COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

2010 STATION NETWORK STATUS REPORT

Mica Dam (BC Hydro), BC, Canada

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EXECUTIVE SUMMARY

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the United States (U.S.) of America and Canadian Entities. The committee is responsible for (i) planning and monitoring the operation of hydrometeorologic data collection facilities, (ii) design of station networks, (iii) management of hydrometeorologic data and (iv) short- to long-range (seasonal, water supply) inflow forecasting in accord with the Treaty. It also assists the Entities in matters related to hydrometeorologic and water supply forecasting.

At the 2005 Annual Permanent Engineering Board (PEB) meeting in Vancouver, British Columbia, the CRTHC presented the annual update on the committee's activities. One of the items presented was a statement "Continued struggle with network station closures/loss through 2004." This comment evoked questions from the PEB as this statement had been included in the previous year's report as well. The PEB was interested to learn more about the nature of the problems being encountered with respect to maintaining station networks and requested a special report be drafted by the next PEBCOM meeting in October 2005.

This report evaluates stations operated in both the U.S. and Canada. In 2001, the CRTHC initiated a new method of reviewing the station networks and agreed to evaluate only changes to stations in the network as they arise, rather than trying to maintain an inventory of all of the Treaty stations. A procedure was created for this review process and has been in place ever since. This review process works well to evaluate the impact of station changes and closures.

In the past five water years (2005 – 2010), the CRTHC has received 42 announcements of intended or realized changes - including closures, additions and modifications - to Treaty and Supporting Stations required for CRT purposes. The affected stations and variables are listed in this report, the changes are described and the actions by the committee documented. The stations affected include

climate, snowpack and streamflow monitoring stations, networks operated in Canada and the U.S., and by various agencies.

In reviewing the communications about station changes and closures over the past five years, it is apparent that communications with most data agencies is good, but that there is room for improvement. The CRTHC can respond only when it has been notified by an agency about a potential change. There are still cases where station closures have been identified by the Committee only when the station stops reporting for some time. The CRTHC will initiate action to improve communications with the agencies, to determine if there are any blocks to communication, and to ensure the agencies acknowledge the importance of maintaining the station network required for the purposes of the Columbia River Treaty. In an effort to minimize surprises regarding station closures, the CRTHC will contact all station providers on an annual basis to assure station continuation.

Furthermore, the committee continues to work on evaluating the sufficiency and adequacy of the existing hydrometeorological network capabilities to support Treaty operations. While this report is the first step in identifying stations that have undergone changes, it is merely a snapshot in time and does not address the overarching question about the sufficiency of the network. The committee realizes that one of the principal challenges to answering this question is that different hydrologic modeling systems require different station network densities. Although it is believed that the network is generally adequate for current project operations, hydrologic modeling and inflow forecasting needs, it can be further improved. Firstly, the closure of climate and snow stations was a major contributing factor in making the redevelopment of Libby water supply forecast models necessary (see section 5.1). This example illustrates the immense challenge of providing reliable hydrometeorological observations through multiagency monitoring networks. Secondly, the committee recommends improving snow observation network; a project is currently underway to address the addition of real-time snow monitoring stations in the Canadian portion of the Columbia drainage, which should help bolster the network (see section 5.2). Thirdly, the committee is involved in reviewing the adequacy of the glacier monitoring network in the Canadian portion

of the Columbia River drainage (see section 5.3). The objective of better glacier data is to help better calibrate snow and glaciermelt parameters in process-based hydrologic models and monitor environmental changes.

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1 INTRODUCTION

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the United States (U.S.) of America and Canadian Entities. The committee is responsible for (i) initiating the installation and (ii) monitoring the operation of hydrometeorologic data collection facilities, (iii) designing environmental monitoring networks, (iv) managing hydrometeorologic data and (v) supervising short- to long-range inflow (including flood and water supply) forecasting activities in accord with the Treaty.

The primary hydroclimatic variables collected under the Treaty include precipitation, snow water equivalent on the ground, air temperature, river flow, reservoir inflow and reservoir levels. Secondary variables collected are water temperatures and glacier mass balance variables.

According to the CRTHC Supplemental Report (CRTHC 2010, App. B, pp.5-6), the CRTHC's area of interest includes:

- The ***Mica*** and ***Arrow*** (including Revelstoke and Whatshan) watersheds on the Columbia River main stem
- The ***Libby***, ***Duncan***, ***Kootenay Lake*** and ***Slocan*** watersheds in the Kootenay River basin
- The ***Clark Fork - Pend Oreille*** basin
- Areas that fall outside these basins, but border them and are of value for determining the hydroclimatic conditions within the above listed basins.

Fundamental to managing the environmental monitoring network is the categorization of the hydrometeorological network into Treaty, Support and Supplemental Facilities (CRTHC 2010, App. B, pp.5-7 and CRTHC 2010, App. C, p.12), whereby the station status is herein interpreted as follows:

- ***Treaty facilities*** are hydrometric and climate stations, as well as other related hydrometeorologic data-collecting facilities that provide information for operational inflow forecasting for the Columbia River. The forecast models include process-based hydrologic models such as (i) the NWS/RFS models and (ii) the UBC Watershed Model, and (iii) statistical, seasonal water supply forecast models.

- ***Supporting Facilities*** are hydrometeorologic stations, which do not provide information for operational forecasting for the Columbia River, but are required as input to the Assured Operating Plan (AOP), Detailed Operating Plan (DOP), Treaty Storage Regulation (TSR) and the HYDSIM reservoir simulation model.

- ***Supplemental Facilities*** are hydrometeorologic stations that provide data that can be from any part of the Columbia River basin and are required by either Entity only from time to time. Those data will be provided by the other Entity upon request.

Previously, at the 2005 Annual Permanent Engineering Board (PEB) meeting in Vancouver, British Columbia (BC), the CRTHC presented the annual update on the committee's activities. A statement about the "continued struggle with network station closures/loss through 2004" evoked questions from the PEB. Specifically, the PEB was interested in learning more about the nature of the problems encountered with respect to maintaining station networks. The PEB subsequently requested that a special Station Network Status Report be written by the CRTHC for the Permanent Engineering Board Engineering Committee (PEBCOM). This report was completed in January 2006. The current report is a 5-year follow-up to the 2005 Station Network Status Report. Its intended purpose is to update PEBCOM on the changes to the station network that occurred from 2005 to 2010 (inclusive).

This document gives an overview of the federal and provincial/state agencies and hydroelectric utilities involved in environmental data collection in the Columbia River Treaty project areas. The CRTHC's process for reviewing the monitoring

network is then briefly outlined. The report lists and describes station changes that occurred from 2005 to 2010 and the CRTHC's actions taken. Conclusions are drawn and recommendations presented at the end of this document.

2 DATA COLLECTION AGENCIES AND STATION NETWORK

To support Treaty operations, hydroclimatic data are collected by a number of federal and provincial/state agencies, and hydroelectric utilities in Canada and the U.S. The agencies and their respective environmental monitoring networks are summarized below. An overview map of hydroclimatic data collection stations in the area of interest for the CRTHC is provided in Figure 1.

2.1 CANADIAN DATA COLLECTION AGENCIES

Six agencies collect hydrometeorologic data that are used to support reservoir operations under the Columbia River Treaty: BC Hydro (BCH), Environment Canada's Meteorological Service of Canada (EC/MSC), Environment Canada's Water Survey of Canada (EC/WSC), British Columbia Ministry of Environment (BC/MOE), Alberta Environment (AE) and Fortis BC. BCH is responsible for maintaining relationships with each of these agencies.

BC Hydro's Hydrology and Technical Services department has been funding and operating a network of Data Collection Platforms (DCPs) at remote locations throughout BC since 1980. It now manages approximately 130 DCPs. A DCP is a real-time transmitting, automated climate, snow pillow or hydrometric station. Standard DCPs measure air temperature and precipitation; some stations additionally measure snow water equivalent, snow depth, water level and/or water temperature. The variables are typically measured at hourly resolution. Climate and snow pillow stations are maintained by BCH's private contractor; hydrometric stations are maintained by the Environment Canada's Water Survey of Canada.

Since measuring reservoir inflows is impractical, reservoir inflows are calculated by BC Hydro's Generation Resource Management department using the principle of conservation of mass as applied to the reservoir water balance. Specifically, inflows

are the residual of power and non-power releases, and the change in reservoir storage for any given time interval. For that purpose, water level data are collected by DCPs and station networks operated by the individual hydroelectric projects. Similarly, plant data are collected by the individual hydroelectric projects.

Environment Canada - Meteorological Service of Canada has been collecting climate data since 1871. The EC/MSC is the single largest provider of climate data in BC. Environment Canada's climate station network is made up of a combination of automated and manual (i.e., observer) stations. Climate observers are from federal, provincial and municipal agencies, or may be a part of the volunteer network of observers. The variables are collected at synoptic times or at hourly resolution.

In 2001, Environment Canada's Meteorological Service of Canada designated a subset of 50 stations in BC and the Yukon as Reference Climate Stations (RCS) for the Pacific Region for the purposes of long-term climate monitoring. RCS stations get unconditional support by the EC/MSC. In contrast, EC/MSC's support of non-RCS stations is contingent on funding and staff levels. The EC/MSC's long-term support of those stations is, therefore, less certain. As a result, BCH financially contributes to the operation of all non-RCS stations which are required for Treaty purposes. An informal understanding between the EC/MSC and BCH is in place that stipulates that the EC/MSC will alert BCH if it plans to discontinue a climate station.

Environment Canada - Water Survey of Canada is the national authority responsible for the collection, interpretation and dissemination of standardized water resource data and information in Canada. A hydrometric network for measuring streamflow, lake levels, sediment data and water temperatures has been in operation for over 125 years. The hydrometric program is jointly funded by the federal and provincial governments, BC Hydro, the Forest Investment Account (FIA, formerly Forest Renewal BC) and a variety of industrial or municipal clients. Consequently, BC Hydro is a partner in the streamflow monitoring program.

The EC/WSC has identified a number of gauging stations in BC which are located in watersheds that are comparatively unimpacted by human activity. These sites, which form the Reference Hydrometric Basin Network (RHBN) in BC, are to be used to detect, monitor and assess climatic change or variability. In addition, several hydrometric stations, which monitor the flow of water across the Canada-US border, are designated Priority 1 Stations within the Water Survey of Canada network.

An informal understanding between the EC/WSC and BCH is in place that stipulates that the EC/WSC will alert BCH if it plans to discontinue a hydrometric station.

In December 2005, the BC Provincial government decided that, in the absence of a sustainable funding program, they would temporarily suspend support for 50 water gauging stations in BC, including 10 in the Kootenay and Okanagan regions (not listed in Appendix A). None of the stations targeted are Treaty Stations.

The British Columbia Ministry of Environment is the provincial agency in charge of operating the snow monitoring network, specifically for measuring the depth and water content of snow cover. These data are used principally for water supply and flood forecasting purposes. Snow surveys have been made in British Columbia since 1935. Some of the sites are equipped with real-time transmitting snow pillows and climate stations. The remaining sites (or approximately 76% of all stations in BC) are read manually. Manual snow survey measurements are made at the beginning of the month from January through April and twice monthly in May and June, although not all stations are measured at every sampling period. BCH funds approximately 70 snow course stations. Conducting the measurements at these sites is contracted out. Every fall, the BC/MOE reviews its snow course network and sampling schedule for the upcoming season and collaborates with BCH, if changes are proposed.

The BC/MOE had a program of replacing manual snow surveys with adjacent automated snow pillow stations and two snow courses have been replaced with automated snow pillows since 2000 (specifically, Celista Mountain (1F06P, South

Thomson River drainage) in 2004 and Redfish Creek (2D14P, Kootenay River drainage) in 2001). An investigation into the most useful snow survey sites that could additionally be converted into automated snow pillows in the Canadian portion of the Columbia Basin is currently underway and is being conducted by BPA (see section 5.2).

The provincial agency in charge of the snow survey network in Alberta is ***Alberta Environment***, Water Management Operations Branch.

Fortis BC is an electric utility that generates and distributes electricity in the southern interior of British Columbia. It provides the official reservoir inflow and discharge (here: streamflow) data for its Kootenay River projects.

2.2 U.S. DATA COLLECTION AGENCIES

In the U.S., hydrometeorologic data needed for the support of the Columbia River Treaty are provided by two separate agencies: National Weather Service (NWS) and the Natural Resources Conservation Service (NRCS). The United States Army Corps of Engineers (USACE) and Bonneville Power Administration (BPA) maintain the relationships with each of these agencies to provide the data for the Treaty. These agencies operate Treaty stations, for both climate and snow, in Idaho and Montana that are used by Treaty projects.

National Weather Service - is one of six scientific agencies that make up the National Oceanic and Atmospheric Administration (NOAA). The NWS is tasked with providing weather, hydrologic, and climate forecast for the U.S. and its territories. As part of their mission, they maintain a network of hydrometric monitoring stations throughout the U.S. Daily river forecasts are issued by the **Northwest River Forecast Center (RFC)** one of 13 National Weather Service hydrologic centers in the United States. This office specializes in flood and water resource forecasting, river modeling, and hydrologic system development. It works with water management agencies to provide the best possible operations of the Columbia reservoir systems. The center is very active in recreational and navigational hydrological forecasting. The area of responsibility encompasses over

285,786 square miles and includes parts of 7 states and parts of western Canada. It is the second most hydrologic active River Forecast Center in the United States.

Natural Resources Conservation Service - Originally established by Congress in 1935 as the Soil Conservation Service (SCS), NRCS has expanded to become a conservation leader for all natural resources, ensuring private lands are conserved, restored, and more resilient to environmental challenges, like climate change. The NRCS Snow Survey Program provides mountain snowpack data and streamflow forecasts for the western United States. The NRCS maintains a network of 261 snow stations across the Northwest.

2.3 COLUMBIA RIVER TREATY STATION NETWORK

Figure 1 provides an overview of the hydroclimatic station network within the CRTHC's area of interest. The stations plotted include:

- Active Canadian climate stations from the BCH and EC/MSC networks,
- Active Canadian and U.S. stations that measure snow on the ground from the BC MoE, AE and NRCS networks,
- Active (real-time and non-real-time) Canadian hydrometric stations from the EC/WSC network,
- Active Canadian water temperature stations from the EC/WSC network, and
- Active U.S. hydrometric stations.

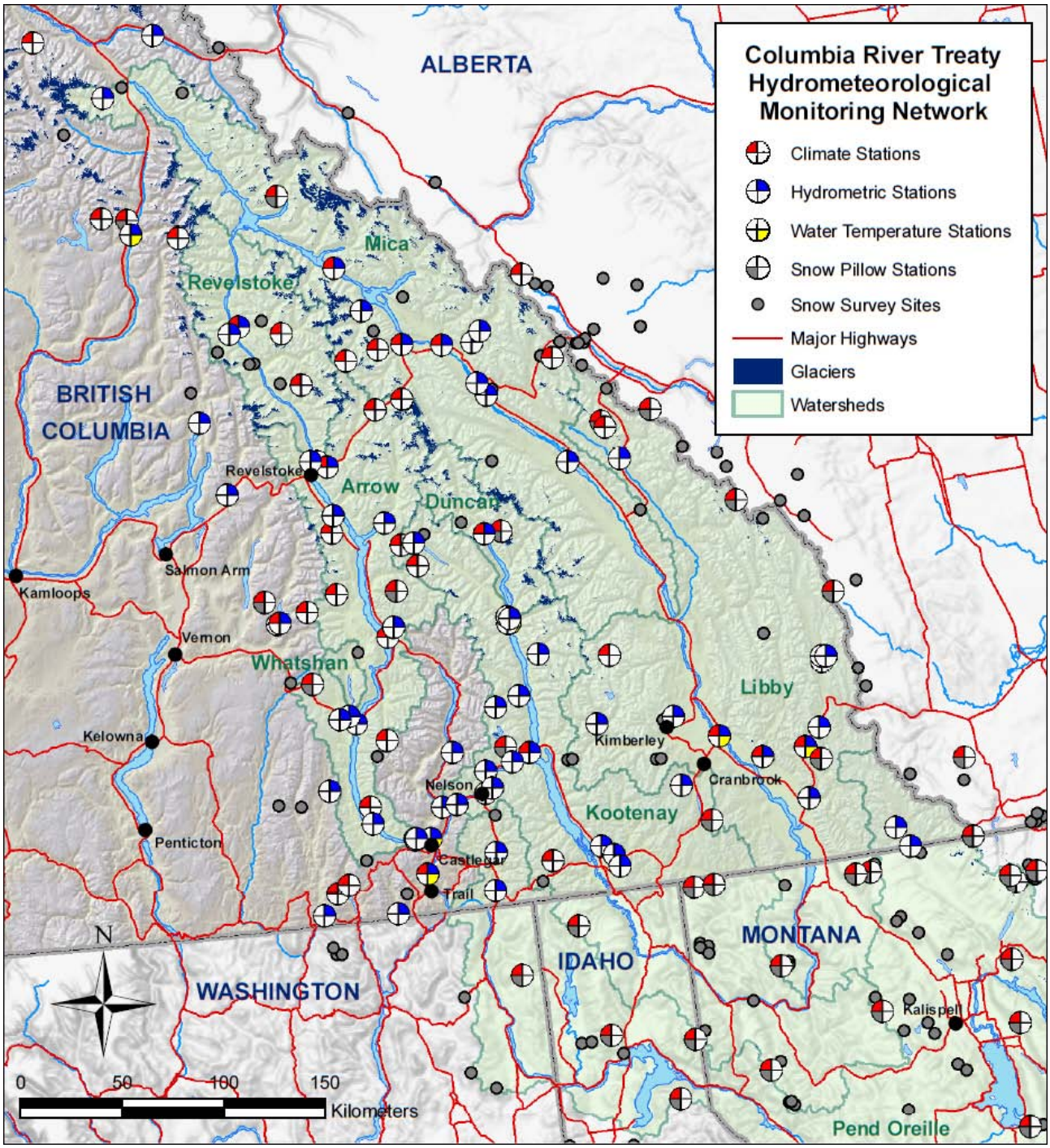

Figure 1 CRTHC hydroclimatic station monitoring network

3 COMMITTEE STATION NETWORK REVIEW PROCESS

The CRTHC's process for reviewing proposed changes to hydrometeorological monitoring stations is described in Appendix C of the Supplemental Report to the CRTHC Annual Reports (CRTHC2010), and is shown below. The process is intended to ensure that changes made to the network do not negatively affect the monitoring, operations and planning of Treaty facilities. The five step review process is given below, current issues with the process identified and the committees activities summarized:

1. Regularly communicate with data collection agencies.

   Each data collection agency has its own objectives for its environmental monitoring networks. These objectives determine the importance of individual stations (and even variables collected at these stations) and, therefore, the level of support. It is the CRTHC's task to assure that the data collection agencies are fully aware of the data requirements under the Columbia River Treaty to proactively prevent station closures.

   In practice, there is room for improvement for communicating with data collection agencies. Unfortunately, the CRTHC has been excluded from the decision making process in the past and stations have been removed from service or inactivated without first coordinating with the CRTHC. Members of the CRTHC will continue to try and proactively insert themselves into appropriate decision processes.

2. If changes are proposed for an existing station, determine the Treaty status of the station; the Treaty status is (i) Treaty Station, (ii) Supporting Station or (iii) none of the above.

   To be better able to respond to impending station changes, the CRTHC will review and, if necessary, clarify and modernize the definition of Treaty and Supporting Stations. The CRTHC will also assemble a database of Treaty and Supporting Stations which require monitoring for notification purposes.

3. Negotiate with the data collection agency if the station is a Treaty Station.

   The CRTHC members have made an effort of conveying the importance of Treaty Stations to data collection agencies and of preventing station closures. For example, Bill Kuhnke, acting head of the BC River Forecast Centre and in charge of the BC snow survey program, was invited to CRTHC's December 2009 meeting in Vancouver.

4. Document the CRTHC's work.

   Meeting minutes, annual reports and special reports, such as this one, were produced to regularly document the committee's work.

5. Regularly review the environmental monitoring networks to assure that they meet the hydrometeorologic network objectives under the Treaty.

   Individual committee member agencies have made efforts to evaluate the adequacy of the monitoring network for their respective purposes. For instance, BPA has taken the lead in evaluating the existing snow survey network and in providing recommendations to the Columbia River Treaty Operating Committee for which manual survey sites should be converted into automated data collection sites.

4 STATION CHANGES FROM 2005 TO 2010

The following section lists the changes made to the monitoring networks from 2005 through 2010 (inclusive) and describes them, organized by country and agency, states whether an issue has been resolved or not, and whether a new station or instrumentation was added.

Network changes, and particularly permanent or semi-permanent station closures, are caused by a multitude of reasons: for instance, stations may be forced to close due to changes to the physical characteristics of a sampling site which negatively affect the characteristics of the data collected. Changes to the physical characteristics of a sampling site can be caused by natural processes, such as forest

fires, animal infestations and vegetation growth, and by anthropogenic activity, such as logging and urbanization. Sometimes stations get destroyed by natural forces, such as avalanches, stream bank erosion and animals, or by humans in acts of vandalism. Other reasons for station closures include termination of leases that stations are located on and the loss of climate observers that cannot be replaced. Stations closures are often due to cutbacks in the environmental monitoring budget.

Appendix A summarizes the 42 station changes that occurred from 2005 through 2010 (inclusive). The table is organized first by country and second by station type. Details are given in the section below.

4.1 CANADA

4.1.1 BC HYDRO

Resolved issues

- In June 2005, the ***Morrissey Ridge DCP*** broke down. When the contractor visited the site, they determined that fairly extensive repair work was needed to restore the station (exact cause was not documented). BCH consulted with the U.S. as to whether the station was critical and worth the cost of repair. The site was repaired in September 2005 after BPA and the NWRFC indicated that it is an important site for the U.S. Note, the data are now used for the 2010 Libby water supply forecast models. This station was again damaged, this time by elk in August 2008. In October 2008, a special service trip was arranged to repair the station and the snow pillow in time for the snow season.

Ongoing issues - None

4.1.2 ENVIRONMENT CANADA – METEOROLOGICAL SERVICE OF CANADA

Resolved issues

- The ***Tete Jaune climate station*** is located in the Fraser River headwaters (BC). In the past, it was used as a reference station for describing the climate in the Mica basin. The station closed December 8, 2006, after the observer

moved away and was not replaced. The station is currently not required for modeling purposes by BC Hydro or any of the U.S. Treaty agencies.

- In 2008, the ***Grand Forks climate station*** closed when the observer retired after 50 years of service. The station was not a Treaty Station and was not replaced.

- Also in 2008, the ***Wasa climate station*** observer is no longer under contract with Environment Canada but, as of November 2010, the station was still active. The station is not a Treaty Station. It was once considered for inclusion to the Libby forecast procedures, but the uncertain future of the station eliminates it as a possibility.

- Environment Canada informed BCH in January 2007 that the ***South Slocan climate station*** may be closing as the station is currently maintained by a Fortis BC employee who will be retiring. The station is a Treaty Station, as it is used as input to NWS/RFC inflow forecast models for the Kootenay Lake, Slocan and Waneta basins. BPA requested that efforts be made to maintain the station. The station was closed on December 24, 2008.

Ongoing issues – None

4.1.3 ENVIRONMENT CANADA – WATER SURVEY OF CANADA

New station / instrumentation

- In November 2009, a new real-time hydrometric station was re-installed at the ***Spillimacheen River near Spillimacheen (08NA011)***. The flow data are regulated by BCH's Spillimacheen run-of-the-river project.

- In November 2010, EC/WSC replaced the standpipe-type precipitation gauge at the ***Duncan River above BB Creek DCP station (08NH119)*** with a weighting-type OTT Pluvio 2 gauge at the request of BCH.

- Two new water temperature sensors were installed at ***Kootenay River at Fort Steele (08NG065)*** and ***Elk River at Fernie (08NK002)*** in BC at request of USACE Seattle District to support water temperature modeling of Koocanusa Reservoir.

Resolved issues - None

Ongoing issues

- BC Hydro was notified in January 2007 that the lease for the land where the ***Slocan River at Crescent Valley (08NJ013) hydrometric station*** is located is up as of November 2007, and that Water Survey of Canada is having difficulties renegotiating with the current landowner to renew the lease. As this is a critical gauging point with a long period of record, both BCH and the province of BC requested that every attempt be made to secure the site going forward. The site is active as of November 2010, but the issue is still unresolved.

4.1.4 BC MINISTRY OF ENVIRONMENT

Resolved issues

- The ***Marble Canyon snow course (2C05)*** was utilized in the 2004 Libby water supply forecast models; however, at approximately the same time the equations were finalized in September 2004, the site was closed due to a large wildfire that destroyed the gauging site and caused extensive damage to the surrounding basin. Starting in the 2005 winter, the nearby Vermilion River No.3 snow course site served as a proxy for the Marble Canyon site (see below).

- The ***Vermilion River No.3 snow course (2C20)*** site was re-commissioned for the 2005 winter after having been closed for 24 years. From 2005 to 2009, Vermillion River No.3 snow course data were used to estimate Marble Canyon SWE, which is required for the 2004 Libby water supply forecast models. In

November 2009, Parks Canada decided to terminate data collection at that site due to concerns over tourists blocking traffic and creating safety issues when Parks' staff was taking the snow measurements.

- The CRTHC was informed by the BC/MOE of their intention to discontinue the two manual ***snow courses at Mount Cook (1E02A)*** and ***Cook Forks (1E06)*** and replace them with the Mount Cook (1E02P) and Cook Creek (1E14P) snow pillows. The two snow courses were located in the North Thompson region, just outside the Columbia River basin, but served as good indicators of regional snow processes in the Upper Columbia River basin. Both snow surveys were sampled in the past through skiing to the location by a local snow surveyor. Since the snow surveyor was going to retire, replacement was difficult to find (access to the two sites required strong skiing and hiking abilities and was inherently dangerous), and the obvious advantages of collecting real-time information, the BC/MOE proposed to install snow pillows. The CRTHC evaluated the potential closures and concluded that the impact to Treaty operations was relatively small.

- Logging to control a Pine Bark Beetle infestation in the vicinity of the ***Oyama Lake (2F19) snow course*** is believed to have changed the snow accumulation and melt characteristics of the site. The snow survey site continues to be monitoring as of the 2010/11 winter. The data were not deemed to be critical and no further action was taken.

- In 2007, reports of high avalanche hazard at the ***Mount Templeman (2D09) snow course*** site prompted the BC/MOE to propose closing the snow course site. After further discussions with BCH, it was determined that, in fact, only the helicopter landing site was in an avalanche path. The helicopter landing site was moved to a safer location and the snow course could remain open.

Ongoing issues

In addition, potential cuts to January 1 and February 1 snow courses in BC were identified in an email dated October 26, 2009.

BPA responded that the **nine stations** were critical to their operations in an email dated October 30, 2009, and noted that these data were critical to meet the TSR requirements. BC MOE will continue the observations this year, 2010. The BC MOE's long-term strategy is to relinquish responsibility for snow data collection, but to continue data quality control and data management. The BC Hydro representative noted that it is incumbent upon BCH to operate a sufficient snow measuring system, and it is BCH's obligation to provide this data.

4.1.5 ALBERTA ENVIRONMENT

Resolved issues

- As of the 2011 water supply forecast season, data from four ***snow pillow stations*** are being used as input to the 2010 Libby water supply forecast models. These include ***Sunshine Village (05BB803), Three Isle Lake (05BF824), Lost Creek South (AB05BL811)*** and ***Gardiner Creek (05AA809)***.

Ongoing issues - None

4.2 UNITED STATES OF AMERICA

4.2.1 NOAA NATIONAL WEATHER SERVICE

Resolved issues

- In 2009, it was reported that the two climate stations**, Porthill and Bonners Ferry, ID,** were facing closure as the NWS was losing cooperative observers at these two locations. BCH has coordinated with BPA and the NWS and learned the NWS is attempting to locate new cooperative observers in the area. Issues with Porthill have now been resolved and it was returned to

service in November 2010 (NWS, Spokane). Bonner's Ferry does have a new observer but the station has been moved to a new location and has come back in service as of March 18, 2010 (NWS, Spokane). Both stations maintained their same ID number.

Ongoing issues

- The Fortine 1N, MT, station is used in the current (2004 Update) Libby Water Supply Forecast equations. It was discovered during the data collection for the Libby forecast equation update that the Fortine 1N station was closed after December 2009. Although there is a new Fortine 2NE station, the Missoula Weather Service Office Service Hydrologist reports that the precipitation data is not compatible with the Fortine 1N station (email from Ray Nickless, May 14, 2010). The NNWRFC has been estimating monthly precipitation values for Fortine 1N and forwarding these estimated values to the Corps for use in their water supply forecast efforts, without any notification that the values provided were estimates and not actual observed values. This same scenario occurred previously following the closure of Polebridge, MT, in July 2000, with the NWRFC sending the Corps synthesized monthly precipitation numbers for over 2 years before it was brought to their attention that the station had been closed.

4.2.2 NATURAL RESOURCE CONSERVATION SERVICE

Resolved issues

- In 2005, the ranger station at the **Ochoco Ranger Station coop site (U.S. site)** was closed because there no longer was an observer to report the readings. Upon review and coordination by the CRTHC, it was determined that there was no significant impact to Treaty procedures or operations, and this station was **discontinued.**

Ongoing issues

- In 2008, there were **nine potential snow course station closures** proposed by the NRCS. Hydromet Committee and others reviewed the proposal and recommended keeping all open.

- Two stations have been modified, and all other sites are now scheduled to be continued, but are on the NRCS priority list to have co-located SNOTEL sites installed in the future. One station has been replaced with a SNOTEL station Annie Springs REV (22G06S). Another station has been replaced with an aerial marker, Government Corrals (18G04A).

5 NEW DATA REQUIREMENTS

5.1 LIBBY SEASONAL VOLUME FORECAST PROCEDURE

The USACE Seattle District commissioned the redevelopment of the Libby Water Supply Forecast models. The models were updated to reflect the closure of two snow stations (Vermillion River #3 and Sullivan Mine) and one precipitation station (Fortine 1N) used in the (previous) 2004 models, to incorporate additional climate indices as new predictor variables, and to improve the consistency of the model structure and predictor variable selection from one forecast date to the next, and improve forecast performance.

The 2010 Libby Water Supply Forecast models (Wortman 2010) uses SWE from four Snow Pillows operated by Alberta Environment as predictor variables. Although these sites are located slightly to the east of a political (provincial) boundary, and technically outside the Kootenay watershed boundary, they are physically much closer to the Kootenay basin than several of the snow sites utilized in earlier versions of the forecast model and all more consistently highly correlated with the Libby seasonal water supply than any of the existing snow stations in British Columbia.

5.2 ADDITIONAL AUTOMATED SNOW STATION DATA

The BC MOE has an active program of replacing manual snow surveys with adjacent automated snow pillow stations. The automated stations are run for a number of years in conjunction with the manual sites to establish a relationship between the two sites, and then the manual surveys are discontinued after agreement by CRTHC. There have been several snow courses replaced by automated snow pillows since 2000. An investigation for additional snow pillows in the Canadian portion of the Columbia Basin is still underway and is being conducted by BPA. The CRTOC tasked the Hydromet Committee in October 2009 to look into the need for additional snow pillows in the Canadian portion of the Columbia Basin. A work plan was finalized in December 2009 and calls for a GIS analysis of the Basin, a statistical assessment as needed, and then recommendations for an additional 3-5 snow pillows. More than likely, these pillows will be located at existing snow course sites. The timeline for the project is to complete a draft report of the recommendations in December 2010; issue the final report in March 2011; acquire CRTOC approval in April 2011; turn the permitting process over to BC Hydro in summer 2011; and install the new snow pillows in summer 2012.

5.3 EXPANSION OF THE CANADIAN COLUMBIA RIVER BASIN GLACIER MONITORING NETWORK

BC Hydro, together with the Columbia Basin Trust and the Department of Geography of the University of British Columbia, has initiated the process to expand the glacier monitoring network in the Canadian Columbia River basin. The objective is to provide information on glacier mass balance and equilibrium line altitude that can be used to assist in calibrating snow and glaciermelt parameters in process-based hydrologic models used for operational forecasting and climate change impact studies.

Any glacier(s) identified as candidates for monitoring should provide information on snow accumulation and melt that is complementary to information from existing glacier monitoring programs in the region (e.g., programs on the Illecillewaet

Glacier), and should enhance the understanding of the spatial and temporal variability of these processes within the Columbia River basin.

The project will occur in two phases: Phase 1 is office-based, and will result in the identification of candidate glaciers that meet a number of specific selection criteria. Phase 2 will involve the set-up of infrastructure to monitor glacier mass balance so that mass balance data will be available beginning with the 2010/2011 glaciological year.

6 CONCLUSIONS

Good communication of the Treaty data requirements to the data agencies is essential to maintaining the network and this continues to be the case. In addition, data collection agencies need to be reminded of the requirement to maintain stations required to meet treaty obligations and need to undertake their best efforts to maintain or replace any stations potentially impacted by closures. The CRTHC has a procedure for evaluating changes to the stations needed for the Columbia River Treaty operations and they compile a list of decisions reached each year in the Committee's Annual Report. This procedure has worked well in recent years, but is reliant on communication of changes from the Agencies responsible for recording the data. In the 2005 report, there were a few cases where notification of station closures had occurred months after the station had closed. This problem still continues in 2010 as station changes and closures without notification are still occurring and have an impact on forecasting for Treaty operations. To date, solutions acceptable to all CRTHC members have been implemented in all cases including keeping stations open, finding acceptable replacement stations, or reaching agreement that the stations are no longer needed.

The committee continues to work on evaluating the sufficiency and adequacy of the existing hydrometeorological network capabilities to support Treaty operations. While this report is the first step in identifying stations that have undergone changes between 2005 and 2010, it is merely a snapshot in time and does not address the overarching question about the sufficiency of the network.

Evaluation components being looked at are distribution and type of automated sensors and the conversion of some stations to daily reporting. The committee realizes that one of the principal challenges to answering this question is that different hydrologic modeling systems require different station network densities. Seasonal water supply forecasting requires specific stations which are easily identifiable. Daily streamflow forecasting systems often take advantage of all data which is reporting. It is the data network for this second type of forecasting capability which is most challenging to describe. These complexities were not anticipated, and the evaluation is taking longer than originally thought.

Although it is believed that the network is generally adequate for current project operations, hydrologic modeling and inflow forecasting needs, it can be further improved. Firstly, the closure of climate and snow stations was a major contributing factor in making the redevelopment of Libby water supply forecast models necessary (see section 5.1). This example illustrates the immense challenge of providing reliable hydrometeorological observations through multiagency monitoring networks. Secondly, the committee recommends improving snow observation network; a project is currently underway to address the addition of real-time snow monitoring stations in the Canadian portion of the Columbia drainage, which should help bolster the network (see section 5.2). Thirdly, the committee is involved in reviewing the adequacy of the glacier monitoring network in the Canadian portion of the Columbia River drainage (see section 5.3). The objective of better glacier data is to help better calibrate snow and glaciermelt parameters in process-based hydrologic models and monitor environmental changes.

7 RECOMMENDATIONS

The CRTHC will:

1. Continue to use the Process for reviewing hydrometeorological data networks as outlined in Section 3.

2. Establish a list of personnel (management and technical) responsible for data collection in each of the agencies involved. The list will include agency, name, title, location, phone and email address.

3. Continue to inform agencies of the importance of data collection to the Columbia River Treaty and get formal agreements in place that CRTHC agencies are to be informed of network changes in advance. The Committee will work with agencies to clarify the agencies' roles in supporting the Columbia River Treaty.

4. Invite data collection agencies regularly (e.g., annually) to meetings and/or conference calls to better convey the importance of hydrometeorological data to Treaty operations.

5. Discuss communications issues with Environment Canada's Atmospheric Monitoring Division to ensure all parties have the same understanding with respect to the importance of maintaining Treaty stations.

6. Establish a list of Treaty stations. CRTHC members will investigate ways to monitor in real-time the operation of Treaty stations for their respective areas of responsibility. A protocol for communicating station issues among CRTHC members will be established.

7. The committee will evaluate new monitoring techniques, such as remote sensing techniques, data collection of previously not monitored hydroclimatic variables, such as evapotranspiration, and other environmental monitoring networks, such as that of the BC Ministry of Transportation, on a case-by-case basis.

8 REFERENCES

Wortman, Randal T.. 2010. Water Supply Forecasting Models for Libby, MT - 2010 Revisions. Unpublished USACE report.

Columbia River Hydrometeorological Committee. 2010: 2009 Supplemental Report. Unpublished CRTHC report.

Oregon Snow Course Data, http://www.or.nrcs.usda.gov/snow/data/snowcourse/or_alpha.html

APPENDIX A - Summary Table of Station Changes for the 2005-2010 Period

#	Station Name, Province/ State (ID)	Station Type	Collection Agency	Station Status	Data Usage	Issue				Status
						Definition	Notified (Date)	Resolved (Date)	Action Taken	
1	Marble Canyon, BC (2C05)	Snow Course	BC/MOE	Treaty	2004 Libby WSF	Proposed for Discontinuation		2005	Replaced with Vermillion	Discontinued
2	Vermilion River No.3, BC (2C20)	Snow Course	BC/MOE	Treaty	2004 Libby WSF			2009	Temporarily reactivated to support Libby WSFs; Parks Canada stop sampling	Temporarily reactivated, then discontinued
3	Mount Cook, BC (1E02A)	Snow Course	BC/MOE	Support		Observed retired		2005	Manual snow course replaced with snow pillow	Discontinued
4	Cook Forks, BC (1E06)	Snow Course	BC/MOE	Support		Observed retired		2005	Manual snow course replaced with snow pillow	Discontinued
5	Oyama Lake, BC (2F19)	Snow Course	BC/MOE	Support		Localized changes due to deforestation by pine beetles could affect long term trend analysis		2005		Active
6	Mount Templeman, BC (2D09)	Snow Course	BC/MOE	Support		Proposed for closure due to avalanche concerns		2007	Moving the helipad location addressed this issue.	Active

#	Station Name, Province/ State (ID)	Station Type	Collection Agency	Station Status	Data Usage	Issue				Status
						Definition	Notified (Date)	Resolved (Date)	Action Taken	
7	Farron, BC (2B02A)	Snow Course	BC/MOE	Treaty	TSR	BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
8	Record Mountain, BC (2B09)	Snow Course	BC/MOE	Treaty	TSR	BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
9	Sullivan Mine, BC (2C04)	Snow Course	BC/MOE	Treaty	TSR	BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
10	Fernie East, BC (2C07)	Snow Course	BC/MOE	Treaty	TSR	BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
11	Ferguson, BC (2D02)	Snow Course	BC/MOE	Treaty	TSR	BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
12	Char Creek, BC (2D06)	Snow Course	BC/MOE	Treaty	TSR	BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
13	Enderby, BC (1F04)	Snow Course	BC/MOE	Treaty	TSR	BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
14	Mount Kobau, BC (2F12)	Snow Course	BC/MOE	Treaty		BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
15	Missezula Mountain, BC (2G05)	Snow Course	BC/MOE	Treaty		BC/MOE proposal to deactivate station		Fall 2009		Active as of winter 2009/10
16	Morrissey Ridge, BC (2C09P)	Snow Pillow	BC/MOE	Treaty	2004/2010 Libby WSF	Out-of-service		2005 & 2008	Repaired	Active

#	Station Name, Province/ State (ID)	Station Type	Collection Agency	Station Status	Data Usage	Issue				Status
						Definition	Notified (Date)	Resolved (Date)	Action Taken	
17	Gardiner Creek, AB (14Z10S)	Snow Pillow	AE	Treaty	2010 Libby WSF	Proposed station for new Libby Forecast equations		2010		Active
18	Lost Creek South, AB (14Y20S)	Snow Pillow	AE	Treaty	2010 Libby WSF	Proposed station for new Libby Forecast equations		2010		Active
19	Sunshine Village, AB (15X03S)	Snow Pillow	AE	Treaty	2010 Libby WSF	Proposed station for new Libby Forecast equations		2010		Active
20	Three Isle Lake, AB (15Y25S)	Snow Pillow	AE	Treaty	2010 Libby WSF	Proposed station for new Libby Forecast equations		2010		Active
21	Tete Jaune, BC	Climate	EC/MSC	Support		Volunteer station and the observer moved away		Dec 8, 2006	Closed Dec 8, 2006 and not replaced	Decommissioned
22	South Slocan, BC	Climate	EC/MSC	Treaty	NWS/RFC models	Station maintained by retiring Fortis employee and may be closed	Jan 2007	Jan 1, 2009		Decommissioned
23	Grand Forks, BC	Climate	EC/MSC	Support		Closed when observer retired	Jan 1, 2009		Closed in 2008	Decommissioned
24	Wasa, BC	Climate	EC/MSC	Support		EC advised that funding for this station is vulnerable	Feb 13, 2004			Active, **unresolved**

#	Station Name, Province/ State (ID)	Station Type	Collection Agency	Station Status	Data Usage	Issue				Status
						Definition	Notified (Date)	Resolved (Date)	Action Taken	
25	Slocan River near Crescent Valley, BC (08NJ013)	Hydrometric	EC/WSC	Supple-ment		Lease for the land where the gauge is located is up as of Nov 2007	Nov 1, 2007			Active, **unresolved**
26	Spillimacheen River near Spillimacheen (08NA011)	Hydrometric	EC/WSC	Supple-ment					Installation of new site	Active
27	Duncan River above BB Creek DCP station (08NH119)	Hydrometric / Climate	EC/WSC	Support		Quality of precipitation data needed improvement			Installation of new precipitation monitoring equipment	Active
28	Kootenay River at Fort Steele (08NG065)	Hydrometric	EC/WSC	Support					Installation of new water temperature monitoring equip.	Active
29	Elk River at Fernie (08NK030)	Hydrometric	EC/WSC	Support					Installation of new water temperature monitoring equip.	Active
30	Fortine 1N, ID (243139)	Precip.	NRCS	Treaty	Libby Forecast		3/1/2010	12/1/2010	Prompted re-evaluation of the Libby Forecast	Unexpectedly closed Dec 2009
31	Porthill, ID (107264)	Climate	NWS		Closed 10/8/2009	Loss of cooperative observers in 2009			Issue Resolved	Back in Service ~ 11/2010
32	Bonners Ferry, ID (101079)	Climate	NWS		Closed July 2009	Loss of cooperative observers in 2009			Moved to new location	Back in Service 3/18/2010

#	Station Name, Province/ State (ID)	Station Type	Collection Agency	Station Status	Data Usage	Issue				Status
						Definition	Notified (Date)	Resolved (Date)	Action Taken	
33	Dead Horse Grade, ID (21E08)	Snow Course	NRCS	In Service		Closure proposed by NRCS	2008		Priority to be replaced with co-located SNOTEL	Not replaced yet
34	Government Corrals, ID (18G04)	Snow Course	NRCS	In Service		Closure proposed by NRCS	2008		Replaced with aerial marker and it has 5 yrs of overlapping data	Resolved, replaced with (18G04A)
35	Meacham, ID (18D05)	Snow Course	NRCS	In Service		Closure proposed by NRCS	2008		Priority to be replaced with co-located SNOTEL	Not replaced yet
36	New Dutchman #3, ID (21E26)	Snow Course	NRCS	In Service		Closure proposed by NRCS	2008		Priority to be replaced with co-located SNOTEL	Not replaced yet
37	Park H.Q. Rev, ID (22G05)	Snow Course	NRCS	In Service		Closure proposed by NRCS	2008		Priority to be replaced with co-located SNOTEL	Not replaced yet
38	Hungry Flat, ID (21F04)	Snow Course	NRCS	In Service		Closure proposed by NRCS	2008		Priority to be replaced with co-located SNOTEL	Not replaced yet
39	Grayback Peak, ID (23G03)	Snow Course	NRCS	In Service		Closure proposed by NRCS	2008		Priority to be replaced with co-located SNOTEL	Not replaced yet
40	Tollgate, ID (18D03)	Snow Course	NRCS	In Service		Closure proposed by NRCS	2008		Priority to be replaced with co-located SNOTEL	Not replaced yet

#	Station Name, Province/ State (ID)	Station Type	Collection Agency	Station Status	Data Usage	Issue				Status
						Definition	Notified (Date)	Resolved (Date)	Action Taken	
41	Ochoco Ranger Station coop site, ID	Snow Course	NRCS	Closed		Forest Service closing ranger station	4/25/2005	4/25/2005	No significant impact	Discontinued
42	Annie Spring REV, ID (22G06S)	SNOTEL	NRCS	In Service		Closure proposed by NRCS in 2008 undetermined	2008		Replaced with a co-located SNOTEL site	SNOTEL in service

Legend

Collection agency

- BC Hydro BCH
- Environment Canada – Meteorological Service of Canada EC/MSC
- Environment Canada – Water Survey of Canada EC/WSC
- BC Ministry of Environment BC/MOE
- Alberta Environment AE
- Natural Resources Conservation Service NRCS
- National Weather Service NWS