Implementing Climate Change Adaptation

in Prince George, BC

Volume 7: Precipitation and Freeze-Thaw

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Executive Summary:

Implementing Climate Change Adaptation in Prince George, BC
Volume 7: Precipitation and Freeze-Thaw

The Prince George climate change adaptation project has been ongoing for several years. With support from the federally funded Regional Adaptation Collaborative (RAC) program, researchers have been working with the City to incorporate adaptation into local process and to address local priority impacts. Most of these actions have been informed by climate information outlined in the report created in partnership with the Pacific Climate Impacts Consortium: *Climate change in Prince George: Past Trends and Future Projections.* However, as the work has progressed, the need for more detailed climate information has arisen to help the City address certain impacts. Therefore, external consultants were contracted to analyze and assess specific aspects of Prince George's climate. Two reports are in the final stages of completion and should be finalized and available on the City's website in the spring of 2012. They are:

Report 1: An analysis of recent changes in temperature, precipitation and freeze-thaw cycles in Prince George (Kerr Wood Leidal Consulting Engineers).

Report 1 looks closely at the intensity, duration and frequency (IDF) of rainfall in Prince George, using data from the airport station from 1950-2009. Precipitation information is used to create IDF curves, which are used to determine the probability of levels of precipitation over periods of time. These curves are used to calculate storm-water capacity and other infrastructure parameters. As IDF curves are created using historical data, they assume that conditions are constant and do not account for climate change. An analysis of rainfall events in the city shows that high-intensity events do not appear to have changed significantly over the last 60 years. The report also examines how freeze-thaw cycles are changing and the trends for hours-above-freezing in the winter. It was found that freeze-thaw cycles are decreasing overall but may be increasing in winter. The report does not make any definitive conclusions as it relies on the one dataset, and future projections are not examined.

Report 2: An assessment of the effects of precipitation and freeze-thaw cycle changes in Prince George (McElhanny Consulting Services Ltd.).

Report 2 uses the information from Report 1 to assess how changes in precipitation and freeze-thaw cycles may impact development, operational practices, and infrastructure. The consultants conclude that, based on the past trends data, it is not currently justifiable to make changes to the IDF curves for Prince George. Some changes related to freeze-thaw cycles and winter thaw temperatures were found, but the shortage of data (from only one climate station) limits the conclusions that can be reached. Snow clearing may get less costly for the City due to warmer winter temperatures and decreasing snowfall, and many other changes have the potential to impact costing. The report recommends that Prince George: collect more and better data to facilitate further analysis, retain the 1-in-10-year return period requirement for storm system design, and carry out a forecasting exercise to determine future projected changes and their impacts on IDF curves.

The analysis and assessment provides comprehensive information about climate variability and change in Prince George over the last 60 years and what it means for the City. The results should be communicated to local engineers and developers, and may help to improve the design and management of local infrastructure (especially storm-water). Prince George can improve its monitoring and local data collection so that more and better analysis

can be done in the future. This type of work has not been completed in many communities. Therefore, as Prince George is at the cutting edge of local adaptation, there are difficulties with performing specific analyses and assessments and no future projections were made. As this is a new field of study the information should also be reviewed by climate modellers and compared to similar studies (both completed and ongoing) to verify the methods used and the final results.

Background

Natural Resources Canada established the Regional Adaptation Collaborative (RAC) program in 2008 to assist communities and regions across the country as they adapt to climate change. Adaptation refers to actions that respond to or prepare for changes in the climate that are either expected or already occurring. Actions can be taken to become more prepared for unexpected events, to minimize the negative impacts of events already occurring or expected, or to maximize any positive benefits that may arise. Adaptation is different than climate change mitigation, which refers to actions that reduce the amount of greenhouse gases (GHGs) in the atmosphere.

Prince George has become a leader in community adaptation, and has been pursuing this topic for over five years in partnership with many organizations. The City was selected to be one of four community case studies to participate as part of the British Columbia (BC) RAC program (NRCan, 2011). The RAC funding allows for Prince George to build upon its climate change adaptation efforts to incorporate adaptation into local plans and begin implementing actions to address priorities within city administration. The City of Prince George has worked closely with the University of Northern BC (UNBC) and the Fraser Basin Council on this project, along with many other collaborators.

Although the focus of the Prince George RAC project is on adaptation, actions that address both adaptation and mitigation are encouraged whenever possible. Both adaptation and mitigation will be necessary for communities to prepare for and respond to climate change. Adaptation is needed to respond to the changes that are occurring in the climate, and mitigation is required to prevent further changes that may severely impact natural and human systems in the future.

The adaptation work conducted in Prince George under the RAC program is documented in this written case study, consisting of eight volumes. Each volume discusses an impact priority or a specific project from the many and varied community initiatives that RAC team members have contributed to in Prince George. Where applicable, the case study draws direct links to Prince George's adaptation priorities, as identified in the strategy document, *Adapting to Climate Change in Prince George: an overview of adaptation priorities* (Picketts et al., 2009a), which was received by City Council in November 2009.

The Volumes of *Implementing Climate Change Adaptation in Prince George* case study are:

Volume 1: The *myPG* Integrated Community Sustainability Plan

Volume 2: The Official Community Plan

Volume 3: Forests

Volume 4: Flooding

Volume 5: Transportation Infrastructure

Volume 6: Natural Areas and Ecosystems

Volume 7: Precipitation and Freeze-Thaw

Volume 8: Ongoing and Future Initiatives

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Introduction

Actions undertaken as part of the RAC initiative are related to either addressing a priority impact for Prince George or incorporating adaptation into a specific plan. However, Prince George has been working with many organizations to adapt to climate change for several years now. The report, *Climate Change in Prince George: Past Trends and Future Projection* (Picketts et al. 2009b), created in partnership with the Pacific Climate Impacts Consortium (PCIC), has been used extensively to inform local adaptation in Prince George prior to the RAC initiative. The PCIC report has provided technical background temperature and precipitation analysis, and has been used in multiple situations as a tool for education and capacity building, envisioning future impacts, and informing specific adaptation measures. The past trends and future projections have been used for many purposes, including creating the list of adaptation priorities in the adaptation strategy document, *Adapting to Climate Change in Prince George* (Picketts et al., 2009a), and informing the local flood risk assessment.

However, there have been occasions where stakeholders have requested or required information related to aspects of precipitation or temperature changes that are not available in the PCIC report. Therefore, some of the RAC resources have been directed toward funding more technical analysis and assessment of the significance of these changes. This work has been completed in two reports: Report 1 consists of a climate analysis used to inform the assessment in Report 2:

- **Report 1**: Analysis of recent changes in temperature, precipitation, and freeze-thaw cycles in Prince George. (Kerr Wood Leidal Consulting Engineers, in progress)
- **Report 2**: Assessment of the effects of climate change on precipitation and freeze-thaw cycles in Prince George, and the implications of these changes (McElhanney Consulting Services Ltd, in progress)

These reports do not simply provide more detailed climate information for the City; they are designed to provide further analysis of specific types of changes in Prince George and to assess how these changes may affect infrastructure and operations. The assessments are designed to inform adaptation actions that address the local priorities outlined in the adaptation strategy, and the results have many applications. Having a better understanding of precipitation events—particularly intense events—relates closely to the proper management of storm-water in the City. Having a better understanding of precipitation events can also help the City better manage flooding, emergency response, and design infrastructure. Understanding freeze-thaw cycles relates directly to the design and maintenance of transportation infrastructure. Furthermore, improving our knowledge of seasonal trends, climate variability, and climate change will also improve local building and utility infrastructure and can lead to more efficient service and maintenance programs.

Both of these reports are currently in the final review stage, and the final drafts should be completed in the spring of 2012. Once the reports are completed they will be publicly available on the climate change adaptation section of the City's website.[1] Please refer to the final reports themselves for detailed information and analysis. This volume consists of an explanation of key terms, a brief summary of each report, the implications of the results for adaptation in Prince George, and recommendations for continued study and application locally.

Intensity Duration Frequency curves and climate change

Intensity duration frequency (IDF) curves are a common tool that uses rainfall data to model the probability of certain rainfall intensities occurring. An IDF curve is created by taking historical data and performing a probability distribution analysis, used to predict the level of precipitation that will occur for a certain frequency of time. Therefore, an IDF curve can tell engineers information such as the maximum amount of precipitation can be expected locally in a 1-in-5-year event or a 1-in-100-year event. This information is crucial for a city or town as it is used to calculate the required sizes of storm-water drains, on-site storm-water capacities, curb sizes, gutter requirements, and other infrastructure. The information can also be used to help plan for flooding and emergency response.

IDF curves are created from historical data and assume that the climate is stationary. Because climate change is expected to result in an intensification of the hydrological cycle (IPCC 2007), it is important to consider how precipitation events are changing in magnitude and frequency, and how they may change in the future. Communities need to consider if IDF curves need to be adjusted to take climate change into account (Prodanovic and Simonivic, 2007). This is a very new field of research, and there are few studies available that have begun to address this challenge.

Freeze-thaw events and climate change

Freeze-thaw events or cycles refer to times when air temperatures range sufficiently above and below freezing in a short period of time so that water in the ground changes state between water and ice. These types of events can have big impacts on infrastructure, especially roads. With climate change, warmer winter temperatures (particularly minimum temperatures) are expected to cause an increase in winter freeze-thaw cycles in Prince George. These cycles stress pavement and other materials as the subsurface water expands and contracts, which makes the materials rise and fall. Freeze-thaw cycles are particularly damaging when there are surface cracks that allow water into a substructure as these small surface cracks can quickly develop into large potholes (Mills et al., 2007). It is important to examine if

[1] See: http://www.princegeorge.ca/environment/climatechange/adaptation/pages/default.aspx

and how freeze-thaw events are changing in Prince George and the effects of climate change on these cycles. This is especially important in Prince George due to the poor condition and short lifespan of local roads. Refer to Volume 5: Transportation Infrastructure for a more detailed overview of the effects of freeze-thaw cycles on roads.

Report 1: Seasonal trends in temperature, precipitation, and freeze-thaw cycles

McElhanney Consulting Services subcontracted Kerr Wood Leidal Consulting Engineers to create an overview of recent changes in the climate in Prince George. The purpose of this analysis was to provide more specific information (than was available in the aforementioned PCIC report) related to past seasonal precipitation trends, precipitation types, and freeze-thaw cycles. Data for the analysis was from the Prince George airport climate station from the time period 1950–2009. This is the longest time span that overlapping hourly data was available.

The report contains an overview of the following information:

- Regional information about Prince George and a summary of previous reports and available information
- A summary of historical average, minimum, and maximum temperature trends in Prince George, including an overview of the effects of cycles of climate variability in the region, such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO).
- A detailed overview of historical rainfall, snowfall, and precipitation trends for Prince George
- An analysis of freeze-thaw days in Prince George (i.e. days where the temperatures goes both above 2°C so that soil thaws and below -5°C so that soil freezes) and average number of hours above freezing per day
- Maximum rainfall intensity trends for 1-hour, 2-hour, 6-hour, 12-hour, and 24-hour durations
- An overview and analysis of the trends for intense rainfall events in Prince George

Report 1 finds many of the same past climate trends as the PCIC report. It does not make strong conclusions about the nature or significance of these changes, largely because of the relatively short period of time examined (60 years). Higher intensity rainfall events do not appear to have changed significantly, and freeze-thaw cycles are increasing in the winter but decreasing in the spring and fall. The report does not present or examine future projections.

Report 2: Precipitation intensity, duration and frequency (IDF), and freeze-thaw

The purpose of this report by McElhanny Consulting Services is to assess the effects of climate change in Prince George related to rainfall and freeze-thaw cycles and to discuss how these changes may impact development, operational practices, and infrastructure. In addition to climate change, the added effects of climate variability and urban growth are also discussed.

The primary focus is on short-term duration and extreme precipitation events, using the information provided in Report 1 to inform the assessment. As discussed above, rainfall events are commonly categorized using an IDF curve. The authors concluded that it is currently not justifiable to make changes to the IDF curves to account for climate change based on the past trend information for 1950–2009. The authors recommend that the City continue to take a conservative approach to storm-water management, reassess the data when more is available, and consider looking at projected future change.

The freeze-thaw analysis from Report 1 shows that more hours above freezing are occurring in winter months, and that winter freeze-thaw trends are increasing. The authors do not recognize major impacts to infrastructure occurring from recent changes to freeze-thaw cycles, but are hesitant to make conclusions based on the single data set since microclimates exist within the city. There is the potential for snow clearing and snow removal operations to become less costly due to warmer winter temperatures and decreasing snowfall.

The report acknowledges many shortcomings in the analysis completed, and does not give many concrete recommendations as a result. All data was gathered from one station (the Prince George airport) and therefore is not necessarily representative of the conditions in all areas in the city. This type of analysis is also quite new, so there are no well-established methodologies or examples to follow. Furthermore, there were no future projections used in the analysis, so it does not consider changes expected in the future. The report recommends periodic reviews of data and the establishment of more monitoring stations so that a more comprehensive analysis can occur in the future. The report acknowledges that the changes noted have direct financial implications for the City of Prince George and local developers. No cost estimates are provided, but many factors are listed that can potentially impact costing.

In conclusion, there were no significant current impacts found on City procedures and processes as a result of climate change. There are four final recommendations proposed in the report:

1. Prince George should review the rainfall data collected locally and make improvements to facilitate future analysis.

2. The City should retain the 1-in-10-year return period requirement for the design of minor storm systems.

3. A trial forecast projection should be carried out for Prince George, developing new IDF curves that take future climate change into account. This may be similar to the forecast completed for London, Ontario (Prodanovic and Simonivic, 2007).

4. The City should continue to collect precipitation and runoff data to develop a longer record. This may be used in the future to adjust design parameters based on climate change.

Recommendations

The analysis completed provides a comprehensive overview of climate variability and change over the previous 60 years. Recent climate changes do not appear to be having a large impact on city infrastructure. The two reports prepared do not examine future climate change and the potential for future impacts on infrastructure, and cannot make strong recommendations based on the information gathered for the past 60 years. It is clear that this type of analysis is still very new and Prince George is at the leading edge of climate change assessments.

There are many potential applications for this information and it is a strong base for ongoing research. The City of Prince George should use the information from these reports to help inform future adaptation and management actions, and obtain more information when there is better data and when there is a more solid understanding of how to assess and predict the effects of climate change on infrastructure. The following actions are recommended:

- Communicate the results of the report to the appropriate City staff responsible for infrastructure upkeep and maintenance

- Share the results of the reports (when they are finalized) with groups such as PCIC to verify and critique the methods used and the conclusions drawn

- Share the results of the reports with infrastructure experts to investigate the impacts of these changes in more detail

- Strive to improve data collection, organization, and communication in Prince George so that more detailed information is available in the future for updates and new studies

- Investigate studies on climate change and infrastructure management such as the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol for assessing the impact of climate change on infrastructure

- Create and analyze future projections for freeze-thaw cycles and changes in precipitation in Prince George

- When sufficient information or better methods are available, reconsider updating the IDF curves for Prince George
- Gather more comprehensive information about the costs of climate change on infrastructure design and maintenance, and how this might impact City budgets

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