COLUMBIA RIVER TREATY HYDROMETEOROLOGICAL COMMITTEE

2014 ANNUAL REPORT

OCTOBER 1, 2013 - SEPTEMBER, 2014

Stahl Peak, MT SNOTEL Site. Kootenai Basin above Libby. Elevation 6030 Feet.

Stephanie Smith	BC Hydro, Canada, Canadian Chair
Adam Gobena	BC Hydro, Canada, Member
Peter Brooks	U.S. Army Corps of Engineers, U.S., U.S. Co-Chair
Ann McManamon	Bonneville Power Administration, U.S., U.S. Co-Chair

DECEMBER 2014

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Introduction

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the Entities. The CRTHC 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 CRTHC activities during the 2014 water year (October 1, 2013 – September 30, 2014). The Annual Report focuses on:

- Station Adequacy
- Computer Systems and Data Acquisition and Exchange
- Forecasting Procedures
- Review of the 2014 CRT water supply forecasts
- Other activities of the Committee

The CRTHC began issuing regular Annual Reports in 2001. General background information on CRTHC 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 supplemental document include:

2014 ANNUAL REPORT

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See 2014 Supplemental Report for a list of acronyms used in this report

COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

2014 ANNUAL REPORT

2014 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	Adam Gobena, B.C. Hydro, Member

The CRTHC met twice in the 2014 water year:
Meeting 73: April 29-30, 2014 at BC Hydro
Meeting 74: August 12-13, 2014 at USACE

In addition, the CRTHC members conducted several interim phone conference calls to discuss impending water supply forecast decisions or provide interim guidance for ongoing projects. The CRTHC maintains a list of all action items arising from these meetings and Schedule 1 attached the end of the main body of the Annual Report details the outstanding action items, and the list of actions completed this year.

The 2013 CRTHC Annual Report was completed in December 2013, in advance of the annual Permanent Engineering Board Meeting.

Stations

The CRTHC process for reviewing proposed changes to the operation of stations within the hydrometeorological network is described in Appendix C of the 2014 Supplemental Report. The process is intended to ensure that changes made to the network do not adversely affect the monitoring, planning, and operations of Treaty facilities. To address a deficit of snow monitoring stations in the Canadian portion of the basin three new snow station sites were installed in B.C. during September 2014 under a cost-sharing agreement between BC Hydro and BPA. Those stations are Wildcat Creek near Mistaya Lodge and Kicking Horse, Colpitti Creek near Sunbeam Lake, and Caribou Creek Upper near Vermont Creek. These new sites, plus one installed last year at Keystone Creek, are in the Upper Columbia drainage and are close to 2100 meters in elevation. These stations provide much-needed high-elevation snowpack information in real-time in an area that historically has been inadequately covered. A discussion of location selection and of how the information received from these stations will be used was presented in CRTHC's 2013 annual report.

The CRTHC continues to add to and re-shape its station database for use primarily in monitoring station adequacy, tracking station changes, and visualization of basin coverage. A significant amount of metadata has been added; and all stations are placed in one of three categories: Treaty, supplemental, and informational. Over the coming year, the station database will be used to generate GIS products to aid in evaluating the stations' spatial and temporal attributes. The CRTHC routinely reviews the basin gaging network for adequacy and at this time believes that the station network is adequate for Treaty purposes.

A number of years ago, BCH and the Seattle district of the Corps reached an agreement for BCH to install two water temperature gauges in Elk River at Fernie and Kootenay River at Fort Steele. The probes were provided by Corps, and BPA agreed to pay the operating costs for the sites (~$700/year each). This agreement has since expired, and at least one of the probes needs to be replaced. BCH would like to

authorize Water Survey of Canada to replace the probes with their own instruments (at BCH's cost) to improve maintenance of the instruments. The Corps' Seattle District expressed a need to continue the gages. The new contract between BPA and BC Hydro for maintenance of the snow stations also includes these water quality stations.

CRTOC asked an opinion from CRTHC on changing the Arrow Treaty gauge from Arrow Reservoir at Fauquier (FQU) to Arrow Forebay. Since the original request, CRTOC members determined they would continue to use FQU to calculate Treaty storage accounts, but would consider using the Forebay to operate to during high reservoir level conditions. This change is in response to BCH Dam Safety requiring BC Hydro to operate to the Forebay gauge when the reservoir exceeds 1444' at the Forebay gauge. BC Hydro initiated a benchmark survey for all three of the Arrow reservoir gauges to try to resolve an apparent discrepancy between Arrow at Fauquier and Nakusp gauges, and the Arrow Forebay. This Survey is complete and the report forthcoming. The survey identified that the Forebay gauge benchmark is high by 0.17m. BC Hydro needs to decide what to do with this information as many of the instruments, drawings and operating levels for the project are tied into the incorrect benchmark. Deliberations are still taking place regarding how to proceed.

Computer Systems and Data Acquisition and Exchange

Each of the agencies has been updating several of their internal water data management systems to make the systems more resilient and to address the need for continuity of operations in a disaster. The Corps finally reached its regional Water Control Data System (RWCDS) end-state. This means that the nationally-required Corps Water Management System (CMWS) is now the hardware and software suite. Old equipment has been de-commissioned, and the CWMS database is now Oracle.

BC Hydro's FTP data server was relocated to a secure facility in Kamloops, BC. And all agencies are obtaining BC Hydro data from that server. BC Hydro has also begun the transition to the use of the secure FTP (sFTP) protocol. Testing has begun with BPA's sFTP site, and will expand to include the Corps' sFTP server. Testing and implementation are expected to be complete in early WY 2015.

BPA identified some irregularities in how the SHEF-encoding was taking place in the Corps database. BPA and the Corps will establish a list of stations that need attention and fix them within the first quarter of WY2015.

Forecasting

Libby Seasonal Volume Forecast Update

The CRTHC spent a considerable amount of time working with the Corps' Seattle District (CENWS) in their preparation of an updated Libby April – August seasonal volume forecast. The Kootenay River experienced three consecutive years of rising April –August forecasts due to late season (May and June) above-average rainfall, including record June precipitation in 2012. The climate indices in the existing forecast procedure were providing spurious and contradictory information to the forecast. The CRTHC and CENWS agreed that the focus of the update should be to review the climate indices, modify the period of record to include 1984 through 2013. The tendency might be to treat 2012 as an outlier; but because late season rainfall happened in three consecutive years the CRTHC believed it important that those types of years be included in the period of record.

The Cross-Validation Standard Error (CVSE), the metric used to compare regression-based forecast procedures, for the PCReg2014 is greater than those computed for the original PCReg2011. It appears that most of the reason for this increase is directly tied to the period of record selected for the latest forecast procedure. It is believed that this longer period which includes 2011 - 2013 in which about 30% of the April-August

volume was due to unusually heavy summer precipitation captures a better representation of the variability of the April-August period. To properly compare the PCReg2011 and PCReg2014, the PCReg2011 was re-trained on this same longer period of record. The results show that the PCReg2014 CVSE is less than the PCReg2011 (re-trained) – hence a forecast improvement. On 29 August 2014 the CRTHC recommended to the CRTOC that the new forecast procedure be approved for implementation. The CRTOC approved the forecast procedure, and the decision was recorded in the 18 September 2014 minutes of the CRTOC.

NWS ESP Water Supply Forecasts

The Northwest River Forecast Center (NWRFC) continues to produce water supply forecasts using the Ensemble Streamflow Prediction (ESP) procedure. In December 2013, the NWRFC announced that it would be changing its ESP set that included 3 days of its short-term forecast to one that included 5 days of its short-term forecast. This change brought them into alignment with other RFCs across the West. The CRTHC did not have a reason to accept or reject the NWRFC proposal, and agreed to use it for the basin-wide ESP volume forecasts for the upcoming season. During WY2014 the CRTHC monitored the performance (at The Dalles and Libby) of the 5-day ESP for accuracy and timeliness and found that it performed adequately. The CRTHC prepared a recommendation for the CRTOC with ESP forecast issue dates that will be the official ones for use in the Treaty FCOP, the Actual Energy Regulation (AER), and the Treaty Storage Regulation (TSR). During the September 2014 CRTOC meeting the CRTHC recommendation to use the 5th working day of the month and the forecast including 5 days of a short-term forecast for the upcoming year was adopted by the CRTOC. The CRTHC will continue to monitor and evaluate the range of ESP forecast lead times to determine what best serves the needs of the Treaty.

The approved official forecast dates are:

8 January 2015,

6 February 2015,

6 March 2015,

8 April 2015*,

7 May2015,

5 June, 2015,

8 July 2015.

* This date is actually the 6th working day in the month of April. The Friday and Monday of the preceding weekend are Canadian holidays, making this date coincide with the date upon which the Canadian forecasts will also be available.

Forecast Verification

The water supply forecasts and information on the hydrometeorology for the year are presented in the 2014 Annual Report of the Columbia River Treaty by the Entities (Section IV), 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.

Canadian Projects

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 80-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 80-year mean. January forecasts are naïve (climatology, 80-year mean) forecasts. August forecasts are the difference between Apr-Aug forecasts and the Apr-Jul volume of the disaggregated Feb-Jul forecasts.

2014 Highlights

- ENSO was not a significant factor in 2014 as equatorial Pacific conditions were neutral. The water year started with one of the driest Octobers on record, with regional precipitation at only 32% of normal for Columbia and 38% of normal for Kootenay. The rest of the fall and early winter season was also drier than normal although conditions were not as abnormal as they were in October. Accumulated water year precipitation at the beginning of February was 80% and 76% of normal, respectively in the Columbia and Kootenay regions. As a result, 1st of February regional accumulated snowpack was only at 94% of normal in the Columbia and 85% of normal in the Kootenay. The rest of the winter season saw above normal precipitation leading to 1st of April snowpack of 109% and 121% of normal, respectively in the Columbia and Kootenay regions. The summer season was characterized by dry and warm conditions. The dry conditions experienced during the fall and summer seasons of the water year partially offset the impact of the above normal snowpack on the water supply.
- The February-through-July observed inflow volumes to Canadian Columbia region projects were near the 80-year average: Mica and Arrow total were 100% and Duncan was 103%. April-through-August observed volumes were from 97% for Mica, 99% for Arrow and 101% for Duncan.
- The evolution of the water supply predictions in WY2014 also mirrored the month to month variation in the hydroclimate of the region. December forecasts for the February-through-July volume were 92% to 93% of the 80-year average and reflected the impact of the abnormally dry antecedent precipitation going into the forecast season. Forecasts declined further and remained between the upper 80% and lower 90% of the 80-year average all the way to the March forecast as the early winter season

also turned out to be drier than normal. The rest of the season saw gradual recovery towards the actual observed volumes as the snow accumulation improved starting in February.

- The nominal forecasts for the February-through-July volumes of Mica and Arrow total underestimated observed flows by between 8% and 12% before April, but the forecast errors were reduced to below 5% for the rest of the forecast dates. However, most of the forecasts enclosed the observed flow in the ±1 standard error prediction bounds, and only in one of the forecast dates for Arrow total did the observed flow fall on the margin of the ±2 standard error prediction bounds. On the contrary, the ±2 standard error prediction bounds for Duncan failed to enclose the observed flow on 2 of the eight forecast dates. In addition, forecast errors for Duncan remained above 10% through the June forecast. The reasons for the relatively poor performance for Duncan appear to be partly due to sampling variability in the snow stations used in the model and partly due to the weight the models assign to the abnormally dry antecedent conditions. Forecast evolution was similar for the Apr-Aug forecast target.

Table 1. Feb-through-July forecast volumes and associated prediction bounds for Canadian projects

Project		01Dec	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul
Mica	FC[1] – 2SE[2]	73%	72%	78%	79%	86%	88%	92%	97%
	FC – 1SE	83%	82%	85%	84%	91%	92%	97%	99%
	FC	92%	91%	91%	90%	97%	97%	102%	102%
	FC + 1SE	101%	100%	97%	95%	102%	102%	107%	104%
	FC + 2SE	110%	109%	104%	101%	107%	107%	112%	107%
	Observed	100%	100%	100%	100%	100%	100%	100%	100%
Arrow Total	FC – 2SE	68%	66%	71%	72%	83%	86%	90%	94%
	FC – 1SE	80%	76%	79%	80%	89%	92%	94%	97%
	FC	92%	89%	89%	88%	96%	97%	100%	101%
	FC + 1 SE	102%	97%	96%	94%	101%	101%	104%	103%
	FC + 2SE	112%	106%	102%	100%	106%	106%	109%	105%
	Observed	100%	100%	100%	100%	100%	100%	100%	100%
Duncan	FC – 2SE	73%	72%	72%	74%	80%	81%	89%	94%
	FC – 1SE	83%	80%	79%	81%	87%	87%	94%	98%
	FC	92%	89%	86%	88%	93%	93%	99%	101%
	FC + 1SE	102%	97%	93%	95%	99%	99%	104%	104%
	FC + 2SE	111%	106%	100%	102%	106%	105%	109%	108%
	Observed	103%	103%	103%	103%	103%	103%	103%	103%

[1]FC = Forecast as % of 80-year average; [2]SE = Standard error of prediction

Libby

The 2014 water year was classified as an ENSO neutral year. The precipitation through the fall and early winter (October – December) was below average at about 72% of average. Throughout the winter the precipitation amounts remained a mixed bag with the averages at the precipitation stations through January and February ranging between 50 and 167 percent of average. The snow accumulation was below average through February, and March with the 1st of March snowpack being 93 percent of average. March was a big snow building month with the precipitation for the month over 200 percent of average and the snow pack jumped from 93 percent of average to 113 percent of average between the 1st of March and April. The snowpack continued to build through April; and the snowpack increased to 122 percent of average by the beginning of May. The spring saw below average temperatures in April and a warm-up in May with the freshet beginning in the first part of May. The month of June was fairly normal with no major precipitation events as had been seen over the last two years. The observed April-August seasonal average snowpack was 113% of average. As seen in the table below, Libby Dam was under-forecasted for the seasonal volume forecasts issued from December through March (a positive value for number of standard errors indicates an under-forecast). The under-forecasting was due mainly to the snowpack being less than average. The April through June forecasts were slightly higher than the observed but performed well within the error bounds as seen in the following table:

Month of Forecast	First-of-Month Apr-Aug Volume Forecast (KAF)*	Model Standard Error (KAF)	Number of Standard Errors Different Than Observed	End-of-Month Flood Risk Management Target (FT)
Dec	5446	947	1.3	2426.6
Jan	5432	841	1.3	2426.7
Feb	5213	564	1.5	2436.4
Mar	5505	527	1.2	2440.9
Apr	6868	532	-0.2	2377.5
May	6996	487	-0.3	
June	7074	418	-0.4	

**Note that the Observed April-August Libby inflow volume was 6673 KAF*

Schedule 1 CRTHC Action Items

Meeting Source	Description	Notes/Updates	Assigned To	Due Date
		OUTSTANDING ACTION ITEMS		
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 2011. BCH has established a remote/backup site in Calgary BCH working on business continuity planning and establishing timelines for recovery	Stephanie Smith	ongoing
72.2.e	Develop list of specific contacts to send letters to in US for Hydromet data needs	Peter working on USGS and Corps contacts, Ann working on NRCS and NWS contacts. Contact list to be used to prepare and send letters to gage cooperators.	Peter/Ann	WY15
73.7.a	Stephanie will set up new SharePoint based on layout discussed at the meeting. Stephanie will check on backup of Sharepoint	New site is up and working well. Documents are still being collected and posted to the site. It is used actively for Committee business.	Stephanie	ongoing
73.4.a.iii	Transition to sFTP for data exchange to CROHMS	Camila Tang-Miya is contact person at BCH. She will connect with Gunnar at Corps and BPA Tech Support on transition plan	Camila + Stephanie / Peter / Ann	
74.5.b.	SHEF data encoding	Provide a list of station IDs parameters and time interval to Gunnar Leffler (RWCDS Team Lead)	Ann	WY15

Table 1 Outstanding Action Items 2014

Meeting Source	Description	Notes/Updates	Assigned To	Due Date	Completed
COMPLETED ACTION ITEMS					
72.2.c, 73.5.b., 74.4.4a-d.	Guide, review, and recommend approval (or not) of updated Libby seasonal volume forecast	CRTHC was intimately involved with the development of the forecast procedure.	All	20-Aug-14	done
73.5.c	use of short-term forecast guidance in ESP WSF forecast	Anne to complete an analysis of variation in 5-, 10-day forecast and climatology to determine if changes in short-term forecast caused large swings in WSF in 2014	Ann	Aug-14	done
74.4.e	Dalles seasonal volume forecasting	Petition NWRFC to add 25% and 75% (or close to it) confidence limits to ESP forecast products	Peter		Done

Table 2 Completed Action Items 2014