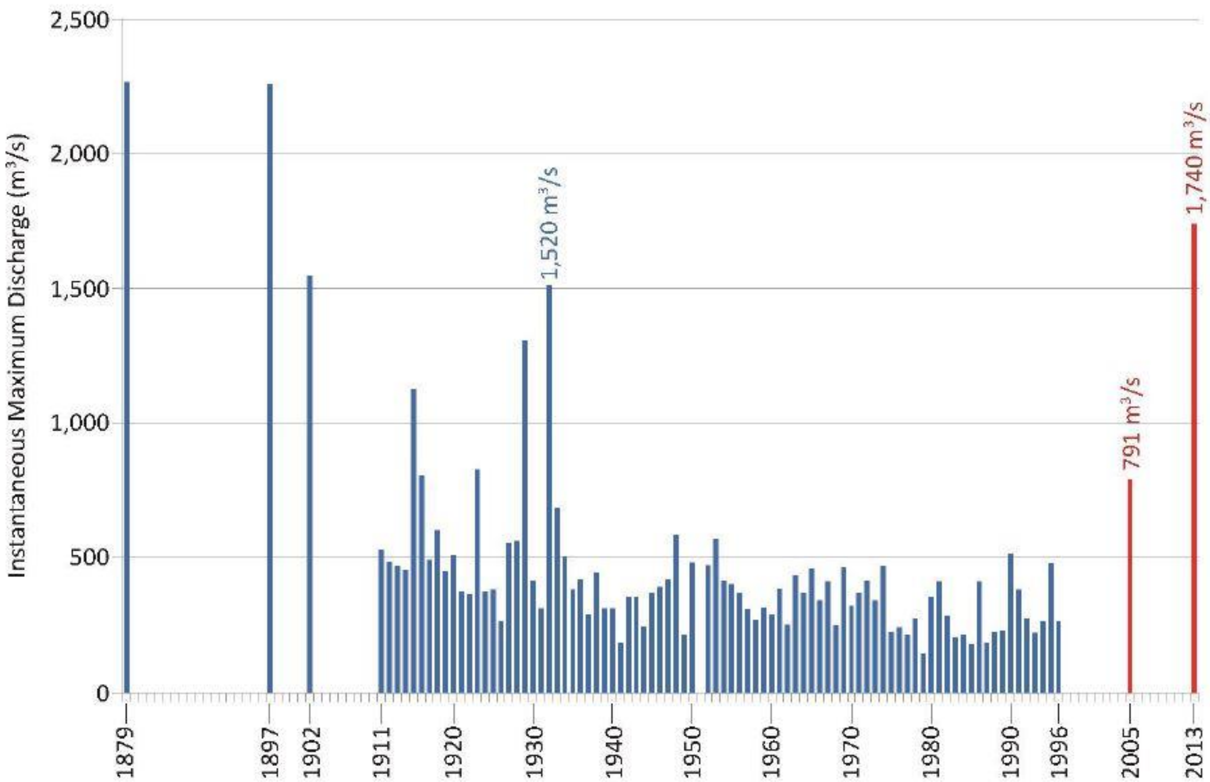
Predicting Elbow River flood flow rates and recurrence intervals (1870's-present).

Dave Klepacki, Springbank Landowners Group, February 2021.

"This year's flooding isn't the worst that Calgary has seen, says historian Harry Sanders. He lists, in order, the three worst floods to hit the city occurred in 1879, 1897 and 1902. (Jonathan Hayward/Canadian Press July 29, 2013)"

The Calgary historian Harry Sanders lists 1897 as the second worst flood in Calgary's history (1879 being the worst). This photo of the 1897 event was taken looking west from a point on the south bank of the Bow River near Langevin Bridge, which connects Bridgeland to the southeast side of what is now downtown. (Glenbow Museum).

Figure 2: Maximum Water Discharge in the Bow River at Calgary between 1879 – 2013



Flood events in the Bow River at Calgary in historical time from WaterSmart, 2013.

The Importance of Sample Size for Predicting Flood Frequency

Predictive analytics uses mathematical models to identify future outcomes based on historical data. Many studies show the critical importance of data quality on decision quality (Ghaemaghaei and Calic, 2019). In natural systems, extreme events "live" in the tails of the distribution and it is very important to obtain as as large a distribution as reasonable accuracy allows in predicting future events (Mohamed and Sapsis 2018).

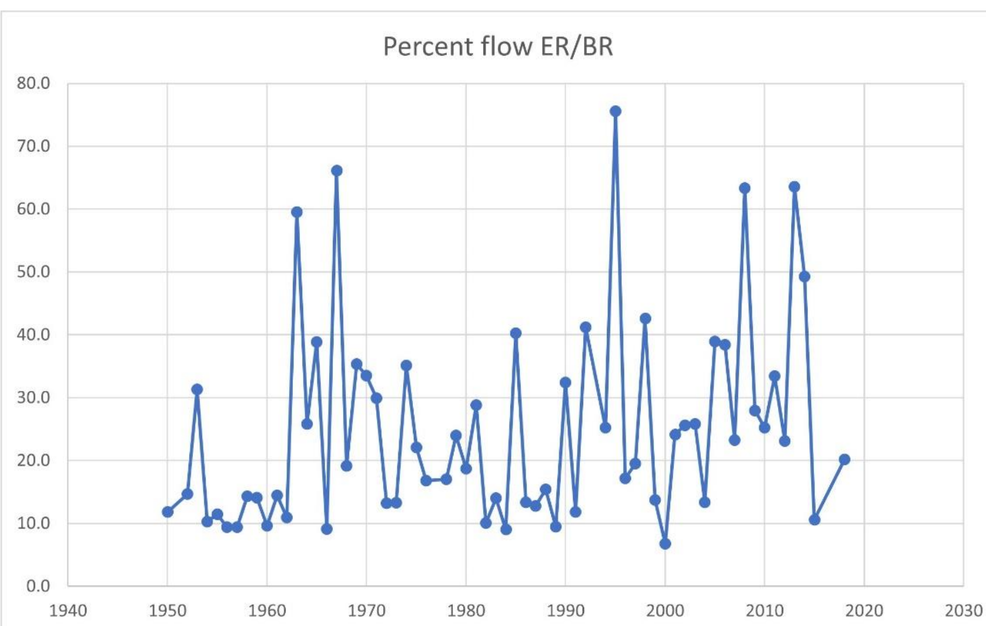
The data Stantec used in estimating flood flows along the Elbow River ranged from 1908-2012 (Table 5 and pp 22-23 Springbank Off-Stream Reservoir Project Hydrology Flood Frequency Analysis, Stantec Consulting Ltd 2015; and Appendix B.2 Springbank Off-Stream Project Hydrology Flood Frequency Analysis, March 31, 2017, Section 2.1). The data Golder Engineering used in it's analysis of flood frequency was 1911-2015 for the Bow River and 1908-2015 for the Elbow River

Each of these analyses does not capture 3 other significant flood events comparable to 2013, including the largest historical observed flood in Calgary in 1879. The were three floods of similar or larger magnitude to the 2013 event: 1879, 1897, 1902, These four floods occurred over a 134 year period suggesting a recurrence interval much less than the 1:200 year Stantec assigns to the 2013 event.

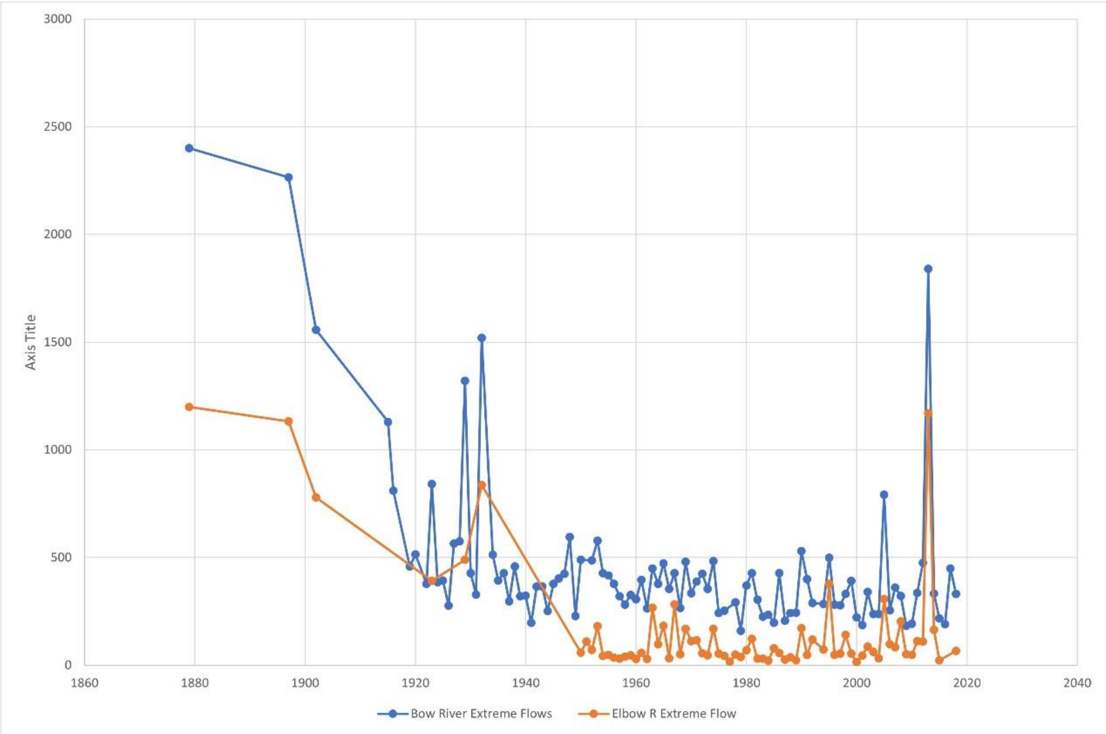
There are no measurements for the flow rate of the 1879, 1897 and 1902 events for the Elbow River. The flow estimates for 1897 and 1902 were calculated from high water marks on a CP Rail bridge over the Bow River. The 2013 flood flow destroyed gauges along the river so flow rates were calculated by high water elevation at Glenmore Reservoir and high water elevation at Bragg Creek. Wagner-Watchel calculated flows of 1096m3/s to 1215m3/s using channel surveys, highwater marks and Slope-Area method with Ven Te Chow's Iteration.

Golder Associate's December 2020 report (pp 43-44) uses a log Pearson Type III statistical calculation as described in USGS Bulletin 17C, as a method for calculating an adjustment ratio for the Elbow River relative to the Bow River. The adjustment ratio for the Elbow is to increase the flow rate calculated from the 1908-2015 series by 1.25 for a 1/100 yr flood and 1.30 for a 1/200 yr flood. Using this method within 95% certainty yields calculated flow rates for the Elbow River (below Glenmore dam) of 310-821m3/s for a 1/100 yr flood and 397-1130 for a 1/200 yr flood. The difficulty with this method is that the Bow River's flood flow upstream from Calgary became altered by dams constructed from 1910 to 1963, with the construction of the Ghost Dam in 1929 especially significant on flow rates.

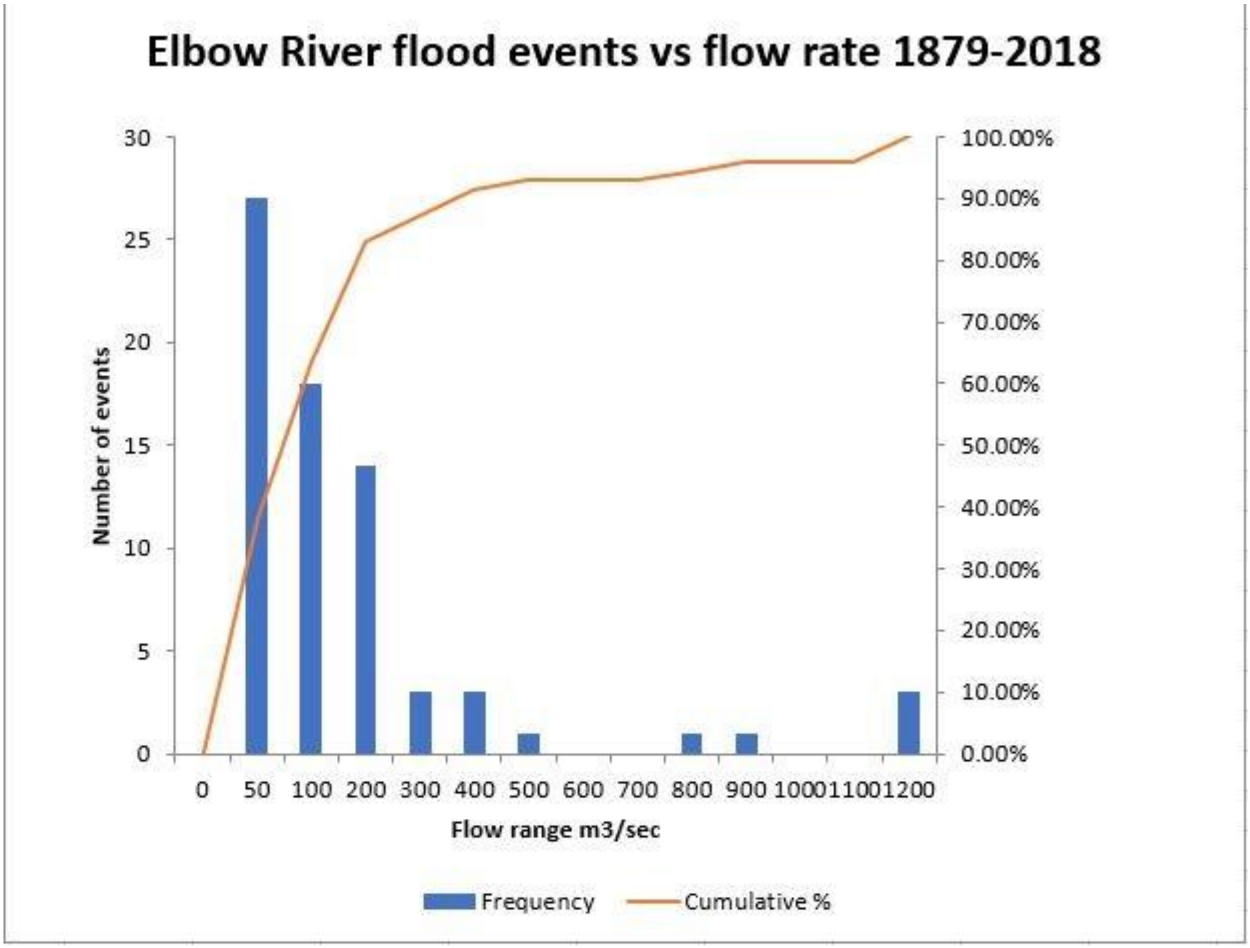
Given the range of uncertainty in quantifying flood flows for the Elbow River, I use a simple method of assigning an adjustment ratio between the Bow and Elbow river using peak flow data for flood years and calculating Elbow River flood volumes for 1879, 1897, and 1908. The following graph illustrates this ratio.



If one uses a conservative value of 0.50 for the ER/BR ratio (recognizing the controlled flow for the Bow River in this interval) and applies that value to the 1879, 1897 and 1902 floods the flow rates have the following values:

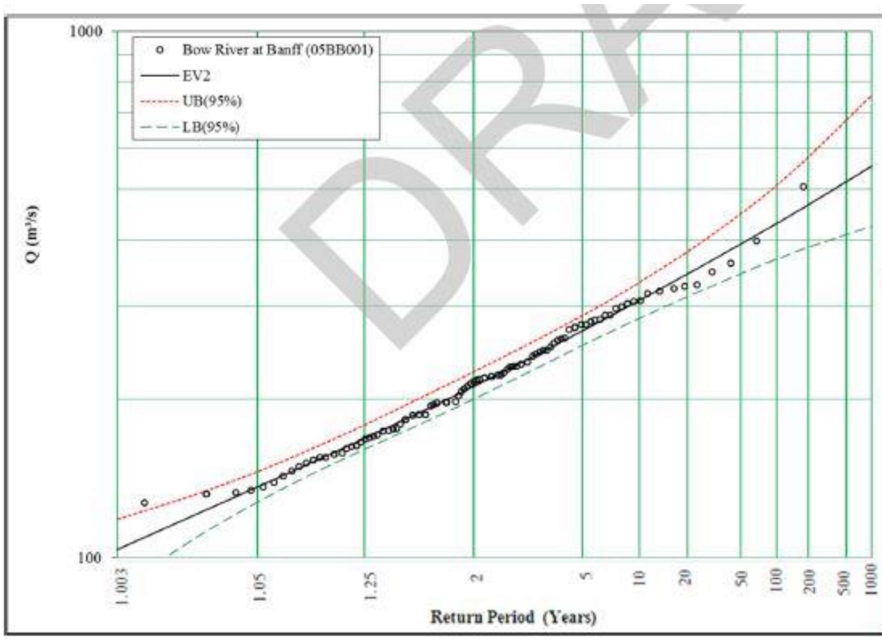


The peak flow values for the interval 1879-2015 can then be plotted on a cumulative frequency (ogive) plot.



Both graphs show the 1879 and 1897 events are in the same frequency bin (1101-1200m3/s) as the 2013 event. This indicates these 3 events, with flows at Bragg Creek larger than 1100m/s constitute 4% of the population and fall into a 1/25 category, and significantly more common than 1/200 assigned by Stantec and Golder using the 1908-2015 dataset with only 1 event was in that category.

To further illustrate the dependence of predictive analytics on data quality and sample size, I compare Golder's (2020) frequency calculation of the 2013 event for the Bow River at Banff to Pomeroy, Stewart and Whitfield's (2015) calculation. Dr John Pomeroy is a world-renowned hydrologist at the University of Saskatchewan and Director of the Global Water Futures Programme who has been working the Marmot Creek Research Station in Kananaskis for decades.



Return Period	3P(MLH)	EV2	Lp3(MLH)	Weibull
2	209	211	209	209
5	268	269	268	271
10	309	308	308	311
20	349	346	348	348
35	382	375	381	375
50	403	394	403	392
75	427	416	428	411
100	444	431	446	424
200	487	468	491	454
350	523	498	529	478
500	546	517	554	492
750	572	538	584	509
1000	591	554	605	520

Golder 2020 Log Pearson III flood frequency of the 2013 event for Bow River, Banff using the 1911-2015 dataset. Note the 2013 event lies close to 1:200 event axis.

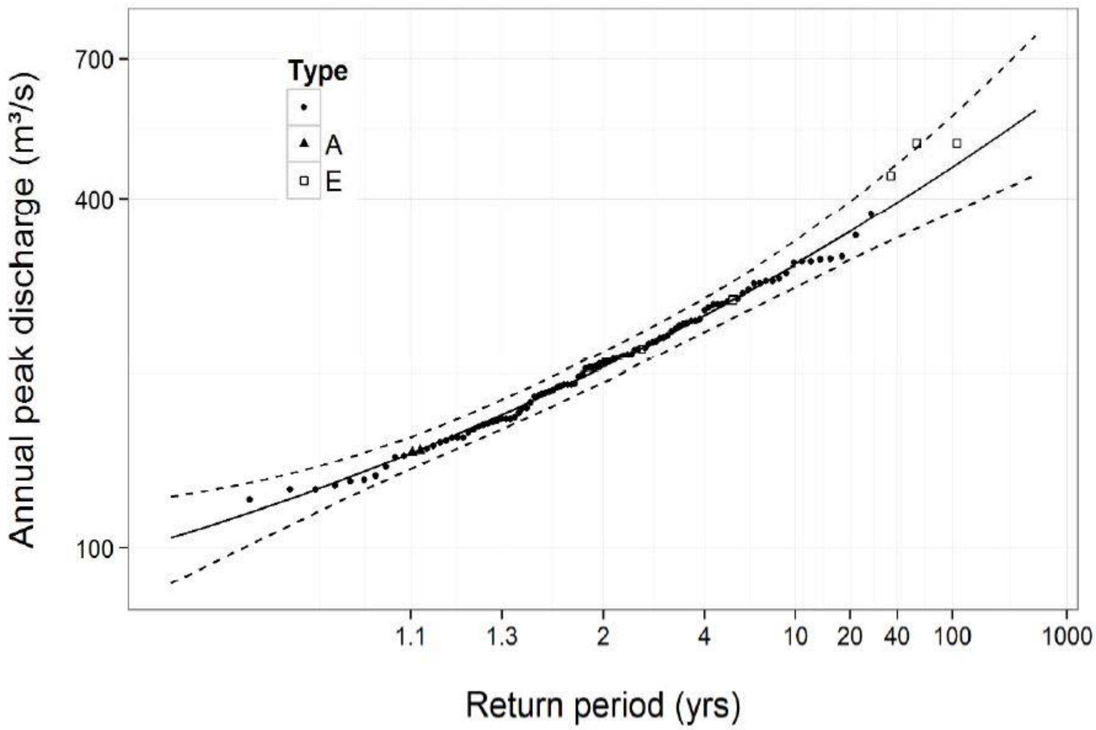


Figure 8. Estimated return periods for the Bow River at Banff from 1884 to 2013 by rank and fitted using the log Pearson type III distribution (solid line) with 95% confidence intervals plotted as dashed lines. Circle is measured peak flow, triangle (A) is annual maximum of a partial year, hollow square (E) is estimated as noted by the Water Survey of Canada. The 2013 event is third from the right (439 m^3/s).

Pomeroy, Stewart and Whitfield Log Pearson III plot of the 2013 event for the Bow River at Banff using an 1884-2013 dataset. Note the 2013 event is a 1:40 event with this expanded dataset verses a 1:200 event in the limited Golder 2020 dataset.

The discrepancy in the calculated return period of the 2013 event between the Golder 2020 analysis and the Pomeroy, Stewart and Whitfield 2015 analysis is the larger sample size of the later dataset which includes the 1897 and 1902 events. A larger sample size allows a more accurate analysis.

The importance of including these historic data is to ensure a sample range long enough to capture climatic wet years in determining return periods. The figure below is from Razavi et al. 2016 and shows modelled changes in river flows from regional climatic variations determined from tree-ring reconstructions. Note the wet period evident in the late 1800's and early 1900's. This period corresponds to the historic flood events of 1879, 1897 and 1902. Neglecting to account for these climate-induced flood events likely leads to significant operational risk for the Springbank Off Stream Reservoir Project and residents in the Elbow River flood plain.

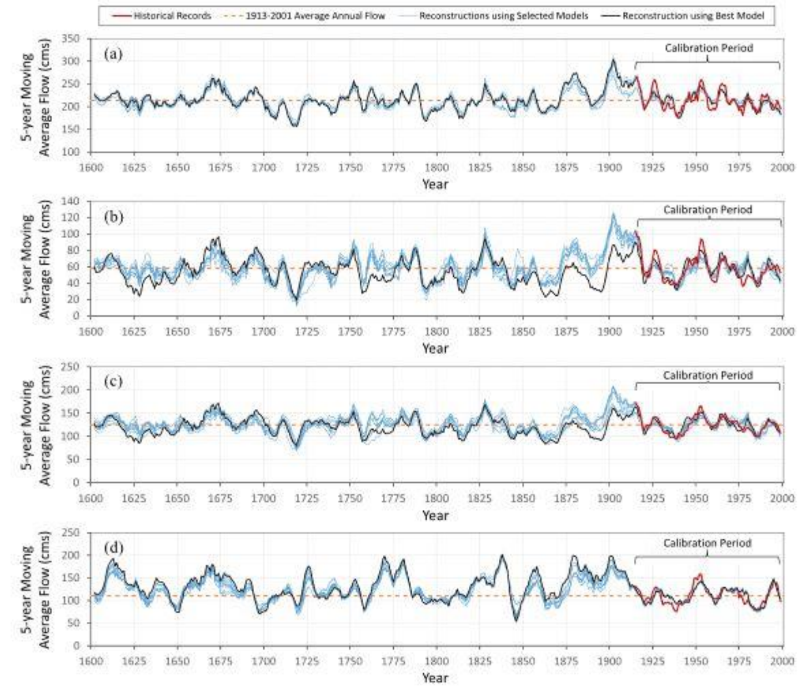


Figure 8. Time series of reconstructed 5-year moving average flows in (a) North Saskatchewan, (b) Red Deer, (c) Bow, and (d) Oldman Rivers. The best model is the model with minimum Akaike information criterion. The shown reconstructed flows for the calibration period are the results of cross-validation

Conclusions:

Stantec and Golder Associates analyses of the flood frequency (return periods) of 2013-like events in the Elbow River watershed are flawed because their input data did not adequately include historic large floods of 1879, 1897, and 1902. Flood events comparable to 2013 are more likely at 1:30-1:50 recurrence intervals as indicated by calculations with appropriate assumptions that include these historic events. There is a significant risk the Springbank Off Stream Reservoir is under-designed for the large flood events in the future. The Changing Cold Regions Network and Global Water Futures predict precipitation and drought extremes will increase in magnitude with our warming climate, generating large floods with more frequent intervals, as well as years of intense drought. The Springbank Off Stream Reservoir project should be abandoned and taxpayer monies reallocated for a project mediating both flood and drought events in the future.

Bow, Elbow, Highwood, and Sheep River Hydrology Assessment, Golder Associates submitted to Alberta and Environment and Parks, September 2020, 318p

Springbank Off-Stream Storage Project Preliminary Design Report, Appendix B.4-1 PMF (Probable Maximum Flood) Analysis Report. Stantec Consulting March 31, 2017,

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