SNOW SURVEY IN CANADA AND THE UNITED STATES - A PANEL DISCUSSION

In 1983/84, the ESC Executive became concerned about the deterioration in snow survey programs which appeared to be occurring in both the United States and Canada. It began a campaign to draw attention to this problem involving petitions to various political levels, publicity and this Panel Discussion.

The Panel was to have been chaired by Dr. Nabil Elhadi of the Surface Water Section, Water Resources Branch, Environment New Brunswick. Unfortunately Nabil, who had done all preliminary work on the session, was ill at the time of the Conference and Peter Adams, Watershed Ecosystems Programme, Trent University, Peterborough, Ontario and the Association of Canadian Universities for Northern Studies, took the chair.

The panellists were, in order of speaking, Dave Harvey, Water Resources Branch, IWD, Environment Canada; Barry Goodison, Atmospheric Environment Service Canada, Al Kachic and Tom Carroll, National Weather Service, U.S.A.; Jerry Lockhart, Canada-N.B. Flood Damage Reduction Program, Environment New Brunswick.

The following is a summary of the panellists' statements followed by a transcript of some of the comments from the floor.

Dave Harvey, Water Resources Branch, Inland Waters Directorate, Environment Canada

Snow Surveys of Inland Waters Directorate (IWD), Environment Canada

At an IWD Directors' meeting in March, 1984, discussion on IWD involvement in snow and ice led to an agreement that, pending further consideration of the issue, snow survey work should continue in those areas where there is an identified need, but that IWD should cease activities in all other areas. As a result, this past winter, IWD conducted snow surveys in only 2 areas during the winter of 1984-85: the Lake of Woods Watershed (13 courses) and the St. John River Basin (9 courses).

IWD has been collecting and publishing snow survey data in some regions of Canada since 1922. The number of IWD snow courses peaked in 1976 at 175 courses, about 15% of Canada's total number of snow courses. There has been a noticeable decline since.

What has caused this decline? Reductions in the number of IWD snow courses have been the combined result of four factors:

1. Increased resource constraints;
2. A diminishing profile within IWD of the snow survey program relative to the national hydrometric data collection program;
3. A lack of clearly identified users and benefits of the snow data; and
4. Uncertainty as to whether the collection of snow survey data is within IWD's mandate.

IWD is currently in a period of transition with respect to snow surveys, but the question remains "a transition to what?" IWD is definitely interested in a snow survey program but feels that the re-establishment of the snow course network which was formally operated by the Water Survey of Canada would not prove to be the most meaningful way of providing the data necessary to improve the management of snow in Canada. Currently, 19 agencies are independently operating snow courses across Canada. This fragmented approach has led to a disparity in sampling equipment and procedures which, in turn, has yielded data of questionable comparability. As well, non-standard analytical procedures and models, used to relate snow data to runoff potential, give inconsistent results. There is little doubt that the lack of a more comprehensive network providing accurate estimates of snow properties has inhibited progress in basic research and in the development of improved measurement and analysis techniques.

Clearly, a more comprehensive and co-ordinated national program is needed. Such a program should ensure the standardization of data collection, analysis and dissemination procedures while at the same time ensuring the introduction of modern techniques.

Such a program should also be responsive to the needs of the water resources community and other users, and it should promote the development of the necessary expertise to apply knowledge gained from basic research to the analysis and interpretation of snow data and thereby provide the information needed by water resources managers. The identification of all potential users and benefits of snow data and arrangements for cost-sharing and/or cost-recovery are considered essential to the successful implementation of such a program.

Having said that, how to effect such a fundamental change? The on-going Inquiry on Federal Water Policy presented a timely opportunity for IWD and others to identify the problem and make recommendations regarding snow data. Next October, the Committee of Canadian Resource and Environment Ministers (CCREM) will meet to deal with the recommendations put forth by the Federal Inquiry. In conjunction with this, IWD is most interested in promoting information exchange in forums such as the Eastern Snow Conference, and will give serious consideration to any recommendations which result from these meetings. As well, snow survey data users are requested to provide information to IWD on data requirements and their opinions with respect to the availability and usefulness of these data. Such recommendations could provide additional input in support of Inquiry recommendations next October.

Barry Goodison, Atmospheric Environment Service, Canada

Snow Survey Program of the Atmospheric Environment Service

Within the Atmospheric Environment Service, there is a Snow Measurement Co-ordinating Committee (SMCC), which serves as a focus for co-ordinating, reviewing, and providing advice on AES programs related to snowfall and snow cover measurement. Given present concerns about snow course operations, SMCC reviewed the current status of AES snow survey operations. A summary of AES activities which relate to standards, network operations, equipment and publication of data is outlined below. It should be realized, however, that all activities are always subject to continued review and possible change to meet revised priorities.

AES operates the only national snow course network, surveying 130 courses in 1982-83 across Canada. All stations take observations twice monthly and many make weekly observations. This network was initiated in 1962 at principal weather stations, where observers were full time employees of the Meteorological Branch or Department of National Defence. The courses were established to provide information not only for water resources, but also for agriculture productivity, water-fowl populations and snow load calculations. A recent review of the AES snow course operations showed that the costs to operate the network were relatively low compared to other operational costs. At the moment, no action to reduce the network is being planned.

AES has published an operations manual on snow surveying, which outlines standard snow course procedures, including guidance on site selection, and the use, maintenance and calibration of standard equipment. Although primarily intended to meet AES operational needs, it can also serve as a useful reference for other operators. The equipment described in the manual is the Federal sampler used in deep packs and the MSC which is used in shallow snowpacks.

AES is in the process of replacing this equipment with new metric samplers, following the recommendations of the Western Snow Conference Metrication Committee. AES initiated the changeover in 1984. Blueprints for the new metric samplers have been completed. The first order of small diameter metric samplers and spring balances have been received, passed inspection and put into operation at stations requiring new equipment. The cutter design has not yet been changed and it is still that of the Federal sampler. Cutters will be changed when other snow survey agencies change their cutters. The first ESC-30 samplers for replacing the MSC samplers have been acquired and will be deployed when new spring balances are available.

The AES publication Snow Cover Data summarizes snow course data collected in Canada by 19 operating agencies. As there is no national digital archive of these data, this

publication provides the only compilation of data collected by all agencies. AES is currently planning to change the method and format of the publication and a computer compatible archive is being created. All AES publications are being reviewed as part of the revenue generation policy; Snow Cover Data is yet to be assessed for its cost effectiveness. Creation of a digital archive from which the data could be easily accessed is one alternative to formal publication.

During the review of AES programs, such as snow surveys, the questions "who are the users" and "what are the data used for" are commonly asked. AES would benefit by having written documentation from users on the value of these data. Users are urged to write to the Director, Climatological Applications Branch, Canadian Climate Centre (Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, M3H 5T4) outlining the benefits and use of these data. Justification for continuing these programs would be assisted by such action.

Al Kachic and Tom Carroll, National Weather Service

Snow Survey Program of the National Weather Service

Operationally, snow survey data is used by the National Weather Service (NWS) for our water supply and Flood Forecast and Warning programs.

In the east, the NWS does not operate any snow courses. We depend heavily upon the snow and water equivalent data provided by the Corps of Engineers, the U.S. Geological Survey, power companies and other agencies. We obtain some snow-water equivalent data from our basic hydrologic river and rainfall reporting network. This data is reported every Tuesday and Friday when there is two inches or more of snow on the ground. The equipment is either a Green fiber glass snow sampler or the standard NWS rain gage provided with a sharp edge to facilitate cutting a "cookie".

Techniques have been developed in the United States and Canada to estimate snow water equivalent and surface soil moisture using airborne measurements of natural terrestrial gamma radiation over a flight line. The Airborne Snow Survey began operations in the mid-west. In the last two years, operational flights have been conducted in the east. These were primarily in the St. John River Basin (U.S.-Canada), Black and Mohawk River Basin in New York and Lake Champlain.

Dr. Tom Carroll, Program Leader of the Airborne Snow Survey Program will give a summary of the theory and operations.

In the U.S. the airborne gamma radiation snow measurement technique is considered fully operational and river and flood forecasts are routinely made using the operational airborne snow water equivalent data. The current flight line network consists of 1,000 flight lines over 15 states and 4 Canadian provinces. In 1985 during the January through mid-April period, 500 airborne snow water equivalent measurements were made and disseminated in real-time to the National Weather Service Forecast Centers and Weather Service Forecast Offices.

Natural terrestrial gamma radiation sensed from a twin-engine Aero Commander flying at 150 m is used to infer mean areal snow water equivalent over a network of 1,000 flight lines. Each flight line is approximately 20 km long and 300 m wide. Consequently, the airborne measurement is a mean areal measure over approximately 6 sq. km. The gamma radiation flux near the ground originates primarily from the potassium, uranium, and thallium radioisotopes in the soil. In a typical soil, 96 percent of the gamma radiation is emitted from the top 20 cm. After a measure of the background (now snow cover) radiation and soil moisture is made over a specific flight line, the attenuation of the radiation signal due to the snow pack overburden is used to calculate the amount of water in the snow cover over approximately 6 sq. km. Three snow water equivalent values are calculated by measuring the attenuation of the gamma radiation flux using data from the potassium window (1.36-1.56 MeV), the thallium window (2.41-2.81 MeV), and the gross count energy spectrum (0.41-3.0 MeV). The potassium photopeak is consistently the strongest in the

energy spectrum and has been used successfully to measure snow water equivalent in Canada and in the U.S. The gross count window accumulates an order of magnitude more counts than the potassium or thallium photopeak windows. Consequently, gross counts are useful when measuring the variability of snow cover along a flight line or a snow cover with 30 to 50 cm of snow water equivalent.

Snow survey flights are scheduled for two Aero Commander aircraft during the January through mid-April period. The flight lines to be flown are based on snow cover conditions and the threat of snowmelt flooding for a particular region. Approximately 30 to 50 airborne snow water equivalent measurements can be made per day and are transmitted to the Weather Service Offices over the AFOS network approximately two hours after each aircraft lands at noon and in the evenings. In this way, it is possible for end users to have access to the airborne snow water equivalent data which are typically only two hours old.

The technique can be used to make airborne snow water equivalent measurements with a Root Mean Square error of 8 mm over agricultural environments and a Root Mean Square error of 25 mm of snow water equivalent over forested environments. In addition, the technique can be used to make airborne soil moisture measurements for the upper 20 cm with a Root Mean Square error of 5 percent soil moisture once a flight line has been calibrated.

References, copies of recent publications, and further information will be provided upon request from Dr. Tom Carroll, Airborne Snow Survey Program, National Weather Service, 6301 34th Avenue South, Minneapolis, MN 55450, phone 612/725-3039.

Jerry Lockhart, Environment New Brunswick

The New Brunswick View of IWD Snow Survey Reductions

With respect to the proposed termination of snow surveys in New Brunswick by the Inland Waters Directorate, we were pleased to learn that the snow survey network within the Saint John River Basin is to be maintained because it is essential to the successful functioning of the Federal/Provincial Saint John River Forecast Centre. However, we are concerned about the discontinuance of the remaining snow survey network in New Brunswick and elsewhere and strongly recommend that this decision be reconsidered.

In this regard, we would note the following:-

1. Approximately 30% of the annual total precipitation in New Brunswick occurs in the form of snow.
2. The only measurement of snow, other than by snow surveys, is carried out at six of the Atmospheric Environment Service Primary and Secondary Climatological Stations where new fallen snow and snow depths are measured within the proximity of the instrument site. The water equivalent of new fallen snow is calculated at the Primary Stations but only a few of the Secondary Stations perform this task. However, the water equivalent of the snow pack, which is of prime concern to the River Forecast Centre and many other users of snow survey data, is not measured at any of these locations.
3. Both AES and IWD have large programs and specific mandates for monitoring weather and surface water but neither have a clear mandate to monitor the water equivalent of the snow pack - one of the most important elements in the hydrologic cycle.
4. Some survey locations in the Province have been monitored annually for up to 25 years and like climatic and hydrometric data, the usefulness of snow pack data in the future will be greatly enhanced if long-term continuous records are available.
5. With the current high level of interest being shown in long-term climate change, receding ice caps, acid rain, greenhouse effect, etc., knowledge of the snow pack will surely be of great interest to scientists in the future. The importance of snow pack records to the user community is evidenced by the following:-

    a. Some agencies have been carrying out surveys for over 30 years;
    b. Nine public and private agencies in New Brunswick, Maine and Quebec provide survey results to the Saint John River Forecast Centre upwards of six times a year;

c. These agencies collect the data largely for their own needs. In most cases its use by the River Forecast Centre is secondary to the main purpose of the surveys;
d. The Eastern Snow Conference which has upwards of 300 members concerned with all aspects of snow in eastern Canada and the U.S. has promoted and coordinated snow surveys for over 30 years. They have also been actively involved in developing new techniques and instrumentation for carrying out snow surveys;
e. The National Weather Service and the National Hydrology Research Institute have spent large sums on the development of the airborne gamma radiation techniques for measuring the water equivalent of the snow pack indicating a high degree of interest in snow pack information.

6. The uses for this information are many and varied, and there should be Federal interest in the following:

flow and flood forecasting
hydro electric development
building (roof) design
airport location and construction
highway location and construction
recreational developments

7. The cost of carrying out snow surveys by IWD is relatively small since the surveys are normally performed by their field crews when they are on routine trips to the areas to carry out hydrometric surveys.

In view of the above it is recommended that: -

1. A mandate for snow pack data collection and archiving be firmly defined and established with the Inland Waters Directorate.
2. Inland Waters Directorate review and continue its current programs of snow surveys considering expansion of their provincial networks as funding permits.
3. Federal research groups such as the National Hydrology Research Institute and the National Water Research Institute be encouraged to develop new instrumentation and measurement techniques for snow pack measurement including investigation of airborne remote sensing techniques utilizing conventional aircraft and satellites.

It is possible that at some time in the future there will be other methods developed to monitor the snow pack but until then the Federal Government should continue and even expand its role in snow surveying.

Comments from the floor

Ming-Ko Woo, McMaster University, Hamilton, Ontario

"A number of us in the educational sector do make use of the snow survey data for the purposes of statistical analysis and in relation to special projects. In most cases, we require a good set of historical records for the particular sites of interest. It is therefore extremely useful, if not essential, to maintain snow survey sites over an extended period of time.

Since snow survey is being carried out by federal, provincial governments and corporations such as the hydroelectric power companies, I hope that a reduction in the federal services would not encourage the other agencies to follow suit. I would appreciate comments from the provincial snow survey agencies in this regard (to which the Albertan and Ontarian responded, I recall)."

Pierre Bernier, Northern Forest Research Centre, Edmonton, Alberta

On the users. Many users of snow survey data require the data on an irregular basis. For example, researchers might start a project one year that requires or benefits greatly from a regularly sampled snow course with a long record. And I suspect that this type of "one shot" use is very common, not only from researchers, but also from engineers or consultants.

As a result, user surveys systematically underestimate the number of users since they will not (1) reach unknown irregular users of current data and (2) count the future users whose work will rely on historical data presently collected.

On cost recovery

Following my comments on irregular users, I propose that cost recovery efforts will tend to force the total cost of surveying on a fraction of users who happen to require the data on a regular basis. As a result, agencies or groups that require regular snow data might be forced into doing the snow surveying themselves, thus creating or aggravating problems with data standardification and availability.

On benefits

With snow course data, as with any monitoring program, we have to go on the assumption that some of the data will be useful at some point in time. Unforeseen future users of data from only a few sampled courses might more than make up for the cost of running the complete network for those additional years. Continued long-term measurement of snow courses is an investment in the future.

Larry Martens and Ron Allen, U.S.G.S., Albany

Comments on the decision to discontinue the New York Cooperative Snow Survey Program

As you know, our office supervised data collection activities for snow surveys conducted by many agencies and groups throughout New York State. Data collected early in the week was compiled and a rudimentary statistical analysis, with water equivalent distribution map (snow bulletin) map, was issued Friday of survey week. At the end of the season, a manuscript was prepared summarizing data collected at each site. This was delivered to NOAA's Albany office of the National Weather Service. They published Snow Cover Surveys by the Eastern Snow Conference. Our office distributed about 100 copies from our mailing lists and bulk shipped about 100 copies to the ESC Secretary.

The following is a summary of the response we received when we sought feedback from users of the snow bulletin.

The bulletin is mailed to 216 addressees, of which 59 are associated in some way with data collection. They were notified by letter of intent, requesting input and opinion. The remaining 157 addressees (data users) were informed of the situation, and their viewpoints solicited via a notice that appeared on the front page of each snow bulletin of the 1984-85 season.

Thirty written replies were tallied as a result of both methods of notification. Those respondents were sent a follow-up postcard questionnaire. Twenty-six of them returned the postcard. The results were mailed to the agency which may take over our duties in some manner, or at least provide an archiving function to guarantee continued publication of Snow Cover Surveys.

At this time, we await a decision from Dr. Bernard E. Dethier, State Climatologist, with the Northeast Regional Climate Centre, Cornell University.

Don Taylor, National Research Council, Canada

Snow survey data has been and still is important for those involved with Building Codes. The snow surveys provide regional information on snow loading which can be extrapolated to structures. Snow depths alone are not adequate for this purpose.

Peter Adams,
Association of Canadian Universities for Northern Studies and Watershed Ecosystems Programme, Trent University, Peterborough, Ontario

29.7.85

*ADDENDUM - SNOW SURVEY PANEL DISCUSSION

David Graham - Alberta Environment

Alberta Environment's Snow Survey Program

Alberta Environment, Technical Services Division conducts snow surveys both in the mountains, and in the plains area of Alberta. Snow survey results are used by the River Forecast Centre for Long Range Water Supply Forecasting and also for the prediction of Spring Runoff (peak flow forecasts) in the plains area. We consider these data essential to our operation.

In 1978, Alberta Environment took over the responsibility of conducting snow surveys in the mountain area from the Federal Government. The program was expanded both in the number of courses and the number of measurements at each site conducted per year. We now measure snow at 39 mountain snow survey sites.

Alberta Environment expanded the plain area snow survey program, in 1973 - 74. Each spring 63 sites are measured every two weeks starting on March 1st and ending once the snow is gone.