Rethinking public infrastructure design and rehabilitation to increase climate resiliency

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CELEBRATING LOCAL LEADERSHIP

• Local governments are confronting one of the most important issues of our time – the alarming recent increase in damage to homes and public infrastructure from severe weather events.

• Ten years ago, ICLR started the Cities Adapt program, researching and promoting the work done by Canadian communities that are adapting to reduce the risk of loss and damage from extreme weather events.

• The first report was published in 2014 and we are now developing the sixth volume, with previous publications looking at municipal initiatives to reduce the risk of damage from flood, wildfire, severe wind, and other hazards.
CITIES ADAPT WITH CLIMATE RESILIENT INFRASTRUCTURE

• Each year, municipal buildings, transportation systems, water supply and wastewater treatment systems, and many other types of public infrastructure are affected by severe weather events in communities across the country.

• Most public infrastructure in Canada was designed many years ago using construction codes and standards that were based on historical climate data in planning for extreme weather conditions.

• Nearly 60% of public infrastructure in Canada is built and maintained by municipalities. The increased risk faced by infrastructure has led several municipalities to consider the current and future resilience of their infrastructure, when faced with rehabilitating or building new assets.
THE REPORT IN NUMBERS

- Twenty communities across eight provinces and two territories, including two indigenous communities.

- Communities varying in sizes from populations of 120 inhabitants to nearly 3 millions.

- Nine different types of public infrastructure including roads, water reservoirs, bridges, and various drainage and stormwater infrastructure.

- Adaptation to eight different types of risk including severe rainfall, erosion, drought, storm surge and landslides.
SENDAI PRIORITIES FOR ACTION

1. **Understanding disaster risk**: Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics, and the environment.

2. **Strengthening disaster risk governance**: Disaster risk governance at the national, regional and global levels is very important for all phases of emergency management. It fosters collaboration and partnership.

3. **Investing in disaster risk reduction**: Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.

4. **Build back better in recovery**: The growth of disaster risk means there is a need to strengthen disaster preparedness for response, take action in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better.
UNDERSTANDING RISK
Norman Wells, NT
Understanding erosion and its impact on local infrastructure

The Science: Changing climate conditions in Canada’s North are threatening the integrity of community infrastructure, including roads and drainage infrastructure.

The Trigger: The Town is located on the shores of the Mackenzie River. Over time, local authorities started noticing increased erosion on the riverbank, threatening the stability of local roads and other infrastructure.

The Approach: Consultants identified the various processes affecting the riverbank. The study reported that thaw settlement of roadways as a result of permafrost degradation could impact road infrastructure, more specifically grades for land drainage ditches and culverts. Second, when looking at slope stability of the riverbank, the study identified key areas of concern that were also faced with greater erosion. Finally, the report noted that surface runoff erosion was observed at several locations along the studied area caused by inadequate surface runoff management.

The Outcome: The report that came out of the geotechnical investigation of the riverbank was well received by the Town’s Council who approved the development and implementation of a comprehensive drainage plan to reduce erosion and flooding risk along 7 km of the Mackenzie River. The study conducted by Stantec also allowed the community to better understand the risks faced by Mackenzie Drive, the road bordering the river, and remediation actions that needed to be taken to ensure its longevity.
“As northern communities are increasingly facing the impact of climate change, it is instrumental to not only inform but to educate community members on the risks faced by local infrastructure and the need to implement adaptation actions.”

- Cathy Clark, Senior Administrative Officer for the Town of Norman Wells
Laval, QC
Understanding risk to support future adaptive actions

The Science: The PIEVC protocol was created in 2005 to allow for engineering assessment of the vulnerability of Canada’s public infrastructure to the impacts of current and future climate risks.

The Trigger: In 2011, the City of Laval was among the early adopters of the PIEVC protocol and used the approach to further understand the vulnerabilities to climate change faced by the combined and partially separated sewers of the tribute Basin of the Belgrand overflow structure.

The Approach: The City of Laval partnered with external partners and recruited the right stakeholders from various municipal departments to understand the infrastructure as a whole. One of the key findings of the study was the necessity to design new structures within the Belgrand overflow structure catchment area that would promote stormwater management at the source and reduce some of the pressure faced by the Belgrand overflow structure.

The Outcome: While the City didn’t have funding assigned within its Master Plan at the time of the assessment to undertake the recommended actions, they were ready to apply for funding several years later when an opportunity arose and were granted nearly $500,000 to build a pilot project of stormwater infiltration features built alongside municipal sidewalks within two different areas of the Belgrand catchment area.
“The protocol allowed us to highlight specific risks and vulnerabilities that we may have otherwise missed without the multi-disciplinary approach that was used. Larger municipalities can have a tendency to work in silos within individual departments and the approach promoted by the protocol allowed to foster strong collaboration between various groups. The work we undertook allowed us to understand the specific challenges faced by the Belgrand overflow structure and enabled our municipality to start planning for future projects and act quickly once capital funding became available.”

- Martine Galarneau, Engineer with the City of Laval
Victoriaville, QC
Reservoir restoration to ensure continuous water supply

The Science: Municipalities around the country rely on reservoirs for potable water. More frequent floods and droughts can reduce the reliability of a reservoir’s water supply. The amount of water available in reservoirs can also be impacted by sediment accumulation, which can worsen under increased erosion conditions upstream.

The Trigger: The City of Victoriaville first started looking into the causes behind the water loss inside the reservoir over 20 years ago. Initial studies revealed that one of the main issues was the high amounts of sediments that had gradually filled the basin at the rate of approximately 16,000 m3 per year.

The Approach: City staff from various departments, consultants, and representatives from several provincial ministries started looking simultaneously into actions that could be taken around the reservoir as well as upstream to reduce the transportation of sediments. The City and its various partners determined that, for optimal results, an initial dredge of the reservoir followed by recurrent dredging over time would provide the best outcome for the community.

The Outcome: The initial dredge as well as the construction process for the separate water reservoir and sediment dewatering plant started in the spring of 2021 and construction was expected to be completed in 2022. The dredging process will be conducted over an 11-week period annually for the next five years, followed by maintenance dredging beginning in 2028.
“It is imperative to work as a team, both internally and externally to make sure all departments and stakeholders are aligned on desired outcomes and deliverables. We found it was key in Victoriaville to build on a unifying goal that brought benefits to all parties involved. While it took a long time to get a comprehensive understanding of the situation we were dealing with and identifying the right adaptation solution for the community, it was key to do so to ensure public funds were invested in a way that would serve the population in the long run.”

- Joël Lambert, Associate Director of Engineering and Environment Services for the City of Victoriaville
DISASTER RISK GOVERNANCE
Toronto, ON
Finch Avenue culvert reconstruction

The Science: As an essential component of municipal drainage systems, culverts serve the dual purpose of conveying water under a road and providing a crossing path for various vehicles, pedestrians, and cyclists.

The Trigger: The Finch Avenue culvert collapse was caused by an extreme rainfall event on August 19, 2005, that brought a significant amount of rain over a short period of time. The existing corrugated steel culvert was undermined by water and debris accumulating behind it. Debris from the upstream stretch of Black Creek gathered downstream and blocked the culvert, resulting in a buildup of pressure and its eventual breach and collapse.

The Approach: The City of Toronto prioritized resiliency in the new culvert design, and conducted research to determine best practice. The City also changed design standards to reflect projected climate changes and designed the culvert to withstand 100-year storms as opposed to 50-year storms, which was the former standard.

The Outcome: The Finch Avenue culvert collapse and subsequent reconstruction brought to light some deficiencies within the City’s culvert design and management system and inspired key changes. All new culvert designs are now based on 100-year storms. Additionally, a new inspection process is now in place after each major rainfall event where operations and maintenance personnel are dispatched to all the major culverts to inspect and identify any deficiencies requiring immediate attention.
“I would suggest undertaking climate change vulnerability assessments for major pieces of infrastructure as it will help identify potential risks and guide the development of programs and procedures to mitigate the future impacts of climate change. It is crucial to put in place whatever is needed now to prevent adverse impacts of climate change in the future, by first establishing where the priority is and by working with local conservation authorities for support.”

- Nazzareno Capano, Manager of Transportation Policy & Innovation in the Transportation Services Division for the City of Toronto
Montreal, QC
Rethinking urban parks to mitigate flood risk

The Science: Combined sewer systems have conventionally been used as the primary system to collect and transport rainwater during rainfall events. However, these systems have frequently been overwhelmed in communities during severe rainfalls. Many cities have started using land use planning tools as a way to increase natural absorption of rainwater into the ground and delay its transportation to the sewer system.

The Trigger: The City of Montreal has faced several extreme rainfall events in recent years, resulting in urban flooding incidents in numerous areas of the community. One particularly devastating event occurred in May 2012 and resulted in over 5,000 basement flooding claims.

The Approach: The redevelopment of a sector of a densely built neighbourhood offered a great opportunity to rethink traditional stormwater management. The planning of the new Pierre-Dansereau park came as an opportunity to incorporate green infrastructure to collect rainwater and delay its transportation to the sewer system. The team planned the park with the integration of natural infiltration and retention zones that could collect stormwater for rainfall events with return periods ranging from three months to 50 years.

The Outcome: The intervention designed by the City of Montreal’s team for the entire neighbourhood includes now a total of three parks with stormwater ponds, one rain garden and only one underground basin. Building new stormwater infrastructure independently from the construction of the park would have been more expensive for the municipality.
“Multi-disciplinary teams must be collaborating and remain in constant dialogue from the initial conception to the completion of the project to ensure all aspects from the design to the stormwater management system are well integrated. The City has relied on traditional stormwater management practices for many years, but we have noticed a big changeover in recent years. Our new approach to designing urban parks has increased in popularity and there is no doubt that the City will allocate more resources to this type of initiative to keep up with the increasing demand.”

- Rémi Haf, Planning Advisor for the Water Department of the City of Montreal
INVESTING IN DISASTER RISK REDUCTION
Tuktuuyaqtuut, NT
Road raising erosion mitigation project

The Science: Road raising may be part of an adaptation and resilience strategy in response to sea-level rise and coastal erosion for coastal communities across the country.

The Trigger: Warmer temperatures have led to a doubling in the frequency of summer storms during open-water season from one to two per summer to three to four, combined with a change in the level of storm surge from 1.7 to 1.9 m. As such, the rate of erosion has increased from 1.8 to 2.5 m per year. Following a risk modelling study, funding became available from the government of Northwest Territories through the Disaster Mitigation and Adaptation Fund for the road raising project.

The Approach: The Hamlet held community consultations to discuss the results of the Erosion Modelling Study and application of its recommendations. In addition to the road raising project, more than 15 houses have been moved in response to erosion near the shoreline.

The Outcome: The road raising project is ongoing. Improvement in road performance has been achieved and, in combination with diligent maintenance and related response to climate-related events, is helping to assure the continued viability of the roadway and its vital contribution to the community in its present location from the current and projected threat of sea-level rise and storm surges.
“Amidst the growing social and economic challenges faced by northern communities – challenges made increasingly more difficult by the COVID-19 pandemic and the changing climate – indigenous communities can still be successful in protecting their infrastructure against climate change. I recommend a three-pronged approach that consists of securing funding, sourcing the right expertise, and ensuring planning that includes public engagement.”

- Shawn Stuckey, Senior Administrative Officer for Tuktuuyaqtuuq
RM of Torch River No. 488, SK

Investing in the rehabilitation of the 6th Mile bridge

The Science: Increases in winter and spring flows have been observed over the last several decades, placing bridges and other infrastructure at risk for flooding. Many rural bridges in Saskatchewan and across Canada are in bad structural condition and either are or will soon be under load restrictions.

The Trigger: The 6th Mile Bridge (6.0 m long and 7.3 m wide) served the tributary of Kelsey Lake situated north of Township Road 532, which channels water year round. The bridge conveyed much of the spring flow, which is expected to increase in the future. Its deteriorating condition suggested an inability to withstand future weather and climate changes and necessitated a three ton load restriction in 2017.

The Approach: Two alternative solutions were considered for the rehabilitation of the 6th Mile Bridge. The first was to repair the timber bridge, to extend its life. The second, which was selected, was to replace the bridge with two 2000 mm diameter culverts and to use financial resources from the Regional Municipality to fund the project. The proposed size of the culverts was also aligned with the Provincial Climate Resilience Report, which recommended the minimum diameter of culverts on the provincial highway network be 900 mm.

The Outcome: Materials and goods can now be transported safely without the risk of failing infrastructure. Because the culvert has been built with expected climate change events in mind, it is now ready to face varying extreme weather conditions.
“In a community, it is important to inspect all assets routinely to allow the municipality to identify a list of assets that need attention. The municipalities just cannot leave the structure out there to fight with climate without looking after them. One way to ensure requirements for inspections and paying close attention to critical infrastructure is to include it within an asset management plan.”

- Samrat Hussain, Engineer with the Rural Municipality of Torch River
BUILD BACK BETTER IN RECOVERY
St John’s, NL
Rehabilitation of a storm sewer to support current and future precipitations

The Science: As changes in precipitation patterns impact municipal stormwater infrastructure, it is crucial for municipalities to plan for the rehabilitation of storm sewers in a way that accounts for future rainfall projections.

The Trigger: St John’s is a coastal city that has been impacted by several severe storms including Tropical Storm Gabrielle, Hurricane Igor, other large rainfall events that resulted in urban flooding, which highlighted the need to upgrade the existing sewer system. The City prioritized its intervention on Kenmount Road, one of St John’s main commercial streets due to its deterioration and lack of capacity to handle severe rainfall events.

The Approach: When approaching the design of the new sewer for Kenmount Road, the engineering team made it a priority to ensure its performance under future climate conditions. The information gathered through modelling allowed the team to design based on a return period of 25 years. The new sewer ranges in size from 200% to 400% greater than the previous pipes that were in place.

The Outcome: The replacement of the Kenmount Road sewer was a capital project for the City that was made possible with contributions from both the provincial and federal government. The City estimated that incorporating future climate projections into the design of the new sewer increased initial costs by approximately 15-20%. These initial additional costs were not a concern for the municipality who anticipated that lifecycle savings would outweigh the additional capital cost.
“These projects take time and money to realize, and it is essential to understand the various risks and rehabilitation benefits associated with infrastructure replacement. There will never be a shortage of projects and the successful completion of impactful initiatives also means there are less things to worry about in the future.”

- Mark White, Manager of Construction Engineering for the City of St John’s
Incorporating climate adaptation measures into the Quesnel bridge design

Edmonton, AB

The Science: Infrastructure assets across Canada are aging and strained due in part to population growth and the expansion of our communities. Additionally, climate change effects often force high pressures or conditions on the infrastructure that it was not initially designed to support.

The Trigger: The Quesnell bridge is one of nine roadway bridges crossing the North Saskatchewan River in the City of Edmonton. Since the bridge was originally built, Edmonton’s population has more than tripled, and traffic volume has increased considerably. In order to alleviate traffic on the bridge, the municipality decided to undertake a rehabilitation of the bridge to include two additional lanes and to do it in a way that ensures structural performance over the next 50 years.

The Approach: The vulnerability assessment of the Quesnell Bridge followed the framework identified in the PIEVC protocol to define, evaluate, and prioritize information and relationships around the climate change impacts faced by the infrastructure. The analysis revealed that two infrastructure components were showing greater vulnerability to future climate risks: the wearing surface of the deck system and the drainage system.

The Outcome: The rehabilitation of the Quesnell Bridge was completed 10 years ago and there have not been any issues, neither has City staff identified any concerns with the structure since the completion of the construction, despite some extreme weather events taking place.
“Investing in the proper rehabilitation of key municipal infrastructure can have immense environmental and financial benefits for communities. I’m a strong believer that the most resilient and environmental structures are the ones in place, the more we can do to protect them, the more sustainable and less costly they will be over time.”

- Mark Scanlon, Bridges Supervisor with the City of Edmonton
BEST PRACTICES

• **Understanding infrastructure vulnerabilities to climate risks:** Policies, design, and construction practices for public infrastructure should be anchored in a strong understanding of climate risks faced by the specific asset and its broader infrastructure system when applicable.

• **Creating asset management plans:** Asset management planning allows communities to establish long-term management plans that can inform decision-makers on priority investments.

• **Leveraging cross-sectoral collaborations:** As cities work to understand their infrastructure vulnerabilities and plan for their maintenance and rehabilitation, it is crucial to leverage the expertise and resources that come with cross-sectoral collaborations.

• **Growing local capacity for climate-resilient planning:** Increasing local capacity to perform climate-resilient infrastructure planning and maintenance is key to ensuring the performance and longevity of public infrastructure across Canada. In this context, building local capacity refers to financial, human, and political resources.