THE SAINT JOHN BASIN WMO/WWW PROJECT

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INTRODUCTION

The World Weather Watch (WWW) is one of four major programs of the World Meteorological Organization. Its primary purpose is to provide all member countries with "the basic meteorological and other related environmental information they require in order to enjoy the most efficient and effective meteorological services possible, both as regards the applications of meteorology and research" (WMO, 1975).

The WWW Consists of three major components: The Global Observing System (GOS), the Global Data Processing System (GDPS) and the Global Telecommunication System (GTS). The three main types of meteorological centres under the GDPS are the World Meteorological Centres (WMC's) at Melbourne, Moscow and Washington, the Regional Meteorological Centres (RMC's), of which there are 23, and the National Meteorological Centres (NMC's) of WMO member states. The Canadian Meteorological Centre at Montreal serves as both an RMC and an NMC.

The World Meteorological Organization's Commission for Hydrology in 1972 appointed the author CHy Rapporteur on Application of WWW to Hydrology and subsequently took action on his recommendation that "pilot projects" be set up in international basins to study such applications in a practical framework. Such studies are now in progress in the Saint John, Rhine, Danube and Niger basins and are likely to be initiated soon in other international basins. WMO has recently published a document based on the Rapporteur's report (WMO, 1976).

The Saint John Basin WMO/WWW project was initiated jointly by Canada and the United States in 1974. A Steering Committee consisting of 4 members from each country held its first meeting in February, 1975, to formulate objectives, to estimate resource requirements and to determine appropriate mechanisms for carrying out the work. At its second meeting in April, 1975, the Steering Committee developed a work schedule including tasks to be carried out and their time constraints. It appointed a Task Force with representatives from all Canadian and U.S. agencies involved and assigned responsibilities for tasks. The organization of the project is depicted in Fig. 1 and a list of cooperating agencies is given in Table 1.

Objectives and Tasks

The objectives of the study are as follows:

1) To evaluate the various components of WWW, as they now exist, with respect to their usefulness in hydrologic forecasting:

   a) observing systems

   b) communications

   c) WMO Regional Meteorological Centre output

Table 1. Canadian and U.S. agencies involved in the Saint John Basin WMO/WWW Project

Canada	
Department of Fisheries and Environment	*- Atmospheric Environment Service (AES)*
	- Environmental Management Service (EMS)
New Brunswick Department of the Environment	
New Brunswick Electric Power Commission	
Quebec Department of Natural Resources	

U.S.A.	
National Oceanic and Atmospheric Administration	*- National Weather Service (NWS)*
	- National Environmental Satellite Service (NESS)
Corps of Engineers	
Geological Survey	
Maine Civil Emergency Preparedness	

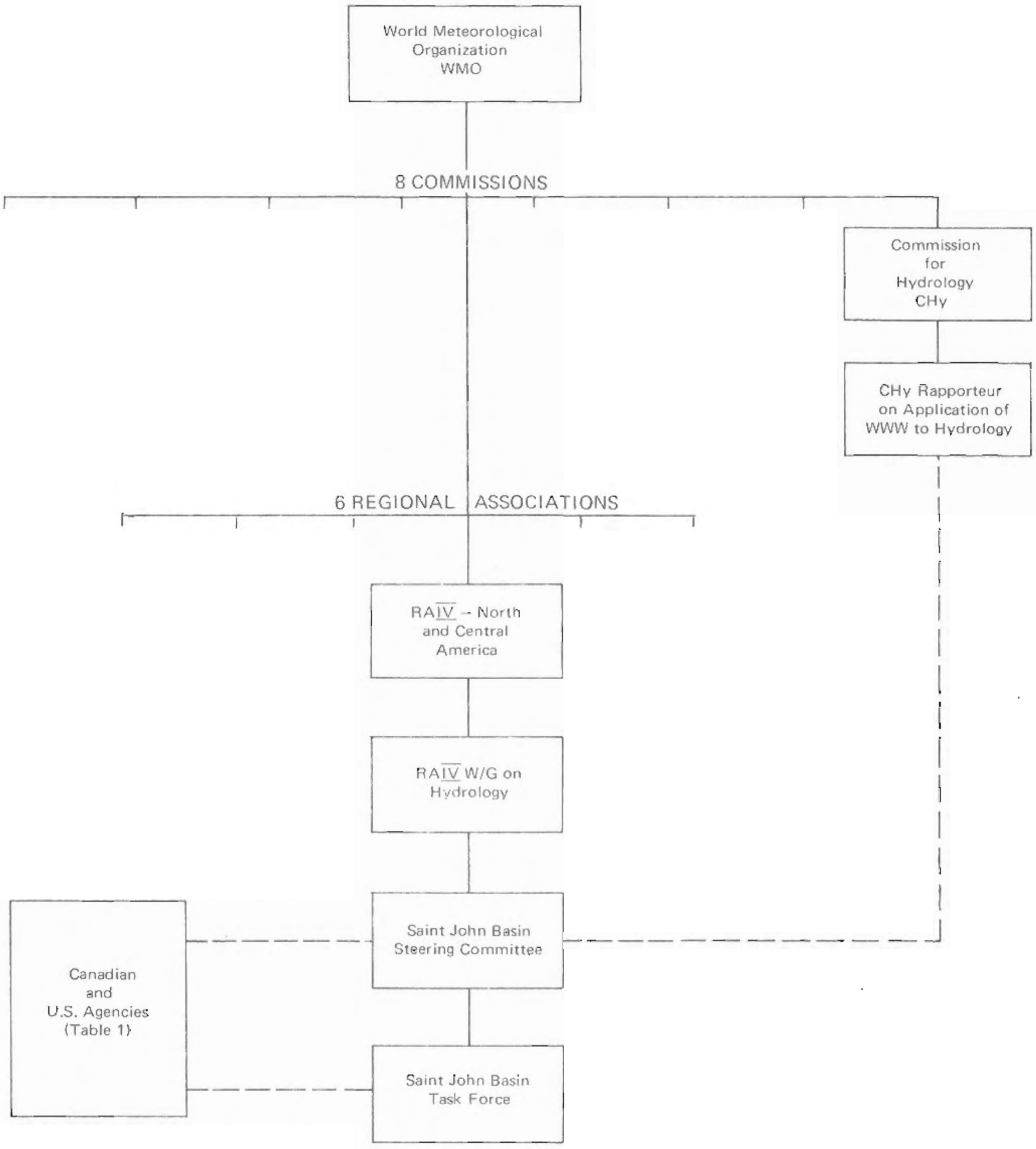

Figure 1. Organization of the Saint John Basin WMO/WWW Project.

including analyses and forecasts (such as QPF)

d) local tailoring of WMO Regional Meteorological Centre output including analyses, forecasts, advisories and warnings

e) supporting research and development

2) To determine improvements necessary in (1) above to meet the requirements of hydrologic forecasting; to implement and test as many of these as feasible

3) To prepare reports for WMO RA IV and CHy Rapporteur paying particular attention to those aspects dealing with WMO Regional Meteorological Centres and international co-operation.

To meet these objectives the following tasks are being carried out:

1) Compile a catalogue of historic data available

2) Compile a summary of present information available at Fredericton in "real time" and the communication links for obtaining this information (data, analyses, forecasts)

3) Review and evaluate the SSARR model in present operational use at Fredericton (accuracy, error analyses, sensitivity, data gaps or needs, possible extension to year-round operation, etc.)

4) *Evaluate other hydrologic models for potential application to the Saint John Basin based on historical data*

5) *If appropriate test and evaluate other models in an operational mode and compare results with the SSARR model*

6) *Investigate other specific hydrologic problems (ice jams, low flow forecasting, etc.)*

7) *Prepare preliminary report*

8) *Implement changes in systems as feasible (observations, communications, analyses and forecasts)*

9) *Prepare final report*

Tasks (1) (2) and (7) have been completed. The preliminary report was presented at WMO/CHy-V in Ottawa in July, 1976 (DOC. #62) and will also serve as the basis for a report to the WMO Region IV meeting in Mexico City in 1977. The remaining tasks are considered to be progressing on schedule.

The target date for completion of the study is December, 1977. It is anticipated that the procedures and co-ordinating mechanisms established during the study may continue to be useful for operational purposes thereafter. Recommendations for basin network enhancement and studies to support and improve operational programs may take a number of years to implement.

Snowfall and Snowcover Aspects of the Study

Floods are a common occurrence in the Saint John Basin and are usually associated with the Spring snowmelt. Measurements of snowfall and late season snow cover are therefore of primary importance to the Flood Forecast Centre in Fredericton. Since 1973 the Centre has issued routine river forecasts, based on the SSARR model, for the two-month snowmelt period from March 15 to May 15. A schematic of the SSARR model is shown in Fig. 2. The existing snowfall and snowcover networks are shown in Fig. 3. It should be noted that not all data from these locations are available in "real time". The Atmospheric Environment Service is carrying out a number of studies dealing with snowfall, snowcover, and snowmelt in the Saint John Basin.

In one study (Pugsley, 1976) a physical equation relating precipitation rate to slope, aspect, available atmospheric moisture and frequency of wind from each direction was applied at 10 km intervals over the basin. The statistical variation of the computed terrain-induced precipitation can be used to estimate network density requirements on a seasonal basis. Fig. 4 depicts the number of measurements required in a 50 km x 50 km area to reduce the error of estimate of the winter season areal precipitation to 20%. The total number of measurements required for the entire basin would be 392, compared to the existing network of 167 precipitation stations and 69 snow courses. In this approach, no account is taken of the implications of point measure-

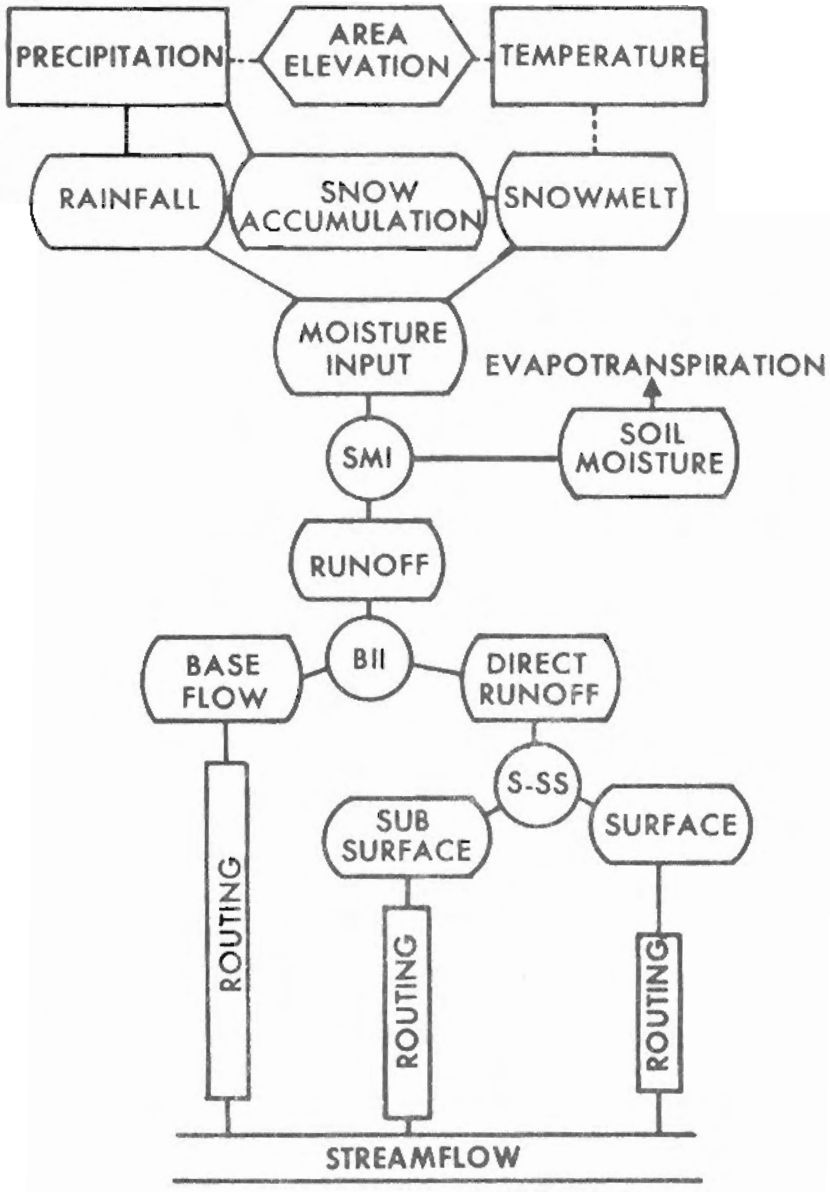

Figure 2. The SSARR Watershed Model (U.S. Army, 1972).

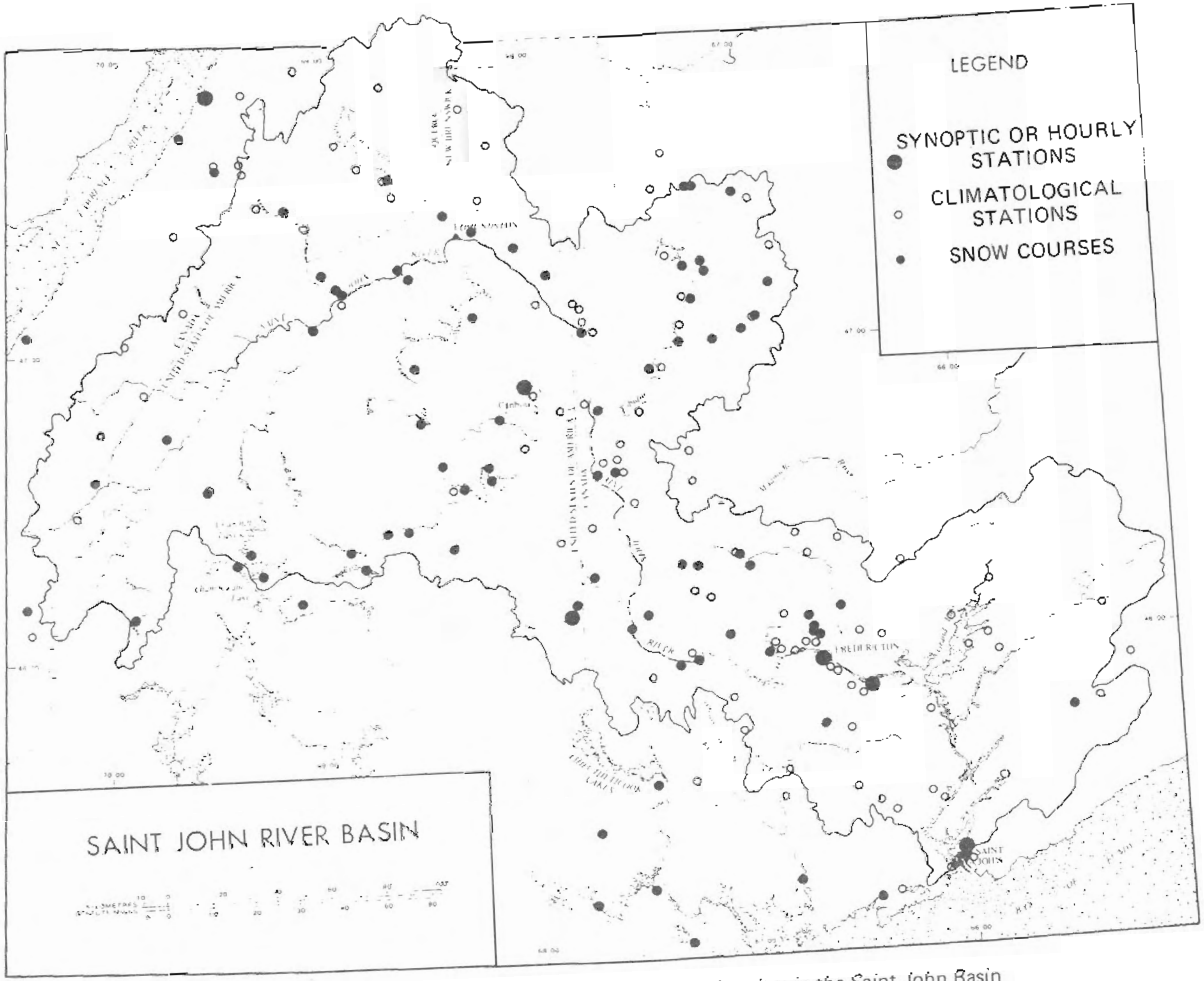

Figure 3. Locations of snow courses and weather observing sites in the Saint John Basin (Ferguson and Lapczak, 1976).

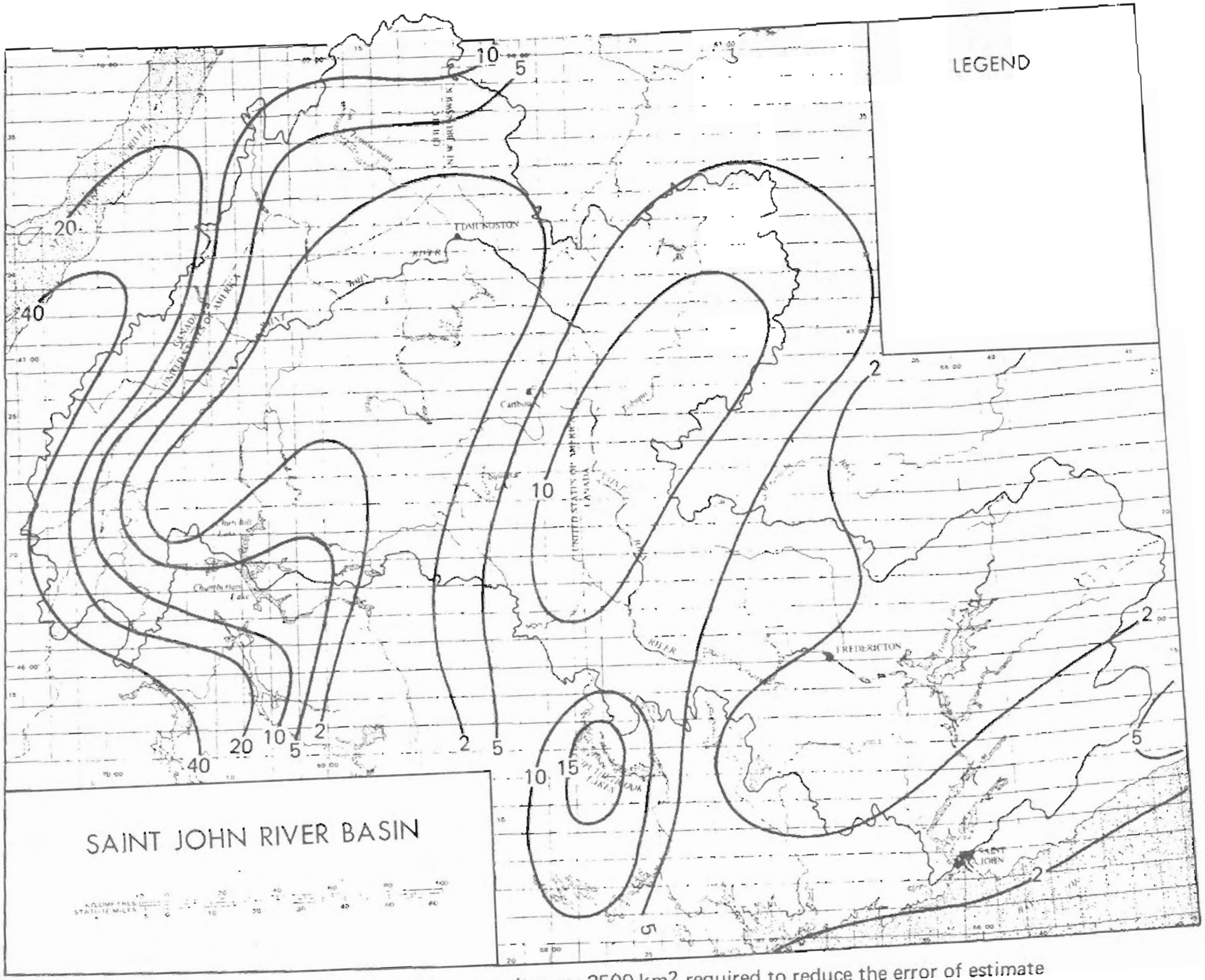

Figure 4. Number of measurement sites per 2500 km^2 required to reduce the error of estimate of winter season areal precipitation to 20% (Pugsley, 1976).

ment errors. On the other hand the analysis does not employ observed precipitation data and so is not limited by existing data gaps. The 10 km grid used in the analysis is also shown in Fig. 4. Cover and physiographic data for the grid squares have been published by the Department of Energy Mines and Resources (1970).

A second study (Pugsley, 1976) makes direct use of observed daily precipitation from 34 stations reporting in real-time to the Flood Forecast Centre. From correlations between all pairs of these stations over 55 storm days in March and April, 1970 and 1971, a statistical measure of the areal representativeness of each station was obtained, as well as the error involved in computing basin precipitation. Results can be depicted in the form of a "data gap" map as shown in Fig. 5. The representativeness of each station for the purpose of obtaining storm precipitation within 2.5 mm is described by the circles drawn around the data points. The areas not covered by the circles can be interpreted as data gaps which would have to be filled to obtain basin storm precipitation within 2.5 mm. When a smaller error constraint is imposed (eg. 1 mm) the circles are, of course, smaller and the data gaps larger. Such maps can be very helpful in pinpointing those areas where additional gauges are needed to achieve a given level of accuracy in estimating total basin (or sub-basin) precipitation for a given period.

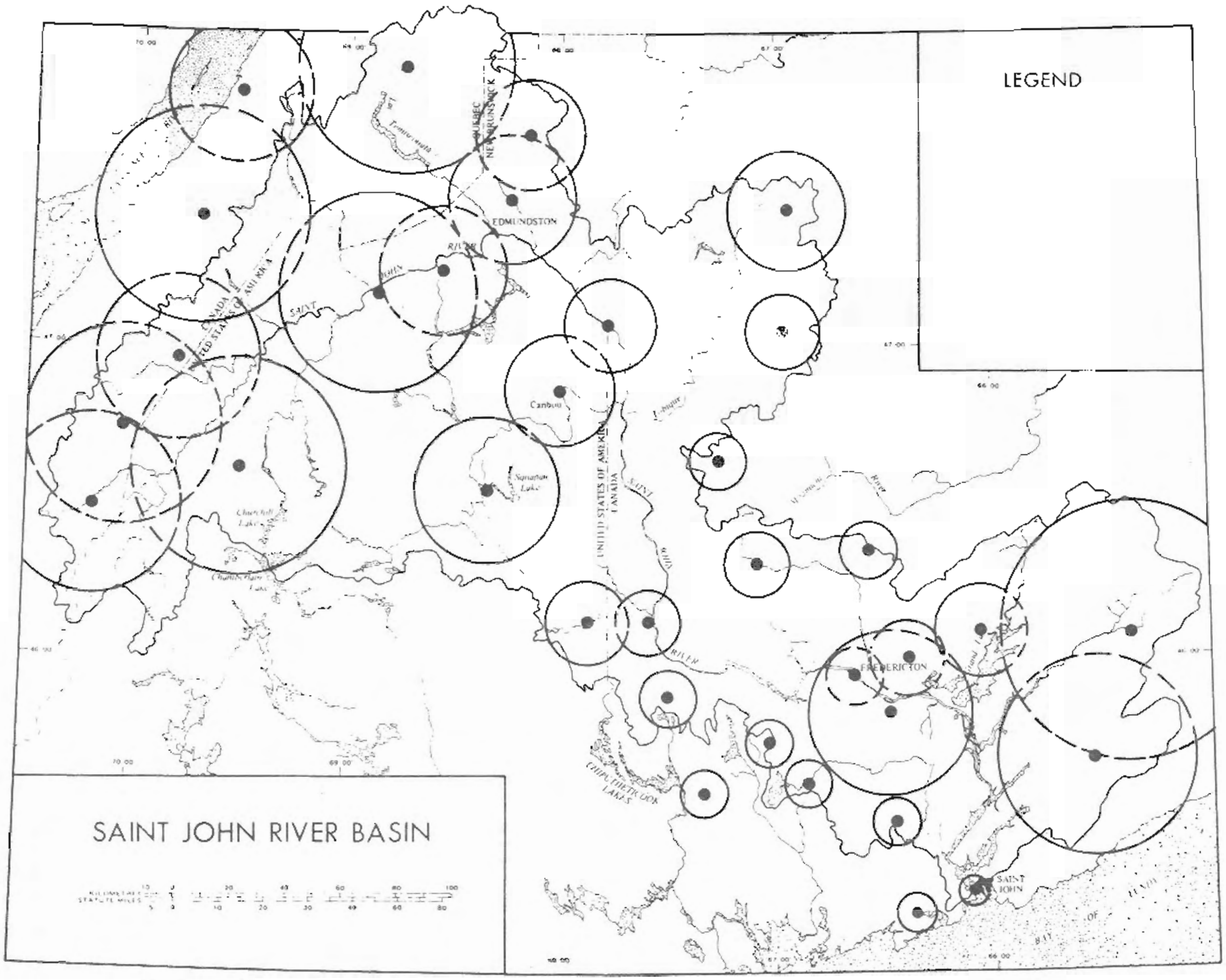

Figure 5. Data gaps in the real-time precipitation network for estimating basin storm precipitation within 2.5 mm, based on data for March and April, 1970 and 1971. Each circle represents the areal representativeness of a station for this accuracy level (Pugsley, 1976).

A third study deals with the accuracies of precipitation and temperature forecasts provided to the Flood Forecast Centre by the Atmospheric Environment Service. During the 1977 snowmelt season the WWW Regional Meteorological Centre in Montreal and the Halifax Weather Office will be providing augmented forecast services.

In a fourth study the sensitivity of various snowmelt equations to meteorological inputs is being examined. This investigation will reveal how accurately the meteorological variables (observations, forecasts) such as temperature, radiation, etc., must be specified to obtain, for example, daily snowmelt within 1 cm.

A fifth study (Trivett, 1976) is examining the relationships between physiography and precipitation using the grid-square approach. Regression equations have been developed for mean seasonal precipitation. Independent variables in the regression equations include elevation, distance to the sea, slope, azimuth and barrier height. These equations can be used to compute mean seasonal precipitation for all 657 (10 km x 10 km) grid areas in the basin. Such relationships may also be useful to estimate monthly and shorter-period precipitation for all grid squares based on station data, and for studying network efficiency of redundancy with a view to optimum enhancement. Fig. 6 illustrates the distribution of precipitation stations with elevation in the Saint John Basin. The relative sparseness of data at higher elevations can create problems in developing statistically reliable regression equations.

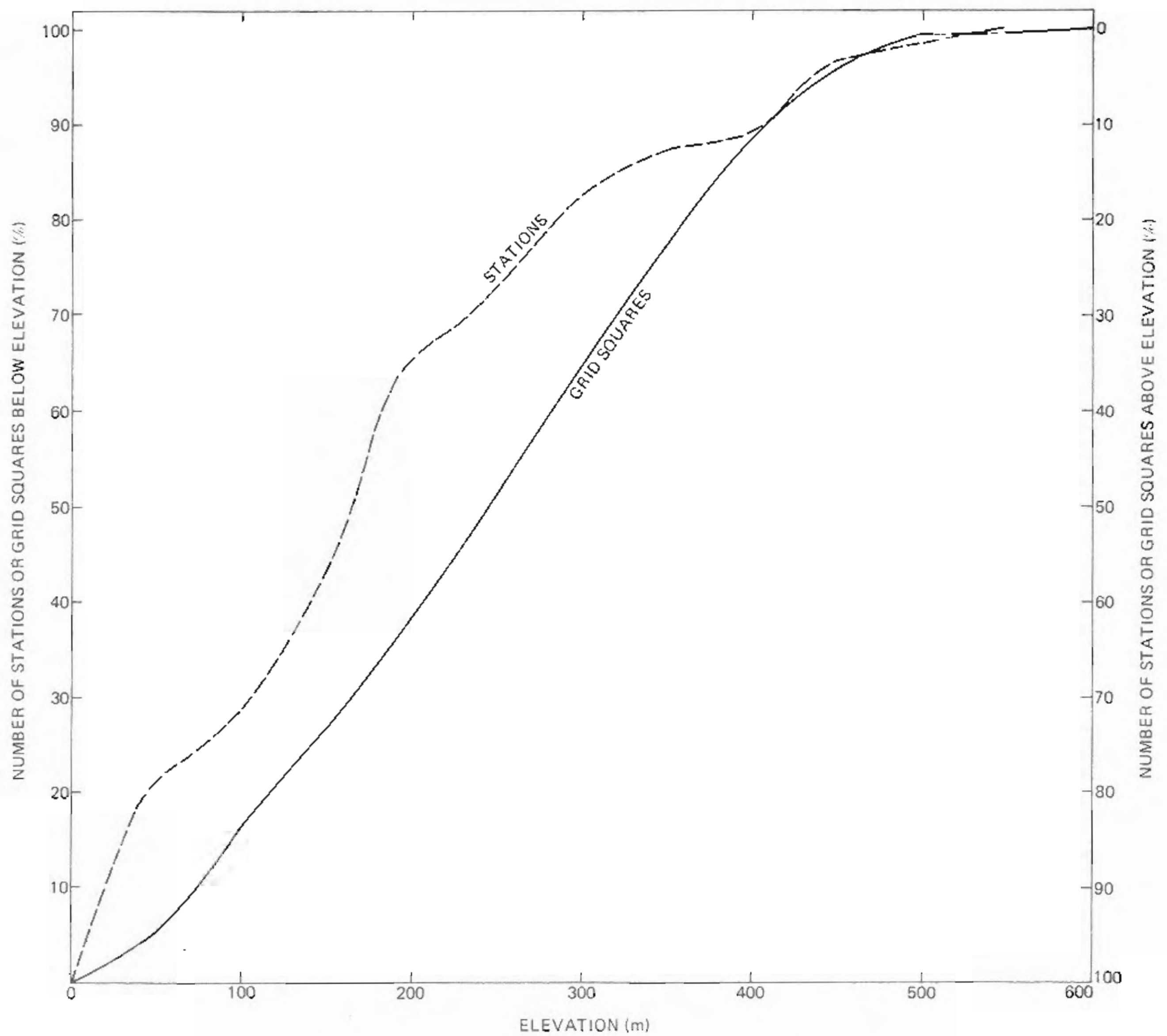

Figure 6. Distribution of climatological network precipitation stations and 10 km x 10 km grid squares with elevation in the Saint John Basin.

Satellite imagery for the Saint John Basin is being analysed operationally by the National Environmental Satellite Service in Washington and the use of this information has been described by Hansen (1975). In 1976 four analyses were obtained by telephone photocopier during the period April 6 to April 29. These analyses are in the form of maps showing the area of snowcover for the total basin, and are normally available 24 to 30 hours after the NOAA satellite pass. At Fredericton the basin maps were used to obtain percentage snowcover values for 32 sub-basins. These values were compared with values generated by the SSARR model and with available snow course data. Where necessary, model values were adjusted to conform to the latest satellite and snow course information. The satellite analyses when used as part of a total observing system have been found operationally useful. Further research on applications of NOAA VHRR and LANDSAT data(when available) to the Saint John Basin is being carried out by the Atmospheric Environment Service (Ferguson and Lapczak, 1976). The NOAA VHRR visible data are received daily at AES Headquarters in Downsview. Programs have been developed to enhance the imagery for snow cover analysis. An Image Analyzer and Zoom Transfer Scope are used for density slicing and mapping of snow cover. The principal problem is the dense forest which covers more than 80% of the basin. In the case of dense coniferous stands (which predominate) when the crown closure is near 100%, the snowcover beneath the trees cannot be seen. However, over most of the basin, by analyzing a time sequence of images and by paying particular attention to large cleared areas and available ground truth information, consistent analyses can be obtained. A wellmarked continuous snowline is not usually observed. Between areas of complete snow cover and no snow cover there is normally a transition zone of partial cover. During the melt season in this zone the cleared areas may be snow free while some snow cover remains in the treed areas. It is sometimes difficult to determine snow cover in agricultural areas adjacent to the main rivers because of the light colour of the soil. Fig. 7 is an example of snow cover analysis produced from NOAA-4 imagery on April 29, 1976. An analysis based on conventional snow course data collected during the period April 27-29 is shown for comparison in Fig. 8. The 5 cm line of Fig. 8 is generally in the transition zone (snow in forest) of Fig. 7. It is suggested that by combining the snow course data with the imagery analysis, a somewhat modified and probably improved isopleth configuration would be obtained.

Because of the particular problems of interpreting imagery for snow cover analysis over natural areas of complex vegetative cover, it is suggested that future experiments should initially concentrate on selected target areas where cover types are simple and well-documented. Forest plantations, operated by forestry services, and agricultural stations should provide excellent targets of this kind and plans are being developed by AES and EMS to conduct studies over such areas in the Saint John Basin in 1977 using synthetic aperture side-looking airborne radar and satellite data.

Conclusion

The WMO/WWW Saint John Basin Project, initiated in 1974, is an excellent example of international and interdisciplinary co-operation. One benefit already discernible is the systematic co-ordination of efforts of Canadian

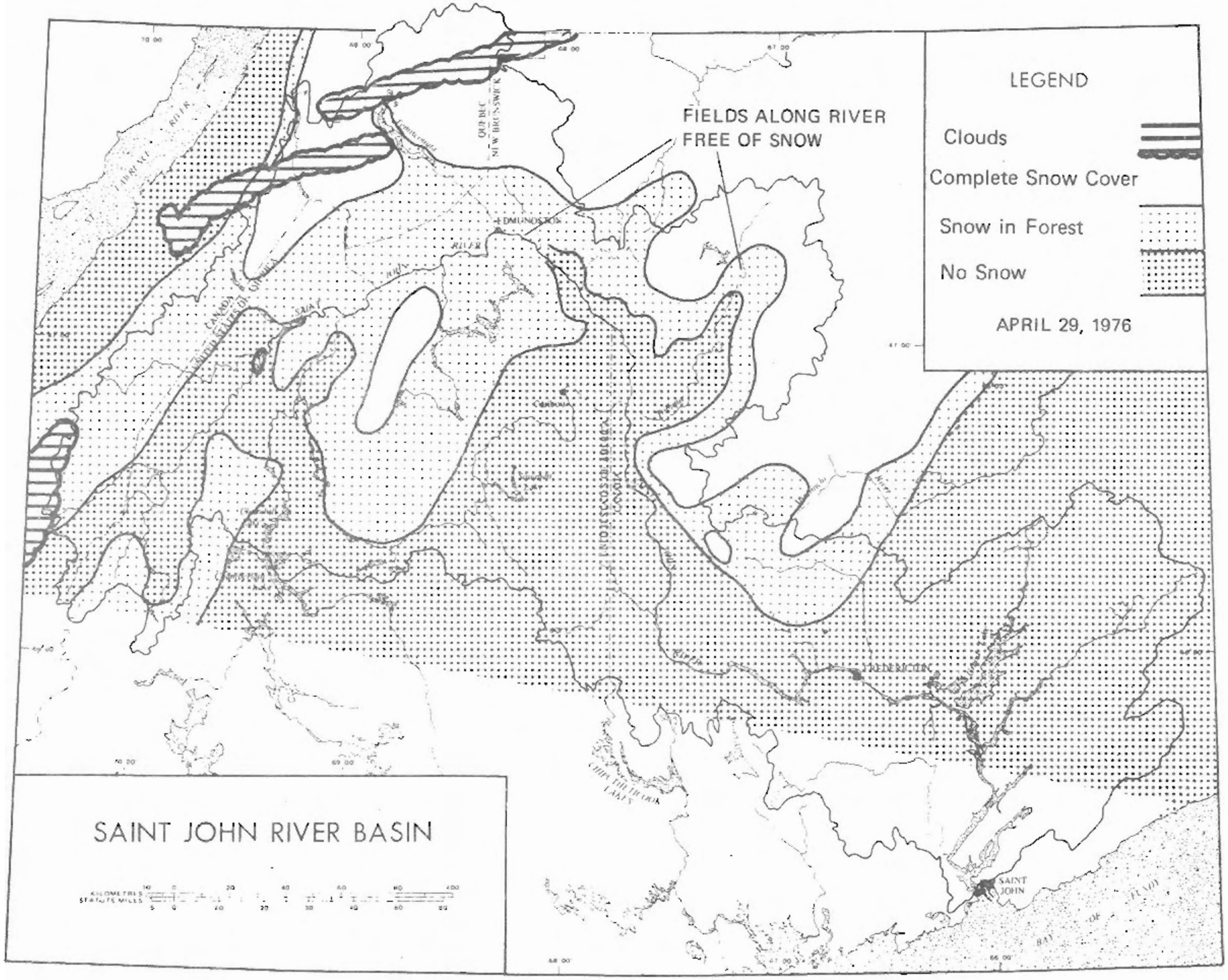

Figure 7. Analysis of snow cover on April 29, 1976, based on NOAA-4 VHRR data (Ferguson and Lapczak, 1976).

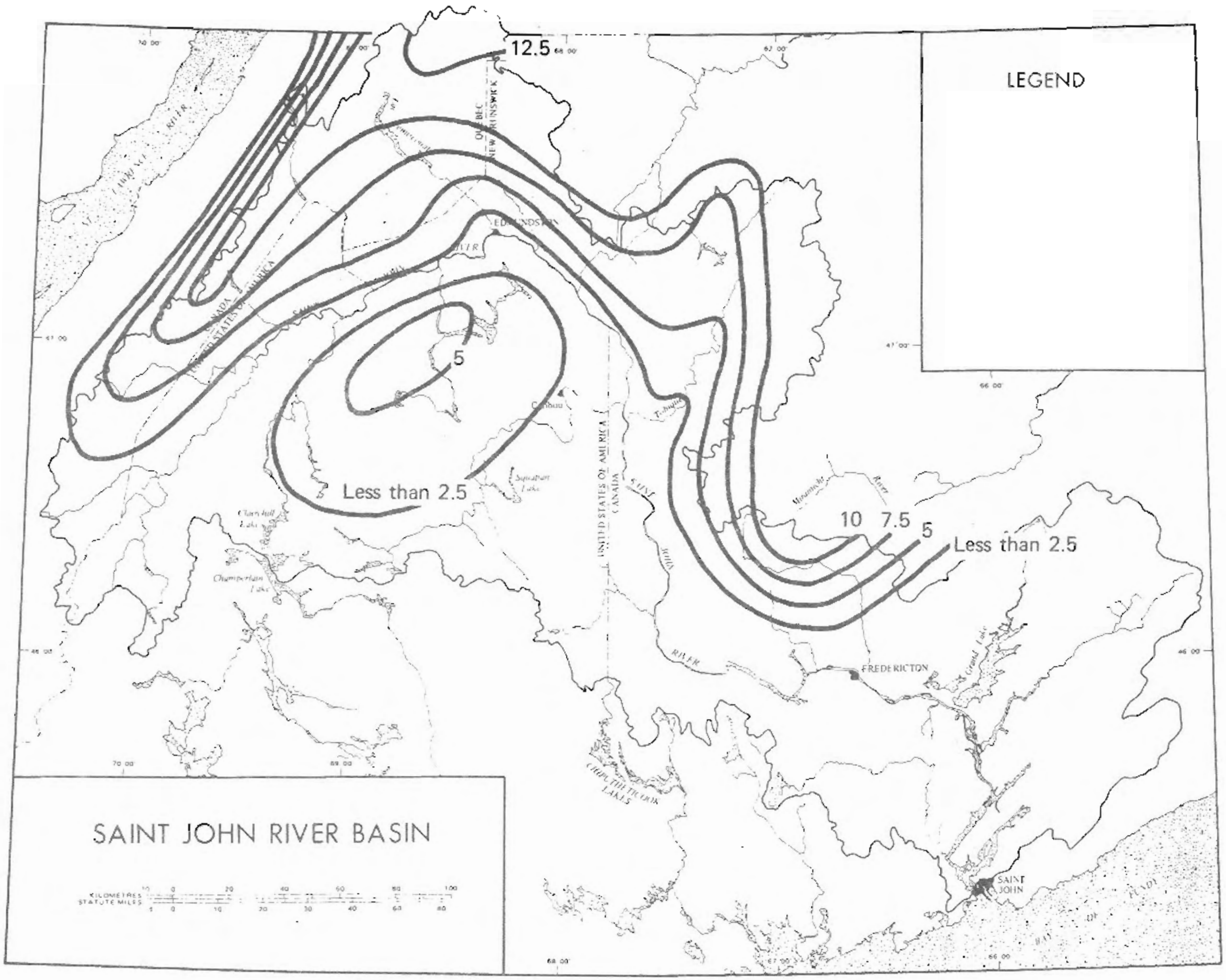

Figure 8. Analysis of snowpack water equivalent (cm) based on snow course data April 27–29, 1976 (Courtesy of P. Hansen, New Brunswick Dept. of Environment).

and U.S. agencies with the common objective of improving the application of meteorological information to practical hydrological problems in the basin.

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