of the Statistics of Maximum Mean Daily Floods. Water Survey of Canada.

Leith, R.M. 1976. Statistics of Mean Annual Flow in British Columbia. In Preparation

Leith, R.M. 1974. Babine Lake Hydrometeorologic Data Inventory May 1972-May 1973. Water Survey of Canada.

Smith, A.G. 1973. Flood of June 1971, Muskwa-Fort Nelson Basin. Water Survey of Canada.

Smith, A.G. 1972. Peak Flows by the Slope-Area Method. Water Survey of Canada.

Yevjevich, V. 1972. Probability and Statistics in Hydrology. Water Resources Publications, Fort Collins, Colorado.

Water Survey of Canada. Surface Water Data Publications.

Water Survey of Canada. Surface Water Data Reference Index.

3. Hydrometric Network Planning

Creation of the Data Bank

Benson, M.A. 1968. Uniform Flood-Frequency Estimating Methods for Federal Agencies. Water Resources Research, Vol. 4, No.5, October 1968.

Chin, W.Q. 1967. Formulae and Tables for Computing and Plotting Drought Frequency Curves. Inland Waters Branch. Technical Bulletin No.8.

Coulson, A., P.N. Gross. 1967. Measurement of the Physical Characteristics of Drainage Basins. Inland Waters Branch. Technical Bulletin No.5.

Hardison, C.H., M.E. Moss. 1972. Accuracy of Low-Flow Characteristics Estimated by Correlation of Base-Flow Measurements. Geological Survey Water-Supply Paper 1542-B.

~~Matalas, N.C. 1963. Probability Distribution of Low Flows. U.S. Geological Survey Professional Paper 434-A.~~

Hydrometric Network Planning and Forecasting Section, Ottawa. 1972. Hydrologic Data Bank. Internal Document.

Riggs, H.C. 1968. Frequency Curves. Techniques of Water-Resources Investigations of the United States Geological Survey, Book 4, Chapter A2.

Water Resources Council, Washington, D.C. 1967. A Uniform Technique  
Determining Flood Flow Frequencies, Bulletin No. 15.

The Existing Network

Benson, M.A. 1972. Use of Multiple-Regression Analysis in the Design  
of a Stream-Gauging Network-Practice in the U.S.A. W.M.O.  
Casebook on Hydrological Network Design Practice.

Carter, R.W. 1970. Surface-Water Program Evaluation. Water Resources  
Division Bulletin April-June 1970.

Kreuder, W.L., A.G. Smith. 1972. A Guide to Station Evaluation. Water  
Survey of Canada.

Leith, R.M. 1975. Streamflow Regionalization in British Columbia, No. 1.  
Regression of Mean Annual Floods on Physiographic Parameters.  
IWD Report Series No. 40.

Leith, R.M. 1976. Streamflow Regionalization in British Columbia, No. 2.  
Regression of Mean Annual Flows on Physiographic Parameters.  
IWD Report Series No. 46.

Leith, R.M. 1975. Generation of Annual Runoff Data in Two Small Basins  
in Southern British Columbia by the Grid Square Technique.  
Preliminary Draft.

Riggs, H.C. 1972. Low-Flow Investigations. Techniques of Water-Resources  
Investigations of the United States Geological Survey, Book 4,  
Chapter B 1.

Riggs, H.C. 1973. Regional Analysis of Streamflow Characteristics.  
Techniques of Water-Resources Investigations of the United  
States Geological Survey, Book 4, Chapter B 3.

- Solomon, S.I., J.P. Denouvilliez, E.J. Chart, J.A. Woolley, C. Cadou.  
1968. The Use of a Square Grid System for Computer Est-  
imation of Precipitation, Temperature, and Runoff. Water  
Resources Research, Vol. 4, No. 5.
- Solomon, S.I., A.S. Qureshi, I. Korngold. 1971. Use of a Parametric  
Model as a Tool for Hydrometric Network Planning. Presented  
at the I.A.S.H. Symposium on Mathematical Modelling in  
Hydrology, Warsaw.
- Thomas, D.M., M.A. Benson. 1970. Generalization of Streamflow Character-  
istics from Drainage-Basin Characteristics. U.S. Geological  
Survey Water Supply Paper 1975.
- Thomas, D.M., M.A. Benson. 1965. Streamflow Generalization in the Potomac  
River Basin. Administrative Report. U.S. Geological Survey.
- Tywoniuk, N., K. Wiebe. 1970. Application of Regression Analysis in  
Hydrology. Inland Waters Branch Technical Bulletin No. 24.

#### The Proposed Network

- Carter, R.W., M.A. Benson. 1969. Concepts for the Design of Streamflow  
Data Programs. Open File Report. U.S. Geological Survey.
- Dawdy, D.R., M. E. Moss, N.C. Matalas. 1972. Application of Systems  
Analysis of Network Design. W.M.O. Casebook on Hydrological  
Network Design Practice.
- Kreuder, W.L., A.G. Smith. 1975. Major Stream Inventory Network for  
British Columbia and Yukon Territory. Internal Document.
- Matalas, N.C. 1967. Optimum Gaging Station Location. ASCE Hydraulics  
Publication.
- Network Planning and Forecasting Section, Ottawa. 1972. Station Class-  
ification. Internal Document.

Shawinigan Engineering Co. Ltd. 1970. Hydrometric Network Planning Study for Western and Northern Canada. Report No. 5019-1-70 for Water Survey of Canada.

Solomon, S.I. 1972. Multi-Regionalization and Network Strategy. W.M.O. Casebook on Hydrological Network Design Practice.

4. Publication of Specific Data

Feth, J.H. 1972. WRD Report-User Survey, Oregon - A Trial Balloon. Published in Water Resources Division Bulletin July-December 1972.

Inland Waters Directorate, Western Region. 1973. A New Look at the Inland Waters Program - Western Region. Internal Document.