Summary of Columbia Lake Stewardship Society's 2021 Water Quantity Monitoring Program

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Executive Summary

2021 was the eighth year of operation for the CLSS Water Quantity Monitoring Program. Despite the continued presence of COVID-19, data collection activities were largely unaffected so that another season of near complete records from all stations was accumulated.

From a climatological viewpoint, the major event of the year was the much publicized "heat dome" of late June although property owners on or near the Dutch Creek delta might have viewed it as the flooding that occurred earlier in the month. To an extent, the events were connected. Warm temperatures led to rapid rate of snowmelt in early June that caused the flooding and led to a peak in lake level on June 6. The floodwaters had not abated before the arrival of a rainstorm followed by the release of more meltwater as the "heat dome" intensified. As a result, water continued to flow onto the delta and into the lake leading to a second crest, slightly higher than the first, on June 30. By the end of the season the lake had twice exceeded its usual crest level and experienced a volume of inflow not experienced in recent years.

Ongoing efforts toward establishing the lake water balance continued. Evapotranspiration losses and consumptive use are at a minimum during the winter months so that inflow is mainly from surface runoff and groundwater. By focusing on the mid-September to mid-April period and ignoring evapotranspiration/consumptive losses the combined surface runoff/groundwater contribution was estimated using the water balance equation:

Inflow = Outflow + Change in storage

The rate of outflow was estimated to be 1.7 cubic metres per second based on the average of fourteen direct measurements made at the lake outlet over the past two years. The rate of change in storage was calculated to be 0.1 cubic metres per second derived from the average decline in lake level observed over the past 8 years during the seven-month period. Application of the equation demonstrates that to achieve balance, the combined groundwater/ surface runoff inflow rate is near 1.6 cubic metres per second. This, once again, calls attention to a potential water supply issue.

The approach cannot be applied to the summer period because evapotranspiration and precipitation play significant roles and the existing network provides insufficient information to reliably estimate their respective contributions.

Apart from two incidences of vandalism, one resulting in the loss of a logger, all equipment continued to function satisfactorily. Near the end of the season the Fairmont Hot Springs Airport (CYCZ) weather station was shut down. The altimeter setting at that location has been the reference for checking the accuracy of the data loggers. Another source will have to be found for use in future years.

1. Introduction

The Columbia Lake Stewardship Society (CLSS) started water quantity monitoring activities in the Columbia Lake Watershed in 2014. This is the eighth in a series of annual reports and summarizes activities conducted during the 2020-21 water year, November 1, 2020 to October 31, 2021.

The CLSS mission is "to preserve the ecological health and water supply of Columbia Lake for present and future generations …". Preserving the water supply is a significant task. It requires an understanding of how water enters and leaves the lake. Long-term records reveal that the lake rises an average of about 0.9 metres each year. That rise is important. It maintains the water quality at a healthy level, provides drinking water for residents, irrigates crops and supports the local tourism industry. It also provides the habitat that sustains wildlife and aquatic species. The demands for water to meet such a variety of needs are growing and are in conflict.

Most of the rise is attributable to overflow from Dutch Creek as the snowpack melts and runs off each spring but it is not the only factor affecting lake level. Others are operating within the local drainage area, including surface runoff, precipitation, and groundwater. These gains are offset by losses to evapotranspiration, consumptive use and outflow. The monitoring program is aimed at determining how these gains and losses influence the water supply and, ultimately, help define a management strategy to accommodate the needs of those placing demands on the local water supply.

2. The Watershed

For convenience of measurement, the outflow point of the Columbia Lake Watershed is often regarded as a point on the Columbia River at the Highway 93/95 crossing near Fairmont Hot Springs. This is a bit of an oversimplification. The area of the drainage area above that point is 881 square kilometres. The bulk, 696 square kilometres, is contained in the Dutch Creek sub-basin.

A delta has formed near the mouth of Dutch Creek. The flow of Dutch Creek over its delta is braided and subject to change. In the present channel configuration, and when flow rates are low and unimpeded, the main channel flows directly across the delta to enter the Columbia River, a few tens of metres below the lake outlet. When Dutch Creek is high the main channel overflows its banks and water spills into Columbia Lake. During this period the flow in the outlet channel is reversed so that a substantial portion of the overflow enters the lake by this means. The main channel is continually shifting, and at times in the past flowed directly into the lake before reaching the river (see Jamieson, 2011).

Thus, the actual outlet from the lake is not at the Highway crossing but just over three kilometres upstream. A series of small creeks enter the Columbia River downstream of the Dutch Creek junction and constitute about nine square kilometres of the entire 881 square kilometre area. The area above the lake outlet is 176 square kilometres. The boundaries of the watershed are shown in the inset of Figure 1.

The overall watershed contains no active glaciers and is uncontrolled.

Figure 1 – Map showing station locations. Entire watershed boundary is shown in inset. Site abbreviations are provided in Section 4.1.

3. Antecedent and Concurrent Conditions

There are no weather stations within the entire watershed having a continuous long-term climatological record. The closest station is the Cranbrook Weather Station (Cranbrook A) located at the Cranbrook - Kimberley Airport, some 60 km south of Canal Flats.

The mean monthly temperatures at that location for the 2020-21 water year (November 1, 2020 – October 31, 2021) are shown in Figure 2. The corresponding long-term normal values based on records accumulated over the 30-year period 1980-2010 are shown for comparison. A similar comparison is made for total precipitation in Figure 3.

The fall started out with temperatures above normal, and they remained above normal until January before abruptly cooling in February. By March they had returned to normal and remained near normal until May. Following that, the much publicized "heat dome" set in and June and July were well above normal. The peak temperature recorded at the Timber Springs weather station was 41.8°C at 16:00 on June 29. Temperatures returned to normal in August.

Precipitation amounts were near normal until January and then fell off with little precipitation recorded during February and March. Drier than usual conditions persisted through until August with July being exceptionally dry. August turned out to be wet and following that, the water year closed out with near normal precipitation amounts.

The *Snow Survey and Water Supply Bulletin* compiled by the River Forecast Centre (2021) was not totally supportive of the Cranbrook precipitation amounts. It stated that by April 1, when snow accumulation is generally greatest, the snowpack in the East Kootenays was 113 percent of normal.

Snow depths measured at the Fairmont Hot Springs Resort Ltd Ski Hill weather station (see Figure 1 for location) are shown in Figure 4. The station is within range of snowmaking equipment so that it may not accurately represent accumulation. However, the period of melt is believed to be accurately represented. A downward trend in snow depth began about March 10 and the rate of decrease sharpened at the beginning of April. The snow had disappeared by May 8. This is consistent with the observations of previous years and again demonstrates that elevations surrounding the lake below 1480 metres above sea level (asl), the station elevation, are nearly snow free by the end of April. The elevation of the lake is 806 m asl.

The accumulated precipitation recorded during the April-October period at the Timber Springs location is compared in Figure 5 against the corresponding average over the seven-year period, 2014 to 2020. The 2020 season started out as an average season but nearly 46 mm of rain recorded during the May 23-25 period boosted the amount to above average. After that, the distribution of rainfall followed the average trend, and it also is at odds with the Cranbrook record above.

In summary, the information from all sources points, except for February, to near normal winter and spring temperatures. The precipitation amounts recorded at Cranbrook appear to underestimate local amounts. The local snowpack was likely slightly above normal and the local rainfall accumulation compared favorably with that of recent years.

4. 2021 Activities

4.1. Stations

Four of the water level monitoring stations installed during 2014 and 2015 remained in operation. Their locations are shown in Figure 1. One was situated in the Columere Marina (Col) and measured lake level. The others were in the Headwaters Park near Canal Flats (CF), on the Columbia River near Fairmont Hot Springs (WSC) at the old Water Survey of Canada site, and on Dutch Creek at the Highway 93/95 Bridge (DC). A fifth station, Lansdowne Creek, installed in 2017 on Nature Conservancy of Canada property, also remained in operation though was subject to vandalism. A sixth station (Outlet), installed in August 2019 on the Columbia River just below the outlet from the lake, continued to operate but only provides meaningful water level information during the October to April period. At other times, the station is flooded by backwater from Dutch Creek. The Dutch Creek Station only operates during the open water season as ice jams during winter render non-representative flow information.

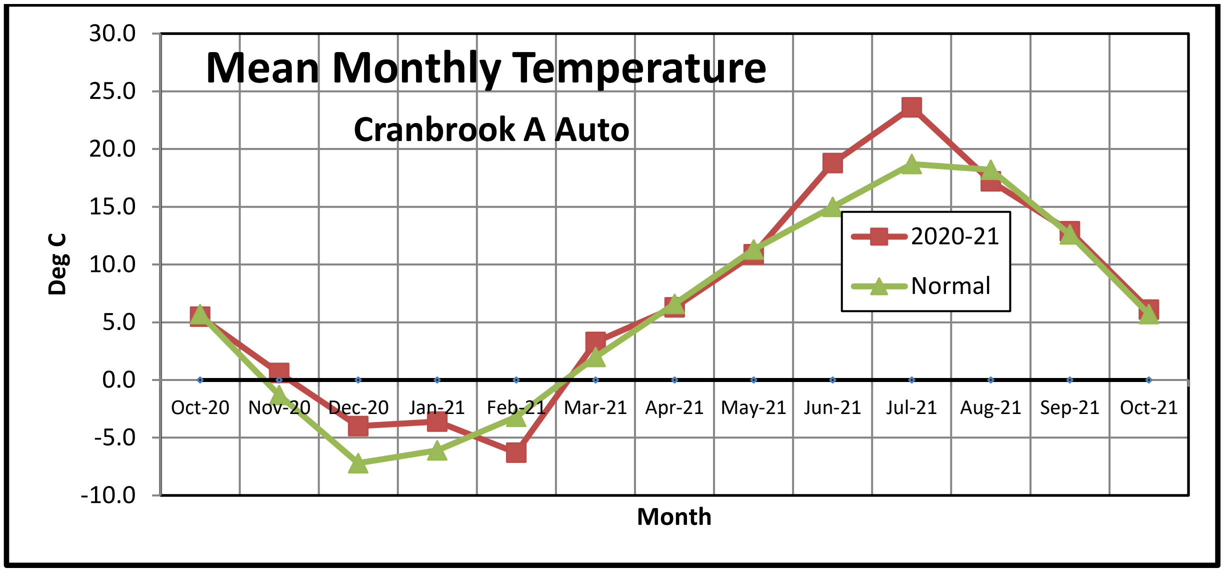

Figure 2 – Mean monthly temperatures at the Cranbrook- Kimberley Airport during the 2020-21 water year and the corresponding 1980-2010 long-term normal values.

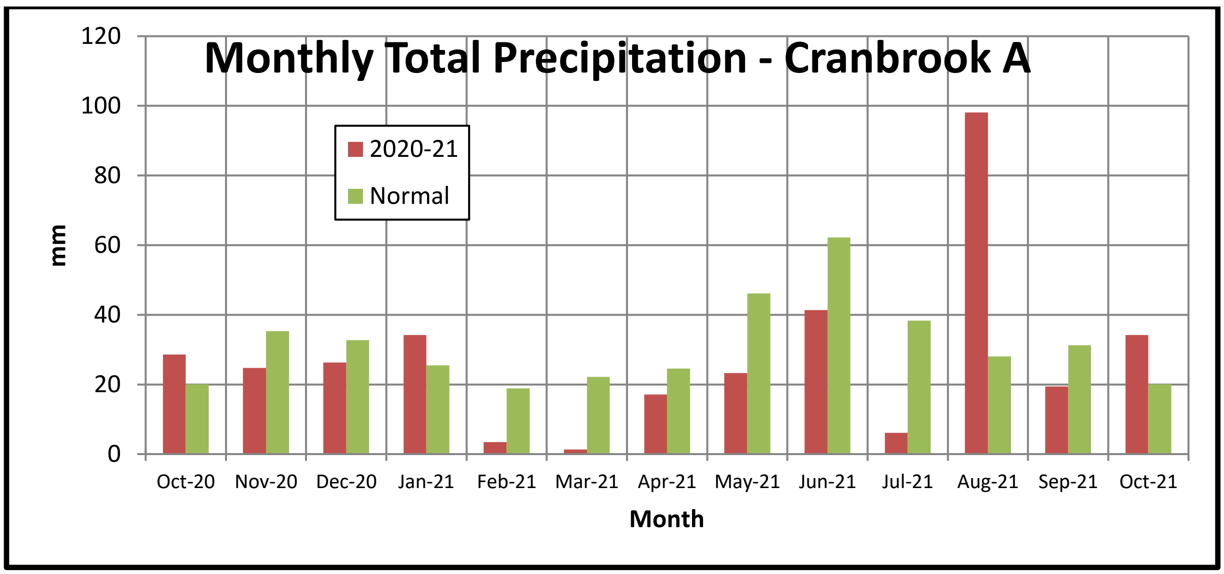

Figure 3 – As in Figure 2 except showing precipitation totals.

The station installed in 2020 at the south end of Columbia Lake was returned to operation during the open water season. It is located near the old Water Survey of Canada lake level station (08NA064) decommissioned in 1984. Its purpose is to tie present day data to the historical record and, when compared to Col water levels, to provide insight into the effect of wind on lake setup.

The recording rain gauge located in the Timber Springs community does not operate over winter. It was opened for the season on March 4 and remained in operation past December 1, 2021.

A weather station is operated at the Fairmont Hot Springs Airport (CYCZ) for aviation purposes. The altimeter setting is a convenient, local reference for verifying the accuracy of the pressure sensors in the data loggers used to measure water level.

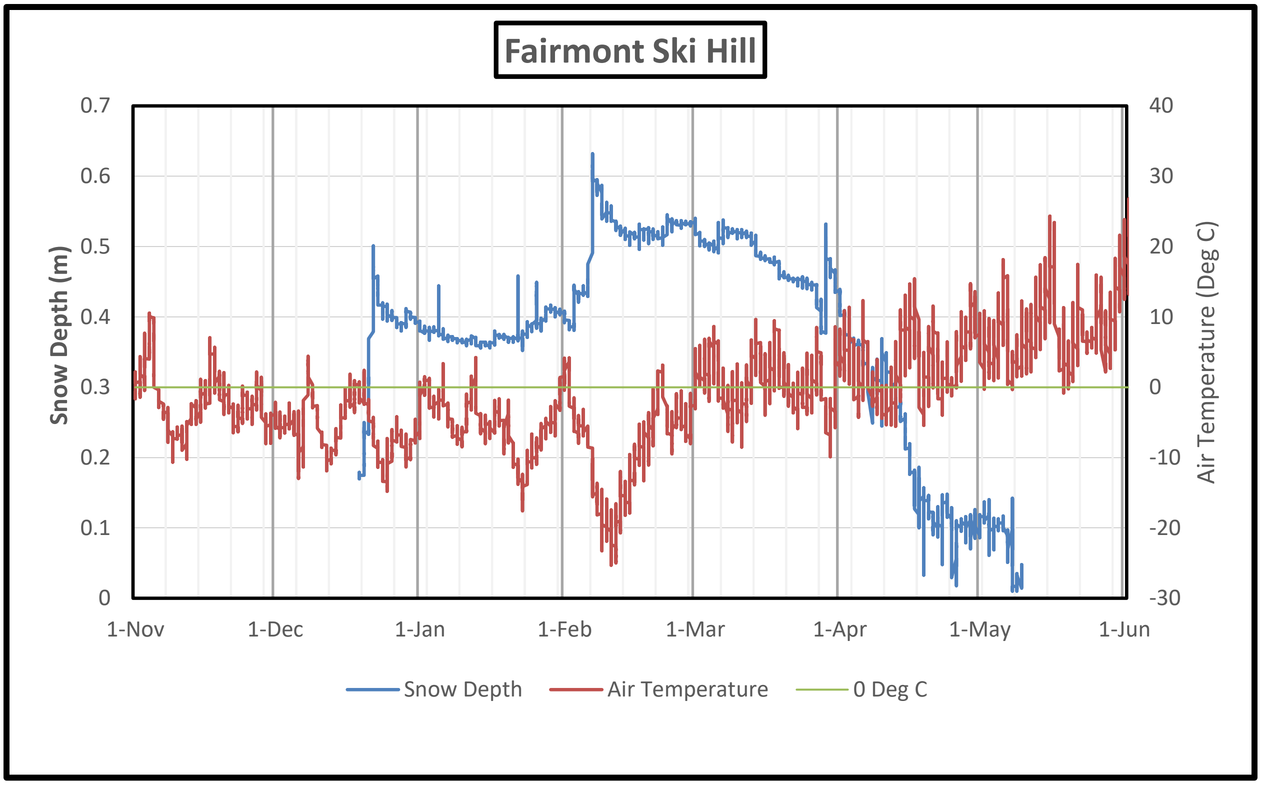

Figure 4 – Snow Depths and temperatures recorded at the Fairmont Ski Hill weather station.

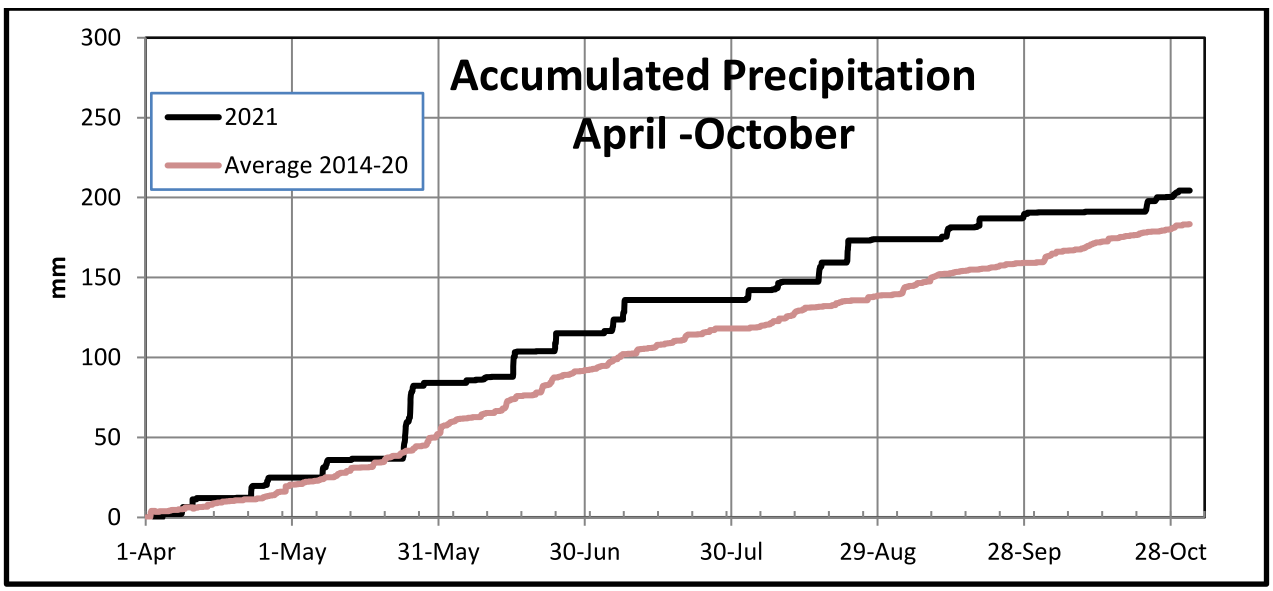

Figure 5 – Accumulated precipitation measured at the Timber Springs weather station during 2021 in comparison to the 2014 – 2020 period average.

4.2. Equipment Purchases

A humidity sensor was acquired during the year and added to the Timber Springs weather station. In time the data will be useful for estimating evaporation losses from the lake.

Two additional rain gauges were acquired at mid-season with the intent of deploying them to remote elevated locations in 2022.

4.3. Data Collection and Management Issues

Two incidences of vandalism occurred. The logger at the Lansdowne site was found missing on February 19. A replacement was installed on February 27. As a result, no data are available between October 7 2020, when the station was last visited, and February 27 2021 when the replacement was installed. The second occurred at the Outlet site. The pin holding the suspension cable was removed allowing the logger to drop to the bottom of the stilling well. It was possible to estimate the change in elevation and reconstitute the affected data so that the record remained intact.

Measures taken to slow the spread of coronavirus only slightly impacted operations so that the data collection program was not significantly hampered.

As noted in last year's report, a disconnect between low flow measurements on the Columbia River made by wading and those made during high flows from the highway bridge was revealed. Two additional high-water measurements were made during the year to help resolve the issue. More are planned for 2022.

4.4. Sensor Accuracy

The performance of the loggers is routinely checked. The steps involved and corrective measures that were applied are outlined in Appendix A.

5. Water Temperature and Level

5.1. Winter 2020-21

The winter water temperature and water level recorded at the primary stations (Col, DC and WSC) are shown in Figures 6 and 7, respectively. Note that the logger at the Dutch Creek station only operates part season due to ice build up on the river. It was removed November 6, 2020 when ice began to appear and re-installed on March 29, 2021.

The mean daily air temperature recorded at Timber Springs is superimposed in Figure 6 for reference. The coldest day of the season was February 13 when the mean daily temperature reached -24.2°C.

5.2 Open Water Season 2021

5.2.1 Water Temperature

The water temperatures recorded during the open water season at the primary stations are shown in Figure 8. Outlet temperatures are superimposed and as was observed last year, indicate the direction of water movement at the lake outlet. About mid-April, when the lake began to rise, the Outlet temperatures approximated those in Dutch Creek indicating the passage of water from the creek into the lake. The flow reversal dominated until just after the surge of water out of Dutch Creek ended in early June (see Figure 9). Over the following month the water temperatures fluctuated between those of

Dutch Creek and those of the lake but gradually reached the lake temperature by early July. By then the lake had crested and outflow predominated.

Mean daily air temperatures recorded at Timber Springs are superimposed for reference.

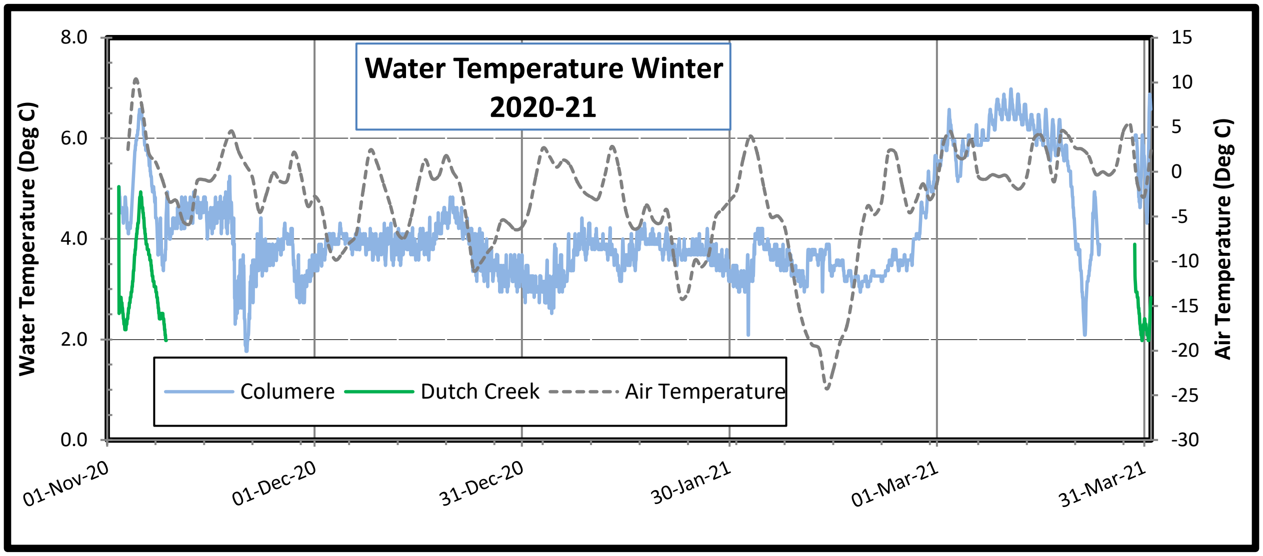

Figure 6 – Winter water temperatures. Air temperatures recorded at Timber Springs are superimposed.

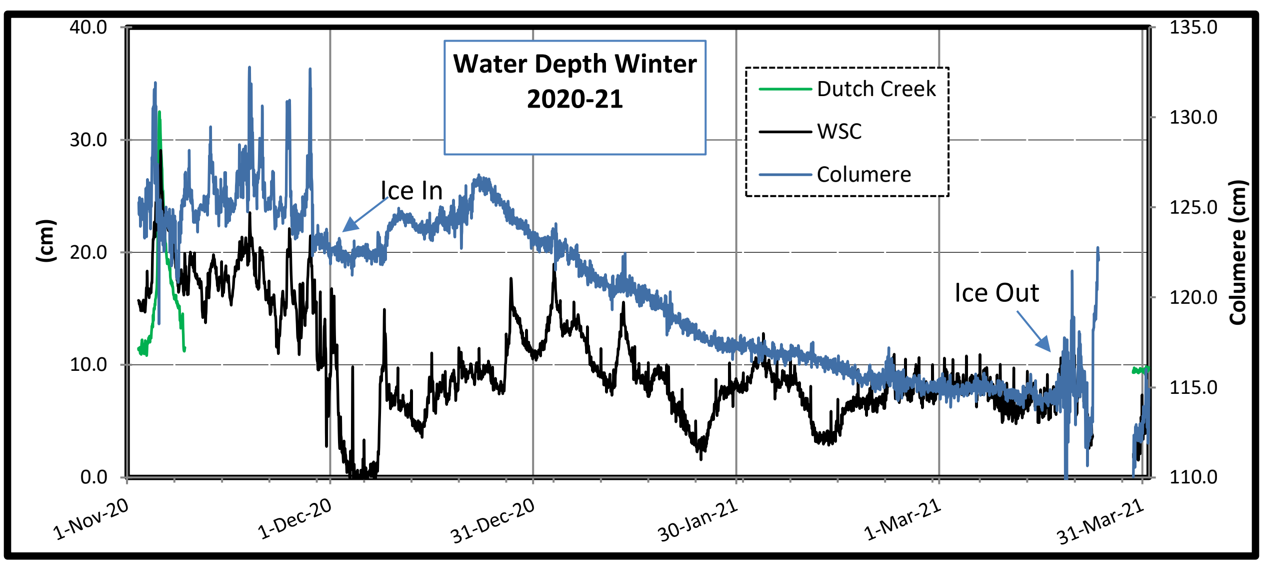

Figure 7 – Winter water depths recorded by loggers. The intakes at the Dutch Creek and WSC sites are exposed at low water levels and are subject to freezing so that water levels below about 8 cm should be viewed with caution. The logger on Dutch Creek was removed in late November due to the presence of ice floes. Ice in and Ice out are the dates of lake freeze over and ice break up, respectively.

5.2.2 Water Level

The recorded water levels are shown in Figure 9. The levels represent the depth of the water above a local reference and bear no relationship to any known elevation standard. The substantial number of spikes in the Columere record is due to wind set-up.

The lake was at its highest level on June 30 when it reached an elevation of about 100 cm above its mid-April low. That peak barely exceeded an earlier one recorded on June 6. The earlier peak was likely initiated by a three-to-four-day period of unusually warm temperatures perhaps abetted by a period of moderate rain a few days earlier that would have added water to a snowpack nearing saturation. Whatever the reason, the result was a rapid rise in Dutch Creek that caused significant flooding of properties on and adjacent to the delta. The circumstances leading to the June 30 peak are less easy to comprehend. It seems that the lake level began to recede following the earlier peak but rose again following a rain event on June 15 that brought another surge of water out of Dutch Creek. That was followed by the build up to the “heat dome”. It reached maximum intensity on June 29 and would have melted the last of the remaining snowpack. Although Dutch Creek did not reach its previous levels during these events, it remained sufficiently high to add more water to the already flooded delta and maintain the flow of water into the lake.

The 2021 water levels recorded on Columbia Lake are compared with the corresponding average levels over the seven-year period 2014 to 2020 in Figure 10. The rise of water levels in 2021 started out at rates comparable to those of recent years though the first crest was a bit earlier and higher than the average. After cresting, additional water entered the lake so that instead of continuing to recede the water level rose again leading to the second crest. The overall result was that the volume of water that entered the lake over the season was greater than in previous years.

5.2.3 Rating Curves

Flow measurements were made on the Columbia River at the WSC site and at the Outlet location. As noted above, a need to refine the accuracy of the WSC rating curve is recognized and steps are being made in that direction. It will not be updated until flow measurements have been conducted for one more season. It is unlikely that a stable stage-discharge relationship can be established at the Outlet site due to a shifting stream bed and backwater influences from Dutch Creek.

6. Local Water Exchanges

In addition to the influx of water from Dutch Creek, the lake level is influenced by gains and losses of water within the local watershed. Evaluating these is a challenge because they cannot be measured directly and their contribution must be estimated by indirect means. The stations CF, Lansdowne, and Outlet make up a secondary network and were installed to aid in those estimations.

The gains arise from surface runoff and groundwater, and the losses from evapotranspiration, outflow, and consumptive use. During the mid-September to mid-April period, the losses due to evapotranspiration and consumptive use are at a minimum. By focusing on this predominantly winter period and assuming that evapotranspiration and consumption are near zero, the combined surface runoff/ groundwater contribution can be estimated using a water balance approach. That is done in the following section. The remainder of the year, mid-April to mid-September (Summer) is examined separately but in a more cursory manner.

For the lake to be in balance, the inflow must equal the outflow plus the change in storage during a time period. In short,

Inflow = Outflow + Change in storage

6.1 Winter Period

6.1.1 Outflow

The outflow is derived from direct measurements. Four more flow measurements were made at the Outlet station during 2021 bringing the total measured during the winter months to 14. The flow rates ranged from 0.7 to 2.49 cubic metres per second with a mean of 1.7 cubic metres per second. It is conceded that issues exist with the use of direct measurements. Backwater from Dutch Creek occasionally impedes outflow. Also, a small amount of water may be bleeding off from the main Dutch Creek channel and entering the lake upstream of the Outlet station. However, the measurements are corroborated by flow rates at the WSC and DC hydrometric stations. The rates at the WSC station consistently exceed those at the DC station, when available, by 0 to 2 cubic metres per second indicating a similar amount of water is entering the channels between these two locations.

6.1.2 Change in Storage

The rate of change in storage can be calculated from the lake level measurements recorded at the Columere station. From Figure 10, it can be seen that the lake level drops by about 9 cm on average over the seven-month period. This equates to a decrease in storage capacity at a rate of 0.1 cubic metres per second assuming a lake surface area of 25.74 square kilometres.

6.1.3 Inflow

By applying the above equation and assuming the foregoing rates of storage loss and outflow are reasonable and that evaporative and consumptive use losses are minimal, the average rate of inflow over the seven-month period is 1.6 cubic metres per second. Nearly all will be from surface runoff and groundwater. A breakdown of the respective proportions cannot be made but some information is available. Rough measurements on Lansdowne Creek show the flow to be consistently in the .02 to .04 cubic metres per second range. Similar measurements at the Canal Flats station show the contribution from the headwaters creek to be about 0.02 cubic metres per second though that station does not capture the entire flow from the creek.

6.2 Summer Period

Establishing the water balance during the summer is even more challenging. The dynamics are different. Outflow from the lake becomes inflow for a portion of the period and cannot be directly measured. One means of estimation might be to apply a technique known as routing to account for water losses between the Dutch Creek and WSC hydrometric stations but more precise flow measurements during high water especially at the Dutch Creek site will be required.

The change in storage is likely one of the easier components to estimate. As before, it can be directly computed from the lake water level measurements.

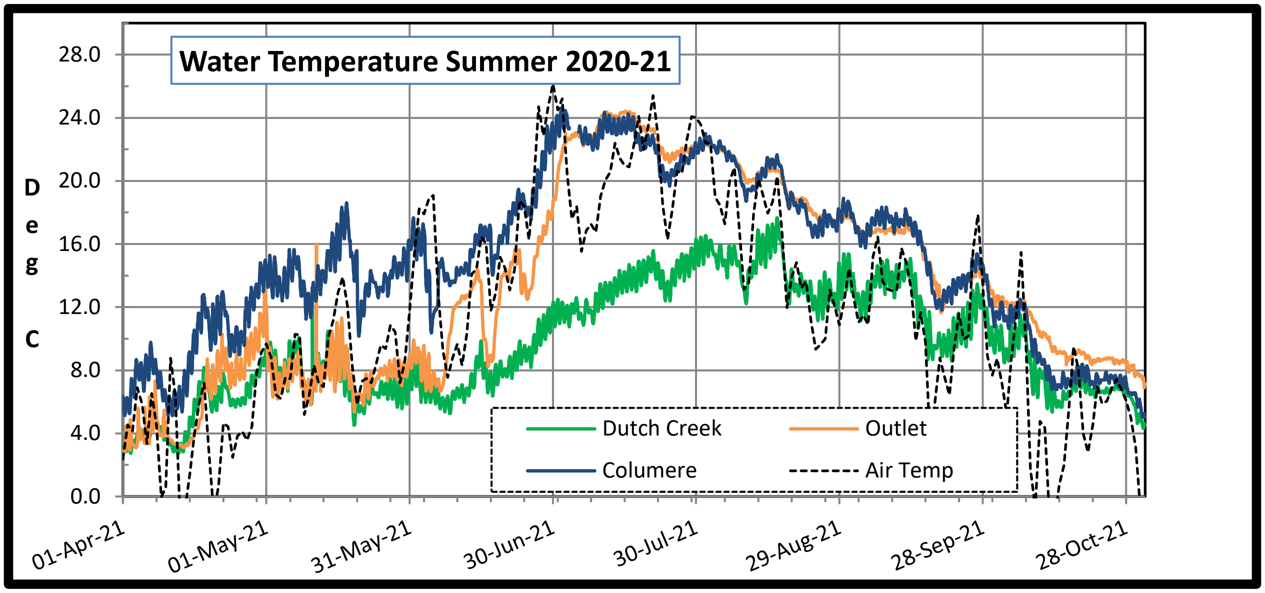

Figure 8 – Water temperatures. Air temperature at Timber Springs also shown.

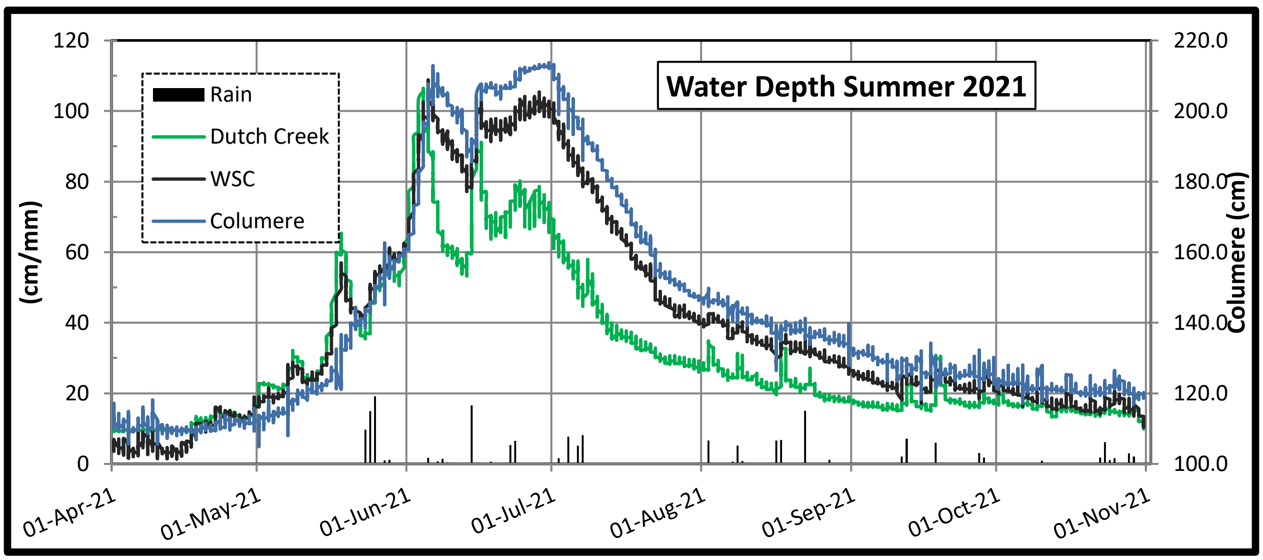

Figure 9 – Hourly water depths in cm. Depths are as recorded by loggers and do not relate to a common reference level. Rainfall amounts are in mm.

Even if the input can be established, separating out the respective contributions will be difficult. Evapotranspiration will be substantial. It can be estimated from measurements of wind speed, temperature and humidity but existing weather stations are too few and not well located to be representative. It is unlikely that surface runoff can be measured with any certainty and will have to be pro-rated based on estimates from representative streams or, in lieu, from precipitation. Inadequate measures of precipitation, both rainfall and snow accumulation, exist to employ the precipitation option. The rate of groundwater entry is known to increase during late spring/early summer but no measurements exist for estimation purposes with one possible exception. Gillmor (2018) has shown that the hydraulic head between the Kootenay River and Columbia Lake varies little throughout the course of the year so that any subsurface transport beneath Canal Flats should be nearly the same in summer as in winter.

In short, little progress has been made on advancing the knowledge of the water balance during the summer months. Further advancement cannot be expected until the monitoring network is expanded.

6.3 Recorded Data

The records of water temperature and depth for the November to March period at the second order stations are displayed for reference in Figures 11 and 12, respectively. Their counterparts for the April to October period are displayed in Figures 13 and 14.

6.4 Discussion

A small amount of progress has been made on establishing the lake water balance over the past year. In last year's Report the winter outflow was estimated to be nearly two cubic metres per second. The additional measurements made this year have reduced the estimate to 1.7 cubic metres per second, again raising concern about the water supply.

This report focuses on surface water. Groundwater is addressed only to the extent of its contribution to the lake. The subsurface transfer of water out of the lake has not been examined.

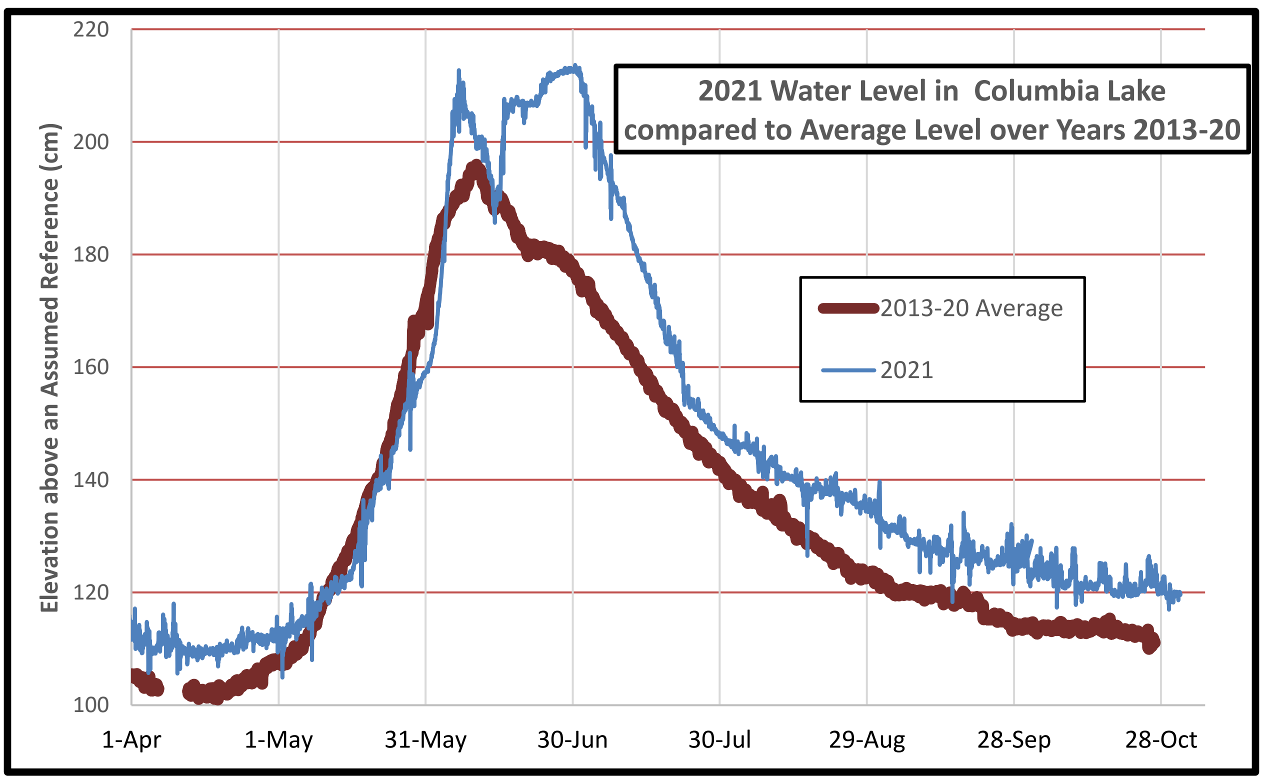

Figure 10 – 2021 water levels compared to 2014 to 2020 average. Levels are above an arbitrarily selected reference.

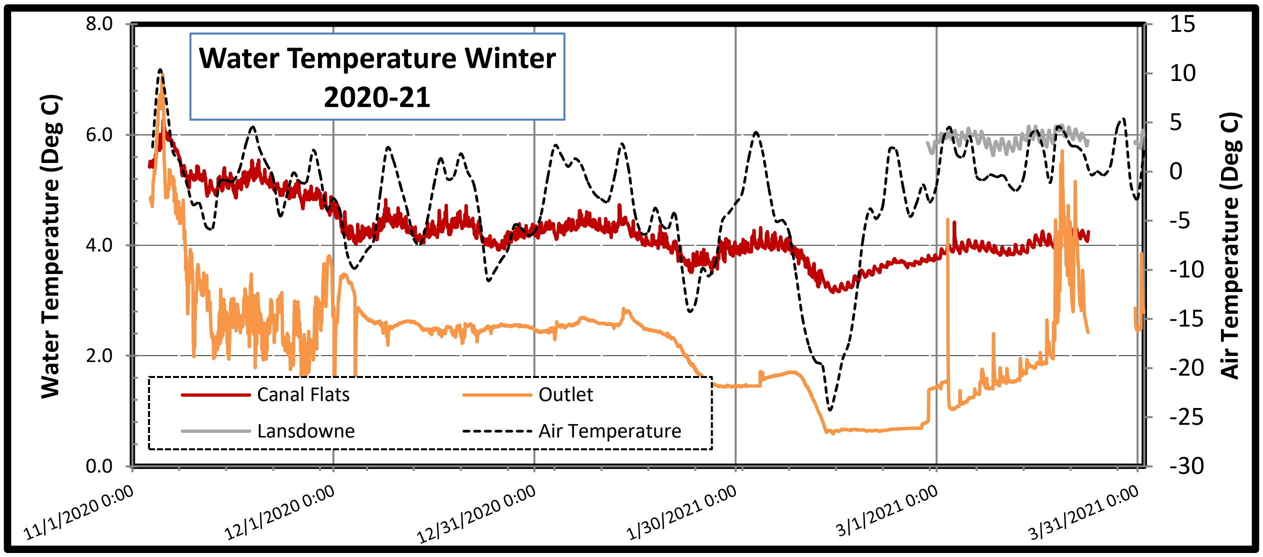

Figure 11 – Hourly winter water temperatures. Air temperature is the daily mean recorded at Timber Springs.

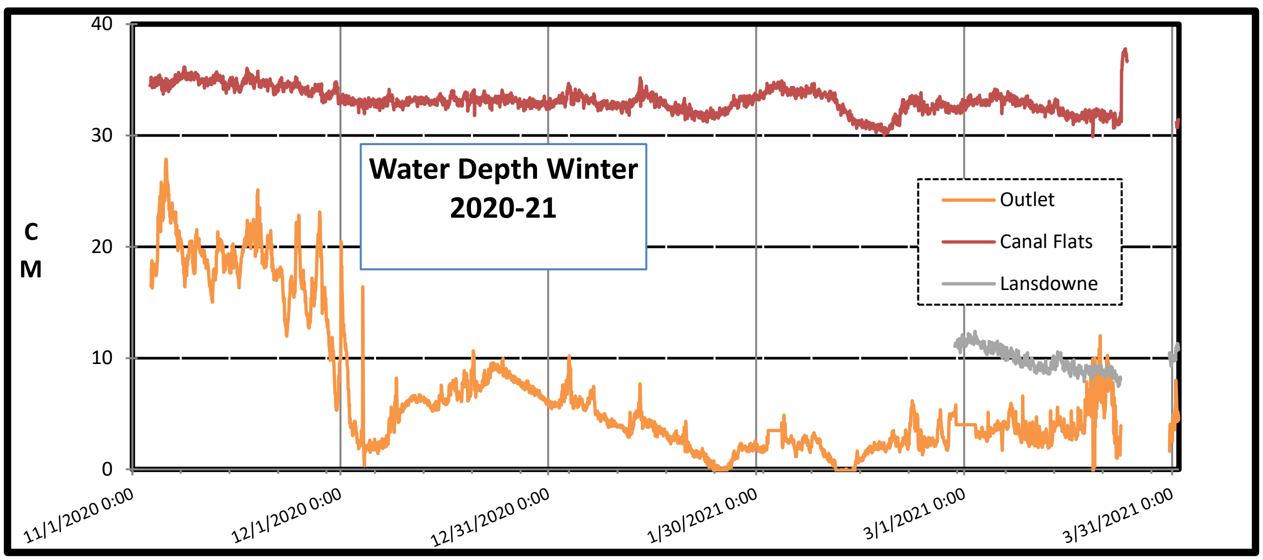

Figure 12 – Water depths during winter. Lansdowne logger vandalized October 2020 and not replaced until February 27. Outlet water level briefly below intake late January and early February.

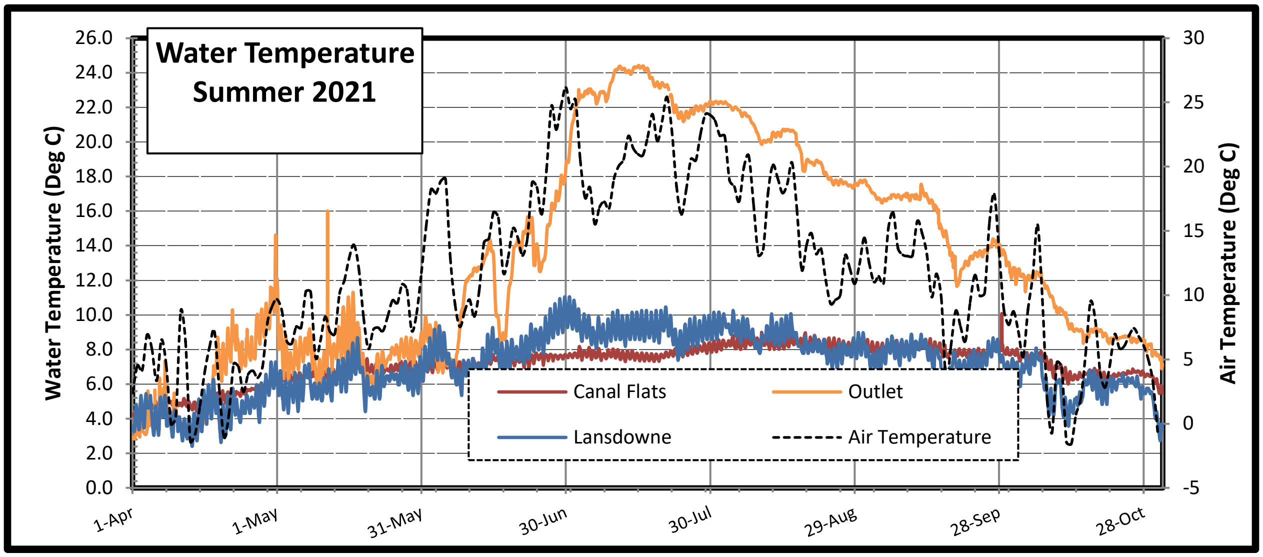

Figure 13 – Water temperatures. Air temperature at Timber Springs superimposed

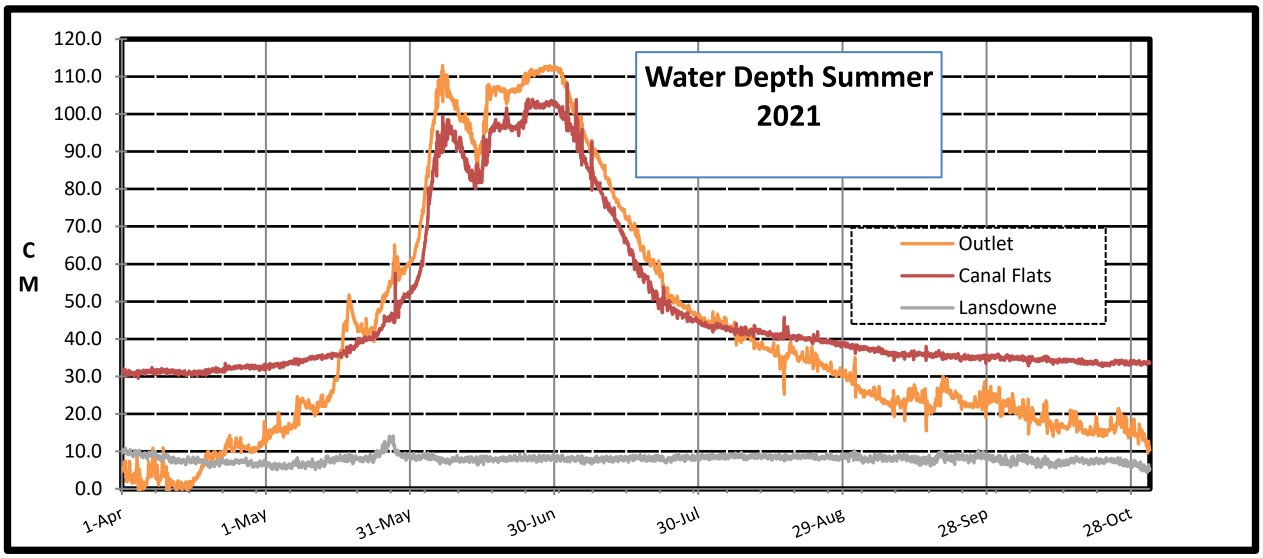

Figure 14 - Hourly water levels. Depths are as recorded by loggers and do not relate to a common reference.

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Village of Canal Flats
Columbia Ridge Community Association
Timber Springs Community Association
Columere Park Community Association
Spirits Reach Community Association
BC Lake Stewardship Society
Nature Conservancy of Canada
Fairmont Creek Debris Flow Mitigation Project
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Appendix A

Accuracy of Measurements

The integrity of an analysis depends on accurate measurements. The following describes the steps taken to evaluate equipment performance and to minimize error.

A1 -Water Level

Water information is collected using data loggers. The loggers measure pressure and temperature and record them in internal memory. The loggers are programmed to record every hour on the hour. Loggers from two different suppliers, Diver and HOBO, are in use.

All loggers are non-vented. This means that the sensor measures the pressure exerted by the column of water above the logger plus that of the atmosphere. The atmospheric pressure must be removed to obtain the pressure exerted by the water alone. Once removed, water depth can be calculated from the water pressure. Atmospheric pressure is measured using a separate logger (HOBO logger 325) mounted at the WSC site at an elevation of 809 metres asl. Most stations are located at lake level (808.5 metres asl) so that an elevation adjustment is not required. Exceptions are the Dutch Creek station which is twenty-four metres above lake level and the Lansdowne station at roughly forty metres above lake level.

Logger H325 also served as the standard for evaluating the performance of all other loggers. Its accuracy in turn was periodically evaluated against the barometer mounted at the Fairmont Hot Springs Airport (CYCZ). The Airport elevation is 811 metres asl so that the pressures are comparable. Spot readings made at both locations during the year were recorded and the differences are displayed in Figure A1. During the first 8 months the differences were minor indicating that a correction was not warranted. After that a downward trend is noted. The management of the Airport changed hands during the year and difficulty was experienced maintaining the weather station. Access to weather information began to decrease in September and ceased altogether in October. The downward trend may have been due to the accuracy of the Airport measurements, not drift of the logger, and it was therefore felt inappropriate to make an adjustment. The closure of the weather station presents a challenge for future operations. A new reference will have to be located to evaluate logger performance.

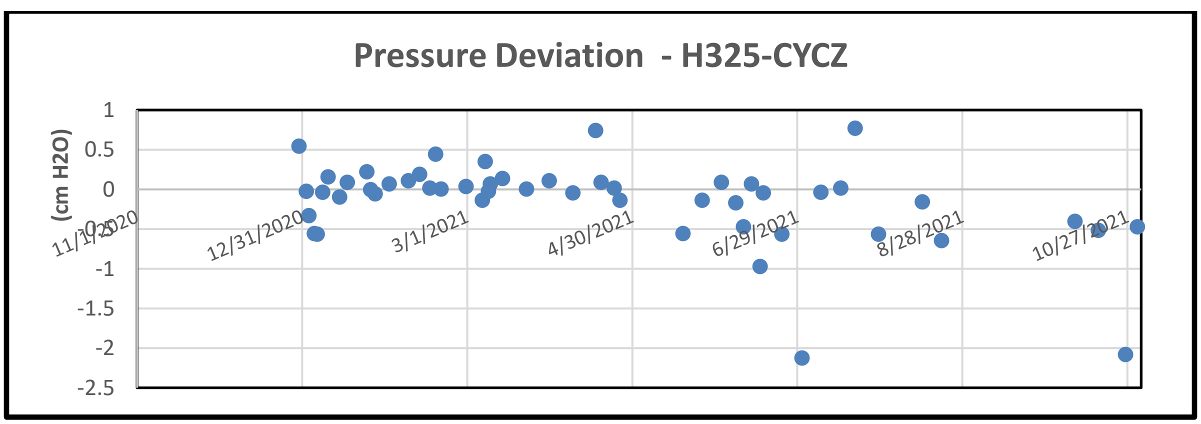

Figure A1 – Deviation of atmospheric pressure measured by logger H325 from CYCZ barometer.

Laboratory calibration was not undertaken due to cost. However, all loggers except 1368 were taken out of service at the beginning and the end of the open water season and collocated with H325 for a period of a few days. The pressures recorded during those periods are shown in Figures A2 and A3. The pressure sensors were not all in agreement thereby indicating a need for an offset adjustment. The mean offsets from H325 were calculated and are shown in Table A1. The offsets were applied to the six-month period following the comparison tests.

No correction was made for the effects of temperature on water density.

The locations at which the loggers were deployed is shown in Table A2.

A2- Water Temperature

Beginning and end-of-season comparisons of the temperature sensors were made in similar fashion. The records are displayed in Figures A3 and A4 respectively. The exposure of the loggers to sunlight was uneven during the April trials causing some to record slightly warmer temperatures than others. Otherwise, good agreement is shown.

A3- Other

Other steps were taken to ensure the integrity of the data. Manual measurements of water level were taken at each location periodically during the season to verify the accuracy of the recorded pressure measurements. The stilling wells and intake pipes at each of the stream sites were periodically back flushed.

The current meter was calibrated by the manufacturer prior to purchase and has not been further calibrated.

Table A1 – Measured Offsets from H325 during Comparison trials

Oct-20			Mar-21			Oct-21		
Logger	**cm H2O**	**Diff fm H325**	**Logger**	**cm H2O**	**Diff fm H325**	**Logger**	**cm H2O**	**Diff fm H325**
H325	*939.5*	*0*	*H325*	*928.6*	*0*	*H325*	*934.4*	*0*
1459	944.8	5.3	1459	933.9	5.3	1459	940.9	6.5
1366	935.7	-3.8	1366	925	-3.6	1366	930.7	-3.7
BARO	940.9	1.4	BARO	929.8	1.2	BARO	933.3	-1.1
U5972	944.4	4.9	U5972	933.7	5.1	U5972[1]		
AV083	939.7	0.2	AV083	928.9	0.3	AV083	934.8	0.4
H012	940.3	0.8	H012	929.4	0.8	H012	935.4	1.0
H013	940.3	0.8	H013	929.8	1.2	H013	935.8	1.4
H326	939.9	0.4	H326	929.9	1.3	H326	934.4	0.0
H109	935.6	-3.9	H109	925.8	-2.8	H109	930.4	-4.0
			H691[2]	929.2	0.6	H691	934.9	0.5

[1] U5972 not removed due to ice

[2] H691 not acquired until fall of 2020

Table A2 – Logger Deployment During 2020-2021 Water Year

U5972	Outlet – Backup – Nov 2, 2020 – Mar 23, 2021 DC – Apr 7, 2021 – Oct 31, 2021
1459	WSC – backup Nov 2, 2020 – Oct 31, 2021
1368	Lansdowne – removed by vandals – no record for 2020-21
1366	Outlet
BARO (1601)	Timber Springs – Atmospheric Pressure (Back-up) – Nov 3 – Mar 24 Timber Springs – Atmospheric Pressure (Back-up) – Apr 2 – May 11 Col – backup – May 11 – Sep 15 Timber Springs – Atmospheric Pressure (Back-up) – Sep 17 – Oct 31
H109	Lansdowne -Feb 27 -Oct 31
H326	Columere – Lake Level – Nov 2, 2020 - Oct 31, 2021
H325	WSC – Atmospheric Pressure sensor – Nov 2, 2020 - Oct 31, 2021
H012	WSC – Nov 2, 2020 - Oct 31, 2021,
H013	DC – Nov 2 – Nov 9 Out of service – Nov 9 – Mar 29 DC – Mar 29 – Oct 31
H691	Columbia Lake South – May 9 – Sep 28 CF – Atmospheric Pressure – Sept 28 – Oct 31
AV083	CF – Nov 2, 2020 - Oct 31, 2021

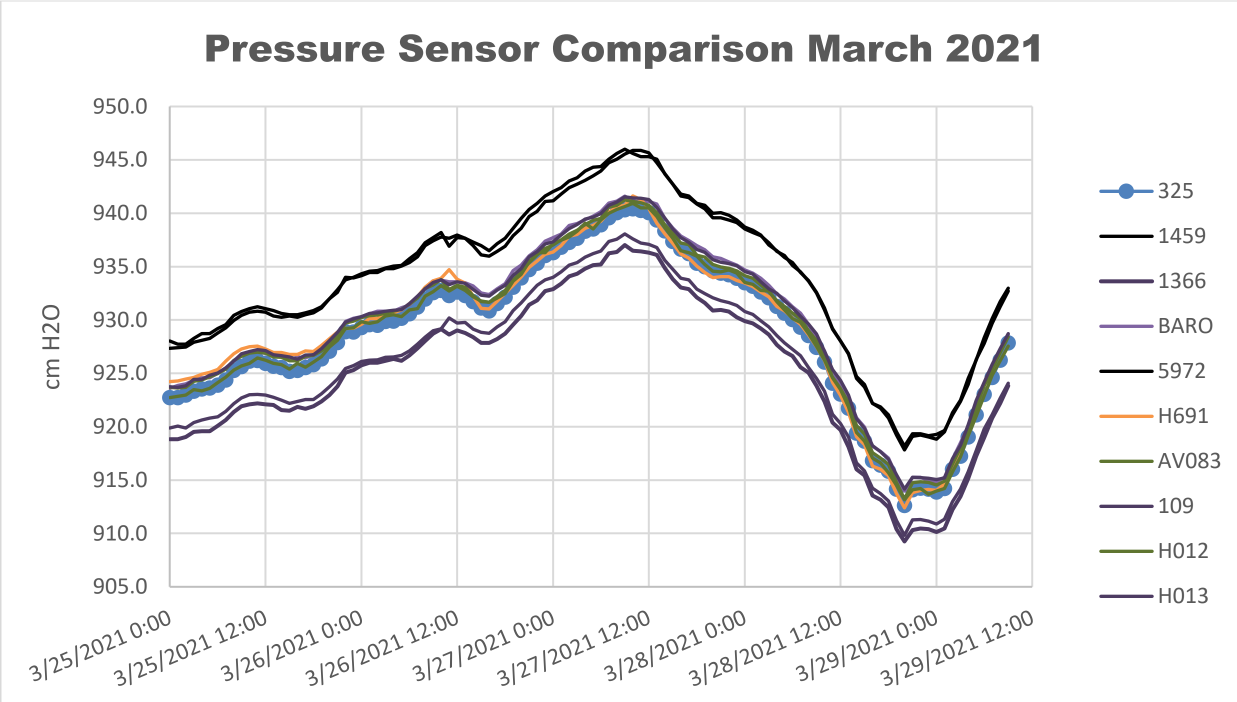

Figure A2 – Pressure readings from all loggers in relation to H325 at mid-water year.

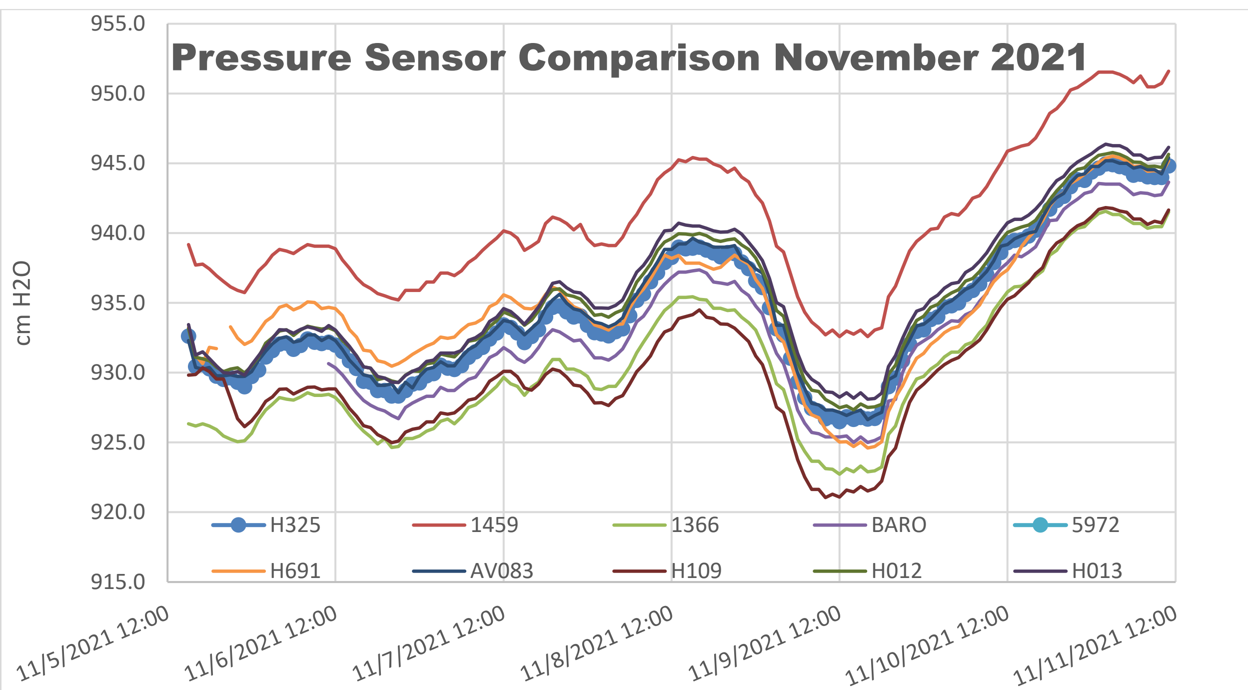

Figure A3 – Pressure readings from all loggers in relation to H325 at end of water year.

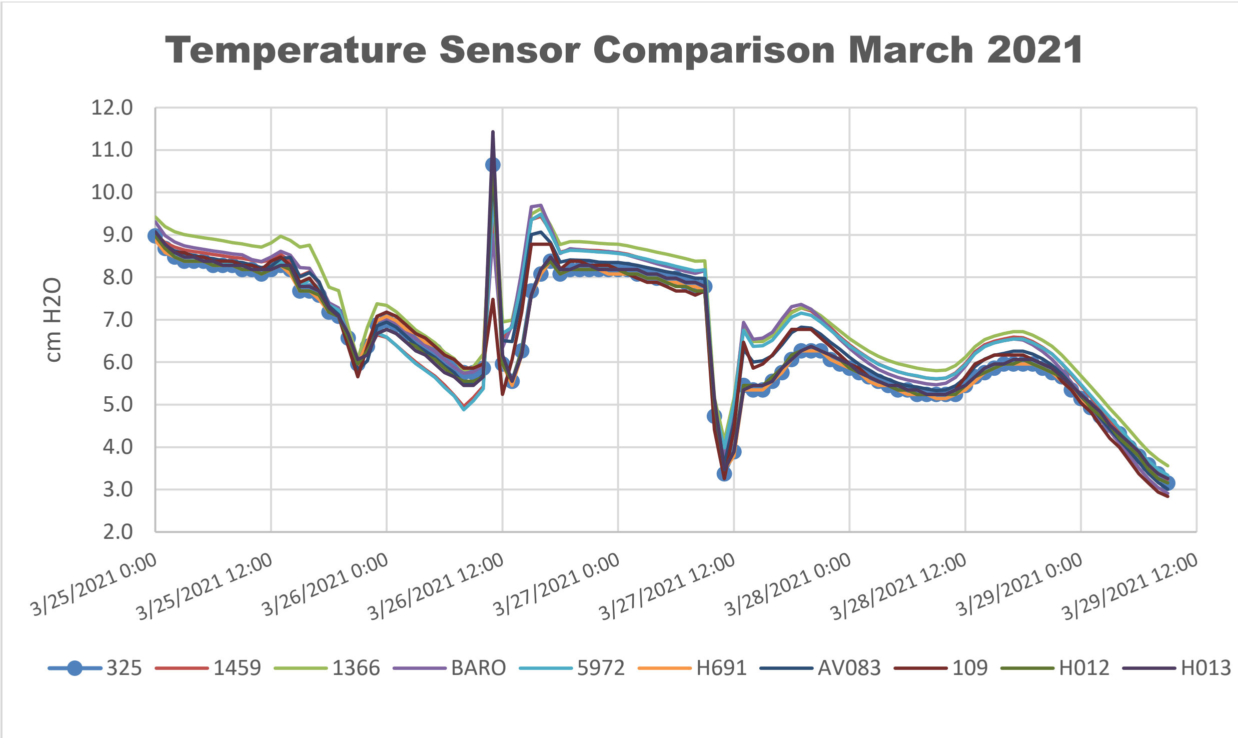

Figure A4 – Temperature readings in relation to H325 at mid water year.

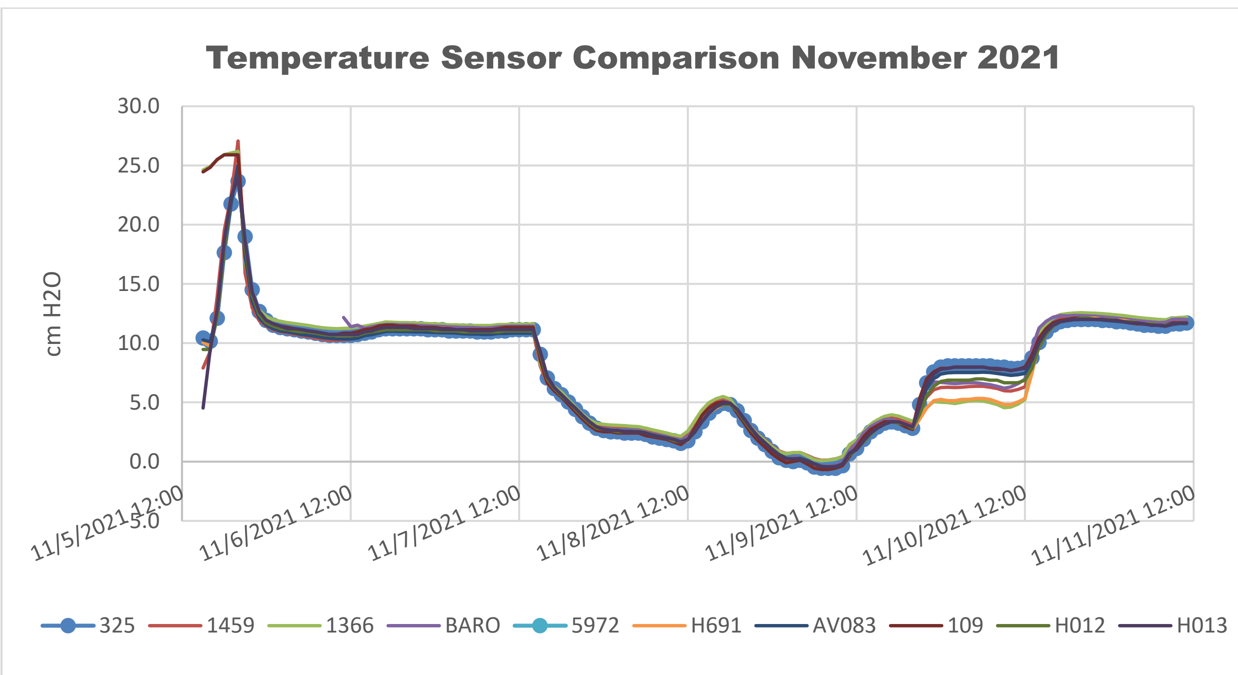

Figure A5 – Temperature readings in relation to H325 at the end of the water year.