FORTY YEARS OF INTERNATIONAL COOPERATION: COLUMBIA RIVER TREATY HYDROMETEOROLOGICAL COMMITTEE 1968-2008

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ABSTRACT

The Columbia River Treaty was ratified in 1964 and established an agreement between the United States and Canada to build three storage projects on the Columbia River system in Canada (Mica, Arrow, Duncan) with the option to build Libby on the Kootenai River in the U.S. The goals of the Treaty were to provide better flood control for communities on the Columbia River, and to provide for the development of hydroelectric power generation in both countries. The Columbia River Treaty Hydrometeorological Committee (CRTHMC, or Committee) was formed in 1968 under the Treaty and was given the responsibility for planning and monitoring the operation of data collection facilities to support the Treaty. The Committee is comprised of members from B.C. Hydro in Canada and the U.S. Army Corps of Engineers Northwest Division and Bonneville Power Administration in the United States. The Committee works with many other data collection and water supply forecasting groups around the Pacific Northwest and has provided the necessary support to help preserve hydrometeorological stations through times of shrinking networks. A data exchange system, CROHMS, was developed by the Corps to manage the exchange of information across the Columbia basin to report on and support planning of the operation of Treaty projects on the Columbia River. The CRTHMC is much more than a data committee. The Committee also reviews any new water supply forecasting procedures proposed for Treaty projects by the project managers. The Committee has provided a forum for the exchange of ideas to advance the science of water supply forecasting in the Pacific Northwest. The Columbia River Treaty is a model of international cooperation on trans-boundary water resource management, and the CRTHMC has been supporting and enhancing that spirit of cooperation for the last forty years. This paper will describe the history of the Committee and relate some recent successes and challenges the Committee has faced.

INTRODUCTION

The Columbia River Treaty (the Treaty) between the United States and Canada was ratified in 1964 and established an agreement between the two countries to build three large storage projects in the Columbia River system in Canada (Mica, Arrow and Duncan) with the option to build the Libby project on the Kootenay River in the U.S. The two goals of the Treaty were to provide better flood control protection to the communities along the river and to develop the hydroelectric potential of the river system. All four reservoir projects were completed by 1973 with the Canadian projects providing 15.5 million acre-feet (19.1 km^2) of storage, and Libby providing an additional 5 MAF (6.17 km^2). It was recognized early on that hydrometeorological data would be required to track and forecast the operations of the Treaty projects. In 1965 an international task force was appointed to investigate what the requirements should be for a hydrometeorological system to operate in both countries. From 1965 - 1970 the task force made seven recommendations including that a hydrometeorological system containing snow courses, streamflow gauges and meteorological stations be established and that protocols be set up to communicate these data in a timely manner for making operating decisions. The task force also recommended seeking technical advice and assistance from Canadian and American federal data collection agencies, such as Environment Canada, the USGS, the Soil Conservation Service, and National Weather Service. The task force was disbanded in 1968 and in its place the Columbia River Treaty Hydrometeorological Committee (CRTHMC) was established with the goals of making recommendations on the hydrometeorological system needed to service the Treaty, and to establish and maintain a means of communicating hydrometeorological information to meet operational and forecasting needs. The CRTHMC also takes on a third role of coordinating forecasting procedures used to plan the operation of the projects.

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THE COLUMBIA RIVER TREATY

Origins of the Columbia River Treaty

The Treaty was negotiated starting in 1954 following a serious flood on the Columbia River in 1948 that damaged homes and infrastructure from Trail, B.C. all the way to Astoria, OR. The city of Vanport, OR (population 35,000) was extensively damaged, and in total between 50 and 60 people were killed. The International Joint Commission had already begun studies evaluating the potential of the water resources of the Columbia River in 1944. It was recognized that the large storage potential in the headwaters region of the Columbia River could provide tremendous flood control protection for the communities along the river. In addition, both countries recognized the enormous potential for hydroelectric generation on the Columbia River. The Columbia River is the fourth largest river in North America, but has the highest energy potential as measured by both flow and change in elevation, or head. The Mississippi, St. Lawrence and Mackenzie rivers have higher flow, but less head. With a number of existing dams already on the lower Columbia, including Grand Coulee, the economic and flood control benefits of developing the upper Columbia were clearly evident to both countries.

Columbia River Treaty Implementation

The Columbia River Treaty between Canada and the United States relating to the cooperative development of water resources of the Columbia River basin was jointly signed by the heads of the respective governments on January 17, 1961. The Treaty was ratified quickly by the U.S. Senate, but not by Canada. British Columbia needed money to build the three Columbia River dams and also had plans for a large dam on the Peace River in the northern part of the province. Part of the Treaty negotiation was to place a value on the flood control and downstream power benefits for the United States of having the large storage projects built in Canada. B.C. wanted to sell this Canadian Entitlement to the downstream benefits negotiated, but the Canadian government initially opposed the sale. Three years of negotiations between the U.S. and Canadian governments led to the Treaty Protocol, signed on the 22nd of January, 1964 which allowed for the sale of the Canadian Entitlement, and clarified several other issues. The negotiations also agreed to set the price of the sale of the first 30 years of the Canadian Entitlement at $US 254.4 million. Final ratification of the treaty occurred when Canada ratified the Treaty on September 16, 1964.

The three Canadian Treaty projects, Duncan dam (providing 1.73 km^2 of storage), Hugh Keenleyside dam (8.76 km^2 of storage), and Mica dam (8.63 km^2 of storage) were completed in 1967. 1968, and 1973 respectively. The Treaty also made provision for constructing Libby dam (6.17 km^2 of storage) in the U.S. was completed in 1973. Figure 1 shows a map of the location of the four projects taken from a 1964 Canadian Government brief on the Treaty. A number of other diversions were outlined in the Treaty to augment the existing storage, but these diversions were never completed. This figure outlines some other potential dam sites in British Columbia, of which the Revelstoke Canyon and Kootenay Canal projects were built subsequent to the construction of the Treaty projects.

Once all four projects were completed, they provide a combined storage of 25.2 km^2 (20.5 MAF) in the Upper Columbia River. Flood control procedures outlined by the Treaty Protocol dictate the operation of the storages to maximize flood control during the peak flows of spring and summer, and storing the water until fall and winter to provide a firm supply of water for hydroelectric power production during the peak energy load period. Figure 2 shows the change in the timing of runoff between the planned regulated flow and what the unregulated flow would be for the Columbia River at The Dalles, just upstream from Portland, Oregon. Note the decrease in peak flood flows in the spring and summer during the freshet, with a corresponding increase in flows in the winter months providing electricity generation during peak electrical loads.

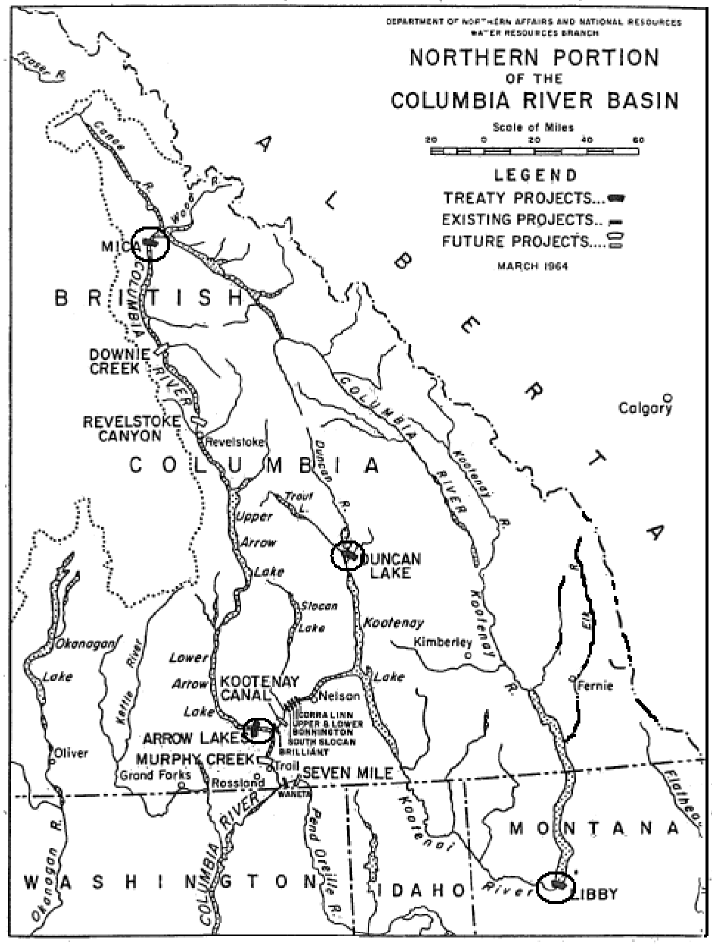

Figure 1. Map of Columbia River Treaty Projects (Government of Canada, 1964)

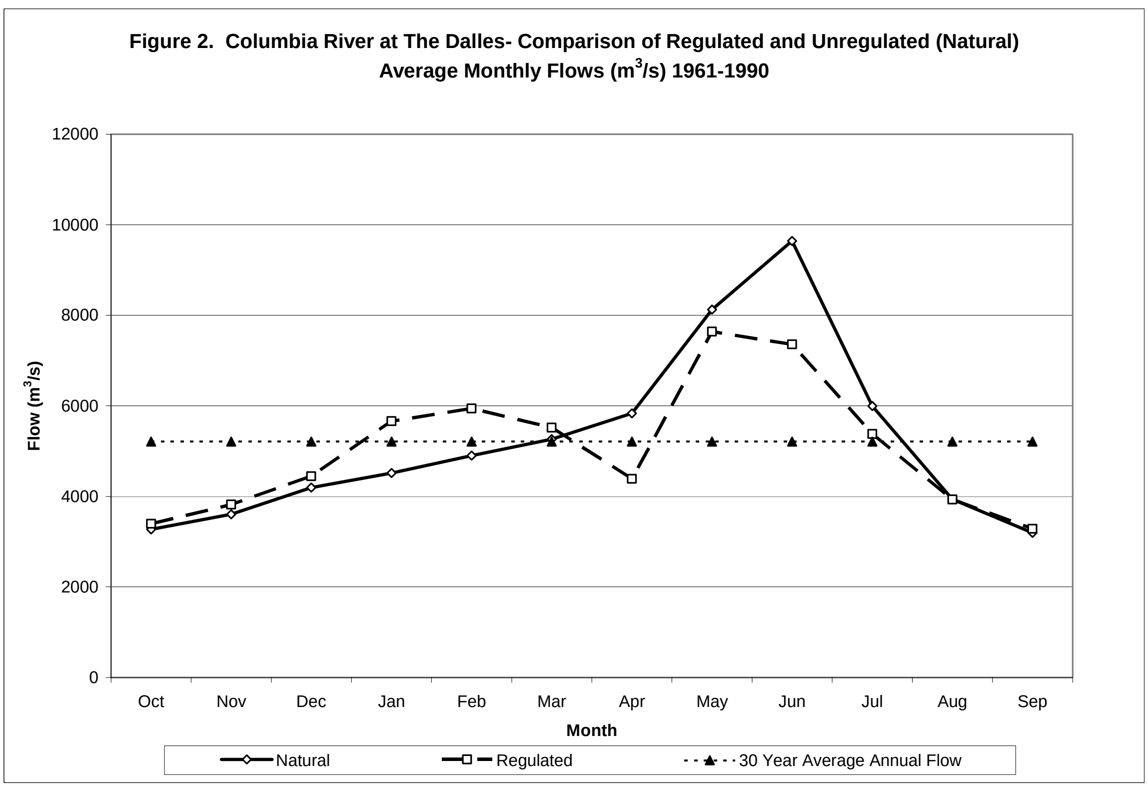

Figure 2. Comparison of Natural and Regulated flows at the Columbia River at The Dalles.

1965 International Joint Task Force

In 1965, an International Task Force on Hydrometeorological Network, Columbia River Treaty was appointed to recommend establishment and operation of the hydrometeorological network and procedures for exchange of information between the two Entities. The Task Force was given instructions to:

1. Recommend additions to the present hydrometeorological network to provide information essential to the operation of the Treaty storage to achieve the benefits contemplated by the Treaty which will:
   a. Provide current data on reservoir and streamflow conditions
   b. Provide sufficient information for forecasting streamflow on a long-range (seasonal), medium-range (10 days to a month or two), and short-range (up to 10 days) basis to meet the operational criteria of each project
2. Recommend establishment and operation of a communication system for timely reporting of all hydrometeorological factors to meet operational and forecasting requirements. This system should utilize existing facilities where possible and new facilities should be recommended where needed.
3. Review the network from time to time and recommend additions to or deletions from the facilities to insure peak network efficiency.
4. Prepare reports and recommendations to entities from time to time as appropriate.

Between 1965 and 1970, the Task Force made seven recommendations to the Entities, the last two made after the Task Force was disbanded and the Columbia River Treaty Hydrometeorological Committee was established in its place on September 19, 1968. Monitoring locations considered critical for the operation of the Columbia River Treaty are designated as “Treaty” stations, while other significant stations are designated “Supplemental” stations.

The first recommendation of the Task Force addressed the need for stream and reservoir gauging in the Canadian portion of the basin for operating the projects and monitoring flows across the border. The Task Force designated 21 water level gauging locations in B.C. as Treaty stations, including recommending 4 new reservoir level monitoring sites on Kinbasket reservoir (Mica dam), Duncan reservoir, and on the Upper and Lower Arrow Reservoir (Keenleyside dam).

Recommendation 2 looked at the snow course network B.C. and recommended the addition of 8 new snow courses and their proposed locations to aid in water supply forecasting for the Canadian projects. These snow courses are considered to be Supplemental stations in support of the Treaty.

Recommendation 3 reviewed the existing meteorological network in both Canada and the U.S. for input into forecasting procedures for the Treaty projects. Under this recommendation, 19 climate stations in Canada and 5 stations in the U.S. were designated as Treaty stations, including 2 new stations recommended at Keenleyside dam and Libby dam. The Task Force also recommended the establishment of one high-elevation station in the Canadian portion of the basin: “The Task Force has noted with interest that experimental work is being carried out by the Canadian Department of Transport to develop an automated high-level station. It is recommended that the need should be stressed for such a station to be established as soon as possible.” (CRT International Task Force, 1967)

Recommendation 4 detailed the snow course network recommended to improve seasonal runoff forecasting for the Libby Project in the U.S. In addition to existing networks in both Canada and the U.S, the task force recommended 7 new snow course locations in Canada and 5 new snow course locations in the U.S. Table 1 lists the 17Canadian snow courses added as a result of Recommendations 2 and 4 and the status of these snow courses today.

Table 1. Columbia River Treaty Influence on Expansion of Snow Survey Network in B.C. and Pacific Northwest		
Description in Recommendation	**Snow Course**	**Period of Operation**
Recommendation #2 Canadian Stations in Upper Columbia Basin		
1. West facing slope of the Rockies. Wood River drainage	Molson Creek 2A21 Molson Creek Snow Pillow 2A21P	1967 – 1995 1980 -
2. East facing slope of the Monashee Range between Mica and Revelstoke	?	
3.West facing slope of the Selkirks between Mica and Revelstoke	Keystone Creek 2A18	1966 –
4. East facing slope of the Selkirks between Golden and Mica. Gold River drainage	Sunbeam Lake 2A22	1967 –
5. West facing slope of the Rockies between Golden and Mica. Bush River watershed	Bush River 2A23	1967 –
6. East facing slope of the Purcell range between Columbia Lake and Golden	Vermont Creek 2A19	1966 –
7. Duncan River basin	East Creek 2D08 Converted to a snow pillow 2D08P	1967 – 1995 1980 –
8. West facing slope of the Selkirks between Revelstoke and Arrow Park. Upper Arrow Lake	St. Leon Creek 2B08 St. Leon Creek snow pillow 2B08P	1967 – 1992 –
Recommendation #4 Canadian Snow Courses in Kootenay basin		
1. East facing slope of the Vermilion Range in vicinity of Floe Lake	Floe Lake 2C14 Floe Lake pillow 2C14P	1969 – 1992 –
2. West facing in the headwaters of the Cross River basin	Mount Assiniboine 2C15	1969 –
3. West facing in the headwaters of the East White and Bull River basins	Thunder Creek 2C17	1969 –
4. South facing in the headwaters of the Elk River basin	Mount Joffre 2C16	1969 –
5. East facing in the headwaters of Redding Creek	Gray Creek Upper 2D10	1969 –
6. Vicinity of Kimberley VOR site – three-level snow profile	Kimberley VOR Upper 2C11 Kimberley VOR Mid 2C12 Kimberley VOR Lower 2C13	1969 – 1969 – 1969 – 1995
7. Vicinity of Moyie microwave site	Moyie Mountain 2C10 Moyie Mountain pillow 2C10P	1969 – 1998 1971 –

Recommendation 5 detailed 14 water level gauging stations in the U.S. required for operation of the Treaty, including upstream of Libby, Pend d'Oreille, Clark Fork and on the mainstem Columbia all the way down to The Dalles.

Recommendation 6 outlined an interim data exchange protocol to be used until a permanent system could be developed (see **Data Exchange** section below).

Recommendation 7 clarified definitions of Treaty Facilities with respect to hydrometeorological monitoring and defined protocols for reviewing and making changes to the network. This recommendation also included the first set of agreed changes and additions to the original stations listed in the first 5 recommendations.

Together the 7 recommendations defined the Columbia River Treaty hydrometeorological network and formed the basis for the first CRTHMC activities.

CRTHMC Terms of Reference

The CRTHMC was formed to address one section of the Columbia River Treaty, Annex A, Principles of Operation: "A hydrometeorological system, including snow courses, precipitation stations and stream flow gauges will be established and operated, as mutually agreed by the entities and in consultation with the Permanent Engineering Board, for use in establishing data for detailed programming of flood control and power operations.

Hydrometeorological information will be made available to the entities in both countries for immediate and continuing use in flood control and power operations". (Canada and U.S. Governments, 1964)

<u>Composition of the Committee</u>

The committee is comprised of four members, two from the US Entity and two from the Canadian Entity. From the U.S. one member comes from Bonneville Power Administration (BPA) and one comes from the U.S. Army Corps of Engineers Northwest Division (Corps). Both Canadian members come from BC Hydro. The Committee reports to the Entities through the Treaty Secretaries and Coordinators. The CRTHMC also works with the Columbia River Treaty Operating Committee, which has responsibility for coordinating the operation of the Columbia River Treaty projects in the context of the entire Columbia River System. The Permanent Engineering Board is responsible to the federal governments for the oversight of the Treaty. Figure 3 outlines the governance structure for the Columbia River Treaty.

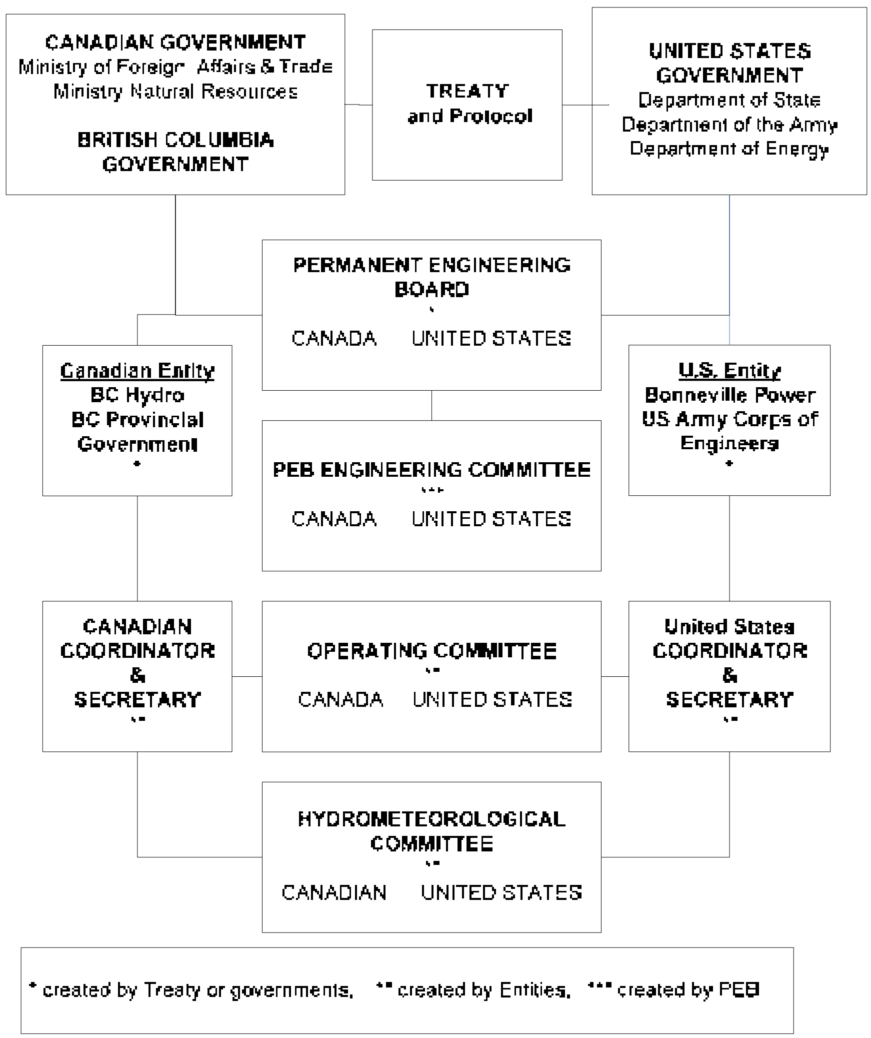

Figure 3: Columbia River Treaty organization

<u>CRTHMC Activities</u>

The CRTHMC has three main areas of responsibility with respect to the operation of the Columbia River Treaty projects. These responsibilities include ensuring the timely exchange of data between the Entities, monitoring the hydrometeorological station network for adequate monitoring and reporting and coordinating water supply forecasting procedures for the Treaty projects.

Data Exchange. The four Columbia River Treaty projects are operated in coordination with the whole Columbia River system. Timely exchange of operating data is critical to efficient operation of each project and for the many objectives for the many parts of the Columbia River system. It is also critical for accurate accounting of water storage and energy exchange that clear records of Treaty operations are kept. Data are exchanged in a number of ways. The principal data exchanges are completed through the Columbia River Operational Hydromet System (CROHMS), a data management system operated by the Corps of Engineers which takes in data from agencies across the Columbia basin to make it available for coordinating operations of all projects on the Columbia River and its tributaries. Data exchanged through CROHMS includes meteorological data, reservoir levels, inflows, outflows and storage calculations for Treaty and other projects. Other data exchanges occur over email, fax and phone communications.

Table 2: List of Agencies contributing data to CROHMS

- Avista Corporation, Spokane, WA
- BC Hydro, Vancouver, B.C.
- Bonneville Power Administration, Portland, OR and Vancouver, WA
- Constellation Energy Commodity Group
- Controlled Area Scheduling Service, Spokane, WA
- Eugene Water and Electric Board, Eugene, OR
- PacifiCorp, Portland, OR
- Portland General Electric, Portland, OR
- PP&L Montana, Butte, MT
- Public Utility District No. 1 of Chelan County, WA
- Public Utility District No. 1 of Douglas County, WA
- Public Utility District No. 1 of Pend Oreille County, Newport, WA
- Public Utility District No. 2 of Grant County, WA
- Puget Sound Energy, Redmond, WA
- Seattle City Light, Seattle, WA
- Tacoma Power and Light, Tacoma, WA
- USACE, Portland, OR, Seattle & Walla Walla, WA
- USBR, Boise, ID

Stations. The original goal of the CRTHMC was to maintain a network of key meteorological, hydrometric and snow observing stations to support Treaty operations. From the beginning the Terms of Reference for the committee encouraged collaboration with existing national and provincial / state observing programs, such as Environment Canada, BC Ministry of Environment, US SNOTEL and National Weather Service networks. In addition, Entity agencies may also operate their own hydrometeorological networks, such as the BC Hydro DCP network in British Columbia. The CRTHMC maintains a list of Treaty and Supporting stations critical to Treaty operations. An observing station is designated a “Treaty” Station if it is deemed necessary for the operation of the Treaty, such as key stream flow and reservoir level monitoring points, and any weather or snow stations used directly in water supply forecasting for Treaty projects. A Supporting station is not used directly in Treaty operations, but provides additional information in the watershed, such as stations used to quality control and estimate the Treaty stations in water supply forecasting procedures. For any proposed changes or closures of stations in the region, the CRTHMC member responsible has to advise the other members of the impending change and seek their input on whether the station is critical and needs to be maintained, or an alternate location sought. If the station is operated by another agency, the CRTHMC member has to negotiate with that agency to either maintain the station, including providing funding or taking over operation of a station if necessary, or work with the agency to identify a suitable alternate station location nearby.

The CRTHMC would keep long lists of Treaty and Supporting stations and had to review them each year to update any additions and deletions. Figure 4 charts the number of Treaty and Supporting stations in US and Canada over the years since the first list was developed by the International Task Force in 1965. This list swelled to an unmanageable size, particularly in the U.S. with the majority of monitoring stations in the region being considered either Treaty or Supporting stations. The change in number of stations in 1975 indicated a divergence in interpretation of the definition of a Treaty station; where the U.S. included not just stations used in the Treaty water supply forecasting, but all stations used in daily stream flow forecasting in the Columbia basin, which is basically most of the real-time stations in the basin. In 2001, in an effort to reduce workload and because of difficulty of maintaining the station lists, the CRTHMC sought permission from the Permanent Engineering Board to report only changes to the network, rather than reviewing the whole list each year. This would allow the Committee to focus attention on where changes might have the most impact on Treaty operations.

Figure 4. Number of Treaty and Supporting Stations 1965 - 2008

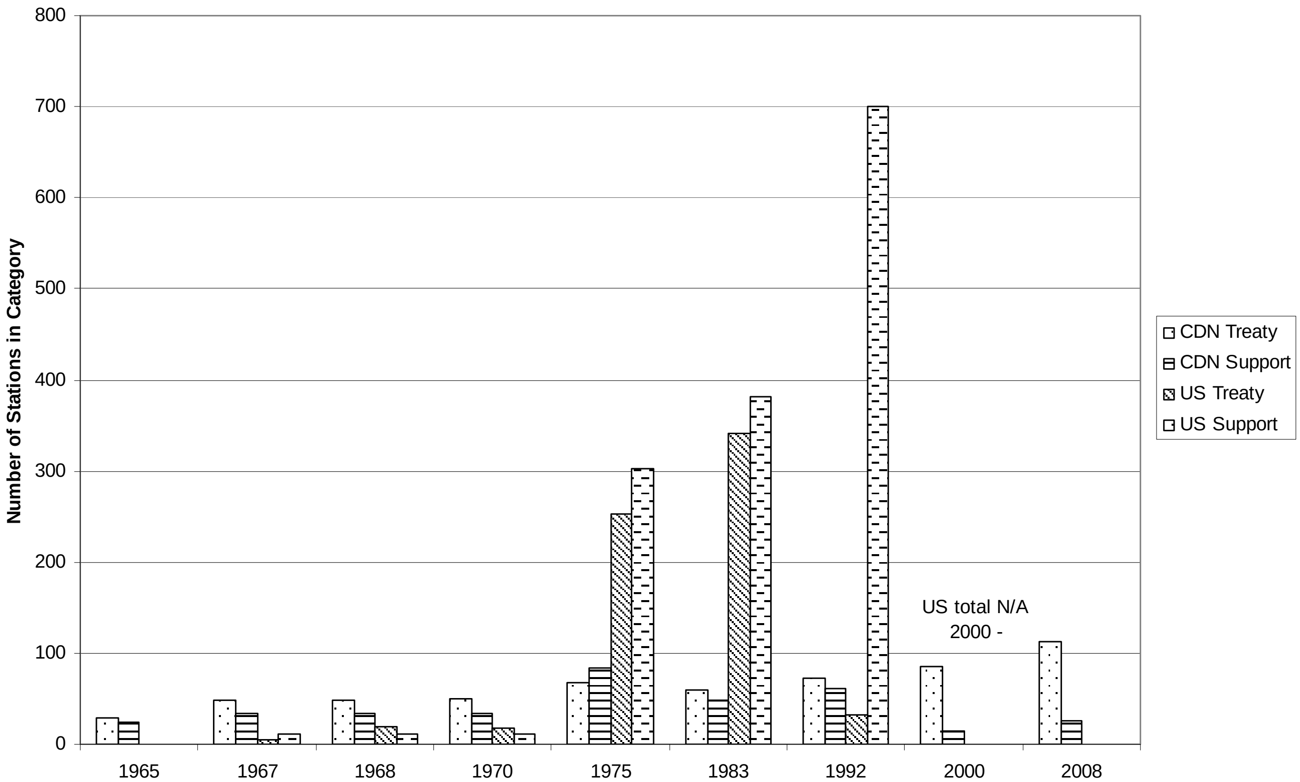

Figure 4. Changes in the number of designated Treaty and Support stations over time.

Once the PEB granted permission to change the reporting requirement, the Committee developed a standard procedure for reviewing stations changes once they were identified:

1. Communicate potential station changes with Committee
2. Determine Treaty status of impacted stations
3. Respond to data agency when change in station operation affects Treaty
4. Document Committee work
5. Review network requirements for Treaty studies & modeling

The Committee has been using this procedure successfully since 2002 to manage a number of stations changes in recent years. In general there are three kinds of issues that can affect the operation of a station: closure due to funding or policy change; closure of volunteer / observer stations; closure due to change in physical site. The first two types of issues are negotiable. The responsible Entity can provide funding to or exert pressure on monitoring agencies to maintain a station, or in the case of a volunteer observer quitting, advise on suitable alternatives for automating or relocating the station. In the case of a physical change to the site making the site either unsafe or no longer suitable for monitoring (avalanche hazard, forest fire, mountain pine beetle infestation, flood damage), an alternate location or nearby station substitution will need to be determined and agreed to by the whole Committee. Some recent examples of decisions made by the CRTHMC are listed in Table 3. Most of the recent issues have been with stations in Canada. This is partly related to the fact that most of the watershed area relating to the Treaty is in Canada, and partly due to inconsistent support of monitoring networks in Canada in recent years.

Table 3: Recent Changes to Treaty and Support stations.

P	Site Name	Operated by	Support or Treaty	Issue	Impact	CRHMC decision or results
BC	BRISCO (climate)	Env Canada	T	Observer unable to continue	Used in Mica equations, estimating station for US	Mica equation being revised in next year, - Discontinued
BC	YOHO NP BOULDER CREEK (climate)	Env Canada	T	Parks Canada no longer able to observe at this station. EC offered Yoho CS (Auto) as replacement	Used in Mica Equations	Estimate from Yoho CS
BC	FERNIE (climate)	Env Canada	T	Observer stopped reporting in Apr 2004. Worked with EC to re-establish observer	Used in Libby equation	Work with EC to maintain station. Station re-established in April 2005
BC	KOOTENAY NP KOOTENAY CROSSING (climate)	Env Canada	T	Parks Canada no longer able to observe at this station as park gate has been closed	Used in Mica July equation only	Small impact so able to estimate - Discontinued
BC	MARBLE CANYON (snow course)	BC MOE	T	Snow Course destroyed by forest fire. BC MOE to re-establish Vermilion no 3 as substitute station	Used in Libby forecasts	Accept Vermilion no 3 as replacement - Discontinued
BC	KICKING HORSE (snow course)	BC MOE	T	Funding for station questionable. BC MOE wants to eliminate May readings	Other months' observations used in forecasting	May observations not required for Treaty. May reading eliminated.
BC	SINCLAIR PASS (snow course)	BC MOE	T	BC MOE wants to discontinue this station due to funding cuts	Station used in US forecasts by NWRFC	BCH will fund station
BC	GRAY CREEK (LOWER) (snow course)	BC MOE	S	Funding for station questionable.	Feb, Mar, Apr reading critical in forecasting for both US and Canada	Sampling months reduced from 8 to 5
BC	GRAY CREEK (UPPER) (snow course)	BC MOE	S	Funding for station questionable.	Feb, Mar, Apr reading critical in forecasting for both US and Canada	Sampling months reduced from 8 to 5
BC	BEAVERFOOT (snow course)	BC MOE	S	Snow survey site damaged by road construction	Used as backup for estimating	Reduce number of sampling sites. BCH to continue funding

Forecasting. The CRTHMC also takes responsibility for coordinating forecasting activities pertaining to the Treaty projects. This is not explicitly outlined as a responsibility under the terms of reference for the Committee, but the individual members on the Committee generally are also involved in forecasting for their agency, so it is a good fit. The Committee reviews all water supply forecasting procedures implemented for Treaty projects, and has to agree on the official procedures used to provide forecasts for the Columbia River Treaty Storage Regulation (TSR) studies conducted every two weeks to plan the coordinated operation of the Treaty projects to achieve set targets for flood control.

Statistical forecast procedures have been the preferred forecasting tool for Treaty forecast over other methods such as conceptual watershed models using ensemble streamflow prediction because of the objective nature of statistical forecasts. With statistical forecasts, either Entity will achieve the same result if the input the same driving data, removing any opportunity for one Entity to shape the outcome of the forecast to their advantage. The Committee has agreed to use a similar approach to developing the statistical water supply forecasting procedures based on principal component regression as outlined by Garen (1993). An early version of the procedure is described in the paper “Application of principal components regression to streamflow forecasting” (Smith and Weiss, 1996). The procedures for all four Treaty projects were updated between 2004 and 2006. It took over a year for the Committee to review and approve all procedures, and then get the approval from the Columbia River Operating Committee to implement the new procedures for the 2007 volume runoff season.

The Treaty water supply forecasts for the forecast period January through July are updated monthly starting with the first forecast on December 1st and the final forecast is issued July 1st. These forecasts are distributed to the Entity agency, and copies are also sent to the Northwest River Forecast Center for inclusion in their forecasting activities for the whole Columbia basin. Each individual agency may also use other forecasting tools for internal planning, but any planning for the operation of Treaty storage in the reservoirs has to be coordinated based on the official Treaty forecasts. There is a series of Principles and Procedures defining how the forecasts are used in subsequent studies. There is a little flexibility to match short-term forecast flows over the near-term, but the seasonal volumes have to add up to the Treaty forecast volume.

Each agency is responsible for its own short term flow forecasting for the projects, and the agencies exchange forecasts to improve coordination of operations of Treaty and other projects in the Columbia basin. There is a spirit of cooperation in sharing knowledge about forecasting methodology, data management and making improvements to techniques. Another area where the member agencies are cooperating is looking a impacts of climate change on the water resources of the Columbia River basin.

Recent Challenges

The Columbia River Treaty Hydrometeorological Committee has faced a number of challenges in the recent past. Network stabilization is not a new challenge, but continues to be a struggle. In 2005, the Permanent Engineering Board requested a special report on the status of the hydrometeorological network in the region in response to several years of reports from CRTHMC about problems with maintaining all of the key Treaty stations, particularly in Canada. The CRTHMC prepared the "Canadian Station Network Status Report" (CRTHMC, 2006) in response and in addition to detailing where the specific station issued had been (Table 3 is a subset of the results from that report), the Committee proposed actions to try to improve the situation, including clarifying responsibilities with senior management in the other monitoring agencies for providing data to support an international treaty, and implementing network performance monitoring to identify potential problems with stations before they are shut down. The deterioration of support for monitoring networks in Canada, particularly at the federal level is an ongoing challenge to this day.

The CRTHMC spent over two years from 2004-2006 revising all the water supply forecasting procedures for the Treaty projects, including coming to agreement on a standard methodology for developing the equations, incorporation of cross-validation standard error in place of regular standard error for reporting uncertainty in the forecasts, and coming to agreement on a methodology to disaggregate the seasonal volumes into the monthly and semi-monthly values needed for input into Treaty studies, not to mention the work to actually compute new statistical equations for all months for all projects. In BC Hydro's case, they updated the equations for all 22 of their reservoirs at the same time, and designed a new application to produce the forecasts.

Data communication technologies have changed in the 40 years since the CRTHMC formed and today's technology allows for quick, automated transfer of information in near-real time. The easy availability and transfer of data has led to some problems, however, as data may come from any number of sources, with varying or unknown quality. The data exchange for the Columbia River Treaty is no exception. Data is primarily exchanged via FTP, but also is sent in spreadsheets via email, transferred verbally over the phone or by fax. This can lead to inconsistencies if the same data is sent by different methods or from slightly different sources. Some of the data systems such as parts of CROHMS have been in place for a long time, and often the original architects of the system are no longer available to troubleshoot problems. Both the Corps and BC Hydro are developing new internal data management systems, and replacing parts of the old systems one piece at a time. A new generation of data managers needs to coordinate and communicate how data will be exchanged and archived to have a clear, consistent record of Treaty operations for all parties to use. The CRTHMC members are working to make sure the people doing the work in each agency have a good working relationship with each other, and develop a clear understanding of the other organizations' structures.

Future Directions

In addition to the ongoing responsibilities of data exchange, station network management, and forecasting, the CRTHMC will also need to address other challenges in coming years. As mentioned above, there is a regional approach to examining climate change impacts to the water resources in the region being led out of the University of Washington Climate Impacts Group and coordinating with the Pacific Climate Impacts Consortium in British Columbia. Both of these research groups are receiving funding and other support from the principal agencies involved with the Columbia River Treaty.

The original Columbia River Treaty has a termination clause allowing termination of the Treaty by either country after 2024, with ten years advance notice. This means that either country could announce as early as 2014 their intention to terminate the Treaty. There is an extensive coordinated effort on both sides of the border to examine and communicate the impacts of alternatives to support decision-making about this pivotal decision. Whether the Treaty itself continues, the flood control provisions outlined in the Treaty will continue for the life of the Treaty projects themselves, although implementation of those provisions would change. As such, the need for hydrometeorological data, data exchange and forecasting will continue to be important, whatever the fate of the Treaty itself.

CONCLUSIONS

The Columbia River Treaty Hydrometeorological Committee has a long history supporting the management of the Columbia River Treaty projects and water management in the Columbia basin. The Committee has been meeting one to two times per year since its inception and the minutes from those meetings reflect the bigger changes and issues facing the hydrometeorological community in the region as a whole. Many of the snow, climate and water level monitoring stations in the region were installed and supported as a direct result of the Columbia River Treaty. The CRTHMC has worked hard to have open communication and collaboration on issues of data exchange to support the operations of the Columbia River. The Committee has advanced water supply forecasting methodology and knowledge sharing of hydrologic forecasting techniques in the challenging and geographically-diverse Columbia basin. While there continues to be challenges in maintaining the base networks, ensuring the accurate and timely exchange of data, whatever the fate of the Columbia River Treaty the relationships established between agencies in the Pacific Northwest will endure long into the future and support the management of water resources of the Columbia River.

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