"OUR WINTER SNOWS ARE OF THE UTMOST IMPORTANCE": THE DEVELOPMENT OF SNOW SURVEYS IN BRITISH COLUMBIA, 1920s-1950s

Blake Butler[1]

ABSTRACT

In the early twentieth century, British Columbian engineers realized that snow was one of the province's most important resources. It was nature's principal reservoir of "white coal," or snow-melt run-off, an important energy source that powered industries and sustained communities. Private industries and large communities conducted some of British Columbia's first snow surveys in the 1920s and early 1930s. The provincial government began its own snow survey program – in partnership with these earlier initiatives – in the mid-1930s in response to the economic challenges of the Depression and in collaboration with American snow science research along the Columbia River. Snow surveys expanded to much of southern British Columbia over the next fifteen years. The program's growth reflected the government's belief that snow and snow-melt run-off could best be understood and forecasted through scientific methods. But, during this period, engineers with the province's Water Rights Branch (WRB) struggled to generate accurate run-off forecasts. In the immediate postwar era, the program's growth was driven by immediate concerns, government policies that promoted economic development, and the continued desire to improve forecast accuracy. Knowing the early history of B.C.'s snow survey program helps explain its importance in the province today. (KEYWORDS: British Columbia, snow, snow-melt run-off, snow survey)

INTRODUCTION

In the early twentieth century, British Columbian engineers realized that snow was an important natural resource. The energy released each spring and summer as snow-melt run-off was considered "white coal," an important energy source that could power industries and sustain communities. One of the earliest descriptions of white coal in B.C. comes from a long-form advertisement written by the British Columbia Electric Railway Company (BCERC) in the *Financial Post* in 1909. At this time, the BCERC provided electricity to the city of Vancouver via its Buntzen Lake Power Plant, a hydro-electric generating facility east of the city. The advertisement described white coal as "the greatest of all of British Columbia's great assets, the most plentiful of its resources, and I will venture the chief element of its vast potential wealth." (British Columbia Electric Railway Company, Ltd., 1909).

Some of the first snow surveys in this province were conducted in the 1920s and early 1930s. These were primarily undertaken by companies that generated their energy from hydro-electric facilities near the Pacific Coast or on rivers in the Interior, such as the Columbia and Kootenay. These included energy-intensive pulp-and-paper industries, such as the Powell River Company (PRC) and Pacific Mills Limited, and electricity generating companies such as the BCERC, the West Kootenay Power and Light Company (WKPLC) and the East Kootenay Power Company (EKPC). Others were undertaken by communities such as the city of Vancouver, which drew its fresh drinking water from the Capilano and Seymour rivers, two mountain streams dominated by snow-melt run-off in the summer months. The Dominion Water and Power Bureau conducted its own snow survey research in these same mountains during the 1920s and early 1930s as well (Church, 1933).

I have not yet ascertained the origins of these early snow survey programs, but there are a few likely possibilities. The first is that engineers with these organizations had read or become aware of James E. Church's snow survey work in the Sierra Nevada Mountains in the 1900s and 1910s. An avid outdoors enthusiast and classics professor at the University of Nevada, Church was also fascinated with meteorology. In 1905, he helped establish an observatory on Mount Rose. Over the next few winters, Church became increasingly interested in snow and the impact that snow-melt run-off had on Lake Tahoe and the communities surrounding the lake. He developed new sampling procedures and techniques for measuring snow water-content and for forecasting snow-melt run-off. Some of these developments included the cylindrical Mount Rose snow sampler, the weighing of snow to measure snow water-content (as opposed to simply measuring snow-depth), and snow courses, fixed surveying locations that

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1 Blake Butler, Western University, London, ON, CAN, mbutle32@uwo.ca

included multiple sampling points. Church published on this work until the First World War, when government resources were diverted from domestic programs such as snow science research (Mergen, 1992; Pickett, 1995).

The second possibility is that these programs were inspired by other domestic projects. In 1916, for example, the Meteorological Service of Canada began a short-lived snow survey program on the Bow River (Church, 1936). The final possibility is that these programs emerged independently of these earlier developments. While this is less likely, it is clear from advertisements such as the BCERC's that private industries were aware of snow's economic potential. Engineers with organizations may have begun measuring snow-depth out of personal or scientific interest and monitoring snow-melt conditions in the mountains to predict when run-off might occur.

EARLY SNOW SURVEYS

Archival records show that these early programs used a variety of sampling procedures and techniques to ascertain possible snow-melt run-off conditions and thus points to the idea that these early programs had multiple points of origin. In the early to mid-1920s, for example, the city of Vancouver's snow surveyor, William B. Taylor, recorded snow-water content and conducted samples at fixed locations at least once every month between December and June. Taylor's reports on snow water-content and possible run-off conditions were significant for a region that did not have large water storage capabilities until 1926, when the Greater Vancouver Water District (GVWD) turned the high-mountain Palisade, Burwell, and Loch Lomond lakes into reservoirs (Kuhlberg, 2016). Interestingly, Taylor also conducted similar studies as Church, such as examining the impact that tree cover and logging had on snow preservation and snow-melt run-off (Province, 1923). I have not yet confirmed if Taylor was familiar with Church's work, but it seems likely. After Taylor resigned or was fired in 1928, his successors only recorded snow-depth, and the frequency of these samples fluctuated from two to six times per year between 1928 and 1933 (Powell, 1934).

Private industries had similar challenges with their early snow survey programs. The PRC first considered implementing a snow survey program in 1926, but did not begin sampling until 1930. A worsening Depression and the installation of a seventh newsprint machine prompted that company's engineers to better understand possible run-off conditions in the watershed surrounding its hydro-electric facility. Between 1930 and 1934, that company only recorded snow-depth totals and sampling dates changed each year. Moreover, the PRC placed its snow courses in the low-lying but more accessible mountains near Powell River instead of the snowier and higher mountains at the lakehead. The PRC thus had an incomplete picture of snow-melt run-off conditions during these years (Farrow, 1938). The PRC's program was at least somewhat more effective than the WKPLC's early snow survey program. In the early 1930s, that company used airplanes to observe changing snow and run-off conditions in the mountains surrounding its hydro-electric facilities (MacDonald, 1934). What we see, then, is that during the 1920s and early 1930s, snow survey research in B.C. was in its infancy, only practiced by a handful of organizations, and producing variable results.

GOVERNMENT INVOLVEMENT

The provincial government became increasingly interested in snow survey research in the mid-1930s. This was prompted by three factors. The first was the election of Thomas Dufferin Pattullo's Liberal Party in B.C. in 1933. Elected in the midst of the Depression, Patullo believed that the state needed to become more involved in the province's economic and social spheres in order to alleviate problems caused by the Depression (Fisher, 1991). The second was B.C.'s inclusion on the American Geophysical Union's Permanent Research Committee on Snow (PRCS). Founded in 1931 by Church, the PRCS sought to standardize methods and promote cooperative snow science research across North America (Church, 1933). Major J.C. MacDonald, comptroller of B.C.'s Water Rights Branch (WRB) joined in 1933. As a division of B.C.'s Department of Lands, the WRB administered water resources throughout the province. In the mid-1930s, this included snow. Finally, and closely linked with the previous point, was a renewed interest in snow science in the western United States, particularly around the Columbia River. This was largely driven by plans to construct two mega-dams on the Columbia, the Grand Coulee and Bonneville dams. Construction of these dams necessitated greater knowledge about snow-melt run-off along the Columbia and its tributaries. B.C.'s involvement with the PRCS was essential, as it contained sections of the Upper Columbia and major tributaries such as the Kootenay and Okanagan rivers (MacDonald, 1934). As an additional benefit, these studies would also help with domestic power and irrigation projects along these watersheds.

The task of implementing the province's snow survey program fell to the WRB's Richard Charles Farrow. Farrow's extensive surveying and hydraulic engineering background made him an ideal candidate for the job. Born in Hornesy, England in 1892, Farrow arrived in Vancouver with his parents in 1903. Following high school, Farrow worked as a B.C. Land Surveyor in the early 1910s. He applied these skills during the First World War, when he served as a Lieutenant with the Canadian Field Artillery. Farrow returned to surveying work following the War and was hired by the WRB as a hydraulic engineer in 1928. Over the next seven years, he conducted hydraulic engineering investigations in some of the province's remote watersheds. (Farrow, 1938).

Farrow established the province's first six snow courses in 1935. One was located on the Capilano watershed, one at Stave Lake, east of Vancouver, and four in the mountains surrounding Okanagan Lake. These latter five locations reflected the WRB's desire to advance snow-melt run-off research for domestic and international power generation. The Stave Lake snow course, for example, would provide the BCERC with run-off information at its Stave Falls hydro-electric generating facility. The Okanagan courses, in contrast, would help American counterparts predict snow-melt run-off on the Columbia below the Grand Coulee but above the Bonneville dam. Moreover, the Okanagan courses would benefit fruit farmers, who relied on snow-melt to sustain their farms in the region's semi-arid climate.

Over the next five years, Farrow expanded the system in the Coastal Mountains and in the Columbia and Kootenay watersheds. The program's growth was primarily driven by increasing interest from private industries. Some of these companies hoped to implement their own programs or to expand and improve their existing programs. In the Columbia and Kootenay, for example, Farrow partnered with companies like the EKPC and WKPLC that operated hydro-electric facilities in the region (Farrow, 1937). In the Coastal Mountains, Farrow travelled to Powell River in 1938 to assist the PRC with its snow survey program. After examining the region and speaking with PRC representatives, Farrow recommended moving the PRC's snow courses from the low-lying mountains near Powell River to the higher-elevation mountains at the head of Powell Lake (Jamieson, 1940). Re-locating these snow courses would provide the PRC with more accurate information about snow-melt run-off conditions in the watershed

These private-government partnerships were vital to the program's early success. With the Depression ongoing, the WRB did not have the resources or people needed to set up and run the program. Private industries, in contrast, were very willing to allocate money and employees to this work, especially if it meant that they could save on future energy costs. Reflecting on snow course development in the Columbia and Kootenay region, for example, Farrow recalled that private industries there were more than willing to co-operate with the Branch (Farrow, 1939).

Unlike earlier initiatives, Farrow's work was guided by a strong foundation in the snow sciences. By 1936, he was B.C.'s representative on the PRCS. He was also an active member of the Western Snow Conference (WSC). Farrow's engagement with both organizations was crucial to the development of B.C.'s snow survey program. Forecasting annual run-off with snow surveys was a complex science. Snow-melt run-off was affected by a myriad of factors such as topography, temperature, evaporation, and spring precipitation, to name a few. Farrow also contributed to this research. Between 1937 and 1942, he authored eight papers on snow science research and the use of snow surveys for run-off forecasting.

FORECASTING CHALLENGES

Farrow and the WRB struggled to develop a reliable snow survey system during the program's first few years. In the late 1930s, researchers considered forecasts within 10 percent of actual conditions to be fairly accurate (although more established snow survey programs were able to achieve results closer to 5 percent). In the late 1930s, only a few WRB forecasts fell within this range. Most had forecasting errors between 15 and 30 percent. At the extreme end of the spectrum, the 1939 forecasts for the Okanagan had a forecasting error of 68 percent (Farrow, 1940).

There were a number of factors that impacted these forecasts. First, the WRB did not have much historical data on snow-melt run-off conditions in the province. Records from the GVWD, PRC, WKPLC, and EKPC offered some indication of historic snow-melt run-off conditions on particular watersheds, but this information was suspect, for many of the reasons mentioned earlier. Second, winter accessibility limited snow course placement on certain watersheds. Writing about the Coastal region, Farrow explained that "the extreme ruggedness and heavy growth…

made it very difficult to locate snow courses where wanted" (Farrow, 1940). Some regions, such as the Fraser River watershed and the Big Bend region of the Columbia, were skipped entirely. Writing about the Big Bend region, Farrow believed that winter travel to this remote area was "quite out of the question" without the use of an airplane (Farrow, 1937). The location of stream gauges further tempered snow course placement, as Farrow wanted to place snow courses in conjunction with these gauges in order to validate the WRB's run-off forecasts. Not being able to place snow courses where wanted affected sampling quality and thus forecasting accuracy.

Third, many watersheds had limited snow course coverage in the late 1930s. By 1939, for example, there were only sixteen snow courses on the Columbia and Kootenay watersheds, a region covering tens of thousands of square kilometres. Fourth, Farrow and WRB engineers had difficulties developing watershed specific run-off forecasts. In his work on the Soil Priming Factor, or the impact that soil saturation had on snow-melt run-off, Farrow highlighted how that particular natural factor affected run-off differently in the Columbia and Kootenay than in the Okanagan (Farrow, 1938). Many of the other natural factors mentioned earlier also affected snow-melt differently in distinct watersheds. As Farrow later explained in 1947, "it has been well said that every watershed is a law unto itself and this is true for snow surveys on watersheds" (Department of Lands and Forests, 1947). Finally, B.C.'s snow survey program only provided snapshots of actual snow and snow-melt conditions in the mountains. In the late 1930s, the WRB only took samples once each year on most snow courses, often at the end of March, before the melt period. While this was not unique to B.C.'s program, it did effect run-off forecasting accuracy, as conditions in the mountains changed suddenly and frequently. Some snow courses were sampled in January and February, but even then, these samples only offered a snapshot of snow and melt conditions in the mountains. In his writings from the period, Farrow explained that he wanted to add earlier and later sampling dates at many snow courses, but the WRB's limited resources prevented him from doing so (Farrow, 1937).

Snow survey work in B.C. slowed during the Second World War, as Farrow left to serve with the Royal Canadian Artillery's 1st Survey Regiment and the province directed its resources toward the war effort. Long-time WRB hydraulic engineer S.H. Frame took over the province's snow survey program during the War. Between 1940 and 1945, Frame added four new snow courses: three in the Columbia and one at the headwaters of the Skagit river. Frame and the WRB continued to struggle with forecasting accuracy during the War years. Commenting on the spring of 1943, for example, Frame reported that only two run-off forecasts fell within the desired 5 percent error range that year. The WRB's other eight forecasts were off by 19 to 49 percent. Responding to Frame's report at the 1944 Hydrology and Snow Conference in Berkeley, California, PRCS member H.P Boardman remarked that there was "room for much improvement in forecasting these rivers" (Frame, 1944).

IMMEDIATE POSTWAR GROWTH

After the War, Farrow returned to the WRB and was promoted to Comptroller in 1946. As head of the Branch, Farrow put greater emphasis on the province's snow survey program. In the immediate postwar period, the program's growth was driven by immediate concerns, government policies that promoted economic development in the province, and the WRB's desire to improve forecasting accuracy.

Immediate concerns, for example, led the WRB to expand its snow course network to new watersheds such as the Fraser River. Prior to the War, Farrow had avoided the Fraser because of the Branch's limited resources. This changed following the spring floods of 1948. In April and May, many snow courses across the province registered well above average snow-water content readings; cooler than normal spring temperatures also delayed that season's snow melt until late May. The ensuing floods devastated low-lying areas such as the Fraser Valley. While Farrow had not designed B.C.'s snow survey program to monitor for possible floods, the WRB's April and May Snow Survey Bulletins had pointed to a potential threat (Department of Lands and Forests, 1949). The 1948 floods prompted the WRB to incorporate flood warnings into its operations, to add additional sampling dates of 15 May and 1 June at select snow courses to better monitor for possible flood conditions, and to expand the system on the Fraser and Thompson rivers in 1949 (Department of Lands and Forests, 1950). Flood monitoring based on snow survey data became a key element of WRB operations in the 1950s and in the ensuing decades.

Government policies promoting economic development in B.C. also shaped snow course development in the immediate postwar era. In 1951, for example, Byron "Boss" Johnson's Liberal government signed a $300 million agreement with the Aluminum Company of Canada (also known as Alcan) to construct an aluminum smelting facility at the head of Douglas Channel, on the Pacific Ocean. In order to generate the needed power, Alcan dammed the Nechako River and diverted this water via a sixteen-kilometre tunnel under Mt. Dubose to the Kemano generating station on the Pacific coast. Snow course placement in the Nechako watershed began in 1951, three years prior to the completion of the generating station (Department of Lands and Forests, 1952). This would become a dominant theme of B.C.'s snow survey program's development during the remainder of the century: the placement of snow courses prior to or in conjunction with major hydro-electric facilities. In the postwar period, companies like Alcan recognized that snow was nature's principal reservoir of white coal and that snow-melt run-off meant power. Whereas Farrow and the WRB had been playing catch up during the program's first fifteen years, laying out snow courses where hydro-electric facilities already existed, as of the 1950s, snow course placement would generally precede or coincide with new hydro-electric facilities.

Finally, postwar snow course development was driven by the WRB's desire to improve forecasting accuracy. This was partly addressed through the addition of new snow courses on existing watersheds. Between 1945 and 1949, for example, the WRB and GVWD laid out three new snow courses along the Capilano watershed. While the WRB and GVWD had conducted snow surveys at Grouse Mountain since 1935, renewed interest in a proposed Capilano reservoir prompted GVWD officials to add further snow courses to improve run-off forecasting (Powell, 1947). During this same period, the WRB added another nine snow courses (for a total of 30 snow courses) in the Columbia and Kootenay watersheds to improve forecast accuracy there. In addition to new snow courses, the WRB implemented a summer maintenance program and a winter training program for snow surveyors (Department of Lands and Forests, 1952; Department of Lands and Forests, 1956). These initiatives – coupled with increasing research and knowledge about run-off conditions on particular watersheds – led to improved forecasting results. In 1952, for example, only one of the WRB's twenty-two run-off forecasts were off by more than 20 percent, with seventeen of these below 10 percent (Department of Lands and Forests, 1953). By 1957, all WRB forecasts fell within 15 percent of actual run-off conditions; half were below 5 percent (Department of Lands and Forests, 1958).

CONCLUSIONS

The developments that took place between the 1920s and 1950s laid the groundwork for future growth and the heightened importance of B.C.'s snow survey program during the latter half of the century. Research and experience from this period showed that, despite some of the challenges surveyors and engineers faced early on, snow survey research was beneficial for private industries and for the province's economic and societal growth. In the 1960s and 1970s, snow courses and snow-melt run-off data would become key components of some of the province's largest hydro-electric projects, such as the Portage Mountain dam (renamed the W.A.C. Bennett dam) on the Peace River and the Columbia River Treaty dams. Today, there are more than 200 snow courses throughout British Columbia. Knowing more about this early history helps explain why the program is so significant today.

REFERENCES

British Columbia Electric Railway Co. Ltd., *Financial Post* September 25, 1909.

Church, James E. 1933.On the Hydrology of Snow. Annual Reports of Permanent Research Committees for 1932-33. 338-345.

Church, James E. 1936. Report of the Committee on Snow. Annual Reports of Permanent Research Committees for 1935-36. 265-286.

Department of Land and Forests. 1947. Report of the Lands, Surveys, and Water Rights Branches, Year Ended December 31 1946.

Department of Land and Forests. 1949. Report of the Deputy Minister of Lands, Year Ended December 31 1948.

Department of Land and Forests. 1950. Report of the Deputy Minister of Lands, Year Ended December 31 1949.

Department of Land and Forests. 1952. Report of the Lands Services, Year Ended December 31 1951.

Department of Land and Forests. 1953. Report of the Lands Service, Year Ended December 31 1952.

Department of Land and Forests. 1956. Report of the Lands Service, Year Ended December 31 1955.

Department of Lands and Forests. 1958. Report of the Lands Service, Year Ended December 31 1957.

Farrow, R.C., "British Columbia," in Church, James E. 1937. Report of the Committee on Snow. Annual Reports of Permanent Research Committees for 1936-37, 269-293.

Farrow, R.C., "Powell River Basin," in Church, James E. 1938. Report of the Committee on Snow. Annual Reports of Permanent Research Committees for 1937-38, 281-314.

Farrow, R.C., "British Columbia," in Church, James E. 1939. Report of Committee on Snow. Annual Reports of Permanent Research Committees for 1938-39, 489-506.

Farrow, R.C., "British Columbia," in Church, James E. 1940. Report of Committee on Snow, 1939-40. Annual Report of Permanent Research Committees for 1939-40, 374-396.

Farrow, R.C. 1937. Snowfall and runoff in the Canadian Columbia Basin: A study to determine the ideal locations for snow-surveys. Transactions, American Geophysical Union, 632-644.

Farrow, R.C. 1937. Snow Surveys for the Purpose of Forecasting Streamflow. The Forestry Chronicle. Vol. 13, No. 1, 271-283.

Farrow, R.C. 1938. Snow Surveys: A New Medium for Forecasting Run-off. The Engineering Journal. Vol. 21, No. 10, 451-455.

Farrow, R.C. 1940. British Columbia Snow-Surveys: Report on Snow Surveys and Actual Runoff in the Upper Columbia, Fraser, and Powell River Basins for 1939. Reports and papers, snow-survey conference – Stanford University. 105-108.

Fisher, Robin. 1991. *Duff Pattullo of British Columbia.* Toronto: University of Toronto Press.

Frame, S.H. 1944. Accuracy of forecasts of runoff for Columbia, Kootenay, and Okanagan Basins and the Coastal Belt adjacent to Vancouver for 1943. Reports and papers, hydrology and snow-conference, Berkeley.

Jamieson, W. to N Beaton, October 2 1940, in Snow Survey Correspondence, 1937-56. F93 acc. 2007.13. Powell River Museum and Archives.

Kuhlberg, Mark. 2016 "'An Eden that is practically uninhabited by humans:' Manipulating Wilderness in Managing Vancouver's Drinking Water, 1880-1930." Urban History Review. Vol. 45, No. 1, 5-60.

MacDonald, J.C., "British Columbia," in Church, James E. 1934. Report of the Committee on Snow, 1933-34. Annual reports of Permanent Research Committees.

Mergen, Bernard. 1992. "Seeking Snow: James E. Church and the Beginnings of Snow Science" Nevada Historical Society Quarterly. vol. 35 no. 2, 75-104.

Pickett, Evelyne Stitt. 1995. James Edward Church, Jr., and the Development of Snow Surveying for Runoff Forecasting. Yearbook of the Association of Pacific Coast Geographers. Vol. 57, 57-75.

Powell, W.H. to P. Sandwell, April 18, 1934, in Snow and Rain Reports 1927-35. AM 1257-S13 Box 64-C-6 fld 08. City of Vancouver Archives.

Powell, W.H., to R.C. Farrow, March 20, 1947, in Water Rights Branch 1936-50 (Victoria) – Section 1. AM 1257-S 13 Box 65-A-1 fld 04. City of Vancouver Archives.

"Watershed logging is danger to water supply," The Province. January 3, 1923.