UNIVERSITY OF SASKATCHEWAN

MASTERS IN WATER SECURITY

Improving hydrological modelling for NWT catchments and communities: A Project Plan

Adapted from the GNWT Project Plan Developed in April/May 2019

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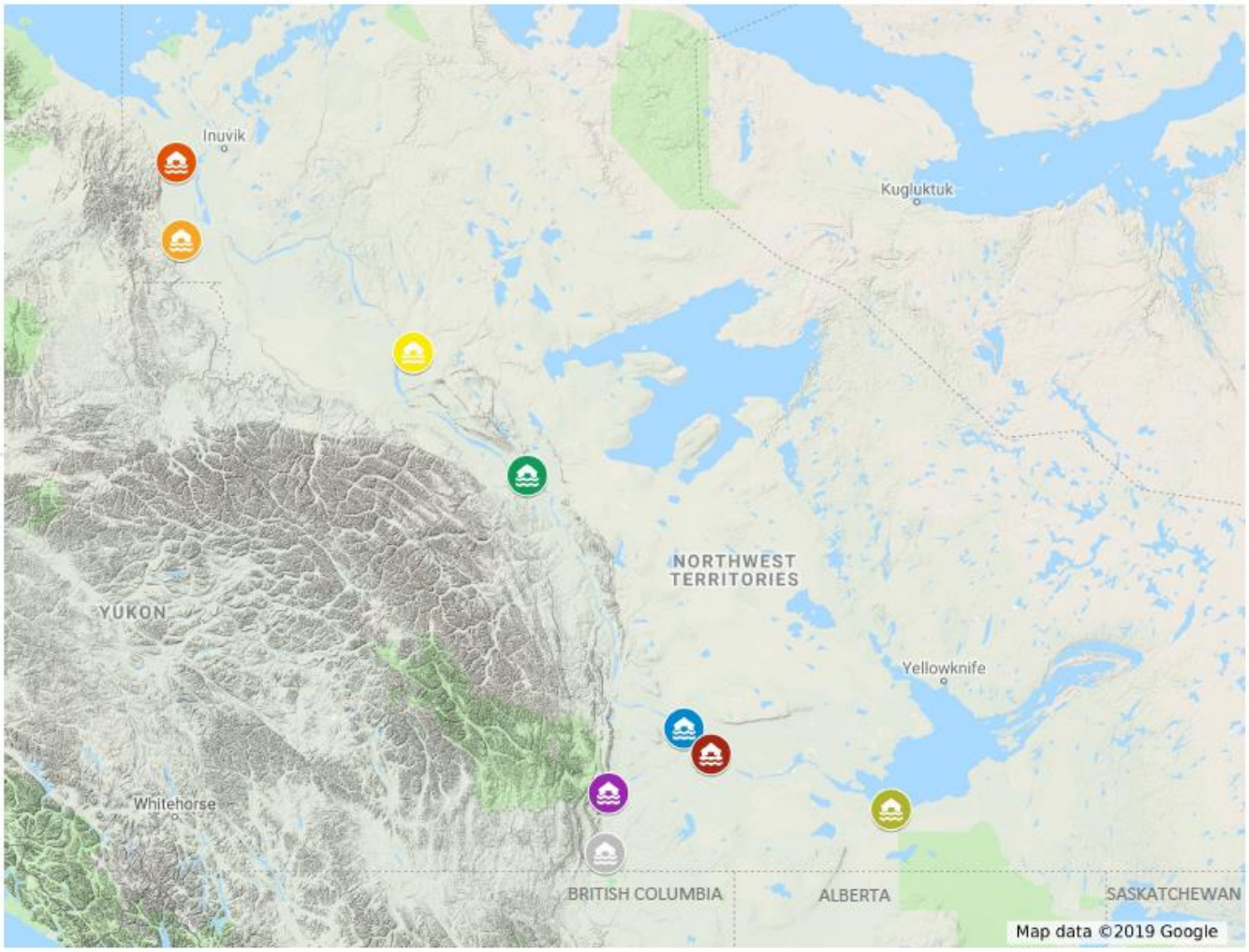
1 INTRODUCTION and SCOPE

This project was developed to assist the Government of the Northwest Territories (GNWT) in understanding the climatic and hydrological drivers of flooding within nine key communities:

- Aklavik (Mackenzie R.)
- Fort McPherson (Mackenzie R.)
- Fort Good Hope (Mackenzie R.)
- Tulita (Mackenzie R.)
- Fort Liard (Liard R.)
- Nahanni Butte (Liard R. /South Nahanni R.)
- Fort Simpson (Confluence of Mackenzie R. /Liard R.)
- Jean Marie River (Mackenzie R.)
- Hay River (Hay R.)



The communities are generally situated on the banks of the Hay, Liard, and Mackenzie Rivers, and flooding in each community is predominantly caused by ice jams. Recently, there has been increasing pressure on Environment and Natural Resources (ENR) in GNWT to develop flood forecasting tools. Lack

of capacity and expertise to understand and model the climatic drivers which result in flooding is causing concerns over municipal preparedness, public safety, and costs to infrastructure in the event of flooding.

Understanding these drivers in conjunction with ice-jam flood characteristics will help GNWT better manage water resources effectively and sustainably, ultimately improving the quality of life for residents of the Northwest Territories (NWT).

The GNWT contracted Amy Cook, a researcher from the School of Environment and Sustainability (SENS) at the University of Saskatchewan (U of S) to address the aforementioned challenges, and to develop a report that identifies appropriate modelling tools to assist in future flood forecasting, and the benefits these tools may provide northern communities.

The duration of the project is approximately 15-week: May 6, 2019 to August 16, 2019. Work will be conducted primarily at the GNWT ENR Water Resources office, located in Yellowknife, Northwest Territories. The researcher will be provided working space within the office, and access to GNWT resources to assist with project goals.

1.1 Document Purpose

The purpose of this document is to lay out the details of this project in a written format. This document will address expectations, project specifics, timelines and approximate deadlines, constraints, and performance standards.

1.2 Project Plan Maintenance

This project plan will be subject to changes as deadlines and tasks are approximate and time-dependent. Edits and updates will be made as necessary, resulting in new versions if applicable.

1.3 Open-ended List of Potential Hypotheses

Throughout the course of this project, the following list of basic hypotheses will be tested, updated, added to, or deleted as research is completed. River ice breakup and subsequent potential ice-jam flooding are complex processes involving many disciplines including river ice physics, thermodynamics, meteorology, hydrology, and hydraulics, to name a few. Therefore, developing focused hypotheses that can be tested within the scope of this four-month project may prove difficult as most will require more research than can be completed in the timespan of this project. As a result, this list may be ever-evolving. This project will be completed by means of an initial literature review and a thorough analysis of historical hydrometric and meteorological data to determine the validity and necessity of the hypotheses. In the future, site specific hypothesis should be developed to detail flood events and conditions for each community. Potential conditions that will be tested that may lead to ice-jam flooding are:

Each hypothesis – should be related to a different control on flooding:

- Delayed spring temperatures in the northern, downstream areas of NWT Rivers will result in a greater risk of ice jam flooding.

- Cool springs lead to delayed melt with prolonged snow on ice.
- Consecutive days of temperatures above freezing during the spring will cause snowmelt in the basin, thereby initiating water delivery to the stream network. This snowmelt water may add sufficient volume to the rivers to that may be retained by ice-jams and result in flooding.
- Higher water levels prior to freeze-up will result in lower probability of ice-jams.
- Rain-on-snow events will lead to rapid snowmelt and increase the risk of flooding
- Higher snow cover results in more mechanical break-up, while less snow cover allows more radiative exposure to river ice. More exposure to solar radiation (on cloudless days, for example) increases the likelihood of thermal breakup, which will result in less ice-jam induced flooding.

2 OUTLINE OF GNWT OBJECTIVES

- Improve hydrological modelling for NWT catchments and communities
    - Understanding key hydrological processes that result in ice jam flood events
    - Develop flood forecasting tools
- Better manage water resources effectively and sustainably
    - Improve quality of life for residents
    - Reduce cost of flood-induced damage to livelihoods and infrastructure
    - Increase public safety and municipal preparedness

The above objectives help address significant safety, environmental, and financial concerns related to potential flooding in the NWT.

2.1 Information provided by GNWT

The GNWT has provided the following information to assist with the project goals:

- Information on historical flood events at each of the nine key communities
- Meteorological and hydrological data
- Existing R code developed by Environment and Natural Resources (ENR)
    - R packages “tidyhydat” r climate and “weathercan” will be useful for downloading hydrometric and climate data, respectively

- Extensive background literature and products related to previous research (University of Alberta) on model development for the forecasting of ice jam floods on the Hay River
- Bibliography of papers and reports on flooding in the NWT

2.2 Success Criteria and Expectations

This project will culminate in a written report with a detailed analysis of historical flood drivers as well as implications/recommendations for future flood forecasting work. It will also produce a literature review on previous flood-related work in the NWT using a provided bibliography of papers in conjunction with additional papers the researcher will find on their own. The researcher will set aside time to learn the coding language R at a level of competency needed to use pre-existing and provided R hydrological data packages, and to develop their own code to be used to as an early warning system for high and low water levels in the NWT.

The researcher will work directly with GNWT Hydrologists Ryan Connon and Anna Coles, and will also receive oversight from faculty advisors Andrew Ireson and Karl-Erich Lindenschmidt.

Drafts of written work will be reviewed by any or all of the above as deemed necessary. Timeline for providing feedback on drafts will be discussed and worked out at that time.

2.3 Definitive Scope Statement

To understand the conditions that have led to ice-jam and rainfall flood events in nine key communities of the NWT, and how these events can inform future flood forecasting work.

3 DELIVERABLES

3.1 Written Report

A written report (to be delivered electronically to faculty advisor and project partners) will be created, including the following information:

- Meteorological and streamflow conditions (including ice formation) that led to historical floods.
- Set of early-warning sign indicators of conditions that may or may not result in imminent flooding at each community.
- Potential locations for future monitoring.
- Code, developed in R, to provide real-time early warning signs of flooding by combining real-time water level data from Water Survey of Canada with real-time climate data from Environment and Climate Change Canada.

The written report will be due no later than August 23, 2019.

3.2 Literature Review

A Literature Review (to be delivered electronically to project partner) will be completed and a subsequent document that includes the following will be created:

- Synthesis of reports and publications that address flood risk in the NWT (particularly on the Hay, Liard, and Mackenzie Rivers).
- Compilation of metadata that has been generated from these studies.
- Goal: to ensure that GNWT is aware of existing flood-related studies and to identify missing pieces, if any.

The literature review and subsequent document will be due no later than August 23, 2019.

3.3 Monthly Reports

Monthly Reports to Faculty Advisors will be created and kept up to date via Google Docs. Each report will be transferred to a Microsoft Word document and converted to a PDF for submission. Each report will be concise and include:

- Heading with the project title, report number, date, and student names.
- Work completed in the last reporting period.
- Team meetings held in the last reporting period (dates, times, attendance).
- Planned work for the next reporting period.
- Information requested from advisors or partners.
- Summary of any challenges.
- Summary of progress as defined by the project plan.

3.4 Capstone Presentation

A Capstone Presentation will be completed for delivery, in person, to all attending parties, the final week in August, 2019, to include the following:

- 10-minute presentation detailing project and project outcomes
- Presentation should be a representative summary of the report

All documents for project completion will be submitted no later than **August 23, 2019**.
Colleague

4 PROJECT APPROACH

4.1 Project Timeline

Important Dates

May 6 – Aug 16	Project timeframe (15 weeks duration).
Aug 9	Draft of final report to GNWT partners for review
Aug 19 – Aug 23	Capstone event – scheduled for one day during this week.

May is detailed out; each subsequent month lists solely monthly goals and will updated accordingly. Specific tasks do not specifically match up with general tasks.

MAY (tentative – will be updated as project progresses):

Week	Dates	General Task	Specific Tasks	Due Dates
1	**May 6-10**	Literature Review	Practice with R (download software)	competency by end of June 2019
		Project Plan (PP)	Develop hypotheses for PP	10-May-19
		R	Create Google Drive folder to share with Andrew and Karl	8-May-19
			Go through lit for (1) Aklavik, (2) Fort Good Hope	14-May-19
2	**May 13-17**	Literature Review	Learn about each community	Ongoing
		Look at flooding and ice jams	Work on synthesizing old reports (from box of historic studies)	End of June 2019
		Attend R webinar (May 15)	Practice with R	competency by end of June 2019
		PP	Finalize Project Plan	17-May-19
		Gather/organize data	Begin Literature Review for (3) Fort Liard and (4) Fort McPherson	22-May-19
		R	Download met and flow data	17-May-19
3	**May 21-24**	Literature Review	Begin Literature Review for (5) Fort Simpson and (6) Hay River	30-May-19
		Gather/organize data	Practice with R	competency by end of June 2019
		R	Synthesizing old reports	End of June 2019
4	**May 27-31**	Literature Review	Begin Literature Review for (7) Jean Marie and (8) Nahanni Butte	7-Jun-19
		R	Practice with R	competency by end of June 2019
			Synthesizing old reports	End of June 2019

JUNE, JULY, AUGUST (tentative – will be updated as project progresses):

Month	General Task	Specific Tasks	Due Dates
June	Literature Review	Finish up with (9) Tulita and any other outstanding literatures that hasn't been reviewed	15-Jun-19
	R	Practice R - Should be able to make graphs by now	competency by end of June 2019
	Ice jam flood research	Synthesize old reports	end of June 2019
		Begin data analysis	ongoing
		Site Categorization	end of July 2019
		Distinguish between thermal vs. mechanical break-up	end of July 2019
July	Data Analysis		ongoing
	R		ongoing
	Work on Report		ongoing
	Work on compiling information for Lit review		ongoing
	Develop list of potential future work	Regional comparison analysis, site categorization (geomorphological, etc)	ongoing
August	**Draft of report to AC/RC**	**Deliver draft report to Anna and Ryan for review**	**9-Aug-19**
	LITERATURE REVIEW	**Draft to Anna and Ryan for review 8/9/2019; due 8/23/19**	**23-Aug-19**
	FINAL WRITTEN REPORT	**DUE**	**23-Aug-19**

4.1.1 Constraints

Some of the constraints foreseen for this project are:

- Time to conduct research and analyses. The time allowed to complete this project is four months. The scope of this project can easily reach beyond those four months, so being able to hone in on specific tasks will be important. That being said, though several different data sets and data types may be considered for future work, only a few key data sets will be focused on for the extent of this project.

- Available data. The NWT is geographically large, and despite the size, there are limited number of hydrometric stations available. Access and presence of forecasting models in this area are also limited, as is field personnel and funding.

4.1.2 Required Data Sets (for current and future studies)

Despite basic meteorological and hydrological data, the following non-comprehensive list of data sets and types may also be considered (if time permits, for this project; if not, for future studies):

- Flow under ice

- Open water streamflow
- Ice thickness
- Backwater effect from ice jams
- Snow cover data (snow on ground)
- Solar radiation
- Radar satellite imagery
- GIS data
- Geomorphological information on each riverine system
- Rain on snow events
- Soil conditions pre- and post-freeze (little soil moisture data is currently available in the NWT)
- Climate change temperature predictions

4.1.3 Performance and Metrics

Each deliverable listed in section 4 will be evaluated by GNWT Hydrologists, and will be marked accordingly by faculty advisors.

Performance during the project will be assessed by GNWT Hydrologists and the researcher will be working directly with for the extent of the project.

4.2 Support System

This project will be supported by the Government of the Northwest Territories (GWNT) in conjunction with the University of Saskatchewan. Funding for living expenses in Yellowknife will be provided by the GNWT.