GHD

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SERVICES AND SOLUTIONS FOR A LIVABLE REGION

Study of the

Impacts of Climate Change on Precipitation and Stormwater Management

Background

Climate change adaptation is one of the most important issues facing local governments today. Increasing frequency and intensity of extreme rainfall events will have a significant impact on existing sewerage and stormwater collection infrastructure. Municipalities must adapt to changing rainfall regimes to ensure that adequate levels of service for infrastructure are maintained in the future.

Engineers, planners, and policy makers use Intensity-Duration-Frequency (IDF) curves in municipal planning and infrastructure design. IDF curves characterize the relationship between the intensity of rainfall occurring over a specified period and its frequency of occurrence. They are based on historical observations of rainfall. Developing future climate IDF curves is essential for planning for climate change.

Currently, there is no standard or accepted methodology to derive IDF curves for future climate conditions. The Greater Vancouver Sewerage and Drainage District (GVS&DD) initiated this project to advance the knowledge and capabilities of GVS&DD and its member municipalities to adapt to the effects of climate change within the region's sewerage and drainage infrastructure.

This project adressed the following objectives:

- ☑ Update the existing IDF curves to present day
- ☑ Quantify uncertainty of climate change impacts on rainfall and develop future climate IDF curves
- ☑ Determine the potential effects of climate change on sewerage and stormwater infrastructure
- ☑ Develop good practice recommendations for incorporating climate change in infrastructure planning and design

Summary

1. Existing Climate IDF Curves

The existing IDF curves for the Metro Vancouver region were updated. Rainfall data from 74 stations across the region were used to perform a regional rainfall frequency analysis (RRFA).

IDF curves were developed for six homogeneous rainfall zones as shown in **FIGURE 1.** A sample updated IDF curve is depicted in **FIGURE 2**.

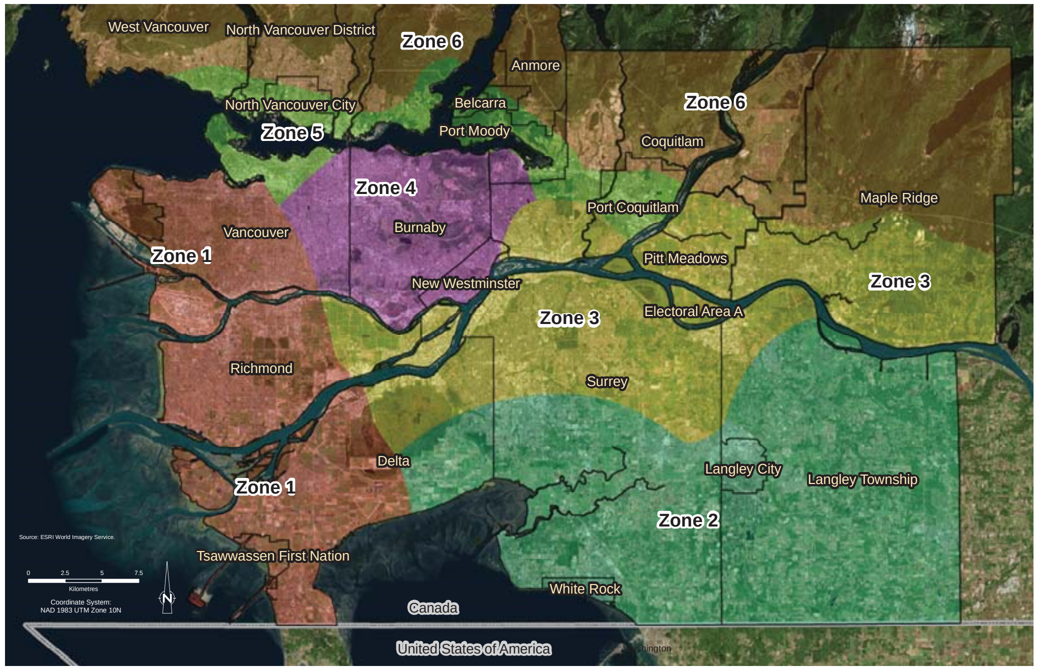

FIGURE 1 – Rainfall Zones

2. Future Climate IDF Curves

Future climate IDF curves were developed from an ensemble of 12 Global Circulation Models (GCM). A new methodology was developed to address challenges in developing future climate rainfall events from GCM data. Projections of future precipitation are subject to many uncertainties in climate modelling, prediction of the future economy, population and technology, and other factors. A sensitivity analysis compared the relative importance of various sources of uncertainty by evaluating over 108,000 combinations of factors and their effects on IDF curves.

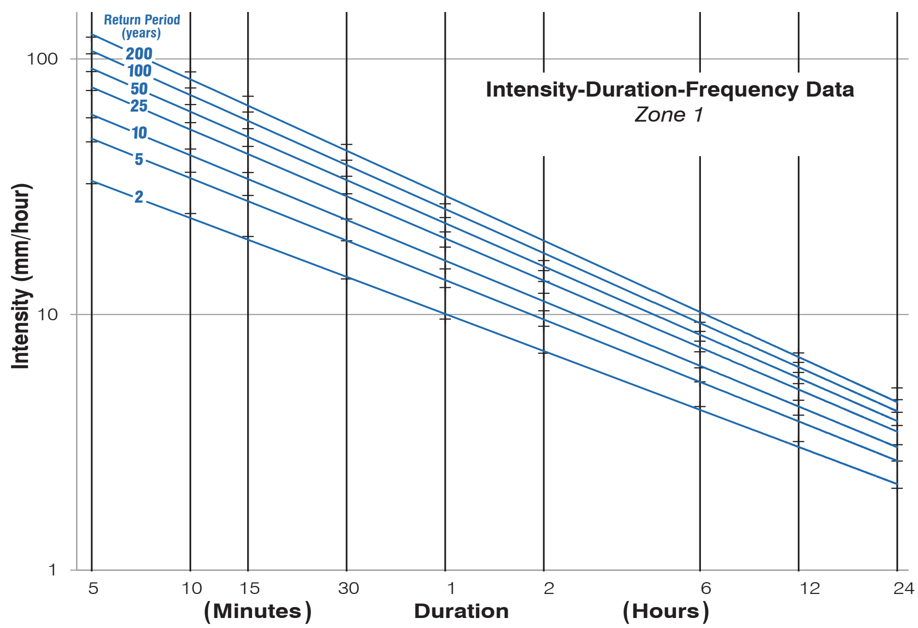

FIGURE 2 – Sample IDF Curve

The results of the sensitivity analysis were used to define IDF curves for a moderate and a high climate change scenario. Both scenarios were based on the Representative Concentration Pathway (RCP) 8.5 "business-as-usual" greenhouse gas (GHG) emissions. The moderate change IDF curve represents the median or likely increase in rainfall. The high change IDF represents an extreme or worst-case increase. Moderate and high change future IDF curves were developed for two time horizons, 2050 and 2100, as shown in **FIGURE 3.**

FIGURE 3 – Future Climate IDF Curves

All of the future IDF curves predict substantial increases in rainfall. The average increase for each future climate IDF curve is shown in **FIGURE 4.** The increase for the high climate change scenario for 2050 is similar to the increase for the moderate climate change scenario for 2100. This indicates that a certain level of increase is expected to occur, but it is not certain when the increase will occur (i.e. it may occur by 2050 in the worst-case scenario, or it may be delayed to 2100 in the moderate scenario).

3. Potential Impacts on Infrastructure

The potential impacts of climate change on infrastructure were analyzed. Three case studies were examined: stormwater drainage networks, sewage collection systems, and combined sewer systems. Significant impacts were identified, and applying adaptation measures will require significant expense.

Increases in future rainfall due to climate change in combination with sea level rise could cause flooding in stormwater drainage networks. Adaptation measures are key to ensuring the levels of service of stormwater drainage infrastructure are maintained.

Stormwater Adaptation Measures

- Best management practices
- Green Infrastructure/Low Impact Development
- Peak flow diversion/storage
- Stormwater management ponds
- Pipe upsizing
- Rehabilitation of infrastructure part-way through design life

Climate change is expected to impact sewage collection systems through increasing rainfall derived inflow and infiltration (RDII). Population growth is also a significant factor for sewage collection systems. Adaptation measures are focused on reducing the impact of increased RDII.

Sewage Collection Adaptation Measures

- RDII reduction
- Peak flow storage
- Private-side measures (e.g. backflow preventors)
- Pipe upsizing
- Increases in the capacities of pump stations and wastewater treatment plants

More combined sewer overflows can be expected with increasing stormwater volume and RDII due to climate change. Population growth also affects the capacity of combined sewers. Along with the adaptation measures already described, accelerated sewer separation should also be considered

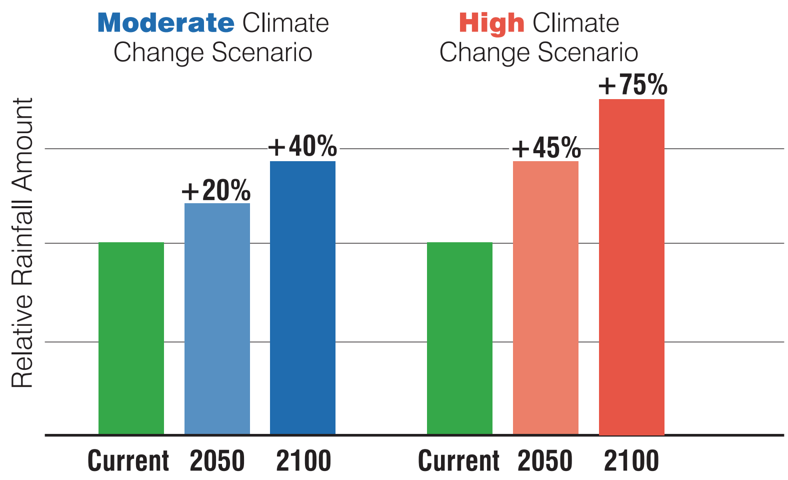

FIGURE 4 – Average Rainfall Increase

4. Good Practice Recommendations

The future climate is uncertain, and climate change adaptation must balance the uncertainty with risk and the infrastructure planning horizon. Selecting the preferred IDF curve for planning and design is a key factor to ensure that the right adaptation measures are selected, at the right time, for the right reasons, and for the right costs.

The selection of the preferred IDF curve for adaptation planning is based on the level of risk, as shown in **FIGURE 5**. Using the current climate IDF curves for design is suitable for temporary infrastructure (e.g. less than five-year design life). Using the moderate change future climate IDF curves is suitable for infrastructure with low to medium risk due to failure. Using the high change future climate IDF curves is suitable for infrastructure where the risk due to failure is high or catastrophic. The selection of 2050 or 2100 depends on the planning horizon of the infrastructure.

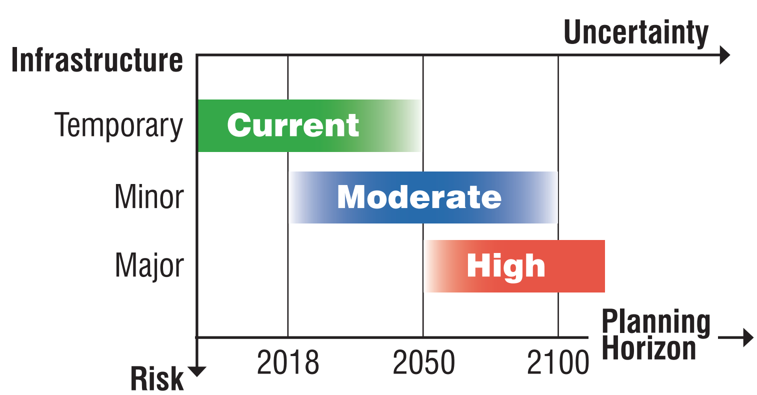

FIGURE 5 – Climate Change Adaptation

Conclusions and Next Steps

Stormwater and sewerage infrastructure in the Metro Vancouver region is vulnerable due to increasing rainfall. The future climate IDF curves developed in this project can be used to plan for and adapt to climate change to ensure that adequate levels of service are maintained.

Next steps to further the development of climate change adaptation planning are included in **FIGURE 6.** The steps have been divided into four categories: Planning and Research, Design and Delivery, Support Services, and Performance Management. These four categories will work together to ensure that climate change adaptation planning is coherent and consistent across the Metro Vancouver region, and that a regional climate change 'culture' is developed.

Planning and Research	Design and Delivery	Support Services	Performance Management
Develop a formal climate change policy Determine level of service targets Perform vulnerability and risk assessments Conduct cost-benefit analyses and select adaptation responses Develop a ten-year capital program	Propose draft version of design updates to incorporate climate change adaptation Integrate climate change adaptation into other capital delivery stages Implement final design updates	Create a climate change Data Management Strategy Create a Knowledge Management Plan Formalize climate change roles within job descriptions and adopt succession planning	Create a formal audit process to benchmark climate change adaptation progress

FIGURE 6 – Climate Change Adaptation Planning

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Metro Vancouver is a federation of 21 municipalities, one Electoral Area and one Treaty First Nation that collaboratively plans for and delivers regional-scale services. Its core services are drinking water, wastewater treatment and solid waste management.

Metro Vancouver and the Greater Vancouver Sewerage and Drainage District (GVS&DD) own, maintain and operate regional trunk sewers and major wastewater treatment plants. Municipal members of the GVS&DD own and maintain collector sewers and manage stormwater systems.

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