Geog 4400 Hydromet instrumentation lab (#1)

Students will learn & report on the basics of how to design, budget and plan the installation of a hydrometric network in a watershed as well as program Campbell Scientific data loggers to monitor a range of hydrometerological variables. (20% - Due February 5th).

Summary:

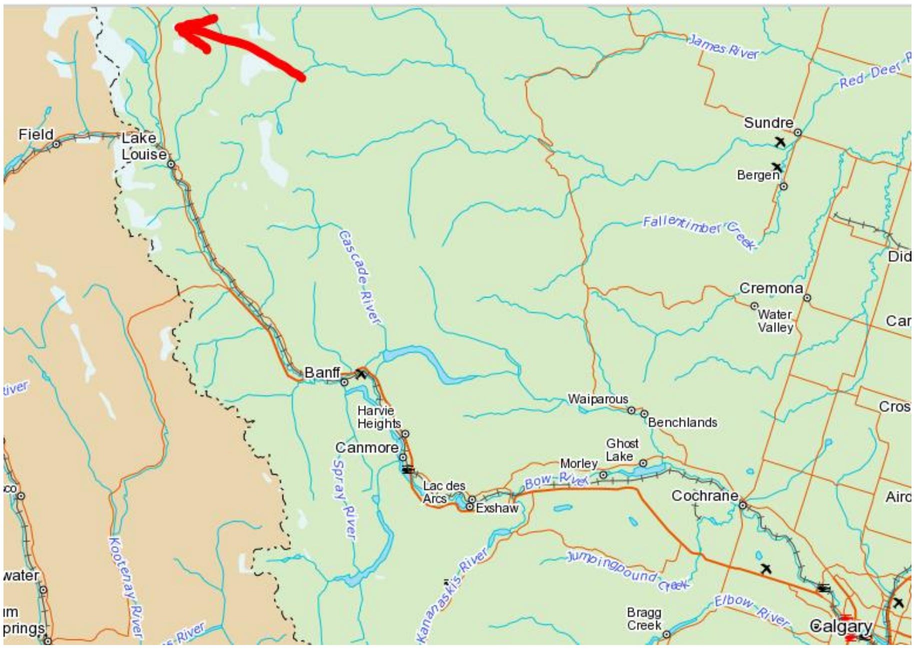
You are a new university professor and the successful recipient of an NSERC Discovery Grant to initiate a long term program to investigate hydrological processes and water yield in a mountainous watershed; Mosquito Creek north of Lake Louise, Alberta. The big picture aim of the project is to study climate and land cover change impacts on basin runoff timing and magnitude as well as to support hydrological model set up. Your first task is to define two specific research questions for your grad students related to the above theme and that require the setup of stream gauge and meteorological installations. In this exercise, you must design the hydrometric data collection and monitoring system needed for the study and provide a logistical plan for the installation, calibration and download of the sensors. NSERC has awarded you a finite budget of $90,000 which must cover installation and maintenance for the first year of this long term project [Note: GST is not considered in this budget.] At the end of year one, the installations will not be removed. You will provide a written report with diagrams, maps and supporting material that describe the monitoring installations, their approximate locations, your plans for installation, calibration and downloads, a budget and the data logger programs used at each site. All choices and decisions made must be justified either with a logical scientific argument or with appropriate supporting evidence. [Note: Though this lab has a spatial element to it and GIS analyses would be helpful, you do not need to do GIS analyses to complete the assignment. Lab #2 will involve GIS-based terrain and landcover characterisation.]

Budgetary assumptions:

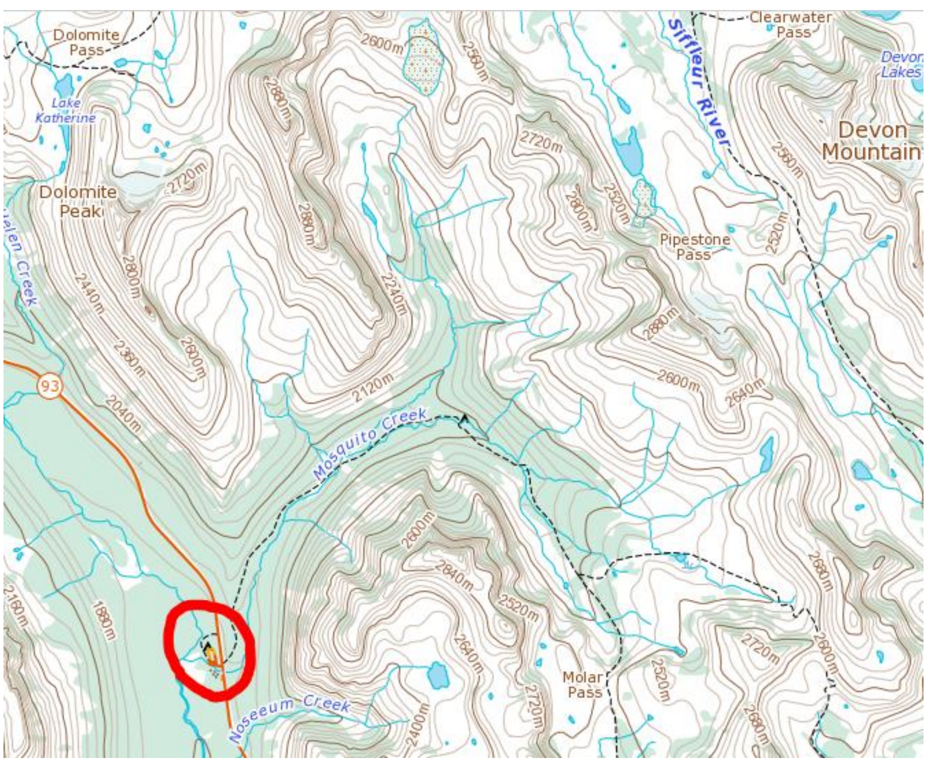
You need to purchase all required data loggers, meteorological sensors, water level recorders and associated enclosures and towers from your budget. Field equipment to support safe travel, installations and any calibration work is already in your possession and does not need to be purchased. You do need to account for the costs to travel to the installation sites and stay in the field using the most appropriate form of transportation and travel; i.e. per diems, overnight accommodations, vehicle rental. A hypothetical price list of some typical items is provided in Appendix 1. Any project expenses that are not listed need to be supported with either a reasonable estimate or with a price quote (e.g. rentals, fuel, accommodation, or instruments).

The watershed environment:

Mosquito Creek is a wilderness area within Banff National Park, ranges in elevation between approximately 1900 and 3000 masl and has a small number of high elevation hanging glaciers on northeast facing slopes. In total, this coverage is 1 - 2% of the 35 km^2 basin area and ice only becomes exposed in late summer during warm dry years. In this respect it is typical of eastern and southern basins within the Bow Valley upstream of Banff. The forested lower elevations of the basin have a thin veneer of organic soils (≤ 0.25 m) with total forest coverage around 25%. The upper eastern slopes of Mosquito Creek are largely bare rock exposures of the Cathedral dolostone formation with some areas of alpine meadow. The watershed accumulates deep snowpack in winter, and stream discharge during this time is restricted to low ground water fed flows within a channel that freezes to the bed. The dominant annual runoff event is spring snowmelt but summertime rains produce a flashy response due to bedrock and shallow soils.



Location of Mosquito Creek, 28 km north of Lake Louise, Alberta



Map of Mosquito Creek Watershed taken from Atlas of Canada

Photo looking into the watershed (facing NE direction downstream of major confluence)

For the purposes of this study, the watershed outlet is conveniently located immediately upstream of the highway 93 bridge over the creek at 52.6299881^{o}, -116.3289904^{o}. There are two major tributaries, one on the north side and the other on the south. You are required to install one stream gauge at the outlet but have total flexibility over the rest of the installations.

Constraints and practical assumptions:

Aside from the budgetary limitations, there are further limitations that must be considered. You are based out of Lethbridge and your site is a 4.5 hr drive one way. Your personnel support is limited to yourself and two grad students. Timing for field trips is limited to university holiday periods or weekends. You are free, however, to use whatever transportation and accommodation methods make sense within the budget available. For this study, you can assume all personnel are experts in summer and winter mountain safety and travel, and university health and safety regulations will not place limits on your activities. Nonetheless, none of you are super human, so to manoeuvre equipment to any location other than the watershed outlet will require either helicopter support or several hiking trips in and out carrying heavy equipment. If traveling to the confluence of two tributaries, it would be possible to easily make two return hiking trips in a day. If traveling by foot to any point in the alpine zone of the watershed you can assume you could only make a single return trip. You can assume that the actual installation of any gauge or meteorological tower will take a full day for one person, half a day if you have two people but having three people will probably not allow you to perform three installations in a day due to time taken traveling between sites. [Note: more people increases safety and will allow you to carry more but it does not always allow you to get more done when you get to the job site.]

The quickest way to carry lots of equipment to remote parts of the watershed is by helicopter. For the purpose of this lab, you can assume there is no constraint on helicopter loading weight and that up to three passengers can be carried in a single trip. [In reality, weight is a constraint and source of expenditure but we'll overlook that here for simplicity]. If traveling by helicopter, you can assume that for each passenger, you can perform one site installation per day; thus three passengers in this case does mean you could install three meteorological or gauging stations. BUT helicopters are expensive and you are on a budget. If using helicopter support, you can assume you'll drive to the watershed outlet and meet it there for pick up. It will have already travelled approximately one hour either from Golden, BC or Canmore, AB, which equals a two hour round trip that you must pay for before you've started doing work in the watershed. For the purpose of this study, assume the helicopter can remain with the crew for a full day of moving around the watershed but over-nighting with the helicopter is not permitted; it must return to base at end of day. Assume each station transport & installation requires a half hour total (including in and out), which means one station will add half an hour to your two hour ferry from base, & four stations will add two hours. Helicopter timing and costs will be the same whether you are doing installs, calibrations or downloads as you only pay for the flying time, not the weight or the waiting time. There will be no flying within 30 mins of sun rise or set.

All sites will need to be downloaded at least two times during the year. Any stream gauges will require at least three full day visits at different times in the year to develop rating curves. Meteorological stations will not require calibrations, as we can assume any necessary calibrations were performed prior to field deployment. One way to save time and/or money on field visits for downloads is to install satellite, cell or radio telemetry systems. Each has particular uses, limitations and costs, so care must be exercised if and how these are used in a hydromet network.

Project report deliverables:

1) An introduction that includes a description of your two specific research questions related to the hydrometeorology of an alpine and montane watershed in the Canadian Rockies. The questions must be realistic in that they represent a problem for which the answer is not obvious. You are free to define the form of the questions yourself; i.e. it could be to understand the importance or relative dominance of various processes within this environment or how they vary through space and time; or it could be a hypothesis requiring a straight forwards test; or it could be to characterise certain hydrological model parameters for which there are no obvious or easily determined values.
2) Details of your chosen network design, including where, how and why it is set up in the way you have designed it. This includes the approximate watershed locations, localised

site positioning considerations, number of stream gauge and meteorological installations and sensor instrumentation needs at each site. A map of your chosen network is required but cartographic and GIS skills are not being evaluated in this lab. That is not to say you can't use GIS to produce a good map but all that is required is a clear communication of the approximate locations for your installations. If necessary, a diagram of the installation illustrating any special considerations such as proximity to channel, vegetation, slopes, hazards or any other local site design considerations can be included.

3) Data logger program files and written descriptions including the rationale for the chosen recording, summary, and storage intervals.
4) Logistical plan describing the deployment of personnel, methods of travel, timing in the field and repeat visits for downloads and stream gauge rating curve activities.
5) A detailed budget describing the costs associated with equipment purchases and field logistical expenses. Salaries are not considered as you can assume you have brilliant students that both have scholarships.
6) It is worth reiterating that all decisions and choices made must be justified; i.e. all elements of design and planning must include rationales or supporting evidence.

GRADING:

This lab tests your ability to design a hypothetical watershed study to meet specific hydrological research goals while considering the logistical elements of installations, transportation, timing and costs. Consequently, it is a rather cerebral task requiring you to consider many simultaneous options and constraints. There is no single correct or ideal project solution but you will be evaluated on your ability to come up with a design and plan that is compatible with the brief provided, where all elements are congruent, is within budget, and where reasonable justifications are provided throughout.

The marking of the lab will be based on two sets of criteria. In the first, marks are accumulated, while in the second marks are lost.

1) Suitable research questions (10)
2) Appropriateness of the overall design to meet the required research needs (10)
3) Is the plan comprehensive; i.e. are all pertinent elements of the design and field plan adequately described (10)
4) Does the chosen equipment list contain all necessary components and has the pricing been correctly calculated (10)
5) Does field plan fit within the environmental (10), logistical (10) and budgetary (10) constraints?
6) Clear and well-presented report. Is the report easy to follow, well-structured and grammatically free of error? (10)
7) Appropriate use of illustrations, maps and diagrams that clearly convey the information intended (10)
8) Are data logger programs free of error and do they meet the intended purpose (10)

9) Are all decisions and choices justified? Unjustified decisions will result in lost marks. (-1 per minor occurrence up to -5 if the implication is major)
10) Are the justifications provided sound? i.e. are they logical based on reason or is supporting evidence provided? Any illogical or factually incorrect assumptions will result in lost marks. (-1 per minor occurrence up to -5 if the implication is major)
11) The report must be complete with all explanations provided but it should not be verbose. Irrelevant or unnecessary information will result in lost marks. (-1 for each unnecessary remark up to – 5 if entire sections contribute nothing of substance).

APPENDIX 1: Unit price examples

- Meteorological sensor tower: $500
- Data logger including enclosure, battery and solar charging system: $1,000
- Rain gauge: $500
- Sonic ranger (snow depth or water level): $800
- Temperature / humidity sensor: $500
- Shortwave radiometer: $1,000
- Longwave radiometer: $1,000
- Net radiometer: $3,500
- Pressure transducer (water depth): $1,000
- Stilling well / gauging installation: $2,000
- Radio telemetry antenna / controller (line of site inc. additional power): $1,000
- Satellite telemetry antenna / controller (inc. additional power): $2,000
- Cell modem (inc. additional power): $1,500
- Annual satellite account subscription: $1,000
- Monthly cell upload costs (requires available network): $50
- Meal per diems: $50 (full day increments only)
- Helicopter time: $1,500 / hr
- Car rentals: market price
- Hotel, hostel or camping accommodations: market price
- Fuel: market price

Note: the above costs are rough approximations and many item descriptions are simplifications of what are in fact more complex integrated systems. If other sensors are required to address research questions requiring more data (such as full energy balance or ground heat flux) more information can be found on the Campbell Scientific web site (www.campbellsci.com).

Hint: while this is a hypothetical scenario the lab is designed to be as real world as is reasonable within the constraints of an extended university lab exercise. That means there is no right or wrong answer and you have a lot of flexibility in how you address the problem! But there are good and not so good ways of meeting this project brief. Furthermore, there is a professor that you know that has worked in this area for many years. He is willing to provide further advice and support once you start developing your watershed research program and start coming up with your own questions. Good luck.