COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

2010 ANNUAL REPORT

Libby Dam ***(Source: COE)***

Peter Brooks	U.S. Army Corps of Engineers, U.S., U.S. Co-Chair
Ann McManamon (lead)	Bonneville Power Administration, U.S., U.S. Co-Chair
Stephanie Smith	BC Hydro, Canada, Canadian Chair
Frank Weber	BC Hydro, Canada, Member

FEBRUARY 2011

COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

2010 ANNUAL REPORT

Introduction

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the Entities. The Committee is responsible for planning and monitoring the operation of the hydrometeorological data collection network in accord with the Columbia River Treaty (CRT). It also assists the Entities in matters related to hydrometeorological and water supply forecasting.

This report summarizes Committee activities during the 2010 water year (October 1, 2009 – September 30, 2010). The Annual Report focuses on:

- action taken on proposed changes to the hydrometeorological monitoring network
- updates to CRT communications and data storage systems
- updates to data exchange requirements
- updates to forecasting procedures
- review of the 2010 CRT water supply forecasts
- other activities of the Committee

The Committee began issuing regular Annual Reports in 2001. General background information on Committee activities contained in the 2001 and 2002

annual reports is now presented in a separate supplemental document. The supplement contains general information that does not typically change from year to year. Appendices in the 2010 supplemental document include:

- Appendix A – Introduction to the Committee terms of reference
- Appendix B – Terms of reference for the CRTHC
- Appendix C – Process for reviewing hydrometeorological data networks
- Appendix D – List of contributors of hydrometeorological data
- Appendix E – Data communication and storage systems
- Appendix F – Data exchange reports
- Appendix G – Treaty studies, models, and forecast requirements

COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

2010 ANNUAL REPORT

Table of Contents

See 2010 Supplemental Report for a list of Acronyms used in this report

COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

2010 ANNUAL REPORT

2010 Annual Summary

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the Entities and is responsible for planning and monitoring the operation of hydrometeorological data collection network in accord with the Treaty and otherwise assisting the Entities as needed. The Committee consists of four members as follows:

UNITED STATES SECTION	CANADIAN SECTION
Peter Brooks, USACE Co-Chair	Stephanie Smith, B.C. Hydro, Chair
Ann McManamon*, BPA Co-Chair	Frank Weber, B.C. Hydro, Member

* There was one change in the Committee Membership in 2010. Ann McManamon replaced David Bright as the BPA co-chair for the US on August 1, 2010.

The CRTHC met twice in the 2009-2010 water year: on December 3, 2009 in Vancouver and on June 28, 2010 in Portland.

The CRTHC 2008-2009 Annual Report was completed and submitted to the Columbia River Operating Committee (CRTOC) in February 2010.

Stations

The Committee process for reviewing proposed changes to the operation of stations within the hydrometeorological network is described in Appendix C of the 2010 Supplemental Report. The process is intended to ensure that changes made to the network do not negatively affect the monitoring, planning, and operations of Treaty facilities.

The committee is continuing to address the question of adequacy of the network. The network review described below is a snapshot in time of station changes. The committee plans to build on this report during the coming year to better define which stations are critical to the operation of treaty projects and to develop a better process for monitoring those stations.

STATION NETWORK REVIEW

The question of adequacy of the hydrometeorological network has been posed many times in the last several years. To begin to answer that question, the CRTHC first conducted a survey of station closures since the last such analysis was completed in 2005. In the past 5 five water years (2005 – 2010), the CRTHC has received 42 announcements of intended or realized changes to Treaty and Supporting Stations required for CRT purposes. These announcements have included:

- Seven Canadian snow stations were either closed or modified.
- One U.S. snow station was closed due to closure of a ranger station (loss of the observer).
- Four new automated snow pillow stations started to be used in Libby water supply forecast models.
- Instrumentation at one precipitation station was replaced with new technology.

- Eight climate stations in Canada (five) and the U.S. (three) that have been or are in the process of being closed. Two of these in the U.S. (Porthill, ID, and Bonners Ferry, ID) were out of service but are now active again.
- One hydrometric station was re-installed.
- Two new water temperature sensors were installed.
- Eighteen stations continue to operate due to actions initiated by the CRTHC.
    - Nine stations had funding issues in Canada, and BC Hydro has temporarily agreed to fund the stations through 2010.
    - Nine stations had funding issues in the U.S. and the CRTHC prevailed on keeping these stations open that are used by Canada.

The cooperative observers at Porthill and Bonners Ferry in Idaho both left that program during 2009, and the NWS informed CRTHC that they were seeking new observers. The National Weather Service was able to prevail upon the observer at Porthill to remain in the program. The Bonners Ferry site has been changed slightly and is now reported by the City Water Department. Both stations are used by Canada in the Kootenay Lake water supply forecasts, and are considered important to forecasting for the Columbia region

SNOW PILLOW PROJECT

Phil Butcher, David Bright and Ann McManamon (BPA) developed a strategy and drafted a work plan to investigate enhancing the real-time monitoring of snowpack conditions in the Columbia basin. The investigation is currently focused on the relatively data sparse headwater regions of the Columbia and Kootenay Rivers above Castlegar. The committee ultimately decided to concentrate its efforts on analyzing the opportunities associated with modifying existing snow course sites into automated snow pillow sites. The study included a GIS analysis of the area and the use of a principal component

analysis to determine those stations which might provide the greatest information while also filling in spatial, temporal and elevational gaps. The CRTHC recognizes that establishing more automated snow monitoring sites does not necessarily result in an automatic improvement in forecasting but it may permit operational forecasters to better monitor changing snow water equivalent conditions on a daily basis. There is an additional advantage to the installation of automated snow pillows at current snow course locations in that the instrumentation associated with snow pillows will also provide enhanced precipitation and temperature data at those same locations.

Forecasting volumes and streamflows is a complex process involving qualitative as well as quantitative analysis. Furthermore, data demands are driven by the type of forecast model employed currently and in the foreseeable future. The CRTHC is pursuing a network review and will evaluate possible forecasting improvements including a cost-benefit. BCH is a partner in a new provincial climate network coordination effort to better integrate the monitoring networks across BC which could provide access to data from stations already operating in the desired regions by other agencies. The CRTHC will also explore possible funding mechanisms including a partnership in funding between the U.S and BC Hydro.

Communication and data storage systems

The Columbia Basin Telecommunications (CBT), other communication systems, and the Columbia River Operational Hydromet System (CROHMS) are described in Appendix E of the 2010 Supplemental Report. The CBT system, operated by USACE in Portland, is the primary communications system for transmitting project data from the throughout the Columbia River. There are 30 nodes (projects) that comprise the CBT system Agencies, including the Northwest

River Forecast Center (NWRFC), USACE, and BCH, also use other communication systems to exchange data. CROHMS is the central system for collecting and re-distributing hydrometeorological data used to support the operations of Treaty projects.

The USACE new Regional Water Control Data System (RWCDS) implementation has been slightly delayed. A prototype system is now expected to be deployed by the end of March in 2011 with the full implementation slated for December 2011. It will use agency standard hardware and software (Corps Water Management System 2.0, CWMS 2.0). The RWCDS will be a tri-node system for redundancy and continuity of operations. All support operations will be managed at the regional level, pooling resources from three USACE districts and the Columbia Basin Water Management Division. Existing HEC programs such as HEC-RAS, RES-SIM and HMS will continue to use DSS (Data Storage System) files for portability purposes.

A Microsoft® Sharepoint site was created by the US Army Corps of Engineers for the CRTHC to share and archive committee documents and activities. Previously, documents were kept by individual members of the committee and confusion could occur on the latest version of a document. The archival feature has been especially useful as members have changed recently and this site provides continuity with ongoing projects.

Data exchange

- Appendix F of the 2009 Supplemental Report describes current data exchange procedures. Data exchanged among operational projects and entity agencies may be categorized according to the type of data and the frequency of transmission. Types of data include project data, weather

and streamflow data, inflow forecasts, as well as reports and messages. The frequencies of transmission may be hourly, daily, or monthly.

Forecasting

LIBBY FORECAST PROCEDURE

A new Libby Forecast Procedure (LFP) using statistical equations was developed to forecast the April-August inflow to Libby Dam, Montana. The models were developed by Randy Wortman of the US Army Corps of Engineers, Portland District under contract to the Seattle District. The LFP was developed using principal component analysis for eight first-of-month forecast issue dates beginning with a 1-November and ending with a 1-June forecast. From November through April, the April-August period is forecast; thereafter, the residual forecast (forecast date through August) is developed, and the actual observed to date is added to the forecast to generate the seasonal volume forecast.

This review and update to the Libby water supply forecast was undertaken to address the following objectives:

- Consideration of new stations, discontinued stations, and additional years of data.
- Consideration of additional climate variables.
- Improved forecast consistency
- Improved forecast performance

The following factors and issues are related to the new forecast equations:

- The 2004 equations were no longer usable due to station closures. One snow and one precipitation station used in the 2004 equations have been closed and the proxy site for the closed snow station is no longer being measured. (The Marble Canyon, BC site was closed in 2004 during review of the 2004 procedure. Vermillion River #3 site was reopened in 2005 to use as a proxy for the Marble Canyon site, however, as of 2010; Parks Canada is no longer taking measurements at this location.)
- The historic inflow data to Libby Dam display two distinct shifts in the record (an upward shift in the mid-1940's and a downward shift in the mid-1970's). The streamflow series is not statistically stationary. The streamflow from 1975 to 2009 (35 years) was identified as stationary and was initially selected for use in the statistical forecast model.
- The use of the Alberta snow pillow sites limits the data calibration dataset to 25 years (1985 to 2009) for the winter season forecast equations, rather than the 35 years that met the streamflow stationarity conditions. The 1-Nov and 1-Dec forecast equations are all calibrated on the full 35 years since these issue dates do not include any snow data. The 1-January to 1-June forecast equations, which all utilize snow data, are calibrated on the available 25 or 26 years of data.
- There is much more variability in the flows in the recent 25 year dataset (1985-2009) than in the longer 35 year (1975-2009) dataset. The most recent 20 years (1990-2009) show the greatest variability.
- These forecast equations make use of three classes of hydro-meteorological variables: climate index variables, fall and winter precipitation and snow water equivalent variables.
- To the extent possible, the real-time availability of data was considered when selecting stations to include in the analysis. Snow information is now gathered from automated snow pillows rather than snow courses.
- The new forecast equations provide both improved forecasts with smaller forecast standard errors and better month-to-month forecast consistency. The forecast consistency is achieved through more consistency in the variable sets used from one month to the next.

- The sample chosen to calibrate the statistical model affects the forecast performance. Forecast performance statistics are not easily comparable when they have been derived from different sample sets.

The procedure underwent extensive review by both the committee and outside reviewers within the region. The procedure was accepted by the CRTOC on November 18, 2010 for use in 2010 beginning with the 1-December equation.

DECISION SUPPORT MODEL FOR DECLARING THE ONSET OF THE KOOTENAY LAKE FRESHET

The annual declaration of the "commencement of the spring rise" on Kootenay Lake by the IJC International Kootenay Lake Board of Control (KLBC) has potential operational impacts on the management of Kootenay River system reservoirs as it can signal a relaxation in the operating restrictions. For this reason, the Columbia River Treaty Operating Committee (CRTOC) commissioned the CRT Hydrometeorological Committee (CRTHC) to undertake a study and provide the KLBC with an additional decision support tool for their annual deliberation of the declaration of the spring rise.

Frank Weber (BC Hydro) developed a model that uses as input observed and forecasted local Kootenay Lake inflows. Key characteristics of the model are its objectivity in declaring the freshet onset, flexibility to accommodate year-to-year variations in hydroclimatic conditions, robustness to day-to-day flow variability caused by poor data quality and natural hydrologic processes, and the use of a 4-day lead-time inflow forecast.

The procedure is not intended to replace human decision making, but provides guidance for declaring the start of the seasonal snowmelt freshet. It has been used unofficially in the water years 2009 and 2010 with success.

The CRTOC chairs presented the methodology to the KLBC in September 2009. Following the response by the KLBC in December 2009 and a conference call with the KLBC in February 2010, the CRTHC agreed to incorporate comments of the KLBC into the final report. Specifically, it became evident that the KLBC, CRTOC, and other US and Canadian agencies did not share the same understanding of the term 'spring rise' and what would trigger the declaration of spring rise. Within the context of the 1938 IJC Order, the KLBC defines the term 'spring rise' to be an increase in unregulated Kootenay Lake levels caused by the increase in local inflow due to snowmelt in spring. Conversely, the CRTOC and some agencies had been under the impression that the term 'spring rise' was synonymous with the term 'spring freshet' and, as such, referred to the process of local lake inflow starting to increase in spring in response to snowmelt.

An updated version of the report and procedure were submitted to the KLBC in January 2011 and are currently being reviewed.

Forecast Verification

BC Hydro presented a 2010 forecast verification report for the Columbia River Treaty forecasts at a meeting of the Columbia River Forecast Group on October 7 in Portland. The presentation included a summary of 2010 climate, hydrology and water supply forecasts. The water supply forecasts and information on the hydrometeorology for the year are presented in the 2010 Annual Report of the Columbia River Treaty by the Entities (p.50 Tables 1M and 1), and will not be

repeated here. This section gives a brief overview of the forecasts and focuses on the results of the verification of the Treaty project forecasts and any lessons learned.

The Arrow local drainage is defined as the sum of the Arrow, Revelstoke, and Whatshan basins, while the Arrow total drainage is defined as the sum of the Arrow, Revelstoke, Whatshan, and Mica basins. Arrow local and total forecasts are aggregates of sub-basin forecasts.

Columbia River Treaty forecasts for Mica, Revelstoke, Arrow local and Duncan are based solely on statistical forecast model (i.e., principal component regression). For early-season (December) forecasts, total Feb-Jul forecast volumes are disaggregated into monthly volumes using the monthly runoff distribution from the 71-year mean. For consecutive forecast dates, total Feb-Jul volumes, or the residual thereof, are calculated by aggregating BC Hydro's monthly forecast volumes and disaggregated using the monthly runoff distribution from the 71-year mean. January forecasts are naïve (climatology, 71-year mean) forecasts. August forecasts are the difference between Apr-Aug forecasts and the Apr-Jul volume of the disaggregated Feb-Jul forecasts.

<u>2010 Highlights</u>

- Columbia and Kootenay River projects' inflow for the Feb-Jul and Apr-Aug periods were well-below normal (75-89 % of 71-yr Avg.).
- Seasonal runoff for all projects and forecast dates were over-forecast throughout the season, but with the forecast volume generally declining over time and asymptotically approaching what was to become the true value.
- There was a progressive and very strong drying trend through much of the water year. Weather (especially precipitation) between the forecast date and the end of the forecast horizon forms the major source of uncertainty in seasonal water supply forecasts. With the partial exception of some modest and inconsistent prediction skill derived from climate indices (see below), it is necessarily assumed in such water supply

models that future precipitation will follow seasonal normals. Hence, if actual precipitation comes in below- (above-) normal, the water supply prognosis will turn out to be an over- (under-) estimate.

- Forecasts for December were particularly poor due to the influence of above normal precipitation in October. For the December through February forecast issue dates and all projects, the final observations fell mostly outside the ± 2 standard error prediction confidence bounds. For the March to August forecast issue dates and all projects the final observations fell generally between the ± 1 and ± 2 standard error prediction confidence bounds, and only in a few cases within the ± 1 standard error prediction confidence bounds.
- The most accessible and perhaps reliable means for providing intelligence on long-term weather between the forecast issue date and the end of the forecast season is the incorporation of seasonal climate information into the forecast system.

  Water Year 2010 experienced a moderate to strong El Niño episode. On average, El Niño conditions tend to give below-normal precipitation and above normal temperatures over winter and spring in southern BC; the temperature signal is the more consistent of the two. Warm and abnormally dry conditions were indeed observed in the southern interior BC during Water Year 2010, which was consistent with the typical El Niño impact.

  June-through-September mean values of the Southern Oscillation Index (SOI) and Multivariate ENSO Index (MEI) are employed in the Treaty statistical forecast equations. However, in Water Year 2010, the Jun-Sep 2009 SOI values pointed to ENSO-neutral conditions, whereas Jun-Sep 2009 MEI values correctly pointed to El Niño conditions. Thus, mixed results were obtained depending on which ENSO index was used in the operational forecasting process. Since many of the early- and mid-season forecasts incorporate the average June-through-September SOI

as a predictor, the use of ENSO information did not have the hoped for impact on early-season volume forecasts.

Libby's first official seasonal (April-August) volume forecast, 6544 Kaf (103% of the 1929-1999 average), was prepared in early December. This forecast is used to establish the end-of-December draft requirement at Libby. The influence of the SOI on the December forecast was negligible. The remaining first-of-month seasonal volume forecasts were progressively lower than that of December and were 5682 Kaf, 5478 Kaf, 5084 Kaf, 5103, Kaf, 4887 Kaf, and 4413 Kaf for the seasonal volume forecasts issued for six months starting with the 1 January forecast. The final observed seasonal volume was 4520 Kaf. The reason for the quick downward forecast change and its subsequent degradation throughout the late winter and spring is due to the introduction of several stations with very low (as low as 31% of normal) monthly precipitation. The slight upward change in the 1 April volume forecast was due to a slight increase in precipitation accumulation during March

Schedule 1 CRTHC Action Items

Table 1 Outstanding Action Items 2010

Meeting Source	Description	Notes/Updates	Assigned To
OUTSTANDING ACTION ITEMS			
57.2.c.2	Explore options to clarify HGH storage tables used for various uses and modeling.	Peter to follow up. **USBR trying to consolidate and standardize to single table (with and without storage) for TSR**	Peter Brooks
60.4.b	Establish a data working group to address ongoing data issues, document and improve data transfer protocols, and coordinate communication around changes and updates to data management systems.	NWS reps will be Harold Opitz and Kevin Berghoff Data group will be discussed in Feb 2011 CRTHC meeting	All - with Corps as lead agency.
60.4.c	Disaster Recovery plans - Stephanie to determine what, if anything, BC Hydro will do about data recovery in the event of a major system interruption	BCH working on in 2010. BCH has established a remote/backup site in Calgary Pushing data to CROHMS to happen in future	Stephanie Smith
63.1.a	Investigate monitoring station coverage of upper Columbia by investigating station density vs. hydrologic response		David Bright
63.1.b	Pull together documentation on how suitable monitoring sites have historically been identified by BCH, Env Canada and BC MOE	64: BC MoE has no documentation on site selection criteria BCH has criteris and will use for impending site selection to convert existing sites	Stephanie Smith
64.2.b	BCMOE is in transition and data nmanagement for SWE data uncertain	Concern to be noted in station update report	Stephanie Smith
64.?.?	Ensure that BPA and BCH data requirements addressed when CWMS v2.x is deployed	Deployment has been delayed and further delays are expected due to staffing and fiscal issues. CROHMS user survey is in progress to canvas	Corps
64.3.a	Address TSR vlume issue ???	Committee will raise concern to CRTOC as to when and how and adjustment to/deviation from the TSR is done.	Frank Weber
65.2.c	Change Table 8 in PoP to reflect errors in Dworshak calues and update Libby error terms from new forecast procedure		Stephanie Smith
65.4.a	Reschedule NWRFC briefings on CHPS/FEWS and station substitution		Peter
66.6.e	Agree on a clear definition 'Treaty and Supporting Stations'		

Table 2 Completed Action Items 2010

File Updated	December 1, 2010		
Meeting Source	**Description**	**Notes/Updates**	**Assigned To**
OUTSTANDING ACTION ITEMS			
58.5.c	Peter to pursue putting electronic versions of forecast-related documentation on SharePoint site	Mtg 59.1.a: Peter to assign someone to give access details to BPA / BCH	Peter Brooks
59.4.a	Stephanie to provide updated list of Environment Canada reference climate stations and core temperature and precip. Stations. Will cross-reference with Treaty station list. Will also include indication if stations are potentially vulnerable	Info will be folded into station update report	Stephanie Smith
60.4.c	Disaster Recovery plans - Stephanie to determine what, if anything, BC Hydro will do about data recovery in the event of a major system interruption	BCH working on in 2010. BCH has established a remote/backup site in Calgary Pushing data to CROHMS to happen in future	Stephanie Smith
61.4.b	Potential SNOTEL closures in Pac NW. Follow up with RFC. Keep updated by NRCS (Jon Lea)	BCH has no issue with potential station closures	Peter Brooks & David Bright
64.2.a	See if BCH getting what they need from Porthill/Bonners Ferry Climate Station	65: BCH is getting what they need	Ann McManamon/ Frank Weber
65.2.a	Review and provide comments to Corps Seattle District on new Libby volume forecast		All
65.2.b	Recommend new Libby volume forecast procedure to CRTOC for approval		
65.4.b.	Provide bulleted list of station siting criteria used by NRCS		Ann McManamon