Floods encountered around the world are diverse and evolving both in their nature and impact on society. In recent years in Canada, we have seen catastrophic and devastating flood events occurring at all times throughout the year, and not just limited to historically prevalent spring flooding driven primarily by snowmelt and precipitation events. In August 2018, a severe thunderstorm in the downtown area of Toronto, Ontario produced 64 mm of rainfall in a period of 2 hr and resulted in infrastructure damage and basement flooding estimated at $80 million (CAD) (CBC News, 2018). In 2019, the province of Manitoba activated the Red River Floodway (an artificial waterway constructed in 1968 to alleviate downstream flooding in the city of Winnipeg) for the first time ever in the Fall season in response to rising water levels and anticipation of 60–100 mm of rainfall (Kives, 2019). Earlier this year, a 36 hr-long precipitation event at the end of January produced heavy rainfall over areas in the south coast of the province of British Columbia, with 371 mm of rainfall recorded in an area on western Vancouver Island, leading to widespread flooding, mudslides and landslides (CBC News, 2020). Ice jams occurring along the Athabasca and Clearwater Rivers in the province of Alberta lead to severe flooding in Fort McMurray in April 2020, inundating over 1,000 structures and displacing 13,000 people (Snowdon, 2020). Recently, in July 2020, concern regarding the safety and integrity of the 60 year-old Rivers Dam along the Little Saskatchewan River in the province of Manitoba mounted following an estimated 1 in 1,000-year precipitation event that produced 200 mm of rainfall in 72 hr (Gowriluk, 2020).

These examples of recent floods resulted in widespread economic damages and countless social and environmental impacts, including evacuation and displacement of people, loss and damage of homes and businesses, and adverse impacts to ecosystems. The causes and drivers of these flooding events are unique, and require, in many cases, very different approaches to manage and mitigate the adverse impacts. Such measures may include large-scale reservoirs and stormwater management strategies to divert water from rivers during periods of high flow, structural measures to reduce the impact of rising water levels and ice jams in rivers, landscape stormwater management approaches to promote green infrastructure and more natural drainage in urban environments, and lot-level strategies homeowners can adopt to reduce the risk of water damage from basement flooding.

Consider, for example, the city of Calgary in the province of Alberta which dealt with an extreme flood event in June 2013 resulting from snowmelt in the mountains combined with a week-long precipitation event that caused catastrophic damages estimated at $5 billion (CAD). In the years since this flood, the province has been investing $1.47 billion (CAD) towards strategies to mitigate impacts of future destructive floods, including the design of a massive off-stream reservoir to temporarily detain water during periods of high flow and flood barriers to combat rising water levels (Labby, 2018). Likewise, the city of Toronto, which has faced multiple economically-devastating catastrophic flood events in recent years, has a commitment from the federal government for an investment of $150 million (CAD) for flood mitigation infrastructure in the region, including expansions and construction of new relief storm sewers to reduce the risk of sewer back-up and basement flooding as well as water quality improvements (CBC News, 2019). In response to historical ice jam-induced flooding such as what was experienced earlier this year, the regional municipality encompassing the city of Fort McMurray has invested $150 million towards the construction of berms and flood walls, with further infrastructure and economic investment planned for the coming years (Malbeuf, 2020).

In light of the immense economic investment required for flood mitigation measures around the world, combined with the unique nature of floods requiring targeted strategies, considerable attention into the performance of such strategies and their optimal design under diverse and complex environmental conditions are of the utmost importance. For example, large-scale structural measures to reduce flood risk have been the focus of recent research including assessment of the effect of simulated detention basins to reduce peak flow from extreme
precipitation events and protect downstream areas from flooding (Vieira, Barreto, Figueira, Lousada, & Prada, 2018) and investigate into the performance of emergency measures (e.g., sand bags) for flood prevention and protection (Lendering, Jonkman, & Kok, 2016). Recent research into the performance of green infrastructure, such as low impact development (LID) or best management practices (BMPs), has sought to identify optimal arrangement of BMPs (e.g., vegetative swales and porous pavement) to address water quantity and quality challenges associated with floods (Behroozi, Niksokhan, & Nazariha, 2018) and examine public perception and behaviour surrounding green infrastructure (e.g., bioswales) to evaluate how these measures can be implemented most successfully (Everett, Lamond, Morzillo, Matsler, & Chan, 2018). Further research is seeking to evaluate the performance of combinations of various flood mitigation measures and strategies, such as the application of both engineered approaches and land use approaches to address muddy runoff flooding stemming from soil erosion from agricultural fields (Boardman & Vandaele, 2020), assessing the effectiveness of structural (e.g., new pipes to convey runoff and storage tanks to detain flow) and nonstructural (e.g., early warning systems and deployment of emergency response personnel to close flood prone areas) measures to deal with increased flood risk resulting from extreme precipitation due to climate change (Velasco et al., 2018), and identify optimal arrangements of conventional stormwater management strategies and LID measures for flood mitigation purposes (Zhou, Lai, & Blohm, 2019). Lastly, consideration and promotion of strategies to reduce the risk of urban flooding at the lot-level (e.g., backwater valves installed in individual homes to reduce the risk of basement flooding from sewer back-up) and coordination between municipalities and the insurance industry to identify areas at heightened flood risk have been explored and recommended (Sandink, 2016).

Around the world, the diverse nature of floods encountered in any one year poses considerable challenges for flood risk management. Continued efforts to evaluate the performance and interaction of flood prevention, protection and mitigation strategies as we encounter increasingly complex and evolving flood risk from shifts in in climate, increased urbanisation and other factors are needed. This is indeed paramount in order to design and implement optimal flood management strategies to improve resiliency and mitigate the most adverse impacts of floods on people and the environment.

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