Strategic planning of meteorological and snow monitoring stations – Case of the Mayo watershed

Technical Note
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Problem statement

State-of-the-art stream flow and inflow forecasting systems rely on strategically located networks of meteorological stations continuously monitoring total precipitation, temperature and a few snowpack characteristics such as snow height and, with advanced technological developments, snow water equivalent (SWE). At this point in time, the development of the Yukon Energy Corporation (YEC) forecasting system for the Mayo watershed is solely based on one operational meteorological station owned and operated by Environment and Climate Change Canada. The station is located at the Mayo Airport and deemed representative of the meteorological conditions of the southern portion of the watershed. However, transferring and applying these conditions to the entire watershed becomes a hazardous exercise. Moreover, should this station, which is operated by a third party needless to say, fail to record data for a few days, the forecasting system would then rely on either interpolated or synthetic data, which increases uncertainties. Considering this situation, this technical note recommends the addition of two (2) meteorological stations located within the watershed limits.

Potential locations and instruments

Potential locations (*i.e.*, sites) to be considered include: (i) the outlet of Mayo Lake where YEC already takes measurements and (ii) the headwater portion of the watershed. Of course both sites need to be easily accessible for basic maintenance or repair and, if located on First Nations territory, agreed upon with local authorities. Based on our experience of conducting research in the James Bay Region of Quebec and after consulting with colleagues conducting research in Nunavik, we recommend the use of Campbell Scientific instruments. Indeed, their meteorological instruments and data transmission capabilities have proven through the years they are robust under the harsh climate conditions of the North. Therefore, a detailed quote for standard measurements of meteorological variables can be found at the end of this technical note. The meteorological variables include: temperature, precipitation, snow height and net radiation. Net radiation should be monitored if budget permits as this would allow the use of a physically-based evapotranspiration equation and provide opportunities to improve modelling of snowpack dynamics. Campbell Scientific also proposes diverse options for data transmission and radiation measurements.

It is important to further underline that access to measured data is crucial for the basic operation of any forecasting system. Thus, each recommended station (see Table 1 below) needs an automatic data transmission system whereby all monitored data are transferred daily to an accessible server; crippling otherwise the forecasting system. That is why it is imperative to invest in a data transmission plan. Should the two-way communication option not be chosen (*i.e.*, alternative satellite communication), it would require at least monthly fees (standard satellite communication with various SBD Data Plan options). Quotation details can be found in the attached Excel file. Above all, the addition of one or two meteorological stations to support the forecasting system would provide robustness, since it would not rely solely on one station, which is operated by a third party who does not have a vested interest in hydroelectricity production.

It was recently decided to relocate a meteorological station previously located in the lower part of the Fantail Glacier of the Yukon River watershed. Potential sites for the relocated meteorological and future meteorological stations were discussed with the Nacho Nyak Dun First Nation by Brian Horton of Yukon College. Table 1 and Figure 1 present a few options for potential locations of the stations.

Table 1
Supplemental information regarding potential locations for the relocated (**ST#1**) and future meteorological stations (**ST#2**) within the Mayo watershed

X	Y	Name	Comment	Option
481194.0	7072185.3	**ST#1 OPT#1**	Station #1 To be installed before November 2017.	Option #1 Preferred location for the station going in this fall (2017).
480020.3	7066378.9	**ST#1 OPT#2**	Station #1 To be installed before November 2017.	Option #2 A second option for this Fall (2017). Technically downstream of the dam.
514051.2	7075146.5	**ST#2 OPT#1**	Station #2 Possibility to install in 2018.	Option #1 Preferred location for second site; access difficult, but culturally significant area.
494168.9	7069368.6	**ST#2 OPT#2**	Station #2 Possibility to install in 2018.	Option #2 Another possibility for second site; probably too similar to ST#1.
488978.8	7080143.6	**ST#2 OPT#3**	Station #2 Possibility to install in 2018.	Option #3 A higher elevation option; flows into Wareham Lake.

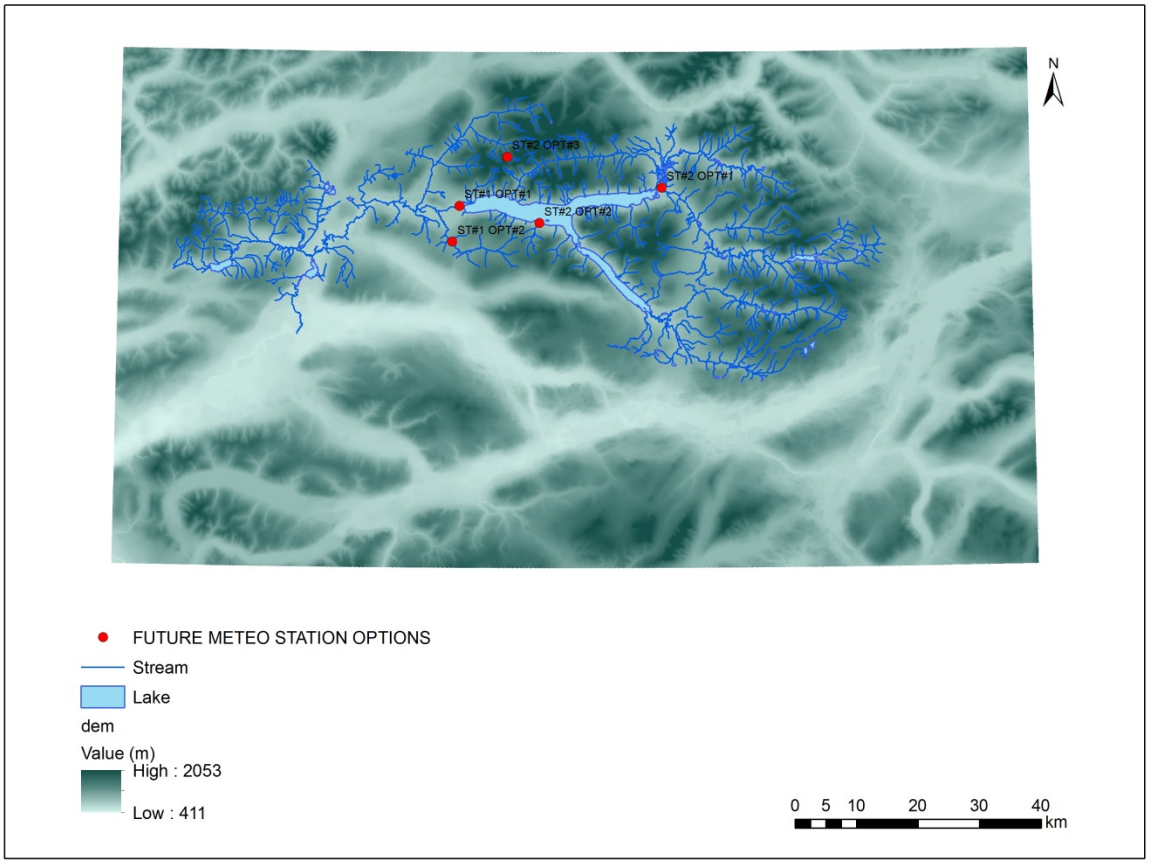

Figure 1. Potential locations (i.e., options) for the relocated (ST#1) and future meteorological station (ST#2) within the Mayo watershed

Investment costs

In term of investment (see also the attached Excel file for more details), a basic meteorological station (Option 1 - temperature, total precipitation) would cost around 20 k$ (+taxes, shipping and monthly data transfer fees). It is noteworthy that for this basic configuration, it would not be possible to communicate with the station. To avoid the monthly data transfer fees, it is possible to have a two-way communication component including a remote modem station and a local modem station (an additional 7 793.28$) for a total of 27 094.33$ (Option 2). A complete station (Option 1 – plus, snow height, net radiation, two way communication) would cost over 34 k$ (+taxes, shipping). Table 2 provides a summary of the content of each option.

Table 2

Individual pricing and total cost for meteorological stations – options 1 and 3

Component	Price	Option 1	Option 3
Datalogger	970.00$	x	x
Battery	670.11$	x	x
Battery Enclosure	440.00$	x	x
Solar Panel	925.00$	x	x
Datalogger Enclosure	600.00$	x	x
Enclosure Mounting Kit	130.00$	x	x
Satellite communication modem	1 642.00$	x	
Setup Fee	240.00$	x	
Temperature Probe	105.00$	x	x
Temperature Probe Radiation Shield	175.00$	x	x
Sonic Ranger Snow Depth	830.00$		x
Sonic Ranger Cable	185.50$		x
Sonic Ranger Tripod Mount	220.00$		x
Geonor Precipitation Gauge	10 598.14$	x	x
Tripod Stainless Steel & Grounding Kit	1 460.00$	x	x
Tripod Guy Kit for Stainless Steel	605.00$	x	x
Project Support Time (3 hour)	390.00$	x	x
Net Radiatometer	5 280.00$		x
Net Radiatometer mounting bracket	230.00$		x
Mount Tripod Net Sensor Crossarm	175.00$		x
Remote Modem Station Package	4 332.84$		x
Base Modem Station Package	5 102.44$		x
Datalogger Software	590.00$	x	x
Total		**19 541.05$***	**34 014.83$****

*Total price does not include taxes, shipping and monthly fees for data transfer.

**Total price does not include taxes, shipping. Moreover, total price will be higher, since net radiometer and remote modem station package would require increasing the size of the power supply as these components have a much higher power requirement.