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Urban Flood Response Planning: Building Urban Resilience in Calgary and Toronto

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URBAN FLOOD RESPONSE PLANNING:
Building Urban Resilience in Calgary and Toronto

by

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Abstract

Flooding is an increasing environmental concern for many Canadian cities. There is increasing awareness of climate change and its impacts on precipitation behavior and flooding in urban areas. Knowledge gaps were identified in the literature concerning urban flood response planning, uncertainty and preparedness planning. This study examines and compares urban flood response measures and resilience building for natural disasters in the Cities of Toronto and Calgary. Non-structural measures for flood risk reduction that include policies, decision-making and community engagement were examined by conducting a literature review and semi-structured interviews of individuals from six groups: provincial government, municipal government, conservation authority, private sector, academics and non-governmental organizations (NGOs). A total of twenty-eight recruited participants from the two cities provided information on a wide range of experiences of flood management practices related to vulnerabilities, uncertainties and possible conflict in flood response planning. The literature review explored different flood response measures such as planning, emergency management, and post-flood recovery, and examined how cities can build resilience to natural disasters. Background literature was used to assess flood response measures in Toronto and Calgary. The data show that Toronto and Calgary are quite distinct cities and have specified commonalities and differences in flood response measures. Common resilience planning priorities in Toronto and Calgary to urban floods included reducing flood impacts, mitigating climate change, implementing adaptation strategies to cope with future flooding, by developing preparedness kits for homes, building partnerships among organizations to share expertise; and building networks among community members to

enhance emergency response, updating flood maps and creating more permeable surfaces. Differences of flood planning strategies indicated that Toronto has effective policies and has a conservation authority that works closely with the provincial and municipal government regulating preventive flood hazard strategies to ensure long-term sustainable and resilient building to help alleviate future flood impacts. Case study results indicated that Calgary does not have this type of regulating agency and flood protection policies, which have resulted in prolonged developments in flood hazardous zones increasing exposure to flood risks. Interview results noted flood management practices in Calgary focus more on structural flood response measures and that there needs to be less reliance on infrastructure. Therefore, research findings recommend effective policy development, collaborative planning, education and awareness programs for citizens to acknowledge the seriousness of flood impacts and to encourage the necessary behavioral changes to enhance pre-disaster and preparedness planning.

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Chapter One - Introduction

1.1 Introduction

Floods have become a major environmental challenge for urban centers across the globe. In many regions flooding has become more intense and frequent as climate change impacts continue to affect precipitation intensity, duration and frequency (Parry et al., 2007). Accordingly there are many challenges in sustaining resilience across urban ecological, social and economic systems (Hunt and Watkiss, 2010). Toronto and Calgary are two large Canadian cities that experienced major flood events in 2013 that resulted in significant infrastructure damage and repair costs. There is a need to enhance flood management strategies to reduce future flood impacts and to build urban resilience. Resilience is defined as the ability to minimize impacts of a disturbance and recover to normal functioning in a short period of time (Liao, 2012; Ahern, 2011). Building urban resilience to floods, fundamentally means mitigating flood impacts to experience minimal or no risks at all and to allow for rapid recovery.

To increase urban resilience to floods there are structural and non-structural measures, which are critical in flood risk reduction planning to natural disturbances. Risk reduction can be defined as decreasing potential flood hazard consequences (Nirupama, 2014). Although structural measures may seem like a solution, there are many barriers to their performance level and ability to collect and store water during extreme rainfall events. Built infrastructure does not always perform to the anticipated design specifications. For example dams, reservoirs and storm water infrastructure do not always have the capacity to mitigate urban runoff. In particular, this study explored non-structural measures and examined how cities build resilience to urban floods. When

developing flood response programs, social, economic and ecological systems in cities need to be integrated in flood response planning. All of these factors are interlinked and it is important to have effective plans in place to respond effectively when an extreme event occurs to enable quick emergency response and recovery.

In recent decades extreme flood events have caused significant property damage and repair costs (Linnenluecke et al., 2012). Flooding in Canada is the costliest natural disaster in terms of property damage, where floods in Southern Alberta cost $2.25 billion in Calgary, Manitoba $1.1 billion in Winnepeg, and Quebec $78 million in damage costs in Quebec City (PSC, 2014; Thistlethwaite and Feltmate, 2013). Having effective techniques and tools in flood response measures allows reducing damage to property and repair costs. There are several climate change models, which project future temperatures and associated changes in precipitation behavior. These models suggest that as temperature increases over time, higher rainfall rates will occur (Hunt and Watkiss, 2011). However, there are still many uncertainties with climate model scenarios, so it is difficult to state with accuracy the recurrence timeframe, magnitude and duration of extreme precipitation events (Hirsh, 2011).

Therefore, these factors emphasize the need for improved urban resilience planning to respond to potential flooding in the future. Since this is a fairly new area of study, there are still great uncertainties in research and the applications of response planning strategies (Ahern, 2011). Uncertainties include lack of knowledge of future flood impacts, indeterminacy and ignorance of other causal factors and responses to urban floods (Khatibi, 2011). There is further research required to examine how flood

planning responses can be improved and to implement collaborative planning integrating top-down and bottom-up planning approaches in the decision making process.

1. 2 Goals and Objectives

In a context of probable, but uncertain, increased frequency and intensity of extreme rainfall events, the goal of this research is to examine the current flood mitigation planning practices of major urban centers to evaluate challenges and tools that have and have not worked in practice and make recommendations to enhance effective and resilient policy and practice.

The objectives of this research are to:

(1) Conduct a comprehensive review of the literature on urban flood vulnerabilities and planning responses.

(2) Evaluate response planning for related flood impacts, exposed risks, vulnerabilities and challenges in two large Canadian cities (Toronto and Calgary).

(3) Assess the policies and practices of provincial, municipal, local authorities, private organizations, academics and NGOs role in resilience and flood management planning.

1.3 Introduction to Literature Review

The literature review is a critical part of this study because it provides context to examine flood response practices in Canada and in other countries. Zhou et al. (2012) stated that socio-economic and ecological factors are interconnected and it is important to apply a holistic view in resilience planning. One of the main challenges in resilience

planning is quantifying the predictability, forecasting future events and developing flood worst-case scenario models (Neil and Watt, 2001). Therefore, the literature review examined how these challenges are addressed in practice and who the key players are in planning, and decision-making, the types of complexities experienced, and existing grey areas in this field of study.

In order to assess flood response practices, there needs to be a foundation in urban flood response planning strategies. The review explored three areas of focus: (1) flood causes and consequences, (2) urban flood response planning and (3) resilience, uncertainty and preparedness planning. In flood reduction planning there are two methods, structural and non-structural measures. Structural measures are the actual physical structures that are built to control the flow of water, and non-structural measures refer to the policy, planning and programs involved in reducing flood risks (Meyer et al., 2011). This review focused on non-structural applications in flood response techniques including policy and citizen engagement practices to enhance anticipatory and preparedness practices to ensure sustainable and resilient planning for urban floods.

Urban flood response planning is very complex and there are many barriers and challenges in developing the best strategies to respond to floods effectively. Flood response planning can be described as the tools and actions taken to respond to floods effectively to reduce flood impacts (Diordjević et al., 2011). Extensive land-use change significantly alters the rate and magnitude of flood paths, which often results in increased runoff rates in urban areas. (Hunt and Watkiss, 2010). Increased development and paved surfaces have allowed for high volume of surface runoff and increasing rate of flow into drainage systems causing floods during high intensity rainfall events (Liu et al, 2014).

This is extremely detrimental in highly urbanized areas, as this increases the occurrence of flash floods. Urban flooding is an emerging concern for cities as regional climate change impacts influence changes on rainfall behavior. There are many grey areas in understanding the relationship between climate and hydrology, and therefore future flood impacts and outcomes are unclear (Solecki et al, 2011). Probabilistic flood scenario models are used to predict future flood magnitudes for different time scales (e.g, 50 year floods, 100 year floods, etc.). Due to limited knowledge and data this creates complexities in anticipatory and preparedness planning.

The majority of the existing urban infrastructure, such as storm water drainage systems, roads, buildings, and housing were developed in a time before climate change and urban flooding became an important environmental concern. Due to increasing flood occurrences, flood risk and impact assessments are necessary in flood management practices to identify types flood hazards. Urban and environmental planners face difficulties trying to quantify exposure to vulnerabilities and risk in developing anticipatory and preparedness planning (Leichenko, 2011). The central concept of resilience is for an entity, such as a city or system (e.g., society, economy and ecosystem) to maintain normal function under changed conditions to natural disasters like floods (Walker et al., 2004). Both physical and social aspects of urban areas need to be analyzed with indicators that can be used to identify what measures will increase resilience capacity.

1.4 Knowledge Gaps

As climate change becomes an increasing threat to regional climate and hydrology, there are more uncertainties in understanding the complex flood scenarios and deciding which practices should be implemented. As urban flooding becomes more frequent it is important for cities to apply holistic (e.g., social, economic and ecological factors) response strategies (Zhou et al., 2012). Preparedness planning and designing worst-case scenarios are strategies used to anticipate future flood intensities exposure to flood hazards.

The problem with this is that there are many uncertainties in predicting future climate conditions and the magnitude of precipitation events, such that a greater flood magnitude occurs (Satterthwaite and Dodman, 2013). Limited data and knowledge on urban flood response measures creates mistrust among decision-makers. Therefore, this leads to difficulties in developing best management practices in resilience building. This study will examine the complexities in flood response planning and urban resilience and identify how flood risk reduction uncertainties can be minimized to improve resistance to hazardous natural disturbances.

1.5 Introduction to Methods and Case Studies

A qualitative cause study approach is used in this research to evaluate flood response planning and resilience building strategies in two large Canadian cities, Toronto and Calgary. An in-depth description of the methods and case studies is presented in Chapter three. A brief overview of the methods used are described below.

The literature review was used to develop a conceptual framework (Appendix A) listing key characteristics of non-structural flood management practices, providing a description and actions required for responding to each factor. A questionnaire (Appendix B) was developed based on the details in the framework to effectively assess flood management practices and to identify existing strengths and weaknesses. In the literature review it was determined that six representative groups (provincial and municipal government, local authorities, private organizations, academics, NGOs) are key players in flood response planning. The degree of participation and involvement in the decision-making process varies among each group in in flood recovery and resilience planning. Therefore, the qualitative analysis consisted of conducting semi-structured interviews of recruited representatives from each group. The interview results in Chapter 4 and 5 were used to assess the effectiveness of flood management practices in both cities. Interview results were used to conduct a comparative analysis to assess major commonalities and differences in planning to provide planning recommendations and identify lessons learned.

The City of Toronto and the City of Calgary have been selected as the case study cities and are of interest because of the major flood events that occurred in spring/summer of 2013. Toronto and Calgary are large urban centers that are distinct in regional locations in Canada and are experiencing significant urban flood challenges (Toronto Star, 2013; The Canadian Press, 2013). In Toronto the flood event that occurred on July 8, 2013 was a result of thunderstorms generating126 millimeters of rainfall causing flash floods in the Greater Toronto Area (GTA) with estimated $940 million of repair costs (PSC, 2014). Calgary experienced a major flood event on June 19, 2013

causing evacuations of 100 000 people and insurance claims estimated to be $1.7 billion (PSC, 2014). These numbers indicate that it is key for both cities to increase resilience to urban floods to not only reduce repair costs, but to reduce future flood impacts and prevent citizens from being evacuated from their homes.

The case studies evaluated the different governmental and non-governmental organizations involved in flood management. Although the mandate for these organizations is to reduce flood impacts and to ensure watershed management, there are significant differences in applied practices to build resilience to floods.

1.6 Thesis outline

The thesis consists of seven chapters. The second chapter is a literature review where various research studies were explored on various topics such as sustainable and resilience building to urban floods and climate change. The literature review also examined studies that analyzed different practices (structural and non-structural) and discussed about the various vulnerabilities, exposures to risk and uncertainties in anticipatory and preparedness planning. The third chapter will go through the methodologies and the methods carried out for the case studies. The case studies involves semi-structured interviews examining urban flood response measures and resilience building in the City of Toronto and the City of Calgary. The case study will conduct a qualitative analysis. Chapter's 4 and Chapter 5 present the semi-structured interview responses for Toronto and Calgary. These two chapters will state participant responses to each interview question and highlight where similarities and differences were found amongst the varying participants. Following the interview results, Chapter 6 will provide

comparative analysis and a discussion of the results. This will help to identify the strengths and weaknesses in flood response planning. The final chapter will be a summary thesis, recommendations and final conclusions of the research.

Chapter Two - Literature Review

2.1 Introduction

This chapter provides a review of the relevant literature. The literature review is divided into three sections: urban flooding causes and consequences, urban flood planning and responses, and resilience and uncertainty planning theory. The first section reviews the causes and consequences of urban flooding. Non-structural flood response planning measures are explored in this second section. The final section in this chapter highlights literature on resilience and uncertainty planning. This comprehensive literature review focuses on flood management challenges, barriers and lessons learned in flood management practices to distinguish knowledge gaps and improvements in increasing urban resilience to floods.

2.2 Urban Flooding Causes and Consequences

2. 2. 1 Urban Floods

Floods can be defined as naturally occurring events that cause the rising and overflow of water out of the boundaries of streams, rivers, lakes or drainage systems (Mendez-Antonio et al, 2013). In urban regions there are multiple types of floods that can occur: costal flooding, riverine flooding, flash floods, urban floods, and drainage system floods. Urban flooding is a growing environmental concern in cities. Accordingly, urbanization has a significant influence on flood behavioral changes in urban areas.

Over the past couple of decades there have been several major urban flood events across the world. In some regions flood events can occur due to short duration high intensity rainfall, combined rainfall with snowmelt, or the gradual increase of flood flows

(Garvelmann et al., 2015). These types of floods are observed in natural waterways causing a surcharge of water levels in natural or built flood paths, infrastructure failure, rapid snowmelt, or deforestation of river catchment basins (Ghanbarpour et al., 2014). Urban floods can be localized or can occur on larger scales. This imposes variable levels of flood exposure across communities where some areas experience severe flood impacts and water pollution while other areas experience minimal or no impacts (Gaitan et al., (2015); Butler and Davies, 2004). It is important for flood management practices to identify and document which communities experience urban floods.

2.2.2 *Urban Drainage Challenges*

There are four main types of urban water systems in urban areas; supply of water, urban drainage, river flood control, and sewage drainage. Supply of water is the water available for residential and commercial sites. Urban drainage is the physical structure of systems to collect rainfall runoff, treat, and discharge water into rivers (Tucci, 2006). River flood control is the preventative management to control natural floods (e.g. riverine flooding). Cities have sewage drainage sanitation systems to collect waste and transport to treatment centers. There are many risks associated with the deterioration of water, quality, and floodplain well-being, causing contamination of water and sewage drainage, from, for example, inadequate documentation of site specific urban drainage discharges, increased flooding in urban areas, and soil erosion (Tucci, 2006).

It is evident that urbanization has led to several impacts on storm water drainage systems altering runoff rate and volume of storm water entering the natural and built drainage system. Urbanization can be defined as the "increasing share of a population

living in urban areas, and is reflected in two distinct processes: changes in the living patterns of humans, and the physical transformation of the natural cover into an urban landscape" (Mill et al, 2010). Urbanization therefore involves the land-use changes of natural surfaces or maintained surfaces (e.g., farmland) to impervious land (Parry et al., 1988). One of the greatest challenges faced in cities is the increasing population growth from rural to urban settlements. It has been recorded that about half of the world's population is now localized in cities (Zevenbergen et al, 2010). The rapid onset of land-use changes in many regions Canada has enhanced flood risks in urban areas (Owrangi et al., 2014). These risks include increased overland flooding causing damage to drainage infrastructure, ecological degradation, and property. As urban centers continue to expand it is important for cities to implement resilience strategies to reduce vulnerability and risk associated to natural disturbances in the environment.

Mendez-Antonio et al. (2013) assessed the effects of urbanization and the rate of flooding between rural and urban areas. They observed that flooding occurs more rapidly in cities than in rural regions due to excess permeable surfaces allowing runoff to infiltrate. Cities generally have less green space allowing storm water runoff to flow into drainage systems and rivers at increased velocities. Rural areas relative to urban areas can experience postponed runoff due to topographic characteristics within the region, vegetative cover, and natural passages help control surface runoff (Campana and Tucci, 2001). Urban drainage systems do not have the ability to slow down the rate of flooding as drainage channels reach their capacity in a short duration of time. Capacity can be defined as the maximum amount of water drainage infrastructure collect (Chung, 2015)

Flash floods are major concerns for cities and are described as the rapid movement of surface runoff exceeding the ability of natural and built drainage systems to accommodate increasing water levels (Mendez-Antonio et al, 2013). The occurrences of flash floods vary across geographic regions and may occur simultaneously with severe weather (Bull, A., 2000). In urbanized areas intense rainfall in short durations of time can cause storm drainage systems to reach capacity and cause overland flooding. As communities expand, flash floods become increasingly important for cities to plan and prepare effectively especially during flood season, and summer months. Storm water drainage systems, dams, dykes, and storm water ponds are structural measures that can help alleviate surface runoff (Ghanbarpour et al., 2014). Sometimes built infrastructure does not have the capacity to withstand high intensity rainfall events, which cause extreme floods, and combined sewer overflow (CSO) (Nie et al, 2009). Alternative structural measures are being considered to reduce urban flooding, such as green infrastructure, low impact development, and permeable surfaces to reduce the flow of surface runoff into storm water drainage systems (Liu et al, 2014). Non-structural measures such as land-use regulations and flood forecasting can aid in flood preventative measures in cities.

Urbanized areas do not only change the rate of surface runoff, they also affect the quality of water as it may contain pollutants collected in catchment infrastructure (Butler and Davies, 2004). In urbanized areas, runoff is also a contributor to water pollution through the addition of nutrients, bacteria, sediment, heavy metals, oils, grease and road salt (Butler and Davies, 2004). These are important factors to note because of their impacts on water body characteristics, leading to soil erosion and altering soil profiles by

increasing clay particles (Butler and Davies, 2004). This is highly important for communities that are built along rivers (e.g., The Don River in Toronto). For example erosion in Toronto's urban river valleys is of concern involving danger to dwellings, loss of adjacent private properties to valleys, loss parklands, vegetation, and sediment (Stratton, 1985). In response to this challenge municipal environmental planners and the Toronto and Region Conservation Authority developed preventative plans to protect and prevent future erosion including: taking early action, having appropriate funding, and apply consistent policies, legislation, and bylaws in preventative measures (Stratton, 1985). Soil erosion places great risks on property, and restoration projects are key in naturalizing volatile areas. Rood et al. (2014) observed the effect of different vegetation in resisting riverbank erosion in the Elk River in British Columbia, Canada and recommended that restoring river floodplains with trees have a greater resistance to sustain equilibrium of river dynamics.

2.2.3 *Impacts of Climate Change on Urban Floods*

Climate change is a phenomenon which is driven by natural and human activity (Ekstrom and Moser, 2014). In understanding climate there are great uncertainties associated with trying to predict the rate and timing of the onset changes and impacts (Linnenluecke et al., 2012). Research has indicated that climate change can be observed through increased greenhouse gas emissions, temperature rise, precipitation behavior, sea level rise, drought, etc. (Oberlack and Eisenack, 2014). As global and regional mean temperatures continue to change, this imposes greater threats on future climate conditions and is a contributing factor to rainfall behavior (Morita, 2011).

Changes in regional climate are predicted to cause higher precipitation intensities and increased frequency causing high levels of storm water runoff (Solecki et al., 2011). Literature has also suggested that in some regions urban flooding is likely to occur during wetter and milder winters where high precipitation combined with snowmelt increases surface runoff (Hunt and Watkiss, 2011). This type of flood event has been observed in different regions across the world where combined snowmelt and rainfall produce greater flood magnitudes than rainfall or snowmelt alone (Garvelmann et al., 2015). When addressing climate impacts, it is important for decision-makers to acknowledge possible impacts and develop adequate flood prevention strategies (Morita, 2011). The probable consequences of increased flood magnitude include increased overland flooding, basement flooding or underground surfaces such as subway systems or garages, sewer surcharge, and combined sewer overflow (Nie et al, 2009).

There are multiple structural and non-structural measures to manage and minimize urban flood impacts. These practices consider climate adaptation and planning as a mechanism to anticipate and prepare for changes in flood duration, intensity, and frequency. One of the challenges is allowing homeowners flood insurance coverage for overland flooding. In Canada flood insurance is vividly provided for sewer back up damages, and does not specifically cover overland flood damages (Shrubsole, 2000; Thistlethwait and Feltmate, 2013). This is attributed to variances and uncertainties of climate data and the degree of flood anticipation. Scenario models predict flooding to intensify, therefore if effective flood reduction measures are not implemented then damage costs and insurance claims are expected to increase as well. Lamond and Penning-Rowsell (2014) discuss that it is difficult to conceptualize the severity of

flooding due to the flood uncertainty in urban areas. Their study indicated that demand for insurance is likely to increase as the environment continues to change causing more flooding and damage to property. This is a problematic area in flood resilience planning and a critical factor to consider in how insurers can improve their insurance coverage and policies in the long run as the likelihood of extreme flooding increases.

Urban floods cannot be prevented but flood management practices can reduce catastrophic flood consequences. Flood management practices involve pre-disaster and post-disaster planning to reduce risks, vulnerability, and flood hazards. These planning measures help cities to respond to external environmental changes such as climate change, land-use changes, and loss to riverine floodplain vegetation. Therefore significant planning is essential to ensure urban resilience to floods. There are variable definitions of resilience in the literature. The definition used here refers to resilience as the ability to cope and recover to a disturbance (e.g. floods) with minimal or no impacts while still maintaining functions of social, economic, and ecological systems (Chang et al., 2014). Resilience is dependent on the degree of exposed vulnerability, risk, and hazard. Vulnerability can be defined as the potential loss to property, money, and casualty (Solecki et al., 2011). Risk is the expected loss due to flood hazards (Muis et al., 2015). Hazard is the level of system failure at the onset of floods (Zhou et al., 2012). Many Canadian cities have experienced rapid rates of urbanization imposing great threats, increasing the occurrence urban floods.

2.3 Urban flood planning and responses

2.3.1 Planning Approaches

Urban flood response planning is defined as the techniques and tools used to respond to floods effectively and to reduce floods impacts. Effective flood management is key to reduce flood impacts by enhancing technology and planning tools (Diordjević et al., 2011). This involves identifying causes of urban floods and developing standards to reduce flood consequences. Urban flood responses comprise integrated socio-economic, and ecological factors. In Canada flood management practices can be distributed into three categories; (1) planning, (2) flood emergency management and (3) post-flood recovery (Simonovic and Carson, 2003). Each of these flood management practices will be explored in detail. Flood management practices can be divided into structural and non-structural measures. Structural measures focus on the development of infrastructure that will protect and reduce the risk of flood damages (Oliveri and Santoro, 2000). This includes levees, high flow diversions, channel modifications to reduce water level, and coverage of flooded areas (Ghanbarpour et al., 2014). Non-structural measures are the non-physical tools used to reduce and prevent further flood hazards, including policy, legislation, land-use management, emergency response planning, and community participation (Kundezewicz, 2009). The literature review will focus on non-structural methods in flood response practices.

Early urban development did not consider flood management in planning strategies. Many cities began to initiate flood response measures after experiencing significant floods. For example in Manitoba flood response planning was initiated after the 1950 flood and Toronto after the 1954 Hurricane Hazel (Bocking, 2006). Since then,

different response planning measures have been established based on the following common framework: modifying flood reduction, modifying susceptibility to flooding, modifying the impacts of flooding and protecting the natural habitat, and function of floodplains (Simonovic, 2002). All four of these common frameworks focus on reducing flood impacts by modifying structural and non-structural measures.

Non-structural flood response planning is an integral part of flood risk reduction planning. This method of planning generally involves policy, legislation, land-use, and watershed management, enhancing recreational use of parks, and protecting environmental, and community well-being (Simonovic and Carson, 2003). Policies are effective in setting goals and objectives in establishing criteria of operations, performance of flood control measures (Schulte-Hostedde et al., 2007). Cities have flood master plans that list requirements and guidelines in flood management. This includes documentation of current and foreseeable flood impacts, identification of policies, and environmental issues, description of storm water issues, cross-jurisdictional interdependencies, definition of priorities, assessments, emergency management, and financing program (Andejelkovic, 2001).

North America has experienced massive flood events that resulted in major damages. Some of these flood events are minor and some are major in rural and urban regions. Flood planning is critical in preparing for the re-occurrence of floods and to reduce damage. Planning reflects the role of government, local emergency, and storm water agencies. Often a top-down planning approach is practiced in cities. The roles and functioning responsibilities are divided among various government levels and

organizations (ex. Provincial, Municipal and conservation authorities) (Brown and Damery, 2002; Stratton, 1985; Mitchell et al., 2014).

In Ontario integrated water resource management is applied. Integrated water resource management (IWRM) is the use of catchment or river basin boundaries instead of administrative units (Mitchell et al., 2014). This involves the management of watershed well-being and conservation, interconnections of water with natural resources, socio-economic, ecological factors, and stakeholder participation. Integrated water management is practiced in Ontario by local conservation authorities to protect water bodies, natural habitats, and to reduce flood and erosion natural hazards. In Manitoba integrated water planning and management system is present. Practices are performed using the Manitoba Water Strategy which supports a watershed-planning framework allowing stakeholders an opportunity to participate (The Manitoba Water Strategy, 2003). This allows the Province to leverage local and traditional knowledge in water management planning and adaptation measures. This applied measure in flood response planning allows opportunities for stakeholder engagement enabling sharing of ecological knowledge in understanding seasonal and annual flood variances (Wang, 2015). This mechanism develops pre-disaster protection to natural disturbances.

Natural disturbances in cities have prompted post-disaster recovery measures to aid assistance to provide flood relief for impacted communities. In the United States a federal law was passed in 1936 specifying that flood reduction programs was a federal government responsibility and that flood management was depended on structural measures (Tucci, 2006). In 1973 a flood disaster protection policy was passed encouraging the use of non-structural measures and insisting on the need for flood

insurance and land-use regulations. Policies and legislation are important planning measures to mitigate floods. In Ontario the Provincial Policy Statement provides policies on wetland protection (MMAH, 2014). These regulations outline land-use regulations and zoning restrictions. Practices in Ontario and other provinces in Canada have observed the absence of effective wetland policy enforcement and penalties (Schulte-Hostedde et al., 2007).

Serre, et al. (2010), Satterthwaite (2013) and Lu (2013) suggest a collaborative approach in flood planning. Collaborative planning involves the integration of top-down and bottom-up planning processes among decision-makers, independent organizations, and citizens. This planning approach allows for the recognition and better understanding of what response planning strategies need high priority. Diordjević (2011) introduced the collaborative research on flood resilience in urban areas (CORFU), which measures the cost-effectiveness of adaptable and integrative resilience planning measures considering different drivers: urban development, socio-economic, and climate change. The CORFU project ultimately integrates the use of new technologies with traditional practices, and developing approaches to adapting to living with floods. The steps in the CORFU approach involve using the DPSIR (drivers-pressure-state-impact- response) framework. The DPSIR is a very useful model when trying to conceptualize and identify key indicators when analyzing the human and environmental relationship, and capacity levels (Diordjević et al., 2011).

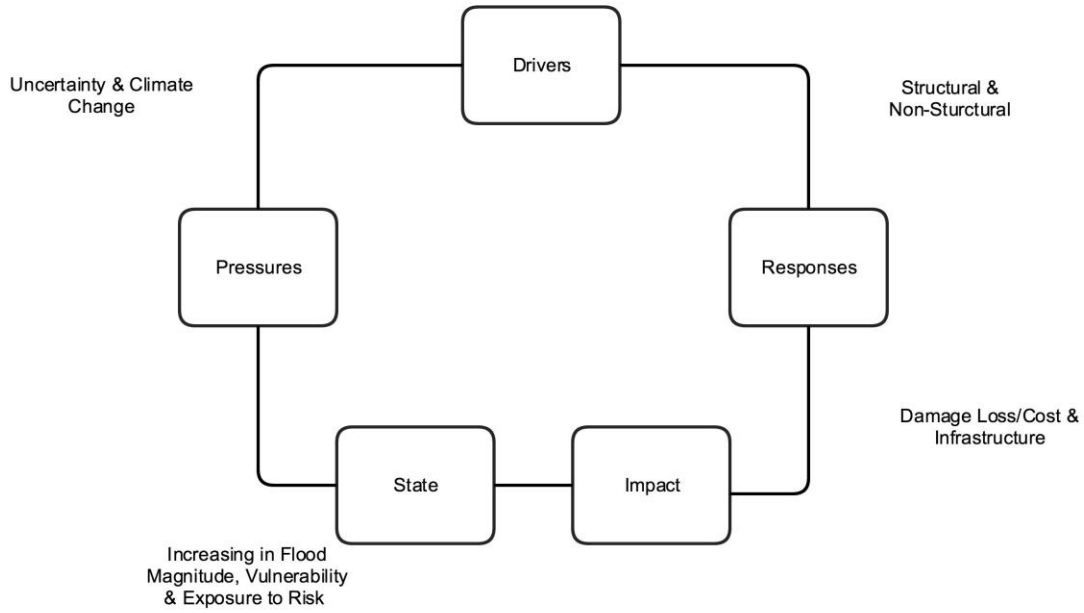

Figure 1. Application of DPSIR (Driver-Pressure-State-Impact-Response) Framework. This diagram illustrates the different drivers, risks and impacts associated to flood response management. This is a useful framework to use as a reference to indicate key stressors in an environment that makes the society susceptible to change. Identification of these stressors helps to build a resilient city and resist change. After Diordjević et al., 2011.

This relates to understanding land acquisition in cities and identifying high risk and low risk communities (Gaitan et al., 2015). Collaborative planning enables better identification and understanding of experienced flood impacts and how to effectively plan accordingly. Collaborative planning also helps to reduce conflict among decision-makers, neighboring jurisdictions, and stakeholders. In the United States the Office of Management and Budget and President's Councils on Environmental Quality issued a memorandum on Environmental Conflict Resolution in November 2005 (U.S. Army Corps of Engineers, 2005). A case study assessing collaborative planning in watershed management, metropolitan waterways, and restoration projects, in Hawaii, Florida,

Oregon, Texas, Illinois, and Alabama indicated it to be successful (U.S. Army Corps of Engineers, 2005). In comparison to traditional planning collaborative planning was noted to be time consuming and costly but has the potential to increase credibility and commitment to implement the necessary measures.

In Canada water management is not based primarily on the division of river catchments which can create barriers budgeting for water management practices (Francesh-Huidobro, 2015). A study conducted by the Institute of Catastrophic Loss Reduction identified that the top-down approach has dominated flood management planning (Shrubsole et al., 2003). Challenges for successful stakeholder participation were described in four parts. First was a democratized peer community among government, non-government, and other professionals; some water operators preferred remaining with the existing management arrangements due to familiarity and to plan adequately (Commission Scientifique et technique Sur La Gestion Des Barrages, 1997). A second challenge reflects emergency organizations and addressing issues of reduced public resources limiting partnership to reduce vulnerability measures (Dovers, 1998). Third, it is difficult to increase citizen participation with professionals to generate discussions and share the same level of understanding of the issue (Bruce, 1999). A final challenge is setting clear distinctions of existing agencies and roles among government agencies, private sectors, NGOs, and communities (Shrubsole et al., 2003). Therefore it is important for flood response planning strategies to take an integrated approach (Yin, 2001).

One of the challenging matters is for stakeholders to take personal responsibility and to get involved in the planning and decision making process. Often many citizens

rely on government agencies to manage all land-use and zoning policies, insurance, and emergency response issues (Linkov et al., 2009). When looking at non-structural measures, many papers (Linkov et al., 2009; Yin, 2001; Tingsanchali, 2012; Fratini et al., 2012) have suggested that stakeholder incorporation is critical for future disaster management and increasing urban resilience. Often stakeholders lack interest in participating in flood management planning (Esktrom and Moser, 2014). Homeowners have shown lack of interest until personally they have been impacted and show greater interest in participating in planning.

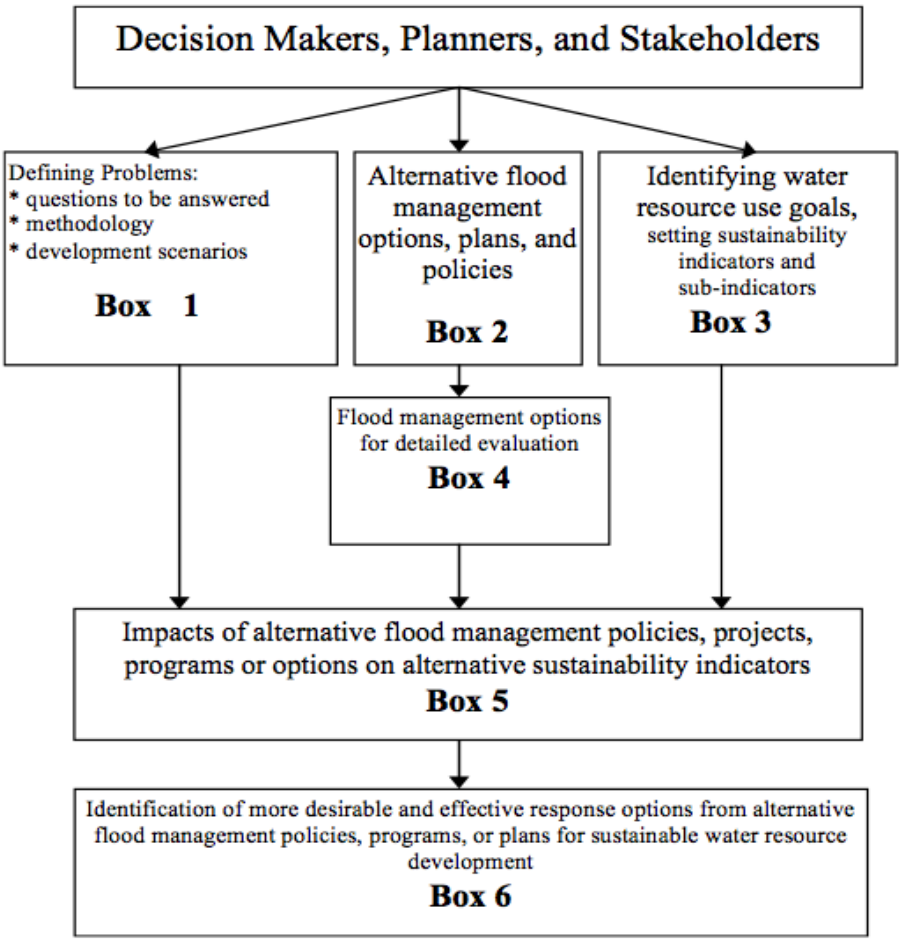

Figure 2. Decision makers, planners and stakeholders research framework (Yin, 2001)

Yin (2001) assessed on integrated approach in flood management planning. This approach involves decision-makers, planners and stakeholders. In the planning process it is important to have all three major groups involved. This will help to reduce and eliminate conflict and as well address all areas of concerns taking the bottom-up approach. Stakeholder involvement can be introduced through a participatory planning process (Hutter, 2015). Benefits that can be achieved by stakeholder involvement include gathering different perspectives, which allows us to consider a holistic understanding of flood risks (Tingsanchali, 2012). The integrated planning approach allows for interest groups and ffected communities to share their experiences, and suggest where improvements need to be made. Therefore the collaborative/ integrated planning approach allows for identification of key problems and target effective and sustainable flood control management (Francesh-Huidobro, 2015). Integrated flood response planning has been an observed practice in areas most affected by flood in the United States and in Europe (Linkov et al., 2009; Yin, 2001; Jabareen, 2013; Lu and Stead, 2013; Simonovic and Carson, 2003). This may seem like an ideal planning mechanism but will face many complexities, such as that there might not be a lot of expertise on the local level. But NGOs can be a creditable resource to consider to involve in decision-making.

Nirupama and Maula (2013) suggest that community participation is key in future disaster risk reduction, considering education, poor health, and limited access to resources are highlighted concerns in stakeholder meetings. They recommend that communities voice their concerns by being more aware of their surrounding regions and having access to resources to enable better response during emergency events.

2.3.2 Flood Emergency Management

There are many challenges faced in flood management planning in order to ensure protection and to reduce vulnerability such as preparing for unexpected flood events. There are great uncertainties in research when trying to understand the complex relationship between environmental stressors and flood behavior (Yin, 2001). Flood emergency plans are necessary to allow significant response to the onset of extreme flooding. Flood emergency management can be described as the plans that outline communication and public information management, first responder coordination, evacuation management and emergency relief (Andjelkovic, 2001). This includes coordination among paramedic, fire, police, and transportation services. Preparedness planning is required to have training, to identify roles, and protocols on response mechanisms during emergency events. Emergency planning involves the comprehensive organization of preparation measures and mobilization-trained professionals to ensure effective response during a flood event.

Hurricane Katrina in 2005, Hurricane Sandy in 2012, and recent urban floods in Calgary and Toronto in 2013 can be used to examine flood emergency preparedness planning. In the US and Canada emergency management planning involves training and education for governmental and non-government agencies to reduce catastrophic damage to property and risk to life. In New Orleans emergency operations measures require an office of emergency preparedness to plan in accordance with the Emergency Management Plan which includes training and education for response teams and the public (Bourget, 2005). Hurricane Katrina and Hurricane Sandy released state warning. Warning was issued to ensure residents, businesses, and transportation services respond

responsibly by evacuating to low risk areas. Hurricane Katrina resulted in 1, 836 deaths and 1 million displaced and Hurricane Sandy resulted in 109 casualties and an estimated 100, 000 displaced residents (Krum, 2012). Lessons learned from these catastrophic events in New Orleans and New Jersey are to have common vision of preparedness, translate goals into feasible preparedness planning, and programs, and develop preparedness for all hazards (U.S. Department of Homeland Security, 2006; Savits, 2013). This highlights that effective preparedness for natural disasters is not limited to flooding, but also includes earthquake, severe snowstorms, and tornedos.

Toronto emergency preparedness planning is documented in the *Risk Specific Plan: Flooding* (TRCA & OEM, 2014). The Risk Specific Plan provides a definition of hazard, role of authoritative institutions and supporting agencies in emergency response (Toronto Fire Services, Toronto Paramedic Service, Toronto Police Service, Toronto Public Health, and Transportation Services). In Calgary, the Emergency Management Agency developed a municipal emergency plan outlining all the division of responsibilities among city emergency medical, fire and police responders (Calgary Emergency Management Agency, 2010). These plans identify protocols of initial response measures to issue public alerts and ensure safety and tools of communication to evacuate residents from high-risk areas and to provide access to immediate assistance. The 2013 floods were documented to be the first and third largest natural insured disasters in Canadian history (Cameron, 2013). These two cities exhibited substantial flood emergency preparedness with zero deaths in Toronto and four in Calgary. The flood in Calgary was more severe and ensured effective crisis response and evacuated 100,000 residents (PSC, 2013).

In flood emergency management, flood forecasting and flood warning is critical in detecting approaching floods and providing public flood alerts. Flood forecasting serves as a technique to collect data, provide surface runoff estimation, predict water levels in drainage basins spatially, and temporarily in flood prone areas (Lawford et al., 1995). This is a useful approach in identifying the occurrences of flood and also identifying the most damage sensitive areas. There are some challenges that are faced using flood-forecasting measures, such that not all models are capable of predicting the timing and magnitude of flood events for all drainage systems with certainty. When looking at climate and flood hazard, changes may occur in the distribution of precipitation regionally (Lawford et al., 1995). There are great differences between climate models and hydrologic models measurable parameters (e.g., large to small scale), which cannot be easily assessed. Climate models and flood forecasting models are based on probabilities, such that the higher the probability the more likely it is to occur during that projected time. Flood forecasting is a beneficial tool to issue warning alerts during the initial flood stages (Kaźmierczak and Cavan, 2011).

Flood warning provides advanced notification of possible flood events in the near future for a specific region. This is used to warn residents and agencies of approaching rainfall activity, to caution to prepare, and ensure safety. Advanced notice enables warning of potential dangers and warnings of required emergency action to ensure safety. Flood warning involves the organization among forecasting and warning centers, emergency first responders, other organizations such as schools, churches, charity and NGOs. Practices in flood warning require rapid status update and provide communication through the use of media outlets (e.g. radio, television, internet, and social media).

During major emergency events communication infrastructure is impacted where phone lines, cell phones, towers, and radio and satellite antennae are destroyed (U.S. Department of Homeland Security, 2005). This affects the ability for emergency responders to get updated situational and operational information prohibiting access to information of affected areas.

Emergency planning includes effective response with first responders and citizens to ensure safe evacuation if necessary. Savitz (2013) reviews Hurricane Sandy's emergency response and suggests that emergency crisis plans need to address six areas of response planning: warning, risk assessment, response, management, resolution, and recovery.

2.3.3 Post-Flood Recovery

Post-flood recovery involves management initiatives in alleviating flood impacted populations and damaged property (Simonovic, 1999). Therefore, this involves identifying flood impacts, vulnerability, and risks. Flood risk assessments can be carried out to examine impacted areas in cities to assess types of vulnerabilities and risks. The assessments can be used for flood disaster reduction planning. Non-structural post-flood planning involves reviewing policy, legislation, land-use activities emergency response protocols, and public education and awareness programs.

Flood risk management (FRM) is the practice of reducing risk in flood prone areas considering structural and non-structural techniques (Meyer et al, 2012). The decisions made in FRM help to improve public safety and to also reduce the negative impacts of flooding imposed on health and social risks. Risk can be understood as the

outcome of flood damage relative to its occurrence probabilities (Morita, 2011). When measuring risk, estimates of flood damages can be conducted looking at monetary damages to generate annual risk density curve based on the occurrence probabilities and design storms (Morita, 2011). Exposure to risk can be examined by looking at the types of property damage, time it takes to recover, recovery costs and lastly the types of citizens are impacted (e.g., elderly, disabled, children) (Kaźmierczak and Cavan, 2011).

When assessing and developing post-flood response strategies it is important to define risk and to quantify it. This can be achieved through flood risk assessment. Flood risk assessment can be defined by equation (1), where risk R is the probability of damage loss which is based on three parameters; where H is hazard (the probability that system failure will result to a flood), V is vulnerability (objects at risk that may be impacted by the onset of a flood), and E is exposure (considers social and physical factors that are prone to the impacts of flooding) (Fontanazza et al., 2011).

$$R = H \times V \times E \qquad (1)$$

In flood risk assessment, there are two approaches in determining risk probability using historical data or designing storm scenarios. In the presence of historical flood time series data, hydrological models can be used to assess the flood frequency behavior for a particular location and provide future predictions of the probable flood risks. One of the challenges faced in flood risk assessment is the availability of historical time series data of floods. Therefore, design storms are used along with urban drainage models to implicitly configure flood estimations of a particular region, frequency, and magnitude when there is a lack of historical data (Fontanazza et al., 2011). Measurement peaks (maximum intensity), intensities, and duration of a rainfall events can be predicted for

future events (Fontanazza et al., 2011). These rainfall descriptions are important to consider in risk assessment to provide successful flood planning response strategies. Therefore before initiating any flood planning responses it is critical to develop a good description of the site being investigated and analyze and determine the expected risks. As described, flood risk assessment can be used to identify indicators to measure the associated risks due to disturbances in the environment. The data can then be used to configure suitable planning responses that comprise of structural or non-structural approaches. Johnstone and Lence (2009) state that risk-based methods are useful in analyzing and assessing flood risk but are limited in the ability to assess the practicality of community preparedness planning and emergency responses such as evacuations. Therefore, further research is needed in analyzing the success of preparedness measures to enhance pre-disaster planning.

The three point approach (3PA) is another planning strategy used in The Netherlands and Denmark with a focus on three domains (1) technical optimization of standards and guidelines for urban drainage systems, (2) spatial planning: increasing urban resilience to future changing conditions and (3) day-to-day values: enhancing awareness, acceptance and participation among stakeholders (Fratini et al., 2012). The 3PA has been suggested to be a useful tool in participatory processes in urban flood risk management (UFRM). Based on the reviews held in The Netherlands and Denmark it was concluded that the 3PA approach serves as a useful technique for water managers and operators in providing great communication and understanding allowing reduction of the level of complexity when developing programs for adaptation measures to the changing drivers, e.g., urban development, climate change, etc. (Fratini et al., 2012)

In flood management practices it is important to have a holistic approach in planning. It is critical to consider all possible aspects of a city including various citizens, economics, ecology, infrastructure, etc. Therefore the 3PA is a great mechanism to consider since it focuses on different aspects, but interlinks it in resilience building.

Pre-disaster and post- disaster planning require the acceptance of possible natural disasters, environmental hazards, and holistic perceptions in policy development, evaluating development projects to meet guidelines of disaster reduction (Adjelkovic, 2001). Legislation is key in disaster preparedness to define responsibilities for planning in flood-hazardous zones. Post-flood recovery planning requires identifying regulations, communication of service facilities, emergency response procedures, methods for public education, and awareness programs. Simonovic (1999) analyzed social criteria in flood control measures in Winnipeg and results indicated that public participation should be included in post-flood planning and decision-making. This supports other literature suggesting collaborative planning can result in significant flood planning allow to increase urban resilience (Serre et al., 2010; Satterthwaite, 2013; Lu, 2013; Diordjević, 2011).

2.4 Resilience and Uncertainty and Planning

2.4.1 Resilience

Resilience can be defined as the capacity to experience a disturbance with minimal or no impacts, maintain functionality of systems, and allow for rapid recovery (Liao, 2012 and Ahern, 2011). Urban resilience is a dynamic matter that incorporates factors such as income, education, gender, age, physical and mental capacity, politics, and social capital (Jabareen, 2013). Resilience is a complex matter and requires a holistic planning approach considering all vulnerabilities and developing strategies to reduce impacts to experience minimal or eliminate all impacts. Building resilience in cities involves the use of extensive resources and time to adapt to lessons learned, and enhance planning measures. Policy is a useful non-structural flood response measure that is capable of directing the future dynamics of a city. Several researchers have noted that regions that are socially and economically weak are more susceptible to exposure to extreme flood events (Shrubsole, 2000). When urban areas encounter an extreme flood event they are vulnerable to property damage and physical harm. Cities need to adapt to the changing environment to become less vulnerable to risks and become resistant to disturbances. Resilience can be viewed as how systems manage disturbances caused by external stressors. The ability for a system to cope with disturbances and still maintain normal functionality can act as an indicator for community resilience to floods (Lhomme et al, 2013). Although there are regulations designed for development and recreational land-use and watershed management, flood planning requires consideration of environmental issues addressing prediction and anticipation of extreme weather events (Jabareen, 2013).

Over recent years there have been a number of extreme flood events, which have imposed challenges for researchers as well as policy makers in resilience planning (Chung et al., 2011). Building resilience in cities to natural disasters requires adaptation strategies and mitigation strategies (Lu and Stead, 2014). It is vital to have the proper methods and indicators to assess vulnerabilities and develop preparedness strategies for extreme events. In this case, identifying useful physical and social indicators can serve effectively for both policy makers and urban planners towards urban sustainable and resilience planning (Satterthwaite and Dodman, 2013). Therefore, carrying out risk assessments and analyzing vulnerabilities in different communities is important. It is important to use tools, such as flood maps, to illustrate areas that are high at risk and prioritize which communities require strict regulations to alleviate flood impacts. Regulations enforcing updated building codes or looking for infrastructure redevelopment opportunities can help to reduce flood impacts. Overall resilience planning is looking for solutions to minimize damage, recovery costs, and allow for rapid recovery.

In order to gain a broader understanding of resilience, three capacities need to be assessed: (1) absorption capacity, (2) recovery capacity and (3) resistance capacity (Lhomme et al, 2013). Absorption capacity is the ability of a system to redistribute flows towards undamaged parts of a system when the system is partly damaged (redundancy) (Lhomme et al, 2013). A redundant system allows for the ability to maintain system function through an alternative route (Balsells et al., 2013). This can refer to the actual flooding and the ability for storm water drainage systems to capture surface runoff. Drainage systems can only retain a certain volume of storm runoff, then overland

flooding occurs and also basement flooding. Recovery capacity refers to the ability of a system to regain function after a disturbance. This capacity corresponds with the degree of damage, such that greater damage reflects the time it takes for the system to restore back to a normal state (Vale et al, 2005). It is also important to note that recovery capacity does not refer to the system returning back to its previous state of disturbance, but to a functional "recovery" of the system (Balsells et al., 2013). In many cities it is observed that when extreme flood events occur there are possible road closures, power outages, out of service businesses and transportation, and residential evacuations. Depending on the severity of the flood it can take multiple days or months to get the city back to normal functioning and for people to return back to their homes if possible. Flood victims in Calgary, New Orleans, New Jersey were displaced from their home for days, months, and years. Rebuilding communities can be viewed as opportunities to modify building regulations to ensure resilience building which is essential to reduce potential flood impacts and allow for rapid recovery (Walker et al, 2004).

Resistance capacity is the ability of the system to resist disturbance and continue normal functioning (Satterthwaite and Dodman, 2013). This is a long-term goal cities would like to achieve. This will involve protective and preventative measures including naturalizing communities built by rivers, monitoring land-use changes, and enhancing flood awareness programs. Resilience capacity requires key identification of the socio-ecological processes, expected risks, and how cities can build adaptive capacity to respond to disturbance while maintaining a functional state (Vale et al., 2005). Adaptive capacity can be defined as the system's ability to adapt to external environmental changes (Downard et al., 2014). This is applied to social, economic, and ecological systems in

cities. In order to fulfill the three categories of resilience capacity it is necessary for cities to increase participation of stakeholders in planning and in policy decision-making process (Ahern, 2011).

2.4.2 Resilience Planning

Resilience planning is composed of preventive and emergency measures (Lhomme et al, 2013). When discussing urban resilience, there are two aspects which can be looked at: engineering and ecological perspectives of resilience (Liao, 2012). Berkes (2007) states that resilience planning in the context of natural hazard management is fairly new. Engineering resilience can be described to focus on system disturbances in which the functionality of a system is affected with low impacts and a rapid coping period to the disturbance (Wang and Blackmore, 2009). Ecological resilience is concerned with a system's persistence against disturbances, meaning that the system's, function such as feedbacks and processes, operate normally (Walker et al., 2004). It is important to identify indicators and understand thresholds to explore ways of maintaining an equilibrium in a system. This will require constant monitoring to observe changes in communities in the floodplain.

Ahern (2011) proposed five urban planning and design strategies for building urban resilience; (1) multifunctionality, (2) redundancy and modularization, (3) bio and social diversity, (4) multi-scale networks and connectivity, and (5) adaptive planning and design. Multifunctionality can be achieved through integrating and combining functions, which allows increased diversity of system function (Ahern, 2011). Redundancy and modularization refer to multiple components provided for a similar function so that the

distribution of the same function makes the system more resilient to a disturbance (Ahern, 2011). Biodiversity alongside social, physical, and economic diversity are vital factors to increase urban resilience. Maintaining diversity helps to prevent system failure and allow rapid recovery to disturbances. Multi-scale networks and connectivity involves functional support of a system through connective networks (Ahern, 2011). To maintain functionality it is important to ensure connectivity to prevent system network malfunction. Resilience capacity is then increased through complex network connectivity in an occurrence of a disturbance. Adaptive planning and design corresponds with adaptation and design planning associated with lack of knowledge about future predictions and uncertainties associated with the degree of disturbances (Ahern, 2011). This last strategy implies the "opportunity" to learn by doing, which relates to the "adapt as we go" method. When discussing building urban resilience this reflects the need to have short term and long term plans, where short-term plans are implemented and improvements are made throughout the learning process (Ahern, 2011; Djordjević et al, 2011; Solecki et al, 2011).

Overall, to ensure flood planning response strategies are effective, mitigation management and control strategies for extreme weather events are needed as outlined by *The 2013 Great Alberta Flood: Actions to Mitigate, Manage and Control Future Floods* report (Alberta Water Smart, 2013). The report provided six recommendations to ensure best practices;

1. Anticipate and plan for extreme weather events
2. Improve our operational capacity to deal with potential extreme weather scenarios through better modeling and data management
3. Investigate the cost/benefit analysis of investing physical infrastructure
4. Consider flood risks in municipal planning and strengthen building codes for new developments in floodplains

5. Evaluate options for overland flood insurance
6. Manage water resources collaboratively

2.4.3 Uncertainty Planning

Uncertainty can be defined as imperfect knowledge or understanding, which causes resource and/or environmental managers to make decisions without knowing the full implications or consequences of their choices (McBean, 2010). There are flood scenario models and forecasting systems designed to calibrate estimations of when future rainfall events are going to occur and their magnitudes. There are many uncertainties in incorporating climate predictions and assessing changes on rainfall activity. There are four kinds of uncertainty: (1) risk which is the there is available data to measure risk estimations with higher probability of accuracy, (2) uncertainty is when there is insufficient amount of available data, in which there is lower probability of estimating flood outcome with greater confidence, (3), ignorance can be described as the non-recognition of a problem and therefore it is not considered in management practices, and (4) indeterminacy is the lack of understanding of the causal and effect relationships due to lack of full knowledge of system functions (McBean, 2010).

Uncertainty analysis can serve as a tool to develop a better understanding of numerical approximations and the limited data available (Merz & Thieken, 2005). This is useful for decision-makers and also for working with model and forecasting uncertainties. Within the decision making process there are characteristics that can be looked at: decision making under certainty, risk, and uncertainty (Mills et al, 2010). This signifies that there are various known and unknown factors in FRM and that decision-makers base their decision on probabilistic models. Merz & Thieken (2005) identify two kinds of

uncertainty: natural and epistemic uncertainty. Natural uncertainty is the variability of stochastic processes. This type of uncertainty "is incorporated in the distribution function of the annual maximum series from which the flood design criteria (e.g. annual failuer probability, AFP) is derived" (Merz & Thieken, 2005). Natural uncertainty considers variables over time, space or even populations (e.g., precipitation levels over several years or clay content in soil) (Merz & Thieken, 2005). To provide a better characterization probabilistic models are used to describe the behavior of these variables.

Epistemic uncertainties are the uncertainties associated with knowledge as a result of limited availability of data, ambiguous or inappropriate statistical assumptions (Hall and Solomatine, 2008). It is this type of uncertainty that may create a sense of conflict amongst decision-makers where there might be mistrust in the data. When implementing resilience measures to floods, millions of dollars are spent and it is critical to review and assess the data to ensure the wrong assumptions are not being made. To reduce uncertainty in flood planning, Diordievic et al, (2011) suggest that the 'learn as we go' adaptation approach can result in significant progress building urban resilience to floods. This approach addresses changes in future drivers (e.g., climate change, urbanization), pressures (e.g., increased precipitation magnitude), state (e.g., increased risk vulnerabilities), impacts (e.g., increased flooding and damages) and lastly responses, e.g., policies, structural & non-structural planning (Gersonius et al., 2012). This also includes looking at the cause-based relationship, identifying the response planning techniques to pressures and impacts that will sustain expected functioning (Jones and Preston, 2011). The problem with this method is the reliance on estimations and uncertainty in direction, rate, magnitude of climate change and changes in hydrological processes in urban

drainage systems, therefore limiting the usefulness of this approach (Willems et al., 2012). It is important to set short term and long term goals in resilience building to respond to climate change and urban flooding. This will allow us to implement measures to reduce impacts and also to review implemented plans and enhance flood alleviation as lessons are learned.

As discussed there are several problems associated with existing urban drainage systems, longevity and capability to withstand climate change impacts. Generally urban infrastructure has a lifetime of approximately 30 to 200 years (Balsells et al, 2013). To assess the durability and sensitivity to climate change impacts decision-makers use impact assessment models under specific climate change scenarios that predict various conditions to change. This method allows decision-makers to establish adaptation response strategies. Climate change uncertainty planning and adaptive strategies can provide optimal decision-making and increase urban resilience.

Many studies (Gersonius et al., 2012; Satterthwaite and Dodman , 2013; Tingsanchalie, 2012; Vale et al, 2005) suggest the managed/adaptive strategy for climate change mitigation. Managed/adaptive strategy mainly consists of adaptive plans for a preliminary goal, such as risk minimization, and implementing incremental modifications to planning measures over time as the environment changes. This can be applied through setting a list of objectives and monitoring applied measures. This allows for more flexibility in climate change uncertainty planning as this permits for more planning options overtime as better understanding and more variables are obtained.

2.5 Summary

The literature review examined various factors concerning flood response planning. It is evident that extreme urban flooding is a growing environmental concern across Canada. Not only is it a major concern for individual property owners, but for business, insurers and the economy as well. Effective flood policy, emergency response, and post-flood response planning are essential in to build resilience to urban floods.

The reduction of green spaces and an increase of urban infrastructure have imposed significant changes to cities and flood activity. As a result many cities are experiencing increased flooding and high damage repair costs and insurance claims. Resilience building is the resistance to disturbance and facing minimal to no impacts. Therefore policies, land-use regulations, and community participation aid in develop flood control and preventative measures. There are many uncertainties and grey areas in research and it is difficult for decision-makers to be certain in flood management practices.

The literature review developed a basis to understand and identify flood response practices. Appendix A portrays a conceptual framework of key characteristics in flood response planning. This conceptual framework was used as a foundation for this research and to assess flood resilience building.

Chapter Three: Methodology

3.1 Introduction

This chapter presents the methodology and methods used in this research. The first section provides a description of the research approach, providing an explanation of why a qualitative analysis approach was selected to evaluate the case studies. This section is followed by methodologies used to carry out the qualitative analysis, including a description of the case studies, methods, and data analysis.

3.2 Methodology

In order to assess and analyze flood management practices a qualitative research approach was used. Qualitative research involves exploring and understanding individuals or groups in a social context (Creswell, 2009). This allows examination of responses from different participant groups ranging from government, private sectors, academics, and NGOs. These groups were chosen specifically because they were identified through literature and flood recovery reports to be key players in flood response planning.

Data collection for this qualitative research consisted of designing an interview protocol (Appendix B) and analyzing the data by interpreting interview responses to generate general themes (Creswell, 2009). Therefore, qualitative research is an appropriate approach to proceed with when assessing weaknesses in existing flood planning responses, identifying and providing recommendations for future planning strategies to increase urban resilience. Morse (1991) states that qualitative research explores problems where the variables and theory lack sufficient knowledge and, understanding and therefore, there is a need for further exploration to develop better

understanding of the phenomena. In this case there are plenty of grey areas when it comes to analyzing urban flood response measures and resilience building.

In the literature review flood response planning is associated with great uncertainty in preparedness planning and building urban resilience. For planners this is a critical debate and creates conflict in the planning and decision-making processes. Key areas in flood response planning identified in the literature were used to construct a conceptual framework in Appendix A. The conceptual framework consists of the different factors that are taken into consideration in flood response planning and resilience building. A description of each factor and suggested response strategies are provided in the table. This research investigates planning approaches indicated in the conceptual framework to evaluate non-structural measures in resilience building.

In this research, the case studies involved a comparative analysis of flood response strategies in the cities of Calgary and Toronto. These two cities were selected based on the floods that occurred in June and July of 2013, respectively. Both cities vary geographically, Calgary being in western Canada and Toronto in central Canada, and experience different factors that cause urban flooding to occur. The case-study approach was selected to analyze flood response measures in these two regions in Canada and to understand the similarities and differences to identify lessons learned in flood management.

3.2.1 Case Studies

Toronto and Calgary are two cities that are of high interest for urban floods. Both these cities have experienced several floods, most recently in the spring/summer of 2013. Although the intensities may differ, Calgary and Toronto are two of the most urbanized cities in Canada (Statistics Canada, 2015). Therefore it is vital for flood response planning programs to be effective to protect citizens, property and to apply cost effective strategies to reduce damage repair costs. When considering flood management in Canada, conservation authorities play a major role in Ontario (Mitchell et al., 2014). Among other cities the conservation authorities develop programs and identify areas that require improvement and investment to build resilience against urban floods **(**Bocking, 2006). The case studies analyze the different roles involved in flood response planning, and identify challenges, and types of improvements needed to increase urban resilience. Flood response planning measures in Toronto and Calgary have similar objectives including flood mitigation, preparedness, response, recovery, and resilience planning. The overall goal is to overcome the challenges caused by social, physical and economic impacts and increase urban resilience (Kelly et al., 2010; City of Toronto Emergency Plan, 2012).

The City of Toronto is the largest and most populous city in Canada. Toronto's population census metropolitan area (CMA) in 2011 was 2 615 060 (5.5 million in the Greater Toronto Area) indicating a 4.5% population growth since 2006 with a population size of 2, 503, 281 (Statistics Canada, 2012). The city of Toronto has experienced several major urban floods, but flood response planning was first initiated after Hurricane Hazel hit in 1954 (Bocking, 2006). Over the past couple of decades Toronto has expanded

greatly and newer communities are continually being developed in the greater Toronto Area. This is of concern in preventative measures to reduce urban floods. Areas such as the Don Valley and Eastern beaches are part of the City of Toronto that have historically experienced flooding and are especially vulnerable to future flooding as these are highly dense urbanized areas (City of Toronto Emergency Plan, 2012). Therefore, it can be expected that future events will face a greater disturbance compared to previous flood events due to increased urbanization in the surrounding areas. It is important to have preventative and regulatory measures in flood management. In Toronto, the Toronto and Region Conservation Authority (TRCA) and the Ministry of Natural Resources are the main actors in flood prevention and emergency planning. These two agencies work together to develop reports on floods and provide recommendations to the municipality to implement necessary flood risk reduction plans (City of Toronto Emergency Plan, 2012).

Current flood response measures focus on regulatory preventative measures in flood control, erosion, forecasting and emergency warning. In the planning process actors from provincial and municipal agencies take the lead in the decision-making. There are other organizations that are contributors in flood response planning, as outlined in the Table 1 below. The Ministry of Environment and Climate Change directs measures to mitigate climate change to apply adaptation strategies to reduce flood impacts. Actors in private organizations are consultants and urban developers that conduct assessments in pre-disaster and post-disaster planning. The Institute of Catastrophic Loss Reduction, The Conference Board of Canada, and Golder Associates are some of the private organizations that conduct environmental assessments and environmental consultation. These reports are provided to the municipality to suggest planning measures alleviate

flood impacts. Researchers from academic institutions also play a role in resilience planning by contributing knowledge on examining flood and impacts on socio-economic and ecological systems in cities. Non-governmental organizations include organizations like Toronto Environmental Alliance (TEA), Evergreen, Greenpeace, and Creating Resilience to Extreme Weather (CREW). NGOs are critical in engaging community members and building networks. These organizations aid in advocating sustainable and resilient responses during emergencies responses and develop preparedness strategies for homeowners. Table 1 below provides a list of key organizations in flood management practices and a description of their role. Following is Figure 3, which is a flowchart highlighting the hierarchical relationship among the different organizations.

Table 1. **Key Institutions and Actors in Flood Prevention, Recovery and Resilience Planning in the City of Toronto**

Institutions	**Description**
Ministry of Natural Resources and Forestry	- Provide provincial flood watch and watershed management
Ministry of Environment and Climate Change	- Mitigate climate change to reduce future flood impacts
City of Toronto: - Environment & Energy Division - Office of Emergency Management	- Assess flood impacts and develop solutions to reduce flood risks - Develop emergency response measures and policy
Toronto and Region Conservation Authority	- Focus on prevention and management of water related hazards; flooding and erosion control - Provide recommendations to the municipality on policy
Private organizations	- Consultants, provides reports on flood response practices and suggest improvements
Academics	- Research flood impacts, sustainable and resilience building
Non-governmental organizations	- Build networks in communities and provide education and awareness programs to create more sustainable and resilient communities to natural disasters

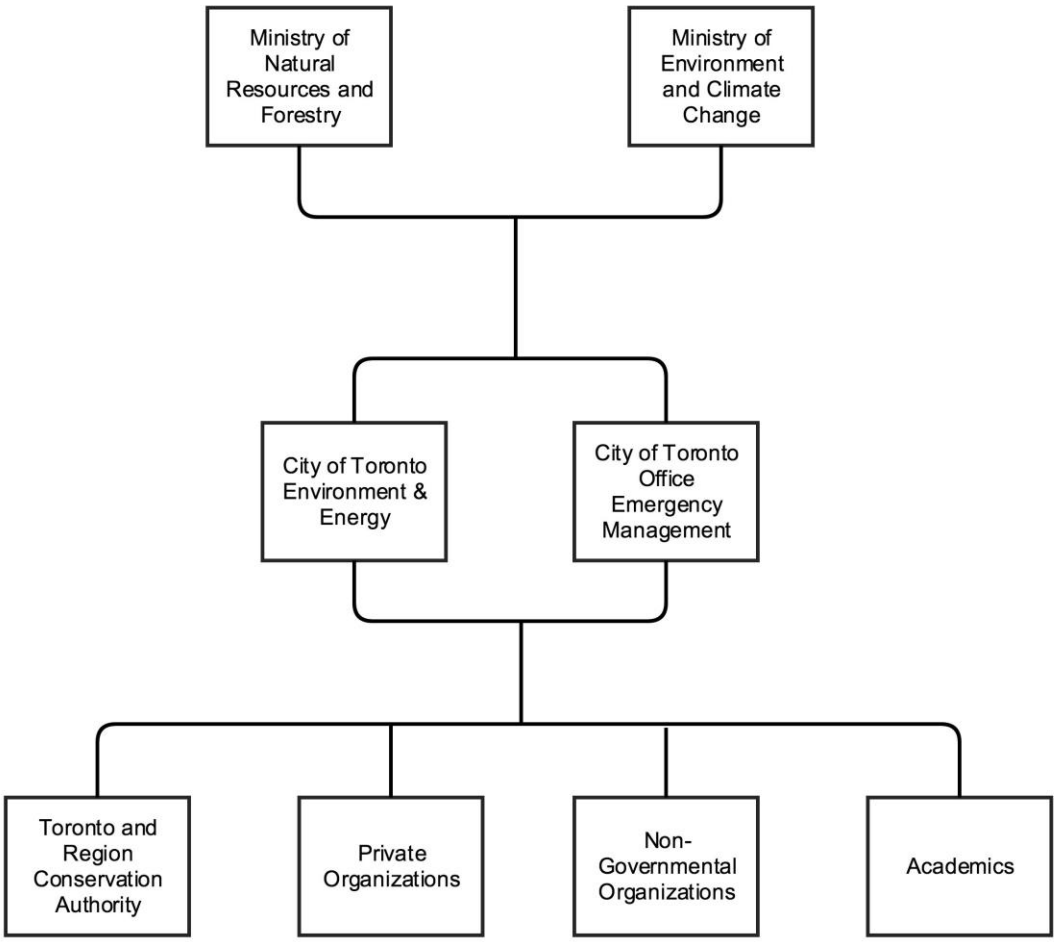

Figure 3. **Organization of Agencies and Actors Toronto**. Displays the organizational relationship between key governmental agencies and non-governmental actors in flood response planning in the City of Toronto

The City of Calgary is located in southern Alberta and is one of the rising business centers with the rapid economic growth in western Canada (Statistics Canada, 2012). Calgary is the largest city in Alberta and the fifth largest city in Canada with a population of 1,214,839 people (Statistics Canada, 2012). Calgary has experienced several major floods prior to the most recent in June of 2013 that left significant costs to damage repairs and insurance claims. There are several factors that can contribute to

urban flooding in Calgary, such as combined precipitation and snow melt increasing the rate of river flow and volume causing flash floods. This type of flooding imposes great impacts on vulnerable communities that do not have substantial flood warning systems, causes significant damage to thousands of homes, and displace large numbers of citizens through a state of local emergency evacuation.

In Calgary snowmelt combined with intense rainfall is a key contributor to major flood events (Kelly et al., 2010). Communities localized by the Bow and Elbow Rivers are low elevation areas that are at most risk. Historically Alberta has a long history of floods, the earliest records going back to 1897 and the following floods occurring between every couple of years and a twenty-year period (Kelly et al., 2010). The availability of flood records has allowed for the development of flood maps to better understand the occurrences of floods and also to predict future floods. The literature review indicated that this is a difficult task because often there is insufficient data to compare flood information. Therefore, predictions of 1-100 year floods estimate major flood scenarios, but do not necessarily mean they will occur every 100 years. In this analysis, the planning process for future floods will be assessed considering impacts of climate change and the complexities in the decision-making process and policy development.

Flood response measures include flood mapping, flood forecasting, land-use regulations, flood and emergency response plans (Kelly et al., 2010). The city of Calgary has formed a Flood Recovery Task Force and an Expert Management Panel to develop strategies in flood response planning and resilience building. Members of the Flood Recovery Task Force include members from “ministries of Aboriginal Affairs,

Environmental and Sustainable Development, Health Services, Human Services, Transportation, Treasury Board and Finance and Tourism, and Parks and Recreation" (Olesen, 2013). Responsibilities of the task force include recovery assistance, mitigation and building urban resilience assistance for the city's business planning and budgeting processes. This program aims to provide a holistic community-based approach of collaborative planning in flood resilience practices. The Flood Recovery Task Force has released a flood recovery framework (FRTF, 2013), which consists of guidelines for long-term flood relief, community restoration and urban resilience. The City of Calgary also established an Expert Management Panel consisting of national and international expertise of engineers, consultants and environmental planners. The panel reviews current flood response programs in Calgary. The overall goal for the Expert Management Panel is to develop strategies to reduce flood impacts focusing on six theme areas; climate change, watershed management, event forecasting, storage, diversion and protection, managing flood risks, and infrastructure and property resiliency (Expert Management Panel, 2014). The Watershed Planning and Advisory Councils (WPACs) are private and non-profit organizations that are designated by Alberta Environment and Parks. There are eleven WPACs that represent major river basins in Alberta; Calgary is designated within the Bow River Basin (AEP, 2015). These WPACs take the lead in watershed stewardship activities such as flood mitigation, watershed management, and facilitating stakeholder awareness. EPCOR Water Canada, AMEC Earth & Environmental, and Engineers Canada are examples of private organizations that provide consultation and develop solutions to improve flood management practices in Calgary. Green Calgary, Cows and Fish, and Alberta Ecotrust are local NGOs in Calgary that

advocate environmental issues and mobilize stakeholders to participate in stewardship activities to build more sustainable and resilient communities. These activities help to increase environmental integrity and well-being of stakeholders. Researchers from the University of Calgary also have a role in contributing information and expertise in understanding urban flood and resilience building. Table 2 and Figure 5 below provide a list of the key institutions and actors in Calgary flood management and an illustration of the relationships of the institutions in planning responses.

Table 2. **Key Institutions and Actors in Flood Recovery and Resilience Planning in the City of Calgary**

Institutions	**Description**
Alberta Environment and Parks	- Provides emergency response, post-flood recovery and preparedness planning to mitigate flood hazards
City of Calgary: - Utilities & Environmental Protections - Environmental & Safety Management - Flood Recovery Task Force - Expert Management Panel	- Municipality division responsible for city infrastructure and utility services - Direct and manage emergency planning - Provides leadership to the City of Calgary and communities within the city including representatives across The Corporation to organize the City's flood responses with other levels of government and partners - A panel of experts of Canadian and international recognized professionals to lead Calgary's River Flood Mitigation Program
Watershed Planning and Advisory Councils (WPACs)	- Watershed management stewardship of private and non-profit organizations directed by Alberta Environment and Parks to conducting watershed status reports, implementing collaborative planning and leading environmental education programs
Academics	- Research flood impacts, sustainable and resilience building
Non-governmental organizations	- Build networks in communities and provide education and awareness programs to create more sustainable and resilient communities to natural disasters

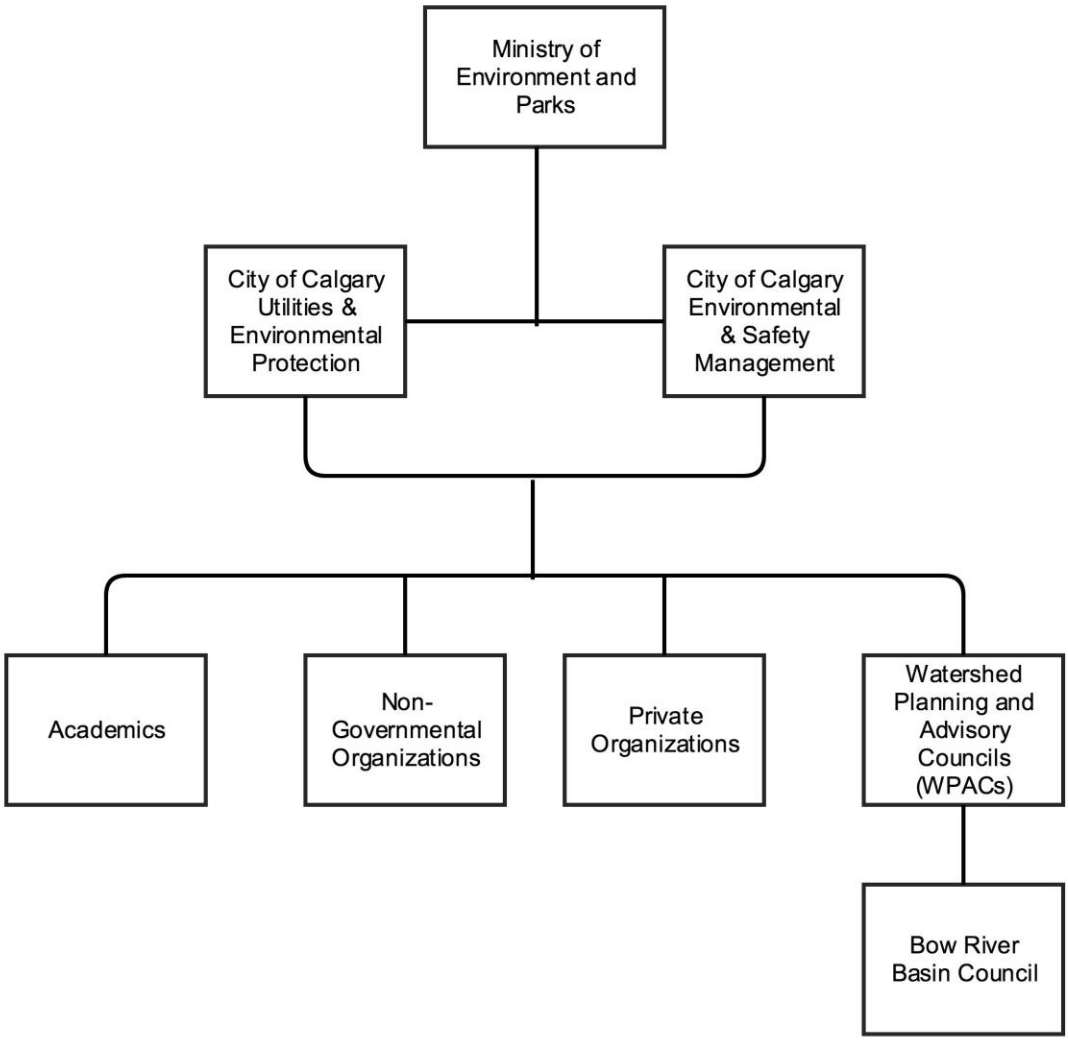

Figure 4. Organization of Agencies and Actors Calgary. Displays key governmental agencies and non-governmental actors in flood response planning in the City of Calgary

3.2.2 Methods

Semi-structured interviews were conducted with key actors involved in flood response planning from provincial and municipal government, conservation authority, private organizations, academics and NGOs. The interviews were used to collect data on flood response practices and resilience building in Toronto and Calgary.

Participants in this study were selected by conducting an Internet search of the relevant organizations/agencies listed in Table 1 and Table 2. The criteria used to recruit prospective participants were based on looking at their position titles and identifying those that worked in positions in actual flood-management related roles. The selected participants from the higher-up organizations work in watershed management or in flood response and emergency response sectors as directors, coordinators, planners and analysts. Academic participants were selected based on a related research interest in flood management and resilience building. Lastly NGOs participants were selected based on the criteria of having hands on experience in directing projects to reduce flood impacts and building community resilience to natural disasters.

An outreach email (Appendix C) was sent to these potential participants. A total of 154 outreach emails were sent to the selected individuals to participate in the research. 28 of 154 of the contacted prospective participants replied and were willing to voluntarily participate in this research. Other contacted individuals that did not participate in the research replied that they were not the best fit for this study or did not have the time to respond to the questionnaire. Potential participants that declined often suggested colleagues that had greater expertise on this topic. Therefore, the sample size used in this study is 28, which is comprised of 14 participants in each of Toronto and Calgary. Each of the participants was provided a consent form (Appendix E), which outlines the approved research guidelines by the Wilfrid Laurier University Research Ethics Board. The guidelines ensured that identifying information will be kept confidential, and required the consent to audio record the interview that was used for transcribing purposes.

The semi-structured interviews took approximately two months, from February to the end of March of 2015. The interview protocol in Appendix B was used to explore flood response planning experiences. The interview protocol was designed to exhibit each of flood planning criteria and to assess strengths, weaknesses, and lessons learned. The interviews varied in duration from half hour to an hour. After all the interviews were conducted the recordings were transcribed and reviewed creating a results table for each city (Appendix E & Appendix F). This table is organized accordingly to each participant group and the participant responses to each interview question

3.2.3 Data Analysis

After the semi-structured interviews had been conducted for both cities, the recorded interviews were transcribed by the researcher. The interview transcriptions were then reviewed highlighting the key points of the responses for each participant and a results table was compiled for each city, presented in Appendix E and Appendix F. The tables outline the responses of each participant to each question. Observing these result tables, similarities and differences in response measures can be identified. A code was assigned to each participant, which can be found in Table 3 and Table 4 in Chapter 4 and 5.

The data analysis consisted of going over the transcripts and identifying commonalities and differences of the interview responses. The results table was used to highlight the key participant responses for each question, which are expanded in greater detail in Chapters 4 and 5. The interview results were used to indicate where responses supported each other and disagreed with each other among the different participant

groups. Shared views or common interview responses were determined by identifying reoccurring key words. This included common expressions of different types of suggested planning measures, identified impacts, challenges, barriers, conflict and unique challenges. Recognizing new key words and disagreeing expressions in comparison to other comments was used to identify differences of interviewee responses. Responses for each interview question were evaluated to assess strengths, weaknesses and recommendations to enhance flood management practices and resilience building.

3.2.4 Comparative Analysis

The comparative analysis evaluated interviewee responses to flood resilience strategies in the Toronto and Calgary. The main objective of the comparative analysis is to identify the strengths and weaknesses and how to enhance future planning. The results tables in Appendix E and Appendix F highlight key results of past and current existing programs and agencies involved in flood mitigation, development of effective response recovery programs and building urban resilience. The analysis also explores climate change impacts as a factor in resilience planning in these urban centers. The comparative analysis assesses five theme areas in the results; resilience planning, anticipatory and uncertainty planning, tools that work well, tools that don't work well and lastly barriers. These five themes were used to conceptualize the differences and commonalities of flood resilience priorities, challenges, effective planning tools, and barriers in Toronto and Calgary. Table 5 in Chapter 6 summarizes the key results highlighting findings that are unique to Toronto and Calgary and common in both cities. Interviewee responses were

compared and synthesized using literature to support research findings to provide recommendations on how to increase resilience to urban floods.

Chapter Four - City of Toronto Results

4.1 Introduction

This chapter will present the data that was collected from the City of Toronto Participants. A total of fourteen interviews were conducted, in which the participants were asked to respond to the questions in Appendix D. Participants were grouped into six categories: provincial, municipal, conservation authority, private organizations, academic faculty, NGOs. Each of these participant groups plays a major role in urban flood response planning. Responses from the interviews represent experiences working in flood risk management, emergency responses, research and resilience building.

A summary of the participant groups and the participant codes are listed in Table 3. The section below examines the key results of the interview responses according to each question. In this chapter the responses are compared among all participants to identify where they agree with each other, where they vary, and where complexities in flood management planning exist.

Table 3. City of Toronto Participant Codes

Group	Participant Title	Code
Provincial Government	Toronto Provincial 1	TP2
	Toronto Provincial 2	TP2
Municipal Government	Toronto Municipal 1	TM1
	Toronto Municipal 2	TM2
Conservation Authority	Toronto Conservation 1	TC1
	Toronto Conservation 2	TC2
	Toronto Conservation 3	TC3
	Toronto Conservation 4	TC4
Private Organization	Toronto Private Organization 1	TPO1
	Toronto Private Organization 2	TPO2
Academic	Toronto Academic 1	TA1
	Toronto Academic 2	TA2
NGO	Toronto NGO 1	TN1
	Toronto NGO 2	TN2

4. 2 Results

Is Flood response planning a priority for your organization/agency? What priorities are your main ones?

Responses to the first question vary among all individuals that participated in the interview. Not all participants stated that flood response planning is a priority for their organization. Those participants that stated no (TAI, TA2), did not work directly in flood response management but contribute understanding of social, economic, and ecological interactions in cities, which reflect resilience dynamics. For provincial institutions such as the Ontario Ministry of Municipal Affairs and the Ministry of Environment and Climate Change flood response planning is a priority by administering infrastructure and allocating money for flood alleviation programs and mitigating climate change. The main priorities include assessing impacts on floods and developing flood recovery responses. The Ministry of Natural Resources and Forestry (MNRF) was described to be responsible for riverine flooding as the municipality and the Toronto and Region conservation authority are responsible for flood response planning (e.g. Infrastructure). Decision-making was noted to be a collaborative responsibility of the provincial and municipal government. Some respondents (TP1, TC1, TC2) made reference to the Provincial Policy Statement (MMAH, 2014), which serves as a tool to regulate land-use policies and guidelines for new developments in Ontario. This is a critical mechanism to prevent development proceeding in flood vulnerable areas and to reduce flood impacts and reduce damage costs.

Municipal participants indicated that flooding has been described as the most expensive natural disaster and suggested that flood response priorities need to take more proactive means in flood response practices (TM1). An emergency management plan is

legislated by MNRF ensuring a flood risk specific plan (TM2). (TM1, TM2) indicated these plans are used and work closely with TRCA where they provide recommendations to the municipality providing flood maps, identifying vulnerable areas in the city and dividing responsibilities in flood response planning.

The Conservation Authority provides and administers regulations, governs planning in some protected areas, and provides flood warning and advisory systems to the City of Toronto (TC1, TC2, TC3, TC4). Primarily, the foundation of the conservation authority is to apply protective and preventative measures in watershed management, reduce risks from flood hazards, ensure municipal development planning follows the Provincial Policy Statement and ensuring resilient building (TC1, TC2, TC3, TC4). Other priorities of the conservation authority are to monitor and regulate flood risk reduction, flood risk avoidance, flood forecasting, warning and preparedness planning. Alongside the conservation authority there are private organizations that provide consultative and research reports to assess disaster response plans and disaster mitigation planning (pre-disaster and post-disaster) (TPO1, TPO2). These organizations provide assistance to local governments and decision-makers to build more resilient communities (TPO1, TPO2). To ensure resilience building it was indicated that building partnerships is key, therefore partnerships among developers and insurers are necessary to adopt in resilience building standards.

Members of faculty that participated do not have a direct working role in flood response planning, but conduct research in related fields of study and are familiar with flood management (TA1, TA2). Responses from faculty members were generally observations of current events occurring in the city and of changes in municipal

administration. A problematic concern in flood response planning observed was change in administration (TA1). This was noted to impact flood response planning as its priority is postponed on the agenda. Another response stated that priorities focus on understanding peak flow predictions in the context of climate change and also enhancing understanding of land-use changes and urbanization (TA2). It was discussed that urban sprawl is a concern for the city and for the Greater Toronto Area (GTA). TA1 and TA2 both support that the city requires strategic planning ensuring smart growth and more resilient building.

Non-governmental organizations (NGOs) play a vital role and have great knowledge on flood response management. (TN1) represented an NGO whose resilience efforts focus on ways of reducing flood impacts, repair costs and sustaining water quality after a flood occurs. TN1 addressed a concern of sewage drainage contaminating storm water drainage during intense rainfall. It was explained that sewage water often mixes with rainwater, which can be detrimental for E. coli outbreaks. Therefore, TN1 expressed high concern for the need to develop effective flood emergency protocols to ensure rapid clean up after a flood occurs. This includes having cleaning equipment on site to respond quickly. Other main priorities include building community resilience to extreme events (TN1, TN2). This focuses on targeting vulnerable communities in Toronto and developing workshops and programs where community citizens are engaged and aware of what steps to take during an extreme weather event and know who to contact before first responders arrive (TN2).

How do you consider resilience in planning for extreme events such as floods?

Participants first responded by asking for a clear definition of resilience and a clarification if the questioned referred to flood planning or flood emergency responses. Resilience was defined for participants as the ability to experience minimal impacts in an occurrence of a natural disaster. This reflects the ability of socio-economic and ecological systems to experience minimal losses and function normally. Resilience planning was referred to a combination of flood planning including: pre-disaster, emergency, and post-disaster planning.

TP1 responded indicating that resilience planning needs to adjust to land-use practices and follow the Provincial Policy Statement effectively. As mentioned before the Provincial Policy Statement ensures future building standards to protect vulnerable communities and new developments have minimal impact on the environment. TN1 suggested that there needs to be consideration of climate change adaptation in urban designs such as soft spaces, green designs and permeable surfaces. TP2 agreed and stated that resilience planning for extreme events, such as floods, needs to look at adaptive and mitigation measures to reduce climate change impacts by lowering greenhouse gas emissions, which will hopefully slow the rate of extreme rainfall frequency. TM1 discussed that planning for resilience flood responses on the municipal level requires assisting people with emergency responses and public health. TM2 recommended that flood response practices need to reflect how extreme impacts can alter as climate changes over the years. This also relates to assessing risks that currently exist and also the possible hazard risks in the future. Therefore, resilience planning requires the

collaboration of many divisions within the municipality to build flood urban resilience (TM2).

Participants from the TRCA expressed their core work focused on resilience planning where risks are minimized by implementing response and mitigation strategies to improve infrastructure, reduce erosion and most importantly prevent development in the floodplains (TC1, TC2, TC3, TC4). Looking at the historical data, 1954 was when Hurricane Hazel hit the City of Toronto, which was indicated to be used as the default extreme flood reference point (TC2 & TC3). Since then there have been policies to prevent new developments being built within the flood hazardous zones. TC1, TC2, TC3 & TC4 described their organization to be an entity where they have developed risk mapping based on flood events and probabilistic storm predictions throughout the city's watershed and other surrounding jurisdictions. In terms of resilience building, the integration of legislated policies and models helps to provide protection for newer developments ensuring minimal risks.

From a private sector perspective, resilience planning involves partnerships with other privately owned organizations and government providing research to limit the impacts of disasters (TP1 & TP2). It was distinguished that many of the organizations involved in response planning are not directly involved in resilience planning and are mostly engaged with incident response and management (TP2).

Interviewees indicated a problematic concern in flood response planning for cities is remaining in the reactive phase and not promoting resilience and risk reduction through proactive measures and pre-disaster planning. Therefore, it was suggested (TP2) that resilience planning needs to focus on improving future building of communities,

minimizing risks of natural disasters, and increasing ability to bounce back up to normal conditions. Academic participants suggested that flood mitigation needs to adapt to climate change as increasing frequency and intensity of extreme weather is expected (TA1, TA2). Resilience planning measures need to implement low impact developments and improve storm water systems to increase capacity to capture storm water (TA2). Having structural measures will help sustain the natural water system and also build urban resilience in communities across the city (TN1)

When discussing resilience to extreme flooding, NGO participants' responses focused on clean up, anticipatory and emergency response planning (TN1) Retrofitting can help mitigate floods since flooding is expected and if we adapt for it to occur we can shorten the recovery period and also reduce damage and costs for clean up (TN1). Retrofitting is also beneficial because adapting property to floods will help to minimize damages and also decrease insurance claims (TN1). Looking at the lower Don River Valley in the City of Toronto there are rain gauge systems that monitor and observe when storm water reaches their threshold, which acts as an alert system to forecast flooding and to send out warning for evacuation and begin contacting response and clean up crews for rapid recovery.

Are there any key uncertainties in response, sustainability or resilience planning? If so what?

Representatives from all groups have agreed that there are great uncertainties in flood sustainability and resilience planning. The number one uncertainty that was stated was the lack of complete understanding of climate change, climate projections, future flooding impacts, and risks of changing precipitation duration, frequencies and intensities

(TP1, TM1, TM2, TC1, TC2, TC3, TC4, TPO1, TPO2, TA1, TA2, TN1). TM1, TM2, TC1, TC2, TC3, TC4 use worst case scenario modeling in predicting future floods on larger to smaller regional scales. There are uncertainties with knowing how to reduce green house gases to mitigate climate change (TM2). These worst case scenario models require updated flood mapping to identify the most vulnerable areas (TM1, TM2). TM2 strongly expressed that in Toronto there is an extensive riverine flood map, but there is insufficient urban flood mapping with proper documentation identifying areas that experienced flooding across the city. This is a vital component in building resilience and identifying which areas are high priority (TM2).

Specialty policy areas are areas that are built in the floodplain that require frequent monitoring and technology to reduce the risks (TC4). TC2 and TC3 expressed that there are uncertainties in this method of resilience planning because there are technical uncertainties relating to climate change, engineering and modeling. These unknown factors may arise in redevelopment for special policy areas, flood proofing methods, and buffers may not be as successful as anticipated.

Many participants stated that there are uncertainties with not knowing when extreme events are going to occur and what their future intensities will be. Therefore climate change needs to be embedded in the learning process and also enhanced understanding of the return period of extreme floods needs to be achieved (TPO2, TA1, TA2, TN1). These participants also suggested the need for education and awareness programs to improve general knowledge about flooding and what actions need to be taken to reduce risk. In terms of planning, (TC4) identified that not all risks are preventable and planning measures depend on how much we are willing to tolerate and

pay for. TP1 and TP2 stated that climate change is a complex concept, and that there are many uncertainties of what the probable exposures to risk might be and what this means for individual property damages and value.

There are many uncertainties surrounding anticipation and preparedness planning because there are complexities in understanding how the extreme flooding will impact the people and the city as a whole (TN1,TN2). It was then discussed that flood response practices come down to understanding how weather systems work and how flow of water down the watershed behaves. TN2 discussed that aside from property damage and overland flooding there are also indirect complications during floods such as power outages indicating existing gaps in management and planning responses.

There is uncertainty in planning in assessing vulnerable citizens and trying to build community resilience for seniors and disabled (TN2). Many of the responses indicated a great deal of uncertainty dealing with lack of information, technical uncertainty, understanding the likelihood of extreme events and exposure to various types of risks (TP1, TP2, TM1, TM2, TC1, TC2, TC3, TC4, TPO1, TPO2, TA1, TA2, TN1, TN2). Not all risks can be prevented, but medium to long-term planning strategies can be developed and appropriate budgeting can be put in place for what needs to be done. (TPC4, TC4).

What urban flood resilience (planning or response) tools and response approaches do you think work well or do not work well?

There are many tools and planning approaches used that can be divided into two categories: physical (structural) and behavioral (non-structural) (TPO2). Participants TPO1 and TPO2 said that the physical tools, such as infrastructure, are the responsibility

of the municipal government, but Toronto lacks the ability to provide consistent maintenance of flood infrastructure. TPO1 and TPO2 suggested that they can have great potential to bring significant change for property owners. The problem with this approach is that the majority of property owners are not aware of what can be done and also lack interest in flood response planning.

TC1, TC2, TC3, TC4 suggest risk assessment is a very useful tool, which allows identifying various risks in vulnerable areas and examining water usage in the city for different uses (e.g. for home, recreation, etc.). The Ministry of Municipal Affairs and City of Toronto Environment and Energy Divison suggested introducing naturalizing programs to help overland runoff to increase infiltration into groundwater (TP1 & TM1). The city is also looking at implementing more green infrastructure and green roofs, which aid retaining water (TN2, TPO2). It has been observed that not all structural measures can protect everything, therefore taking a more naturalized approach is needed for Toronto to help deal with and reduce flash floods (TN1)

Communication tools are key for the municipality and for the conservation authority for using media outlets and other forms of communication tools to notify various divisions, first responders, and release public storm alerts in a timely matter and to get trained individuals out on the field (TM2, TA1, TN2). In terms of notifying the general public, more work is required to provide accurate information. Academic representatives (TA1, TA2) also stated that there is a need for more effective communication for accurate information, since it easy for inaccurate information to circulate.

Tools such as the Provincial Policy Statement ensure resilient building, when developers have to go through an approval process ensuring that new development is not in the floodplain (TC2, TC3, TC4). The TRCA monitors this closely along with the city making sure all policies and legislations are followed. Having the policies in place has proven to work well in Toronto, minimizing risks for later developments since Hurricane Hazel and also developing protective measures in special policy areas. TC1, TC2, TC3 and TC4 also noted that risk reduction does not work well because there are many risks associated with flooding. The city has identified risks pretty well although the urban flood map isn't as extensive as the riverine flooding map, and more work needs to be done because of the existing old infrastructure (TM2). The conservation authority provides assistance in suggesting which measures should be taken next, but it is up to the municipality to make the final decision and implement the changes (TC1, TC2, TC3, TC4). Private organizations suggested that risk can be reduced with proper infrastructure design and ensuring that it has the capacity to accommodate high intensity and volume of rainfall (TPO1,TPO2).

Academic representatives stated concerns about the lack of attention focusing on wetlands, grey spaces, ecosystem and hydraulic functionality (TA1 & TA2). Landscape management was discussed to be integrated with watershed management with the assistance of the conservation authority to regulate watershed-overlapping jurisdictions. These representatives also mentioned that the integration of other infrastructure, such as transportation and energy, is needed to respond well to floods dealing with road closures and power outages, indicating the need for more integrated holistic planning approach including all service sectors and also considering the indirect impacts (TA2).

NGO participants showed great support for retrofitting sites where flooding is expected to occur frequently, and having preparedness kits in place and equipment on site to allow for rapid and less costly recovery. Technology such as rain gauge monitors and mapping systems is useful in forecasting when there is an upcoming storm event allowing some time for safe evacuation if needed (TN1). It is also important to have preparedness planning tools in communities, building partnerships within the community to allow for better behavioral responses when an event occurs (TN1 & TN2). TN2 noted that planning strategies need to engage and mobilize citizens to work together and understand the seriousness of exposure to risk to ensure effective change. Also TN2 expressed that having preparedness kits in homes is a beneficial tool, which will allow for an effective response once alerts are received.

How do you plan so that future events have less severe impacts? Do you try to plan to make the city more resilient and less vulnerable?

Provincial and municipal participants indicated the importance of to mid-to long-term flood response plans working in conjunction with other divisions allocating resources and sharing information to ensure more effective preventative measures (TP1, TM1, TM2). It was also discussed that future events can experience less severe impacts by implementing more pre-disaster planning as opposed to post-disaster (TC4, TPO1, TPO2). All participants have agreed that as climate change progresses, adaptation and mitigation measures need to be in place to ensure significant preparedness planning to anticipated major floods.

Since the city's infrastructure is owned by the municipality, there are great responsibilities for the municipality to take action (TM1). This will require the

municipality to build partnerships with the conservation authority and other like-minded groups to enhance preparedness planning, education and awareness of vulnerability and risk (TM1, TM2). Sharing information and building partnerships with other organizations/agencies such as service providers is important to plan towards flood proofing planning resilient future developments (TM2, TN1, TN2). The conservation authority acts as a regulating body that oversees development in flood prone areas, assesses areas with high vulnerabilities, and looks for opportunities for redevelopment and infrastructure upgrades. It was suggested that prioritizing areas based on a set of factors and damage costs will help to identify areas at risk and assess evacuation and reducing risk to life in those areas (TC4, TN1). This will allow development of a significant flood remediation program indicating where exactly money should be invested in resilience planning (TC4).

Overall, in developing flood response programs, there needs to be a greater understanding of the flow of water in the watershed and learning how to reduce risk and limit development along rivers. The private sector provides consultative research work on these matters that suggests which flood implementations of low impact measures can help to improve storm water infrastructure to protect private properties (TPO1, TPO2). This also suggests that having pre-disaster plans can allow for a significant reduction of flood damages, but requires the collaboration of homeowners and the government. TN1 listed multiple low impact measures that can be implemented: un-paving spaces and placing permeable surfaces, rain cisterns, trenches in parking lots, storm management ponds and allocating the water where it can be used for other purposes as well, e.g. gardening as academic and NGO representatives suggested. There are structural measures such as

reservoirs and dams to help minimize floods, That alone cannot reduce impacts greatly, but combined with low impact development can allow for a better result.

Lastly community engagement is a critical component to improve emergency response and planning resilience building within communities as this allows for successful preparedness and anticipatory planning (TN2). This is vital in vulnerable areas to ensure good behavior in response to when an extreme event occurs, for example to ensure minimal vulnerabilities and physical injuries. Other measures the city can take to ensure resiliency and better response planning would be to have a resilience officer with expertise in these matters (TN2).

What are the barriers faced in response planning? Can you provide an example of particular case and what kind of issues arose?

Most common barriers identified in response planning included limited financial budgets (TP3, TM1, TC1, TC2, TC3, TA1, TN1, TN2), limited knowledge (TM2, TC1, TC4, TA1), and coordination and communication among service providers (TC1, TC2, TC3, TPO2).

Financial barriers in Toronto are observed as the inability to implement substantial flood remediation programs (TP3, TM1, TPO1, TC1, TC2, TC3, TA1, TN1, TN2). Barriers lie among decision-makers, determining who is going to pay for losses, and how much the municipality or the province is willing to pay. TC4 discusses risk analysis and assessing the level of anticipatory planning and tolerance of risk. Interviewees indicate that risk assessments have difficulty quantifying potential risks. In Toronto this is a significant barrier when developing response strategies to aging infrastructure (TC1). Limited resources in flood recovery practices can be attributed to

competing priorities that require urgent response such as transportation and health care (TA1). This argues for a shift of political interest and commitment to implement the necessary pre-disaster planning (e.g. policy development, legislating land-use) (TM1, TC4, TA1, TA2, TPO1). Financial constraints are also expressed to be a barrier for NGOs to implement effective education and awareness programs (TN1, TN2).

Limited knowledge was discussed to be a significant barrier in preparedness planning for flood events that have not happened (TPO1, TA1). Probabilistic models are used to predict future flood outcomes and to develop response strategies to prepare for anticipated floods (TM2, TC4). There are concerns regarding the accuracy and credibility of scenario based analysis, demonstrating barriers in decision-making and policy development. Identification of flood vulnerability in communities helps to reduce barriers in assessing factors in response planning (TM2). This consists of identifying exposed vulnerabilities of citizens, property, and aging infrastructure (TC1, TC2, TC3). This can be exhibited by considering early urban developments in Toronto where flood management and pre-disaster planning were non-existent (TPO1). Interviewees expressed concerns for the changing environment and the need to pursue proactive and pre-disaster measures.

Barriers exist in emergency response, anticipation, preparedness planning and communication (TM2, TPO1, TPO2, TC1, TC4). Extreme flood events can cause road closures and power outages and there are barriers for service providers to respond effectively (TC1, TA2). TM2 noted that there isn't enough planning to get roads closed in a timely manner in areas that are expected to flood such as the Don Valley Parkway in the low-laying parts of the low Don River Valley. Road closures prevent access for

emergency crews to respond to citizens located in high risk areas requiring medical assistance. Participants from TRCA indicated that there are barriers to various sources of communication outlets providing accurate flood updates in a timely manner such as radio stations providing variable flood updates on road closures (TC1 & TPO2). This includes flood status updates of road closures, power outages, available services and medical or evacuation assistance. Inadequate information update can prevent communication among first responders and citizens to get access to necessities during a flood event.

Other barriers exist when considering watersheds that cross over jurisdictions (TC1). Coordination among cross-jurisdictional partners, first responders, and community members is key in responding in emergency responses. Participants noted that in practice they know potential flood vulnerabilities, but the city doesn't have a program in place to identify vulnerable areas and how this will impact emergency responses.

What types of conflict, if any have arisen with other institutions and/or government in response planning?

Some conflicts that may arise are functionality across different levels of governance and changing interests and priorities (TP1, TM1, TC1, TC4, TA1). Changing interests and priorities affect which resources are being put in place. As suggested by the provincial government there needs to be horizontal planning, meaning that different levels of governance and local organizations/agencies and communities need to work together and share information so that resources aren't being wasted and there isn't repetition of response plans (TM2, TM3). The municipality already has a great

partnership with the conservation authority where effective regulatory programs are in place to protect the watershed and flood prone areas.

The provincial and municipal governments have their own priorities, and other issues compete resulting in postponing flood response plans on the administration's agenda (TM2, TC4, TA1, TA2, TPO2). This becomes a major concern especially after a certain period of time passes after an event occurs. This prohibits responding effectively because the urgency to enhance flood planning declines after an extensive period post-flood. This infers that strong political will is necessary to allow decision-makers to implement rapid flood response measures. Since there are many uncertainties with climate projections there are grey areas on where and how investments should be made in resilience building (TPO1, TPO2, TC4). Academic participants (TA1, TA2) also agree and referred to change in municipal administration as problematic where there is an interest shift, altering previous city plans such as transportation or climate adaptation. Since most public officials are in office for a short period of time it is difficult to make long term decisions and invest in flood response measures in the long term (TA1, TA2). Competing priorities and issues arise as to where to allocate funds and in identifying which problems can be realistically solved at the current time. This comes back to having experienced staff in the city that know how to respond to flood management conflicts, such as a resilience officer (TN2).

Conflicts also arise when developers propose to develop in floodplains or in areas identified as vulnerable to risk (TC1). A clear distinction of who has authority and a Provincial Policy Statement stating where development is prohibited help to reduce conflict and have been proven to be effective in Ontario (TM1). Planning measures need

to consider all sectors in the city and prevent creating gaps, such as in the energy sector to prevent power outages, and to coordinate with the rest of the response team. Some conflicts may arise when communicating with emergency responders and the public and getting accurate information out in a timely matter. Using social media as an outlet to send out a mass message to the public may be effective if the information is accurate.

Is there any community or NGO involvement in the planning process? How and how involved are they? Could local communities be more involved in the planning process? If so how?

Provincial, municipal, private and conservation authority groups expressed that NGO and/or community groups are involved in flood response planning in consultation and research work (TP1, TP2, TM1, TM2, TC1, TC2, TC3, TC4). NGOs also serve on working groups and committees, such as the environmental bill of rights (TP2). NGOs are also viewed to be credible in Parliament, providing accurate information and with a diverse background of cultures and people from different parts of the world (that have experience with flooding, and are useful in engaging conversations and developing response strategies) (TP2). Challenges community groups and NGOs face are not having enough resources to implement the necessary changes (TM1, TPO1, TPO2). Therefore these groups advocate their concerns and seek assistance from the municipality. Communities and NGOs are often involved in the preliminary consultation phase, but do not have a role in the decision-making. The information they provide during consultation period can help influence the decisions made on the municipal level.

It was discussed that even during the consultation period it is sometimes difficult to engage community members due to lack of interest (TC4, TPO2). Often those that do

participate and seek to share or get more information are those individuals that have been continually impacted by flood damages such as basement flooding. Public commenting under the Planning Act and community outreach in flood forecast awareness impacts are shared by individuals participating in community meetings to riduce risk and enhance preparedness planning (TC1, TC2, TC3, TC4). Generally, private organizations, conservation authorities and NGOs work together as like minded organizations sharing information and trying to develop flood response strategies and provide this information to the municipality. In other scenarios, low development regions have significant NGO and stakeholder involvement for a greater voice in preventing land-use changes in the protected area (TPO2).

The city of Toronto is a great city in terms of the strong presence of government and a strong network among different organizations and interest groups (TA2). Stakeholder involvement provided input on ways the city can plan and allow for smart growth and green initiatives and for social issues in marginalized areas influencing planning and policy (TPO1). There are many programs such as the Water Protection Act and River Keepers indicating stakeholder involvement in providing different perspectives and useful information in resource and preparedness response management activities (e.g. Emergency kits) (TN2)

A significant portion of NGOs' work is achieved through community members and volunteers where they work along with stakeholders and engage the community to build strong relationships and develop response strategies when an extreme event occurs. For some organizations community members may not be involved in flood management

initiatives, but are involved in sustaining the well-being of an area by tree planting and naturalizing watersheds (TN1).

What might be some of the unique challenges faced here for urban flood planning, compared to other cities?

Unique challenges the City of Toronto faces include being a large city and having much aging infrastructure (TP1, TP2, TM1, TM2, TC1, TC2, TC3, TC4, TPO1, TPO2, TA1, TA2, TN1, TN2). The city requires a strong political will across all levels of governance in resilience planning. Another thing to note is that not only is infrastructure aging, but also Toronto has a large, aging population creating more communities with vulnerable citizens (TP1, TM1, TM2, TC4, TPO1, TPO2, TA1 TA2). Another unique challenge the City of Toronto faces is its position in the lower watershed (TC4). Because Toronto is positioned at the bottom of a watershed, there is a lot of storm water management and flood control (TM2). In conjunction with aging infrastructure and increased development north of Toronto the rate of runoff may increase flooding and be observed to become more flashier (TC4). Some parts of the city are more complicated than others in terms of exposure to risk when an event occurs, making certain communities more vulnerable than others (TC1). (TA1, TA2) expressed that there are many rivers within the city compared to other cities and that there is a legacy issue of the mindset of early settlers developing along rivers and not thinking about storm water management during the time of development (TA2). Since Hurricane Hazel, comprehensive flood mapping took place and about twenty years later still it was updated. Toronto's flood map now need to be updated again and not only are communities built along rivers experiencing floods, but other parts of the city where

buried creeks are being discovered are experiencing flooding as well (TN1). A final unique trait observed in flood response planning is the response behavior of marginalized communities. (TA1, TA2) discussed that marginalized communities respond better because they are aware of the resources they can access.

Do you have any other thoughts about these issues?

Provincial and municipal government expressed their final thoughts on getting response measures effective rapidly and avoiding flood preventative measures getting lost in priorities list (TP1, TP2, TM1, TM2). Working towards greater public education and awareness of flood vulnerability and risk and engaging citizens in making conscious decisions about their contribution to the problem, are key; as well as collaborating with governments, organizations and communities to reduce flood impacts. Individuals can contribute to building more resilient cities by implementing changes to their own properties such as permeable driveways.

The conservation authority has been shown to be a great regulatory body and also an organization with expertise providing recommendations to the municipality as to which measures should be taken. It is important to continue this partnership to ensure that future communities are built resiliently and also seeking for opportunities to redevelop and revitalize urban communities to help minimize risks to flood hazards. All of this is possible by the municipality and the province investing in and acknowledging climate and partnering with other jurisdictions (TC1).

Academic and NGO participants expressed their final thoughts concerning education and awareness programs to enhance understanding floods and how weather

patterns behave. Most importantly understanding what the term 1-in-100 year flood means, which can be misinterpreted by the general public assuming that a 1-in-100 year flood occurs only once in a hundred years and now no extreme event will occur for another 99 years (TA1 & TA2). There are a lot of misconceptions in understanding extreme flooding, climate change and forecasting. Therefore these are complex issues, where building resilient communities is important and ensuring citizens understand the exposure to risk and ways to organize effective response measures during an event before first responders arrive.

4.3 Summary

Overall the responses from the interview process indicated that generally all participants do acknowledge that urban flood management is important and is a matter that requires high priority. Participants suggested that there are great uncertainties, which restrict the ability to understand with certainty how climate change can impact the hydrological systems and how this impacts anticipatory and preparedness planning. References to scenario-based modeling are made for decision-making. There are great uncertainties associated with these models and it is difficult to determine with accuracy of the best practices and assumptions are made based on high probability (TC4). Flood response planning practices are the municipality's responsibility (TM1) and there are other organizations such as the TRCA and independent organizations and interest groups that assist to provide information and make recommendations as to which practices should be implemented to ensure safety and also to minimize extreme flood impacts. It is evident that based on Toronto's flood history, the city has benefited by having legislated

policies restricting further development in vulnerable flood zones. As stated in the results Toronto's large size and aging infrastructure are a major concern and require strong political will, enhanced communication and partnerships to ensure resiliency to extreme flooding.

Chapter Five – City of Calgary Results

5.1 Introduction

This chapter presents the data that was collected from the semi-structured interviews with the participants from Calgary. A total of fourteen interviews were held for the following five participant groups: provincial government, municipal government, private organizations, related NGOs and academic faculty. The interview responses provide a broader understanding of the flood response planning prior and post 2013 flood. Table 4 below provides the codes for each participant and which group they are categorized in.

Table 4. City of Calgary Participant Codes

Groups	Participant Title	Code
Provincial Government	Calgary Provincial 1	CP1
	Calgary Provincial 2	CP2
	Calgary Provincial 3	CP3
Municipal Government	Calgary Municipal 1	CM1
	Calgary Municipal 2	CM2
Private Organization	Calgary Private Organization 1	CPO1
	Calgary Private Organization 2	CPO2
	Calgary Private Organization 3	CPO3
Academic	Calgary Academic 1	CA1
	Calgary Academic 2	CA2
	Calgary Academic 3	CA3
NGO	Calgary NGO 1	CN1
	Calgary NGO 2	CN2
	Calgary NGO 3	CN3

5. 2 Results

Is flood response planning a priority for your organization/agency? What priorities are your main ones?

Response planning was expressed to be a main priority for all participants. The provincial government flood response planning priorities focus on having response centers and having effective communication, information delivery to the municipality, to first responders, and other trained individuals to validate information (CP1, CP2, CP3). The municipality's main priorities look at working towards long-term resilience planning, which has been on the top of the agenda since the 2013 flood. Municipal services provide utility, sanitary, storm water drainage and are managed to reduce risk due to rain-related flooding and ice-related flooding (CM2).

The private sector provides consultative work for the province and the municipalities where they provide research work, assess which strategies do and do not work well, and recommend which actions should be taken to minimize risk as well as damage costs (CPO1, CPO2). The main priorities identified were providing technical support for the government and industries looking at water policy, and how to improve flood responses.

Academic faculty priorities in flood response measures look at safe evacuation, housing and providing shelter and ensuring emergency response preparedness (CA1). Faculty members provide their academic expertise in suggesting what measures should be taken in flood response and resilience planning. This involves mitigation programs and participating in civil meetings to develop reports, and finding ways to reduce flood risks (CA2, CA3).

CN1, CN2 and CN3 expressed their main priorities in resilience planning to focus on watershed protection management and also urban groups working towards sustaining and building resilient communities and city. Resilience priorities also include climate change adaptation and mitigation planning, watershed management, education, and awareness programs about landscape and land-use changes. These priorities may not directly focus on flood response planning, but indirectly involve flood risk reduction management and also resilient development.

*How do you consider resilience in planning for extreme events such as floods**?***

Participants requested clarification of the definition of resilience and the context it is being applied to. A definition of resilience was provided as the ability to experience minimal impacts to natural disturbances and to cope rapidly. Resilience was referred to in the context of Calgary's ability to effectively respond to floods and to reduce flood impacts. Some participants understood resilience in terms of physical, policy, emergency and community well-being responses.

Responses reflected that resilience planning for extreme events is complex and requires a combination of various factors. CP1 stated that in resilience planning there are many complexities and it is difficult to quantify future precipitation intensities and also that the province is working on flood response measures for minor floods. Many participants agreed that building resilient infrastructure and public safety is a major priority, as well as reducing damages (CP1, CP2, CP3, CM1, CM2, CPA, CPA2, CPO1, CPO2, CN1, CN2). It was noted that key components to consider in resilience building are building partnerships, preparedness planning, and training to respond effectively (CP2

& CP3). This is also important when there is a shortage of resources to implement programs, therefore financial mutual aid agreements with neighboring cities and provinces are key to share resources.

The municipality's main priorities focus on six main objectives: climate change, event forecasting, storage diversion and protection, infrastructure property resilience and additional risk management of non-structural measures (CM2). It was expressed that the combination of these six main objectives helps to prepare for a wide range of flooding and emergency responses to extreme weather events, allowing for flexibility in response measures. CPO1 and CPO2 suggested that there is great variability with climate and there are hypothetical stream data that is looked at to examine hydrology and to develop probabilistic models to work towards anticipation and preparedness planning for future events. This approach can be useful to allow pre-disaster planning and to minimize repair costs. Other issues discussed by CPO1 were having trained professionals in other fields prepared to work in flood recovery roles, such as insurance assessors who were not expecting to take on longer hours of work in stressful conditions, and also being personally affected by the 2013 flood.

When discussing resilience there can be multiple approaches in resilience building such as engineering modeling and also adaptive management (CA2). In Calgary resilience to flooding was observed as social solidarity of the public supporting each other and offering physiological help for affected individuals. CA3 indicated that community engagement is important in resilience planning where citizens become more aware about climate mitigation and adapting to the changing environment through behavioral changes to build resilient communities. As a response to resilience planning

CM1 made reference to the 'room for the river' planning strategy, which is a practice adopted from the Netherlands that has had a significant result by allowing rivers to behave naturally by moving communities out of the way and allowing water to flow freely. This is a complex and fairly new idea, but is an option the City of Calgary is thinking about as a method to prepare for future extreme events and to build urban resilience.

Are there any key uncertainties in response, sustainability or resilience planning? If so what?

There are many uncertainties when working at a large scale to determine when and where flooding will occur (CP1, CP2, CP3, CPO2, CA3, CN1). This involves looking at probabilistic models and predicting 1 in 100 or 1 in 300 year flood events (CP1). These models are considered especially when designing newer communities and determining what kinds of development need to be put in place to ensure resilience to future extreme events. CM1 and CM2 discussed complexities in climate uncertainties and predicting future events and impacts. Impact risk assessments are undertaken to observe and understand what exposure to risks result and what future risk possibilities are (CPO2). For the City of Calgary this is critical because the core of the city is built in the floodplain putting high value property at high risk.

CM2 specified that due to Calgary's geographic location it is difficult to predict and characterize what types of flood events will occur because there are variations of peak volume, duration and annual snowmelt. The flood season is pretty consistent annually, but the intensity of floods varies, which also depends on the amount of

snowmelt (CM2). Therefore it is difficult for the municipality to plan for future flooding because there are annual variances in flood intensities.

All participants agree that there is great uncertainty in understanding climate change and how it will impact future rainfall events and the associated risks (CP1, CP2, CP3, CM1, CM2, CPA, CPA2, CPO1, CPO2, CN1, CN2). This is a concern for all groups, especially when trying to design and prepare for future events and not knowing if the next event will be similar or worse. The fact that these extreme events do not occur frequently also creates greater uncertainty in developing effective forecasting and preparedness planning measures as suggested by academic participants (CP1, CP2, CP3, CM1, CM2, CPA, CPA2, CPO1, CPO2, CN1, CN2).

Other uncertainties lie within the lack of coordination among different organizations, where there may be duplication of services (CN1). This is important to know if resources are being spent over the same services. All NGOs have similar goals in promoting healthy ecosystems and watersheds, but there is a lack of critical monitoring equipment, and responses indicated a decrease in flow monitoring rather than an increase, creating gaps and uncertainties in flood forecasting and providing updated accurate flood maps (CN3).

What urban flood resilience (planning or response) tools and approaches responses do you think work well or do not work well?

There are many tools and approaches available, but the challenge is having the financial resources to implement them. Flood mapping is used to illustrate the flood ways and flood fringe to predict where floods will occur, and this tool is also offered online (CP1, CP2, CP3). This is a beneficial tool to help communities understand where floods

occur and understand the multiple risks and what to anticipate for different events. As noted before, 'room for the river' is a strategy which allows room for the rivers to occupy space in the floodplain by moving existing development out of the way (CP2, CN2). Another useful flood response tool is land-use bylaws, which oversee development in flood prone areas and look for opportunities for redevelopment for more resilient designs in existing areas. This tool is great for the municipality as it ensures long-term planning and well-being for future communities reducing future risks from extreme events. As stated there are six theme objectives that the municipality considers in resilience planning. It is important that the city takes on a holistic planning approach of all six areas to ensure resilient building (CM2).

Other tools that can be considered include looking at the watershed as a whole, and using real time models to develop decision making tools to identify the possibility of building new structures and bringing communities together for building relationships and promoting awareness and education (CPO1). This tool will involve assessments looking at what practices went wrong and writing reports to emphasize what worked and suggest long term plans. The city has also suggested a buy out program where property will be bought out to remove communities from the floodplain (CM1, CM2, CM3). This is problematic because there are expensive existing communities making it very expensive for the province and the city to remove these communities. The municipality has organized a panel of experts that work toward developing solutions to build a more resilient city and respond effectively to extreme floods (CA2). A challenging aspect of concern to the Expert Management Panel is that its composition does not allow for a broader perspective since members of the Expert Management Panel are mostly

engineers (CA2). This will require a wide range of representatives and expertise and different perspectives to plan for better solutions for the city.

Communication tools are important during flood events where information is delivered by the municipality to news outlets and then through radio, television and social media. Based on the most recent flood event, communication tools were indicated to work well where people were getting accurate information and community members were helping each other (CA3). Another problematic area faced in Calgary was forecasting, where the extreme event could have been predicted or anticipated to occur earlier, and there was only a couple of hours of notice for citizens to prepare. This was also supported by CN2 indicating that Calgary is positioned in close proximity to the Rocky Mountains which makes the city susceptible to being one of the first points where the flooding will occur.

How do you plan so that future events have less severe impacts? Do you try to plan to make the city more resilient and less vulnerable?

Risk assessments, observing previous flood events and determining what responses worked well and what did not work well are approaches that can ensure that future events experience less severe impacts. CP1 implied that applying situational learning to specific areas, looking at flood probabilities, and observing different perspectives and experiences from stakeholders is a useful method to improve flood response planning. All participant groups agreed that there is the desire to improve preparedness planning, flood warning and prediction (CP1, CP2, CP3, CM1, CM2, CPA, CPA2, CPO1, CPO2, CN1, CN2). Flood warning and forecasting will allow predicting upcoming storms ahead of time allowing citizens to evacuate homes or get basic

necessities. Since the flood in 2013 many of these measures have been in place, for working towards education and awareness of possible risk and trying to get preparedness tool kits into homes.

An important factor to note is that not all risk can be eliminated, but mitigation efforts need to be in place to minimize and plan for rapid recovery. The municipal government has organized an expert panel which focuses on the six theme areas as mentioned. CN1, CN2 and CN3 suggested that there needs to be more emphasis on property owners and educating them about preparedness planning and what measures can be invested to reduce overland flooding on their properties In order to get the interest of individuals, risk needs to be translated into economic costs to understand risk and also to assess how much risk they are willing to tolerate (CM2). CPO1 suggested implementing education programs for property owners to increase water infiltration with permeable surfaces, green roofs and bio-retention, snowmelt flooding and looking at alternative snow removal.

Faculty members noted that flood response planning requires a broader view, looking at planning measures that do not only limit plans within the city boundaries, but upstream as well (CA1, CA2, CA3). This will involve ecological solutions in riverbanks and avoiding developing in floodplains. Other factors that need to be considered in resilience building are marginalized communities and addressing issues of inequality for which communities will have opportunities for redevelopment (CA2). CA2 suggested that marginalized communities can be left out in plans and do not really benefit from redevelopment, which often provides assistance for wealthier communities.

A resilient measure that is being practiced by a participating NGO, is not only looking at the city as a whole but also targeting each citizen in each community and working towards building relationships and empowering them to adopt changes to their own properties (CN1). Many homeowners face overland flooding, so that if mitigation measures are implemented on their lawns, gardens, driveways, etc. this will help to recharge groundwater. CN2 and CN3 recommended riparian restoration and land-use bylaws creating set back distances from the watercourse, helping to support biodiversity and other direct benefits. Some other responses suggested the need for a open mind for alternative flood response planning and land-use activities, such as beavers to help mitigate floods and act as a tool towards climate change adaptation in head water region (CN3).

What are the barriers faced in response planning? Can you provide an example of particular case and what kind of issues arose?

Major barriers demonstrated by interviewees included: finances (CA1, CM2, CP3), flood planning (CP1, CP2, CN2, CP3), behavioral changes (CA2, CN1, CPO1) and response coordination (CA3, CN1, CPO2).

Interviewees expressed that since extreme flood events do not occur frequently it is difficult to plan accordingly (CP3, CP1, CP2). CP1 noted that this makes it difficult to assess risk and to decide which flood-based scenario models to plan for. This indicated that the low frequency of major flood events caused flood planning measures to be a minor priority (CP2). A ‘two year window’ was described to be the time period post-flood consisting of high interest in flood planning as the high level of interest eventually

declines and is forgotten about in the consciousness of citizens and political actors (CP2, CN1). This creates barriers for inadequate pre-disaster planning such as emergency response coordination and organization of authority to make decisions, and form partnerships (CN1, CPO2, CA3). Responses indicated that a decline in political commitment and interest in flood response planning results in postponed plans as other competing priorities arise (CA1). Interviewees indicated that post-the 2013 flood the need for effective preparedness planning and training was realized. Barriers in proactive planning indicated the need for a culture of behavioral changes, risk analysis and understanding the seriousness of flood impacts (CA2, CM2, CPO1). Interviewees expressed that the lack of participatory planning and lack of knowledge prevents homeowners from acknowledging the potential of flood impacts and landscape issues (CPO1). Responses suggested that buy-outs of existing property in flood zones are not practical for Calgary as this would be very costly (CN2).

Other financial barriers in response planning reflect the cost of investing in structural methods such as drainage systems, dams, and green infrastructure. Interviewees indicated there is a high dependency of dams in the Bow River and major tributaries (CN3). This is problematic because this gives a false sense of security of physical structures given that these structures such as hydropower dams cannot serve multipurpose use and control floods. Other financial issues reflect municipal and provincial spending on resilience projects (CM1). Lack of information sharing among agencies creates challenges such as competing for resources and forming partnerships (CP3). These issues reflect barriers in limited financial resources allocated for independent organizations and NGOs.

Understanding risk and conducting risk analysis are critical in overcoming barriers in reducing uncertainty in response planning (CM2, CA1). Since major flood events do not occur frequently, there is limited data in assessing and modifying response measures to identify lessons learned (CP3, CP2). This results in lengthy decision-making process among provincial and municipal agencies (CM1). It was expressed that often barriers can arise when the municipality wants to implement plans but have to wait to hear a response from the province to assess other factors to ensure best decisions are being made for the city.

What types of conflict, if any have arisen with other institutions and/or government in response planning?

Responses expressed that there isn't really conflict now, but there is misunderstanding and miscommunication amongst other levels of government and organizations (CP2, CN3, CM2, CPO2, CN1). Urban flood planning and flood impacts are interrelated and complexities arise during the decision-making processes where costs and information mistrust in data become a major concern.

Conflicts may arise between the provincial and municipal government where there are disagreements on which program should be implemented and also in determining who will the proposed plans (CP1, CP2, CM1, CM2). Other types of conflict arise between agencies where they are competing for the same resources during quiet times post-disaster. During this time agencies seek opportunities and compete to get involved in decision-making, conducting research which results to lack of sharing information.

Mechanisms taken to reduce conflict include setting initial rules to follow during assessment and decision-making (CPO1). If these guidelines are put in place from the beginning then this will help to reduce conflict during the planning and decision making process. Other conflicts may arise with other groups like NGOs if they are not involved in the planning processes. This is critical in identifying where vulnerable populations are located and what types of services they require (CPO2).

Interviewees expressed thoughts concerning infrastructure and how the province and the city are planning and budgeting to implement response measures (CN1, CN3). Ultimately there is little to no conflict because many of these organizations have similar goals to better watershed preservation, protect flood prone areas, and zone areas to prohibit development. The province seeks NGO involvement as key stakeholders having great interest in community members, businesses, agriculture, environment, First Nations and all levels of government (CN2).

Is there any community or NGO involvement in the planning process? How and how involved are they? Could local communities be more involved in the planning process? If so how?

Responses indicated that NGOs have done many studies including setting advisory committees and experts on flood management (CP1). These groups work along with other service providers such as healthcare workers and communities. Community members and NGOs have been noted to be involved during public consultation and stakeholder meetings (CP1, CP2, CP3, CN1). During this process partnerships can be built among government, interest groups and the community. NGOs can provide very useful information and can work toward getting mutual government funding. Building

partnerships is also beneficial to work towards implementing long-term goals and maintaining and sustaining resilience operation. In Alberta, the Watershed Protection and Advisory Councils (WPACs) are an example where the provincial involvement looks to concentrate and support communities and to specialize to build efficiently (CP3). During emergency events it is important to work on a social services framework where better guidance is provided for communities and NGOs (CM2, CPO1). This is important to allow better information sharing and collaboration among communities.

Since the flood in 2013 there have been organizations formed to provide better information and insights expressing their concerns and priorities in urban flood management/response planning (CPO1, CPO2, CN2, CN3). The Alberta government has hired independent organizations to host stakeholder consultation and develop reports. These stakeholder meetings help to spread awareness and education. Some other NGO work looks toward working community-to-community identifying what their major priorities are and determining what types of measures should be taken (CN1, CN2, CN3). Some of the work that the municipality gets involved with is with emergency response groups or with watershed protection-oriented groups. NGOs focus on building community resilience. The municipality assists these groups to be more engaged and leverages them by providing accessibility to resources.

Interviewees expressed that since the flood in 2013, there has been a lot of NGOs advocating for resilience building. One of the drawbacks for these groups is that they do not have a large voice and are under resourced, therefore looking towards an integrated planning approach with the provincial, municipal and federal government allows for more discussion and understanding of the issues, and implementing changes where

needed (CA2). To encourage this type of planning, responses encouraged pre-established partnerships before major flooding occurs. These groups already have done extensive research and assessments and developed a template on how to tackle issues. NGOs are not highly credited for their citizen-based communal work and watershed management which requires more support from the province (CN1, CN2, CN3). Lack of expertise in flood response planning is a factor to consider when discussing citizen engagement (CA1).

NGO participants noted The Watershed Planning and Advisory Councils (WPACs) which are watershed stewardship groups that are community based and do a lot of work in bioengineering and community monitoring in the watershed (CN2, CN3). The WPACs also work on policy and plans that should be implemented and assesses the issue focusing on a local watershed scale and applying it to a boarder policy plans.

What might be some of the unique challenges faced here for urban flood planning, compared to other cities?

Calgary is unique in Canada due to being in close proximity to the Rocky Mountains and the foothills (CM1, CN1). This is detrimental because flooding is dependent on the amount of rainfall on top of the snow and snowmelt or when it rains in the valley. This creates a large volume of water to flow towards the city. This is highly problematic because the downtown core of Calgary is adjacent to the Bow and Elbow rivers and flooding is expected. Calgary does not have the advantage of early forecasting systems such as Winnipeg. In Winnipeg, their flood forecasting systems were indicated to be significant where floods can be forecasted weeks in advance (CP2). In contrast, in Calgary flood warnings can be called out a couple of hours before a flood hits.

Currently at the provincial and municipal level there are many changes that are being made and have been working proactively since the 2013 flood. The City of Calgary is growing rapidly and is facing issues such as densification in vulnerable areas in the city which brings questions of how to ensure appropriate regulation and design standards for future developments instead of after an event occurs (CM2). The city needs to take extra precautions as it is in a tough situation where prolonged development was permitted in the floodplain. This brings topics of the culture of awareness, risk, change and support not only for citizens living in the city, but also for neighboring jurisdictions allowing decision making processes to be more transparent and ensuring there are available finances (CM2).

Some potential flood management measures being considered, include practices adopted from the Netherlands (CPO1). Compared to the City of Calgary, the Netherlands has little geographic variation, but their flooding issues were reduced effectively. There is great variability in flooding in Calgary which is a huge challenge, where the amount of snowfall varies year to year and makes it difficult to anticipate and what types of flood may occur (CPO1, CPO2). In the floodplain there is a lot of expensive property, which makes it difficult to relocate citizens utilizing a buy out program (CA1, CA2). This creates unique challenges in adapting to limited flood planning measures to ensure assessing and implying more preventative measures in future land-use developments.

Do you have any other thoughts about these issues?

Anticipation and preparedness planning are major challenges because there are grey areas in not knowing what to expect and investing money to implement planning strategies (CP1, CM2, CA3). Because there are uncertainties in understanding risk and future impacts there isn't a lot of proactive response planning. Provincial responses indicate that flooding is a major issue and that there needs to be less reactive planning and improved hazard identification, mitigation and minimize risks (CP3).

To allow for effective response strategies there needs to be development of collaborative partnerships amongst different organizations, NGOs and communities. Building relationships with other organizations in other provinces that are equivalent to their services would help. During the last flood the city showed a strong sense of community and willingness to help each other. There needs to be great improvements in flood mapping, use of technical tools, and investment in planning (CA1). Private organizations suggested that there should be open minded thinking when planning for disaster. It is important to not only to look at lessons learned within the city but also for other similar geographical locations (CM2, CPO2, CN2).

It is always difficult to enforce change, but risk awareness and education can be promoted through flood insurance where risk can be placed with monetary value (CA1). This will help to encourage people to take risk reduction practices seriously. Having economic incentives in the areas helps to target change where needed. Possibly providing high cost flood insurance in vulnerable areas will help re-direct development to lower flood risk areas as suggested by an academic participant.

During flood response planning there are various demographic groups to consider. Homelessness is something to pay high attention to as these groups are often marginalized and re-development projects often seem to benefit wealthier populations (CA2). The idea of resilience building is to target all areas and consider ethics and care. As suggested by an academic representative this is a conversation that is being started. Urban flood impacts are trending up across Canada, and urban flooding is a common issue (CN2). Careful discussions need to be engaged, along with realizing climate change creates great variability of future events. There is a heavy reliance on physical structures, and a need to improve land-use planning activities creating a resilient landscape keeping in mind environmental and ecological health and integrity (CN3).

5.3 Summary

Based on the responses, it is observed that the City of Calgary is situated in a complex geographic region in close proximity to the Rocky Mountains making it highly susceptible to flooding. Also, the fact that the main core of the city is built in the floodplain places many properties and business at risk whenever an extreme flood occurs. Since the city is urbanized and developed it leaves limited options to develop a strategy to alleviate flood hazards. Based on the responses from the interview there are several suggestions of what the city can do. Some stated recommendations included leaving room for the river to behave without having infrastructure in the way, targeting individual community members by area and encouraging them to retrofit their own properties, implementing low impact development technologies to help increase infiltration, implementing development regulations and retrofitting existing properties (including

business) in flood prone areas. The suggested comments by the participants are important in that they signify the challenges between adaption and mitigation of flood hazards.

Chapter Six – Comparative Analysis and Discussion

6.1 Introduction

This chapter provides a summary of the case study, comparative analysis, and discussion of the results presented in Chapter 4 and 5. There are three sections in this chapter: case study summary, comparative analysis and discussion. The case study summary will highlight the key results of the research indicating the common findings and unique differences in flood response planning in Toronto and Calgary. The second section will be a comparative analysis of the key results in the context of relevant literature. The final section will be a discussion of the research findings and provide recommendations to enhance urban flood resilience planning in Toronto and Calgary.

6.2 Case Study Summary

A total of twenty-eight semi-structured interviews were conducted to collect data on urban resilience planning for floods in the Cities of Toronto and Calgary. The case studies examined flood response planning, tools, and the barriers experienced. The interview questions generally covered five theme areas: resilience planning, uncertainty and forecasting, tools that work well, tools that didn't work well, and barriers. Each of these themes brings together several related points addressed in the interview protocol. The table below identifies differences and commonalities in flood management practices between the two cities.

Table 5. Summarized Key Results

Themes	Commonalities	Unique to Calgary	Unique to Toronto
Resilience	-Managing and minimizing flood vulnerability and risk -Mitigating climate change -Flood hazard education and awareness -Consistent pre-disaster planning	- Storage, diversion, and protection - Infrastructure and property resilience	-Flood preventative planning -Monitoring high risk communities to flood hazards -Regulate development in flood prone areas
Uncertainty and emergency response measures	-Flood scenario-based uncertainty -Future flood impacts (e.g. frequency and intensity) - Flood risk assessment -Ineffective flood forecasting warning	- Close proximity to the Rocky Mountain Foothills, likely to experience combined snowmelt and rainfall flooding - Require improved emergency response coordination	- Communities located in lower watershed areas vulnerable to flash floods, difficult to detect well in advance
Tools that work well	- Flood mapping -Assessment report to develop response strategies -Watershed management	- Establishment of Flood Recovery Task Force and Expert Management Panel	-Policy (e.g. Provincial Policy Statement) -Partnership between provincial, municipal and conservation authority
Tools that didn't work well	-Reliance on physical infrastructure -Outdated flood maps - Communication (e.g. accurate information in timely manner)	-No effective flood policies -Enforced regulations preventing development in flood hazardous zones	- Eliminating risk - Response to power outages - Emergency coordination (e.g. power outages & road colures)
Barriers	-Financial budgets -Lack of knowledge -Political and personal interest -Competing priorities -Collaborative planning	- Mitigating flood impacts of extensive development in flood zones	-Large size and population -Aging infrastructure

Both Toronto and Calgary share the same goals in building resilient cities. Table 5 lists the key results and identifies the similarities and differences experienced in flood response planning. Resilience planning priorities are composed of minimizing risks and vulnerabilities through pre-disaster planning. Uncertainty was acknowledged in the context of climate change projections, regional climate changes, and impacts on flood behavior. The main differences identified are in forecasting measures and in enforcement of flood preventative policies, and strategies to prohibit development in flood hazardous zones. Although both cities have set ideal goals in their flood recovery and resilience plans there are barriers that have limited applying best flood management practices. Barriers such as financial constraints, political and personal interest, competing priorities, and collaborative planning are the most commonly noted challenges to be faced in flood resilience planning. The comparative analysis in the following section will discuss each of they key results in greater detail.

6.3 Comparative Analysis

This section will provide a comparative analysis of the case study results. The results will be compared and contrasted to identify where there are similarities and differences in flood response practices. This section will be divided into five sub-sections: resilience planning, uncertainties and forecasting, tools that work well, tools that didn't work well, and barriers in flood response practices. These sub-sections will cover the topics in the interview protocol highlighting common strategies and distinct challenges each city experiences in urban flood resilience building.

6.3.1 Resilience planning

Resilience planning involves planning strategies to minimize flood impacts (Liao, 2012; Ahern, 2011). Participants from both case study cities expressed similar commonalities in supporting that resilience planning is a priority for their organization. The provincial government and the municipality play a larger role in resilience planning that includes minimizing risks, preparedness and anticipatory planning, regulating development in vulnerable areas and emergency response (TP1, TP1, CP3, CP3, TM1, TM2, TM2, CM1, CM2).

Interviewees suggested that it is important to have holistic planning methods which consider interrelated socio-economic and ecological factors in building resilience in urban ecosystems. Shrubsole (2000) discusses that commonly in Canada a top-down planning approach is used in flood management practices. Other related research suggested that collaborative/integrated planning can allow for effective rapid response planning, pre-disaster planning, and embedding resilience policy in future building (Francesh-Huidobro, 2015). This planning approach can be described as contemporary governance where the government facilitates planning, while private, commercial, and NGO actors take the lead in flood management. TM2, TN2, CA2 show great interest in integrated planning where top-down and bottom-up planning are combined allowing for more horizontal planning. In Chapter 2 Figure 2, Yin's (2001) framework for decision-makers, planners and stakeholders illustrates the organizational relationships, roles and processes in collaborative planning. As shown in the framework this planning approach allows assessing and identifying desirable and effective flood management plans, policies, and programs. The remaining interviewees expressed that this would be ideal

and there are barriers in allowing independent and non-governmental organizations to participate in the final decision-making. Findings highlighted that private organizations, NGOs, and community engagement are involved in the preliminary planning during the consultation phase.

Resilience planning requires policies and consistent pre-disaster planning to manage and reduce flood vulnerability and risk. Differences between Toronto and Calgary indicate that Calgary flood recovery practices emphasize structural measures to store, divert flow of water to build property resilience to floods. Toronto flood reduction planning reflected the use of policies to ensure preventative measures to reduce future risks in flood prone areas.

6.3.2 Uncertainty and Emergency Response Measures

McBean (2010) highlights uncertainty associated with insufficient data, ignorance and indeterminacy. These types of uncertainties are present in understanding possible flood impacts and developing preparedness plans to respond effectively. Interview responses indicated that a major uncertainty in flood response planning is the lack of understanding of climate change and its associated risks. This correlates with Parry and Carter's (1998) study discussing that in climate change research there is amplified uncertainty in future precipitation duration, frequency and intensity. Both Toronto and Calgary interviewees implied that it is difficult to anticipate future flood outcomes, such that there are many grey areas in determining regional climate and hydrology changes. Solecki et al. (2011) analyze climate uncertainty and indicate that understanding past climate conditions is becoming less useful in developing future guides

as the environment continues to change. Variances in the regional causes of floods suggest managed-adaptive planning involving improved policies, training, education, and awareness programs on how to respond effectively (Hunt and Watkiss, 2010; Linnenluecke et al., 2012; Lu and Stead, 2013).

Worst case scenario models are used to project future flood events. Although there are many scenario models available there is always a degree of uncertainty. TC1, TC2, TC3, TC4, CM1, CM2, CPO1, CPO2 discussed the use of climate models to synthesize future extreme floods and what to expect in fifty, one hundred, two hundred, years etc. It is evident that with uncertainty, probabilistic assumptions are made to determine what is likely to occur in the future. In decision-making this can create mistrust and low confidence in determining appropriate flood recovery plans. TC4 expressed that anticipatory and preparedness planning depends on how much risk the city is willing to tolerate and how much the city is willing to pay for.

Flood response planning involves assessing and quantifying risk, which is the interaction between hazard, exposure, and vulnerability (Kaźmierczak and Cavan, 2011). In Chapter 1 risk assessment was defined by the following formula (Fontanazza et al.,2011).

$$R = H \times V \times E$$

This formula is used to quantify hazard, exposure, and vulnerability variables when assessing the degree communities experience flood impacts. In both Toronto and Calgary interviewees suggested that enhancing pre-disaster planning can allow for significant risk reduction. Risk reduction can be assessed in two parts: disaster management (e.g., response, relief and recovery), and structural (e.g., dams, storm drainage, levees, etc) and

non-structural (policy, land-use management, risk documentation, cost-benefit analysis) mitigation activities (Solecki et al., 2011). This research particularly focused on non-structural measures, which include policy, legislation, community preparedness analysis, and emergency response measures in resilience planning to environmental risks.

Emergency response measures are key in developing response plans to coordinate communication among first responders and the public. These measures ensure effective emergency response to road closures, power outages, provide shelter for flood evacuees, and flood alerts (TM2, TA2, CA1, CA2). TM2 discussed that emergency response responsibilities are divided among local trained professionals of emergency medical services, fire and police to prepare and to ensure responsible behavior during floods and to minimize injuries.

Both Toronto and Calgary participants made mention of looking at marginalized communities and community demographics to assess risk and vulnerabilities specific to each community. This relates to Kaźmierczak and Cavan (2011) who suggest assessing risks and vulnerabilities needs to consider children, elders and the disabled, analyzing their exposures to risk. In flood resilience planning, factors such as access to information and ability to respond during a flood need to be incorporated. Specific planning measures can promote education and awareness programs acknowledging flood hazards, how to access information, how to prepare for flooding, how to respond, and lastly the ability to recover. Therefore citizen mobilization is key in building urban resilience to floods and identifying community-specific vulnerabilities to prioritize planning methods for significant flood recovery and also reduce threat to life.

Flood warning is critical in resilience planning to detect floods in advance and to ensure significant preparedness planning at the onset of a flood event (Andjelkovic, 2001). Toronto and Calgary are distinct in their geographic location that limits the effectiveness of flood forecasting and warning. A unique challenge the City of Toronto faces is its placement in the watershed. When there is rain activity in the northern communities, river volume and velocity increases flowing down the watershed rapidly. As rain activity progresses down the watershed flash floods are likely to occur. This allows for little warning to forecast flooding. In comparison, the City of Calgary is situated in close proximity to the Rocky Mountains. Rain activity in the foothills combined with snowmelt cause major floods to occur in Calgary. This type of flooding has been described as resulting in major flooding and is dependent on the distribution of snowpack (Garvelmann et al., 2015). These floods were characterized to occur rapidly (CN1, CN2) causing flash flooding and cannot be more forecastable then in Toronto.

Some regions, such as Winnipeg, have significant flood forecasting and warning systems that have the ability to detect floods days or even months in advance. Flood alerts in Calgary and Toronto were only issued a couple of hours in advance. Overall it is difficult to implement different measures because these extreme events do not occur often. It is difficult to budget for flood recovery relief when the future outcomes and the degree of impacts are unknown. Although there are uncertainties in scenario-based methods, Muis et al. (2015) indicate that a probabilistic approach provides quantitative variables which helps to assess risk in adaptation approaches and that further research is needed in integrating socio-economic development with regional climate modeling.

6.3.3 Tools That Work Well

Many tools that are being used in non-structural flood resilience practices such as planning, monitoring, policy making, policy coordination, and flood documentation were discussed in the interviews. Participants from both cities addressed that because these events do not occur frequently it is difficult to document the flood events effectively. This creates complexities among decision-makers when investigating flood causes and consequences and developing criteria in resilience planning. Policy is a significant tool to ensure short-term and long-term resilience planning.

Integrated water management is practiced across Ontario by local conservation authorities that regulate and monitor watershed conservation and do preventative flood planning (Mitchell et al., 2014). In Toronto, the Toronto and Region Conservation Authority works closely with the municipality and helps regulate policies and provide recommendations on which measures should be taken in flood management practices. The development of policies and legislated regulations are significant tools to protect vulnerable lands and apply flood preventative measures such as flood zoning regulations to ensure sustainable communities and long-term resilience planning. For example the Provincial Policy Statement and the Flood risk-specific plan provide guidelines on pre-disaster and post-disaster planning to reduce vulnerability and risk to flood impacts (MMAH, 2014; TRCA and OEM, 2014). Toronto participants noted that these regulations have helped to alleviate and reduce flood impacts in Toronto since Hurricane Hazel hit in 1954. Hurricane Hazel is used as default reference point for an extreme flood event in Toronto and building standards and response measures are designed to meet the needs to withstand the flood. Reactive flood response to Hurricane Hazel

benefitted Toronto by consistent pre-disaster planning and enforcing policies to prevent further developments in flood hazardous zones which helped to reduce risks to property and life.

In comparison, in the City of Calgary this type of organization and partnership with the municipality does not exist to regulate and monitor water natural resources and flood response planning. Ineffective land-use regulations and preventative flood management have allowed for continued development in major flood zones. Interviewees made multiple references to the 2013 Calgary flood to place emphasis on recent flood impacts. Since the 2013 flood, a Flood Recovery Task Force was formed providing leadership and expertise in flood management and resilience planning. An Expert Management Panel was also established to mitigate river flooding focusing on six theme areas: (1) climate change, (2) event forecasting, watershed management, (3) storage, diversion, protection, (4) infrastructure and property resiliency, (6) managing flood risk. Calgary participants discussed that this will help to minimize risks and improve flood recovery practices, but (TA2) argues that the panel mainly includes engineers which inhibits the holistic view that requires diverse expertise and to better identify risks and vulnerabilities specific to each community.

Interviewee responses (CP2, CM1, CN2) made notable references to the 'room for the rivers' adaptation strategy adopted from the Netherlands. This method promotes river restoration by allowing rivers to flood and occupy space by moving existing development out of the way (Rohed et al., 2006). This adaptive strategy was observed to alleviate flooding in the Netherlands and interviewees indicated that it is a proposed plan.

Challenges arise with this response as there are many expensive properties in flood zones and a buyout program will be costly.

6.3.4 Tools That Didn't Work Well

TC4, CN3 made notable remarks indicating that it is impossible to eliminate all risks. It was discussed that in response planning cities can plan to a level of risk that is tolerated, which is dependent on the amount of budgeting available and how much risk the city is willing to tolerate. Risk can be minimized but not completely eliminated, therefore adaptation and mitigation measures are key in effective urban flood response planning. Therefore policies and legislation need to be modified by assessing risk analysis to identify damages and enhance preventative planning. This can include updating flood risk maps and improving emergency preparedness planning and public education and awareness programs. Outdated flood maps prevent the ability to identify current high risk and low risk communities.

A Calgary interviewee (CN3) discussed the strong reliance on structural measures which gives a false sense of security that built infrastructure can provide optimal protection from extreme flooding. Shrubsole (2000) supports this concept, indicating that aging infrastructure is a major contributor to urban flooding and emphasizing that non-structural measure are necessary in mitigating flood hazards. Applied flood reduction planning in Toronto included significant policy development permitting pre-disaster planning that reduced potential flood impacts. This is a major lesson learned for the Calgary that must place more emphasis on policy enforcement.

Communication tools were described to have strengths and weaknesses in flood emergency events (TC1, TM1, CM1, CN1). Both Toronto and Calgary interviewees have indicated they have the division of roles and responsibilities to respond effectively during an emergency. Challenges such as power outages occur during extreme floods (TA2). Armenakis and Nirupama (2014) stated that this a concern for the City of Toronto as power outages have occurred in recent extreme rainfall, flooding, and ice storm events causing residents to be out of power for days. TA2 discussed that there is further need to incorporate power outages in emergency plans to restore power across the city. Radio, television, online forecast sites, and social media serve as a platform to provide flood-warning notifications and flood status updates. Interviewees from Toronto and Calgary share common concerns regarding accuracy of information and receiving updates in a timely manner among different communication outlets. In Toronto, in particular, issuing road closures in the lower Don River Valley in a timely manner was a concern. There are several access points to enter this high risk area which allows many commuters to get stuck in high levels of water.

6.3.5 Barriers in Flood Response Practices

The number one barrier identified in resilience building in Toronto and Calgary is not having enough resources to implement the proposed programs, build new or re-build existing infrastructure. This is problematic, especially in Toronto, as there is extensive aging infrastructure placing large populations at risk. NGO participants in both cities expressed that insufficient funding limits developing significant public education and awareness programs. This is highly important to address because many citizens have

been described as lacking personal interest to participate in flood planning (Oulahen, 2012). Therefore education and awareness programs have a vital role in enhancing preparedness planning to ensure safety and responsible behavior during floods. Lack of community empowerment, education and awareness about flood hazards affects flood resilience planning (TN1, TN2, CN1,CN2). CA2 suggested that flood response planning should be expressed in monetary value so flood response planning can be taken seriously.

Research findings indicated that lack of data impacts resilience planning. This creates complexities in understanding the dynamics between social-economic and ecological systems. Participants from both cities identified climate change as a barrier due to minimal understanding of future flood impacts and how to prepare and anticipate for major floods. CP1 expressed that since major flood events do not occur frequently, it is difficult to determine which flood scenario model to plan for. The infrequency of major floods impacts the ability to implement pre-disaster planning. A 'two year window' was noted to be a concept that limits the city's ability to plan effectively (CN1, CPO2, CA3). This is related to the decline of politician interest and flood planning after a significant time has passed post-flood. This was described to be a barrier because is inhibits significant planning to improve flood preparedness. Interviewees from both cities indicated that competing priorities, were indicated as a barrier in resilience planning, as flood planning does not remain a high priority. TN1, CA2 suggest lack of expertise and familiarity with urban flooding limits the ability to improve pre-disaster planning and post-disaster planning. Having a resilience officer in Toronto was suggested to direct effective planning (TN2).

Common findings indicated that both cities work with like-minded organizations that share the same goal to reduce flood impacts and build urban resilience to extreme weather events. Although they may share the same purpose in their work, conflict may arise during the decision-making process and determining who will cover damage costs. A study conducted by the US Army Corps of Engineers (2005) argued that collaborative planning can help reduce conflict among decision-makers. Both Toronto and Calgary NGO participants expressed that conflict may arise when interest groups and community members and organizations are left out in the planning processes. TP1, TN1, TN2, CN1, CN2 implied that NGOs and interest groups are credible sources providing research and indigenous knowledge in specialized areas. This further supported prior references for integrated/horizontal planning to allow successful information sharing (Serre et al., 2010; Satterthwaite, 2013; Lu, 2013; Diordjević, 2011).

6.4 Discussion

The purpose of this research was to assess flood response planning and resilience planning in the Cities of Toronto and Calgary. It is evident that flood damages are the leading natural disaster damage costs in Canada (Armenakis and Nirupama, 2014). There are various factors discussed, such as climate change predictions indicating changes in rainfall intensity and frequency. There are areas of uncertainty in understanding future flood impacts and developing substantial flood reduction plans to respond effectively (Willems et al., 2012). Aside from the technical difficulties there are barriers in flood management concerning pre-disaster, emergency response, and post-disaster planning.

The literature review explored different concepts regarding flood management; urban flooding causes and consequences, urban flood planning and responses, and resilience and uncertainty planning. Each of these sections examined the causes of floods, the associated risks, and non-structural response methods, non-structural planning tools such as policies, land-use regulations. The literature recommended that non- structural measures and policies, building codes, emergency preparedness, communication, public education and awareness tools are effective tools for flood resilience planning.

Urban flooding is a phenomenon that is occurring across Canada and 1-in-100 year floods are being observed to occur less than once every 100 years. This suggests that worst case scenario models of anticipated 1-in-100 year, 1-in-200 year floods are predicting greater flood intensities and frequencies. It is important for decision-makers and urban planners to consider climate change impacts in building to accommodate the changing environment and future flooding. Gersonius et al. (2012) advocates for embedding 'adapt as you go' and 'no-regrets' climate adaptation and mitigation in planning to reduce risk and minimize damage cost significantly and allow for rapid recovery to disturbance. In conjunction, collaborative or integrated planning approaches are recommended to allow for increased holistic planning.

Distinct differences between Calgary and Toronto are the presence of flood policies that apply protective and preventative measures to reduce flood impacts. In Ontario, integrated water management is practiced where each watershed has a conservation authority that regulates and conserves natural resources (Mitchell et al., 2014). Toronto has the Toronto and Region Conservation Authority which works in partnership with the municipality. Together these two agencies utilize the Provincial

Policy Statement to ensure all land-use developments and recreational use follow strict guidelines and regulations to ensure sustainable and resilience building (MMAH, 2014). Integrated water management implies that each municipality in the province plans in accordance to these regulations to ensure preventative flood planning. Interviewees from the Ministry of Municipal Affairs, Office of Emergency Management and the Region of Toronto Conservation Authority indicated that these policies and legislation have enabled Toronto to reduce flood impacts post Hurricane Hazel.

In Calgary this type of partnership between a local watershed/flood management agency and the municipality does not exist. The lack of this type of integrated water management approach prevents Calgary having a more organizational approach in coordinating and developing effective flood reduction policies and land-use regulations. It is evident that the flood that occurred in Calgary in June 2013 caused considerable impacts, displacing many residents out of their homes. Calgary interviewees expressed a unique challenge in Calgary is having extensive property in major flood zones exposing considerable flood hazards to these communities. The Alberta Government has proposed buy out programs to relocate residents out of these zones, but interview results suggest that this is not practical and would be too costly. Therefore it is recommended that Calgary build partnerships with local watershed/flood management agencies. Integrated planning involves stakeholder participation. This allows utilizing stakeholder local and traditional knowledge in natural resources management and adaptation measures.

Interview responses and literature were used to support the need for collaborative planning to ensure that best flood management practices are being developed. This supports Ahern's (2011) five proposed urban planning design strategies for building

urban resilience: (1) multifuntionality, (2) redundancy and modularization, (3) bio and social diversity, (4) multi-scale networks and connectivity, (5) adaptive planning and design. This suggests that multi-scale networks and connectivity allows, planning for sustaining resilience of social, economic, and ecological systems. Collaborative planning was noted to significantly aid in building urban resilience to flood events. This can be attributed to effective public education and awareness programs to help gain awareness of flood hazards and become knowledgeable about preparedness planning strategies. This helps to create a dialogue between the public and decision-makers to achieve the same level of understanding (Dovers, 1998). Increasing education and awareness programs are critical in resilience planning and ensuring safety for communities.

Common urban flood impacts observed in both cities are basement seepage, sewage backup, storm water backup and overland flooding. Through the literature review it was seen that effective response planning requires short and long term goals and objectives to reduce flood damages and involves a process of modifications of flood response planning (Conservation Ontario, 2013). This requires cities to conduct risk assessments to measure development, recreational land-use, emergency response, and preparedness planning in post-disaster planning. This approach to post-flood planning supports identifying new exposures to risk and modifying regulations to can help to reduce repair costs. Conservation Ontario (2013) recommended cities invest in flood risk mapping, flood management operation (monitoring, regulation and watershed planning), existing flood and erosion control infrastructure, green infrastructure, storm water management and building watershed resilience. Case study results also indicated that both Toronto and Calgary have outdated flood maps signifying the inadequate

documentation of existing areas experiencing urban floods. This is critical in identifying high-risk communities and prioritizes developing effective flood emergency preparedness kits for homeowners. Conducting risk analysis also benefits in identifying vulnerable community members such as the elderly, disabled, and young children. Preparedness planning can improve emergency response guidelines and provide information of local assistance, city emergency responders, and help line contact information.

The results of the study suggest that municipalities know which best practices will help alleviate floods, but they face a wide range of barriers that limit their ability to implement appropriate mitigation measures. Therefore broadly recommended strategies to build urban resilience to floods in Toronto and Calgary are:

1. Top-down planning mainly dominates in Canada, therefore collaborative and integrated planning could help develop improved developing best flood management practices and policies. Stakeholder participation in Toronto and Calgary occurs during consultation and the results indicate that incorporating stakeholders can enhance resilience planning. Best flood management practices and policies can be developed through collaborative and integrated planning since stakeholders have significant local and traditional knowledge of flood mitigation practices.
2. Establishing stronger watershed/flood management authority in Calgary and partnering with municipalities to enforce land-use policies. Results demonstrated that Toronto is more resilient to urban floods due to the partnership between the municipality and the Toronto and Region Conservation Authority. These two agencies work closely together to develop and enforce flood preventative policies.

This flood preventative planning has indicated significant results in Toronto of flood risk reduction of vulnerable communities. Results indicate establishing this kind of partnership in Calgary can aid in enforcing regulation of land-use in flood zones and flood risk reduction in high-risk areas.

3. Promoting education and awareness programs to increase stakeholder participation and awareness. Results indicated that there is a substantial lack of stakeholder participation in flood planning. Education and awareness programs can help stakeholders understand potential flood hazards and the need for flood planning to reduce risk in communities. This would allow developing the same level of understanding and creating a dialogue between decision-makers and stakeholders.
4. Update municipal flood maps and documentation of urban overland flooding sites. Land-use changes (e.g. recreational parks) and new built infrastructure (e.g. roads) affect urban drainage capacity and new communities can experience floods. Aging infrastructure is a special challenge in Toronto where it increases the potential for new communities experience overland flooding. There is poor documentation of specific sites that are now experiencing urban flooding.
5. Enhance emergency preparedness, warning and communication with first responders and public. This will involve assessing potential risk in each community and developing, flood emergency preparedness kits. First, vulnerable community members (e.g. elderly, disabled, and children) need to be identified and, strategies developed on how to provide assistance within the community network. Second, is developing a network within each community designating

selected individuals as a first point of contact responsible for ensuring that all residents are aware of an issued flood warning. Third, is enhancing communication infrastructure such as phone lines, cell phones, towers, and radio systems are not impacted to ensure emergency response crews get updates of situational and operational information and respond to the public.

Chapter Seven - Summary & Conclusion

7.1 Introduction

Chapter seven is a concluding chapter consisting of three main sections. The first section will be a summary of the thesis and key results. The second section will provide research reflections, and research recommendations. The final section will include the conclusions about the thesis.

7.2 Thesis and Key Results Summary

The research goals and objectives were to conduct a literature review, assess flood response planning in Toronto and Calgary and lastly to evaluate urban resilience practices and identify strengths and weaknesses. The main goals and objectives of this research were achieved and the main findings will be summarized.

The literature review was conducted to examine flood management practices focusing on planning, flood emergency response, post disaster planning. The literature helped to gain further understanding of different practices and external environmental issues. Urban flood resilience planning was assessed in three parts: urban flooding causes and consequences, urban flood planning and responses and resilience and uncertainty planning. Relevant literature was used to describe non-structural measures in urban flood planning identifying key flood preventative practices: policy, legislation, land-use regulations, emergency response, flood warning, communication, public education, and awareness programs.

The second objective was to assess two case study cities in resilience building for urban floods, Toronto and Calgary. The case study involved conducting semi-structured

interviews of individuals that work in flood management related activity from key agencies in flood management: provincial and municipal government, local authorities, private organizations, academics and NGOs. The interview protocol was designed to grasp a broader understanding of the key agencies' roles in flood urban resilience planning. The data collected were analyzed to determine the key strengths, weaknesses, commonalities and unique differences flood planning practices in Toronto and Calgary. Table 5 in Chapter 6 presents a summary of the key results highlighting five theme areas: resilience planning, uncertainty and emergency management, tools that work, tools that didn't work and barriers highlight similarities and differences between Toronto and Calgary.

The final objective was to evaluate policies and practices of the case study cities. This was fulfilled through a comparative analysis assessing the commonalities and differences in the research findings. The interview responses recommended how cities should plan towards building urban resilience through flood mitigation measures to reduce risks and vulnerabilities. Literature was used to support interviewee responses and provide further explanation on types of non-structural measures that should be implemented.

Non-structural management was described as the non-physical strategies in flood reduction and prevention. Policy and legislated regulations are key in enabling an increase in urban resilience to floods by maintaining consistent proactive planning by preventing land-use development in flood hazard zones, coordination, communication, preparedness planning. Risk analysis is necessary to assess communities and document flood impacts. The identification of flood impacts is used to re-evaluate and modify

planning guidelines to enhance preventative and preparedness planning. Risk analysis also allows updating flood risk maps to identify high risk and low risk communities efficiently, and to document specific sites experiencing overland flooding in Toronto and Calgary. Updated maps can improve coordination and communication among first responders to issue road closures and to provide alternative routes in case of road closures. Education and awareness programs are highlighted as a key factor in resilience planning. Both the literature and participant responses indicated that citizen engagement is necessary in implementing collaborative/integrated planning for adaptation and mitigation measures to urban floods. It was noted that it is necessary for citizens to take responsibility to understand the seriousness of floods, make behavioral changes and to engage in flood response planning.

Findings noted resilience priorities in Toronto and Calgary are managing and minimizing flood impacts, mitigating climate change, maintaining consistent pre-disaster planning, public education, and awareness programs. Flood mitigation planning in Calgary identified reliance on structural measures as opposed to non-structural resilience building. In Toronto, flood preventative and reduction planning is dependent on policies and regulations that protect and control watershed and land-use activities.

The cities are distinct in their geographic locations, and uncertainty planning was identified as the inability to predict future flood impacts and provide efficient flood forecasting and flood warning to ensure effective emergency response. Emergency response in the results and literature was described as effective coordination and communication during flood events. The results indicated that lack of coordination and preparedness planning increases injuries and risk to life.

A successful planning tool unique to the City of Toronto is the established partnership between the Toronto and Region Conservation Authority and the municipality. Together these two agencies develop protective and preventative policy and legislation that helps to alleviate flood impacts and ensures resilient responses to floods. This type of partnership and regulating entity does not exist in Calgary and case study results recommend that integrated watershed management can benefit Calgary to build resilience to flood disasters.

Common barriers include financial constraints, lack of knowledge, competing priorities, lack of stakeholder participation, political and personal interest. Unique barriers to Toronto included aging infrastructure and exposure of flood risks to a large population size. Calgary faces many challenges including mitigation options to extensive development in the flood zone. Research participants indicated that these are critical barriers in ensuring urban resilience, which impacts decision-making and implementing flood mitigation measures.

7.3 Research Reflections and Research Recommendations

A total of twenty-eight semi-structured interviews were conducted. Although, the sample size is not large there was a fair distribution of participants representing the different agencies involved in flood planning. Finding potential participants was difficult because there is limited information on individuals that work on the provincial and municipal level. Coordinating emails, following up with referred participants, and setting interview dates was a lengthy process. Twenty-eight participants out of 154 initial outreach emails is not an exceptionally low response rate for this kind of work.

Ultimately there was repetition in the interview results, as well as clear distinguishing of flood planning differences in Toronto and Calgary, which suggest that the sample size was reasonable.

It is evident that both Toronto and Calgary are working towards increasing urban resilience to flood disasters. One of the challenges is making sure there is sufficient flood anticipatory and preparedness planning. In Toronto, the results demonstrated there is significant flood planning and preventative planning measures in place to reduce future flood impacts. In comparison to Calgary, Toronto indicated unique traits such as having extensive aging infrastructure placing many citizens at risk during a flood. Therefore, policy and legislation development is key in ensuring resilience building and protection for flood vulnerable areas. The results also indicated that flood response planning does exist in Calgary, but is not as extensive as it is in Toronto. Participants implied that many flood mitigation strategies rely on structural methods and suggested a need for policy development and enforced land-use regulation. Both cities have specified the need for increased stakeholder participation and collaborative planning. These planning approaches were suggested to enhance pre-disaster planning and emergency preparedness.

Recommendations for further research included assessing cross-disciplinary planning among researchers, practitioners, decision-makers and stakeholders in both cities to enhance pre-disaster and emergency preparedness planning. Further research can examine how vulnerable groups such as the elderly, mobility impaired, and children are impacted in flood risk areas and how effective flood emergency planning can reduce flood impacts for these communities. Further research can also examine the participation

of immigrants from other parts of the world that have experienced severe flooding and how their past flood experience can improve flood risk reduction and preparedness planning. A final recommendation is to examine integrated watershed management in Alberta and assess what lessons learned they could adopt from Toronto in their flood reduction planning.

7. 4 Conclusions

This research highlights a wide range of operational and policy differences in pre-disaster preventative planning in the cities of Toronto and Calgary. This is demonstrated in the greater use of effective flood planning policies and legislation that provide protective measures to reduce future flood impacts in Toronto. It's not to say that preventative planning does not exist in Calgary, but policies and regulations for watershed management and land-use changes are not strictly enforced. Both the Municipalities of Toronto and Calgary share similar priorities in flood response planning, and require the support of citizen engagement to do so. Financial budgets and model uncertainties are one of the main limiting factors in implementing adaptation measures and prolonging the decision making process. One of the main difficulties in flood response planning is predicting future floods and developing significant emergency and anticipatory preparedness planning for service providers, businesses, schools, and homeowners.

Based on the literature review and interviews it is understood that in order to guarantee substantial urban response planning and resilience planning the main priorities should focus on ensuring safety and risk reduction by assessing risk analysis to re-

evaluate flood planning policies, legislations, emergency responses, communications, education, and awareness programs to meet the criteria to increased flood hazards. Therefore to ensure resilience building it is important to integrate each of these priorities and to maintain consistency in planning and commitment to implement plans. In recovery planning, key components consist of strong leadership, community empowerment, partnerships and communication using a holistic integrated approach, acknowledging lessons learned and planning for a transition to adapting and introducing a change in culture and environmental well-being.

This analysis proved that flood response planning is a complex matter that requires taking many factors into consideration. Most importantly, it is necessary for both municipalities to have short-term and long-term plans and goals. As the literature suggested there are uncertainties in predicting future outcomes, therefore adaptation measures are necessary. This reinforces that applied strategies need to be modified as the environment changes, enhancing system multifunctionality through integrated planning.

It is important for citizens to indulge in a culture of change where they adapt and normalize to resilience planning. It has been acknowledged that resilience building requires a holistic view of planning which involves society, economy, reconstruction, environment, communication and learning. Yin (2001) examines where a top-down planning approach is perceived to limit resilience building and therefore we need to allow for more collaborative planning. Interviewees discussed that NGOs are credible resources and have extensive knowledge of local environmental issues. Therefore, NGO and interest group involvement in planning provides a platform and access to resources and promotes integrated planning. This will allow for greater support of rehabilitation and

restoration of damaged property to adapt, protect and re-establish a healthy sustaining environment and increase resilience to future disturbances (Flood Recovery Task Force, 2013).

The results in this study reinforce concepts identified in literature. Differences in Toronto and Calgary are observable in the organization and division of roles for watershed/flood management agencies and policy development. The results indicate that Toronto likely has a greater resilience to urban floods than Calgary.

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Appendix A: Table 6. Conceptual Framework

Characteristics	Description	Key Actions and Strategies
Vulnerabilities	- Causal factors of floods (flash floods high concern for cities) - Identification of most susceptible factors (ex. Economy, infrastructure) to natural disaster - Identification of most affected communities	- Planning strategies include examining previous flood events and associated vulnerabilities and planning measures to reduce impacts - Assess existing planning measures and latest flood events and examine how vulnerabilities affected areas have decreased.
Risks	- Identification of physical risk (infrastructure, human health, economic loss, etc) - Identification of risk reduction mechanisms against floods	- Assessment of social, environmental and economic impacts - Improvements to reduce risks based on lessons learned from previous flood events and planning measures - Preparation for recovery
Forecasting	- Identification of useful tools or where improvements can be made to enhance forecast of future weather events - To detect when events occur and build resilience capacity and prevent flood damage loss - Asses trends of past events to provide better estimates for future climate and extreme rainfall	- Forecasting provides better understanding of rainfall behavior - Targets most vulnerable areas - Develop regulatory programs to asses sites most affected by floods. - Up-to-date flood mapping - Improve early detection
Policy	- Multi-governance involvement in planning and decision making - Aims, objectives and importance towards building resilient cities - Regulatory and planning law approaches in flood risk management policies	- Examination and revision of land-use planning policies and guidelines to minimize future developments in flood prone areas - Planning strategies involve targeting areas brought most attention by the public - Up-to-date progress reports accessible for everyone - Revision and implementation of recommended changes to regulations
Climate Change	- How to deal with uncertainties in hydro-climate studies - Identification of climate impacts over time and how we should manage rivers and infrastructures in cities and surrounding regions	- Planning measures should include short and long term goals for possible climate change impacts - Planning strategies should be time-phased as climate and rainfall activity change overtime, allows for effective adaptation practices has research progresses
Adaptation	- Implementation of flood risk reduction strategies. (Structural and non-structural methods) - Involves land-use management and watershed management policies - Barriers faced in implementation due to socio-institutional factors rather than technical	- Revision of existing flood management practices and lessons learned in public and private sectors - Implementation of suggested improvements (monitoring runoff, infrastructure, accuracy and timeliness of the information and alerts) - Adapt as you go approach (short and long term vision goals) - Establish national workshops to exchange ideas of best practices
Citizen participation	- Involvement of local communities in the planning and decision making process - Help to distinguish main areas of vulnerability	- Implementation of flood preparation and awareness programs for the affected public

	- Community engagement in adaptation planning	- Cooperation and partnership amongst provincial, municipal, other agencies and local communities to develop integrated planning - Providing tools to the public to observe flood alerts and risk reduction guidance
Mitigation	- Process of various strategies to reduce flood damages - Structural (ex. dykes, storage reservoirs) and non-structural (ex. Regulations for future developments) - Cities need to focus on effective sewer systems and runoff reduction strategies to protect against flash floods.	- Planning strategies that involve structural measures to reduce flood impact - Actions include building new or improving existing infrastructure - Enhance protection against flood water levels, storage and diversion - Reduction of runoff level through the use of protection barriers - Assess mitigation impacts on social, economic and environmental factors
Sustainability	- Assess watershed management and land-use management, identify areas that require improvements - Identification of ways to manage flow and store water	- Monitoring implemented programs, assessing the successfulness and make improvements - Assessing past events and current events and examine how sustainable - Establish a group of member's responsible for managing preparedness and resilience planning
Resilience	- Identification of strategies to make cities resistant to extreme floods - Reduce or eliminate the impact of any natural disturbance - This applies to any impact to the economy or society - Incorporating climate change in long term resilience planning	- Regulation and decision making involving developers, engineers, insurers, related professionals - Holistic planning considering multiple factors for best practices to minimize social, environmental and economic impacts - Progress updates for city council and revisions - Support programs for property owners (private or public) to implement flood resilience measures

Appendix B: Interview Script & Questionnaire

Hi my name is Sarah Asrat, I am the researcher for this study.

The purpose of this study is to analyze flood response practices and how future planning can be improved to resist floods. The results of the study will help to gain further knowledge on what planning approaches are most effective and what alternative methods can enhance flood preparedness planning. This will also help to provide more insight dealing with climate uncertainties and future predictions of rainfall behavior.

The interview should take about half an hour to an hour. If you are willing, I will be recording for transcribing purposes. The recording will be destroyed after it has been typed up for confidentiality purposes.

I would like to ensure you that all confidentiality procedures will take place. Your identity or any other indication of your identity will not be used for research purposes and will not be presented in the final report.

I would like to remind you that participating in the interview is voluntary and if you have any concerns and question feel free to ask at any point during the interview. If the interview questions make you feel uncomfortable and you feel that you cannot not proceed with the interview please let me know at any point.

Lastly I would like to inform you that this research study has been approved by the WLU REB following all guidelines by the REB as outlined in the consent form.

Okay, now we may proceed and begin the interview.

1. Is flood response planning a priority for your organization/agency? What priorities are your main ones?
2. How do you consider resilience in planning for extreme events such as floods?
3. Are there any key uncertainties in response, sustainability or resilience planning? If so what?
4. What urban flood resilience (planning or response) tools and approaches responses do you think work well or do not work well?
5. How do you plan so that future events have less severe impacts? Do you try to plan to make the city more resilient and less vulnerable?
6. What are the barriers faced in response planning? Can you provide an example of particular case and what kind of issues arose?
7. What types of conflict, if any have arisen with other institutions and/or government in response planning?

8. Is there any community or NGO involvement in the planning process? How and how involved are they? Could local communities be more involved in the planning process? If so how?
9. What might be some of the unique challenges faced here for urban flood planning, compared to other cities?
10. Do you have any other thoughts about these issues?
11. Do you have any suggestions of other people I should talk to, or reports and papers I should look at?

Interview wrap up

The interview has now come to end.

I would like to thank you for giving me your time and participating in this interview. Your participation in this study is greatly appreciated and hope that you will find the results interesting.

After the analysis is complete I will send a follow up and inform you of the findings of the results are.

Appendix C: Contact Email

Hello,

My name is Sarah Asrat and I am a graduate student here at Wilfrid Laurier University. Under the supervision of Dr. Scott Slocombe at Wilfrid Laurier University, I am conducting interviews for my MES thesis to understand urban flood response planning practices.

I will be conducting interviews to examine how key professionals, decision makers and interest groups feel about current and future flood planning practices. If you agree to participate in the research study, I will be asking you questions about current programs and activities in your city and suggestions for how the city can become more resilient and less vulnerable.

The study will involve participating in a 20 to 60 minute in person or phone interview (which will be recorded if you agree). The interview questions that you will be asked will be provided in advance. Your identity will not be included in the interview transcript and all confidentiality procedures are outlined in the consent form attached.
PARTICIPATING IN THIS STUDY IS VOLUNTARY AND APPROXIMATELY 20-30 OTHER PARTICIPANTS WILL BE INTERVIEWED (11).

There are no risks associated in participating in this research study. There will be benefits to taking part in this study by providing feedback that will help improve city planning and urban flood responses

Research participants have the right to ask questions about the research before, during, and after participation. For any inquires please contact me at (416) 858-4247 or email at asra3370@mylaurier.ca or my supervisor at 519 884-0710 ext.2781 or email at sslocombe@wlu.ca.

If you require any information about this study, or would like to speak to the researcher please call (416) 858-4247 or email asra3370@mylaurier.ca or my supervisor at 519 884-0710 ext.2781 or email at sslocombe@wlu.ca. THIS RESEARCH STUDY IS APPROVED BY THE RESEARCH ETHICS BOARD (REB) AND if you have any other questions regarding your rights as a participant in this research, you may also contact the REB CHAIR Dr. ROBERT BASSO (519) 884-1970 EXT. 4994 OR EMAIL RBASSO@WLU.CA (2), RESEARCH TRACKING NUMBER 4333 (1).

Sincerely,

Sarah Asrat

Appendix D: Consent Form

WILFRID LAURIER UNIVERSITY

INFORMED CONSENT STATEMENT

URBAN FLOOD RESPONSE PLANNING: BUILDING URBAN RESILIENCE IN THE CONTEXT OF CLIMATE CHANGE

PRINCIPAL INVESTIGATOR: SARAH ASRAT ADVISOR: SCOTT SLOCOMBE

You are being invited to participate in a research study for a Master's thesis at Wilfrid Laurier University on urban flood response planning. In particular, this research study is interested in analyzing how flood responses can help build toward a more sustainable and resilient city.

INFORMATION

This research will require about 30-60 minutes of your time. During this time, you will be interviewed about your experiences and thoughts about current and future flood response planning in your city. The interviews will be conducted in person or by phone and will be recorded. There will be approximately 20-30 participants in the study.

The interview will discuss your city experiences in flood response programs and to share planning suggestions. By participating in this research, you may benefit others by helping city planners, decision makers and interest groups have a better understanding of what the cities limitations are and what futures perspectives will be for a resilient city.

RISKS & CONFIDENTIALITY

In taking part in this research there are no risks and several steps will be taken to protect your anonymity and identity. Confidentiality will be ensured by allowing access to data by only the main researcher, research supervisor and thesis committee. All data will be stored in an encrypted file save with no identifying indicators. While the interviews will be recorded, the recording will be destroyed once it has been typed up. The recorded interview will not contain any mention of your name, and any identifying information from the interview will be removed. To ensure anonymity in the results of this study, participant quotations will not be included in the results and only with consent will quotations be stated in the results. The raw data and any participant information will be retained only until the study findings have gone through complete analysis and the thesis has been completed. After completion of the study, all data will be destroyed by deletion and erasure of files containing critical information.

Your participation in this research is completely voluntary. You may withdraw from the study at any time for any reason. If you do this, all information from you will be destroyed.

The results from this study will be presented in writing for a master's thesis. The research committee and departmental members will read the thesis. The results will also be presented to in research seminars and departmental members and conferences. At no time, however, will your name be used or any identifying information revealed. If you wish to receive a copy of the results from this study, you may contact one of the researchers at the telephone number and email given below.

If you require any information about this study, or would like to speak to the researcher please call (416) 858-4247 or email asra3370@mylaurier.ca or my supervisor at 519 884-0710 ext.2781 or email at sslocombe@wlu.ca. This research study is approved by the Research Ethics Board (REB) and if you have any other questions regarding our rights as a participant in this research, you may also contact the REB chair Dr. Robert Basso (519) 884-1970 ext. 4994 or email rbasso@wlu.ca, research tracking number 4333.

I have read the above information regarding this research study of urban flood response planning, and consent to participate in this study.

_____ (Printed Name)

_____ (Signature)

_____ (Date)

I HAVE READ THE ABOVE INFORMATION REGARDING THE RESEARCH STUDY AND AGREE ☐ OR DISAGREE ☐ TO AUDIO RECORDING AND THE USE OF QUOUTATIONS. (10)

_____ (PRINTED NAME)

_____ (SIGNATURE)

_____ (DATE)

Appendix E: Table 7. City of Toronto Results Table

Interview Question	Response
Is flood response planning a priority for your organization/agency? What priorities are your main ones?	**Provincial Government** - Flood response planning is primarily the responsibility by the Municipal government and conservation authorities. The ministry is responsible for riverine flooding. use the provincial policy statement to regulate land-use policies and guiding new development. (TP1) - Administer infrastructure and allocating money for flood alleviation. Priorities look at climate change, vulnerability and impacts associated to floods. (TP2) **Municipal Government** - Floods are the most expensive natural disaster, therefore as climate changes more precautions and adaptation practices need to be in place (TM1) - The municipality is required to have an emergency management plan legislated by the provincial government ensuring a flood risk specific plan. It is in the top priority list. In conjunction with conservation authority, mapping, identifying vulnerable areas in the city and dividing responsibility. (TM2) **Conservation Authority** - Provide regulations and administer regulations, govern planning in protected areas, mitigation and to get information out through flood warning and advisory systems (TC1) - Foundation of the conservation authority is to look at watershed management, reducing risks to flood hazards, ensuring municipal development planning is aligned with the provincial policy statement and resilient building. (TC2 & TC3) - Flood risk reduction, flood risk avoidance, flood forecasting, warning and paparedness planning are main priorities. (TC4) **Private Organization** - Look at disaster response, specifically disaster mitigation, pre-disaster planning to limit the impacts of disaster. (TPO1) - Provide assistance to local government, decision-makers to build disaster resilience in communities, partner with developers to construct resilient buildings and infrastructure and insurance companies (TPO2) **Academic** - Priority in the sense of species biodiversity. Looking at changes in city administration priorities have changed, which shifted environmental concerns. But resilience planning should be a priority (TA1) - Understanding peak flow predictions in the context of climate change and Ontario regions that have experienced land-use changes and urbanization. (TA2) **NGO** - Is a main priority because it is a big financial cost for clean and operation loss of events on site and also prevention of E.Coli and bacteria clean up due to mixture of storm water and sewage. (TN1)
How do you consider resilience in planning for extreme events such as floods?	**Provincial Government** - Need adjust land-use practices and follow the policy provincial statement effectively and need to consider climate change adaptation in urban deigns (ex. Soft spaces, green designs, permeable surfaces) (TP1) - Resilience planning for extreme events look at adaptive and

	mitigation measures to reduce climate change and by reducing greenhouse gas emissions to slow the impacts of climate change. This will allow to slow the rate of extreme rainfall frequency and reducing the impacts. (TP2) **Municipal Government** - We help people to deal with extreme weather and public health. Programs need to consider climate change and how extreme weather can be impacted as climate changes. (TM1) - Looking at hazardous risks and assessing existing risk. Don't specifically work on resilience, but work along with other division in the city. (TM5) **Conservation Authority** - Resilience planning is the core of our work by minimizing risk implementing response and mitigation programs; reducing erosion, improving infrastructure services and preventing development in floodplain. (TC1) - Planning looks at worst case scenarios using Hurricane Hazel as an extreme event bench mark and ensuring newer developments are built out of the flood zones. (TC2 & TC3) - Developing risk mapping based flood events and predicting storm events that will likely occur throughout the watershed and jurisdictions providing protection future, which models will be integrated in policies and legislation in preventing developing in flood zones. (TC4) **Private Organization** - Work along with other private organization and government providing research to limit the impacts of disasters. (TPO1) - Those groups working in response planning are not with resilience planning and are dealing mostly with incident response/management and not promoting resilience and risk reduction. There needs to be a focus on future building to make communities better than what it was before reducing risk and more resilient. (TPO2) **Academic** - Planning for extreme events should at the top of priority and need to look at mitigation and adaptation to climate change and extreme weather events. (TA1) - Resilience can be integrated into planning measures looking at low impact development and storm water systems. These implementations will help to sustain the natural water system and allow to build resilience in communities. (TA2) **NGO** - Look at resilience in terms of clean up, we anticipate flooding and have retrofitted as a method to mitigate flooding (ex. Power outlets 3 ft high) Therefore building design looks at methods to reduce damages possible. Based on rain guage monitoring when threshold is reached call out clean up crews- allows recovery to be rapid and less costly by not relaying on insurance claims. (TN1)
Are there any key uncertainties in response, sustainability or resilience planning? If so what?	**Provincial Government** - Understanding climate change, implementing adaptive measures and working towards medium to long term planning and budgeting (TP1) - Having the resources and money to have a planning framework in place. This comes to recognizing and accepting the fact that the environment is changing and not repeating the same mistakes over again. Uncertainties lay in areas of having a complete environmental solutions (ex. Building, watershed protection and urban management). (TP2) **Municipal Government** - There are great uncertainties in future climate projections,

	knowing how to reduce green house gases and building based on worse case scenarios (TM1) - Uncertainties lay between flood mapping and predicting the severity of future storms. Update floodplain mapping every 5 years using the best modeling at the current time using hurricane hazel as a regulatory flood event. There is great riverine flood mapping, but insufficient urban flood mapping. (TM2) **Conservation Authority** - Using technology to monitor and minimize risks in specialty areas daily. (TC1) - There are technical uncertainties about climate change, engineering (ex. Flood proofing, buffers, etc.), modeling and redevelopment in special policy areas. (TC2 & TC3) - Future events are unknown and over the last decade extreme floods are occurring more intense and more frequent, need to embed climate change in the learning process and understanding probability assumptions of the likelihood of events. Not everything can be preventable and measures depend on how much willing to tolerate and how much willing to pay for. (TC4) **Private Organization** - Uncertainties include not knowing about the exposure risk to floods because there're unknown factors of individual homes (ex. Use & value). Other uncertainties include condition of aging infrastructure and the ability to accommodate increasing volume of storm water. (TPO1) - Resilience planning is complex and there are many uncertainties include trying to anticipate what the risks will be in the future (ex. Strength of the hazard), design of a community and preparing for a flood in the next 50 years (what kind of houses/buildings will be built) and lastly the behavior of how citizens react (Some behaviors may make the event worse or better) (TPO2) **Academic** - Uncertainties about preparedness planning to flooding and other extreme weather events and understanding how this impacts people in the city. (TA1) - Predicting flood events, identifying infrastructure impacted by flood at risk, indirect complications, such as power outages existing gaps in management in planning responses. Climate change projections and using models looking at regional scales. (TA2) **NGO** - Understanding weather systems and patterns and making sure accurate information with conservation authority. Other uncertainty includes time in which there are rain gauges to monitor volume of water in the Don River and respond accordingly when threshold is surpassed. (TN1) - Building community resilience and dealing vulnerable citizens that are not interested so there are uncertainties in effective preparedness planning. (TN2)
What urban flood resilience (planning or response) tools and approaches responses do you think work well or do not work well?	**Provincial Government** - Risk assessment tools are useful in identifying vulnerable areas and looking at water usage in the city for various uses (ex. Home, recreation, etc.) developing short term plans, but there is a lack in more long term preventative work (TP1) - Naturalizing programs to increase runoff infiltration. (TP2) **Municipal Government** - Implementing more green infrastructure and green roofs are tools that work well because they help to retain water. Not all structural measures can protect everything, therefore more naturalized approach is need to reduce flashy floods. (TM1) - The communication have shown to work well notifying various divisions, conservation authorities and first responders that there

	is a storm coming and to get out in the field. The city has a great riverine flood mapping system and requires urban flood documentation and mapping in all part of the city. (TM2) **Conservation Authority** - Using applications to send out alerts and notify people of upcoming storms has been a useful tool. But more work needs to be done to improve providing accurate information. Also emergency preparedness such as preparedness kits needs a better job (TC1) - Tools such as the provincial policy statement and approval process to ensure that development is kept outside of floodplains works well. (TC2 & TC3) - Legislation preventing development in flood prone areas, which has shown to work well. Risk reduction doesn't work well because there are many challenges and typically good at identifying risks, such as old infrastructure. The authority generally provides recommendations of what should be done by the municipality. (TC4) **Private Organization** - Reducing risk with proper infrastructure design and making sure that it can accommodate rainfall and impacts from exceeding and limiting water. These aren't perfect measures, but is a primary effective measure (TPO1) - There are two types of tools; one being physical engineering changes (ex. Sewer pipes) and second behavioral measures done by home owners. The first measure is the responsibility of the government and are not doing a good job of maintaining it after it has been put in place. With the second option there can be a great potential to bring greater change, but home owners are not well informed how they can contribute to build resilience. (TPO2) **Academic** - There is great attention on wetlands, paved spaces and unpaved spaces and ensuring functionality of ecosystems and hydraulics, but do not have a enough of that in the city. More work needs to be done in communications ensuring that accurate information is available since rumors can get around easily and becomes difficult to determine reliable weather information. (TA1) - Tools that work well are landscape management using the watershed area for integrated management, conservation authority mandate and regulation according to watershed boundary. Tools that have not worked well include the integration of other infrastructure systems (ex. Transport and energy) experience major flooding in expressways always experience power outages. (TA2) **NGO** - Retrofitting the site to reduce damage looks, building a network with clean crew and purchasing equipment for clean has allowed to reduce cost. Over the last two experience 1-100 year floods and have show significance reduce in cost. Use monitoring and mapping systems to forecast upcoming storms, which allow some time to respond and evacuate site if needed. (TN1) - Use social measures to build community resilience to ensure effective preparedness planning to extreme weather. There is a need for better community outreach and engage get citizens more interested in understanding the seriousness of the situation. (TN2)
How do you plan so that future events have less severe impacts? Do you try to plan to make the city more resilient and less vulnerable?	**Provincial Government** - Having mid-long term flood response plans working on conjunction with the municipal and other ministries and allocating resources where needed appropriate for more effective preventative measures. Need to plan pre-disaster opposed to post-disaster. (TP1) - Reduce climate change impacts through mitigation an adaptation.

	This in whole will allow to reduce the impacts of extreme floods in conjunction of suitable design and building. (TP2) **Municipal Government** - Designing for something to fail so there wont be any unpredictable damages and quickly bounce back (ex. Designing roadways to be flooded instead of basements so it can't back up as much). (TM1) - Building more partnerships with the conservation authority, enhancing preparedness planning and education, understanding vulnerability to risk, infrastructure and accessibility of information. Possibly conduct public awareness campaigns. (TM2) **Conservation Authority** - Effective use of regulations and working closely with service providers (ex. Subways, flood protection), flood proofing future developments (TC1) - Opportunities for redevelopment and infrastructure upgrades can be used to build resilience and mitigate flood with effective infrastructure. There is a program that looks at identifying vulnerable areas, get information out to the municipality so redevelopment and flood remediation can occur. (TC2 & TC3) - Identify areas at risk, prioritizing the areas based on a set of factors and damage costs if a flood occurs, also look at how quickly people can evacuate and most importantly reducing risk to life. This will lead to developing flood remediation and emphasis where money should be invested. (TC4) **Private Organization** - Land-use planning for rivers and coastal risk reduction, understanding the flow of water and limiting development in those areas. Apply low impact measures to improve storm water infrastructure to protect private properties. (TPO1) - Majority of the urban flood damage can be preventable if investments are made by the government for storm water infrastructure in collaboration with work home owners can do to protect their own property. (TPO2) **Academic** - Climate change needs to be addressed and try to adapt to it and aside from that accept the reality of extreme weather events and have experts, communication tools and response plans in place. Efforts such as un-paving spaces and using new development opportunities for low impact developments to withstand extreme events and also programs to help vulnerable citizens. (TA1) - Flood prediction of when and where a flood would occur, mitigating floods by operating reservoirs and dams to minimize flooding and also mechanisms to infiltrate water into pipes or natural streams and increasing low impact development. (TA2) **NGO** - On site there have been many retrofits not for the propose of flood proofing but because of anticipating floods and to minimize the damages and reduce the risks of floods including rain cisterns to collect rain water and use for gardening, bio swells, green ways, trenches in parking lot to infiltrate water to bio swells and storm management pond, replaced wood shelving to plastic to reduce waste and lastly would suggest pervious concrete. (TN1) - Increase community engagement to understand emergency response efforts and resilience building by creating preparedness programs to reduce risk in vulnerable areas and to ensure good behavior during an extreme weather event. The city would also benefit if it had a resilience office with expertise to these events. (TN2)
What are the barriers faced in response planning? Can you provide an example of	**Provincial Government** - Finances are barriers because resources are limited now. The society is more reactive than proactive and are trying to recovery

particular case and what kind of issues arose?	after an event. Dealing with different attitudes and response in discussing who is going to pay for repairs and adaptive measures. (TP3) **Municipal Government** - Money and also not having enough staff to manage flood related projects. (TM1) - Lack of a program identifying vulnerable flooding areas and how it will impact emergency response, not enough planning to get flooded roads closed (ex. DVP) and trying to develop response strategies to complex situations. (TM2) **Conservation Authority** - Coordination amongst service providers, providing clear information, strong leadership, cross jurisdictional partnerships, funding issues and aging infrastructure (TC1) - Barriers include cost of implementing flood remediation programs, working with other jurisdictions and funding solution measures and how this may impact land owners as well. (TC2 & TC3) - Lack of information, developing response planning based on assumptions and if those assumptions aren't accurate to a high probability then money is wasted on implementation. Also jurisdictional issues of where water bodies are located, technical challenges in forecasting and warning and lastly budgets when implementing programs across jurisdictions. (TC4) **Private Organization** - First settlers in urban areas developed along the rivers where there is high value land. There are poor understanding by citizens and decision-makers about the likelihood of extreme events and impacts and the need to implement measures before an event occurs to reduce the risks. (TPO1) - there are few barriers in response planning, but there is always room to identify what can be improved. Communication is key and communities that communicate effectively during an event do well and those that don't fail on communication. (TPO2) **Academic** - Economics, planning for an event that hasn't happened yet with great uncertainty and not know how that is going to result in the contingency planning/paying for different worst case scenarios when the city is also dealing with other competing priorities as well. It all comes down to how much we are willing to spend on mitigation and adaptation plans. (TA1) **NGO** - As a non-for profit organization finance and implementation of programs is difficult when working with limited budgets. Other barriers include multiple areas being flooded and facing limited resources of people to responds to clean up needed in the city. (TN1) - Having the resources to implement preparedness programs and kits for every household. (TN2)
What types of conflict, if any have arisen with other institutions and/or government in response planning?	**Provincial Government** - Looking at the different levels of governance to local communities there needs to be horizontal response planning so we aren't wasting any resources. There are institutional barriers, but there are outreach attempts to local community groups and NGOS. (TP1) **Municipal Government** - Functionality of government and changing interests and priorities. (TM1) - Have great partnership with conservation authority and also partner with the training management course. (TM2) **Conservation Authority** - Every institution have their own top of the line priorities, therefore there are competing priorities and difficult to maintain flood

	response as a priority and work together. (TC1) - Work with municipal partners and have a good working relationship. If issues arise they can be overcome. We keep up with technical information, mapping and watershed monitoring and set long term watershed management allowing to stay ahead of anticipating planning and provide support to the municipality in their planning exercises. (TC2 & TC3) - There is a great collaborative process, where the conservation authority is viewed as experts providing recommendations to the municipality and the rest depends on the municipality's political priorities and budgets. (TC4) **Private Organization** - Conflicts arise with the desire to develop in flood vulnerable areas, thinking short term and not long term. (TPO1) - Very little conflict and there is a clear distinction of who has the authority to act and what their responsibilities are. If the resources are available and everything is done in a timely matter then there will be very little conflict. Conflict will only arise if those responsibilities are not met. (TPO2) **Academic** - Change in administration also changing priorities (ex. Paying for transportation vs. mitigation towards natural disasters). It is difficult for short-term officials to make long-term decisions since they are in office for a short time and have other competing priorities of where to allocate funds and looking at what we can do realistically at the moment and how to save for the future "saving for a raining day". (TA1) - We have great communication and interaction between different levels of government, conservation authorities and first responders. There are gaps between energy sector and not well coordinated with the rest of response team. (TA2) **NGO** - There is no conflict, our partners have invested in organization and have the best interest to improve and protect the watershed. (TN1) - Have a loose partnership with the city, but since they are under-resourced and under capacity of experienced staff there isn't much help we can get. (TN2)
Is there any community or NGO involvement in the planning process? How and how involved are they? Could local communities be more involved in the planning process? If so how?	**Provincial Government** - Climate Change will be a great way to get more community involvement and NGO participation will be advantageous if they know where their participation is (Consultancy). Not sure how local communities will be more involved with first responders. (TP1) - There is significant community involvement and just depends on the ministry. NGOS are hired for consultancy and research work and serve on working groups and committees, such as the environmental bill of rites. NGOS are viewed in the parliament as most credible. Toronto has a diverse population and consist of different immigrants from different parts of the world and have first hand experience with floods. Reaching out to cultural groups that have experienced floods in home countries can be advantageous in engaging conversations and using their feedback in developing solutions. (TP2) **Municipal Government** - Civic action groups advocate and incubate environmental, but don't have the recourse to implement changes. Involvement is minimal in decision making, but provide useful information. (TM1) - Work closely with the conservation authority, which they provide consultation. Local communities are involved in other work not specifically related to flood management. Citizen concerns are

	considered in the next annual update. (TM2) **Conservation Authority** - NGO and local community involvement is mainly based on consultancy process. Difficult to engage stakeholders unless they are directly impacted by a flood. Therefore their feedback is important to develop more efficient flood warning advisory, protection of flood prone areas and more education and awareness programs. (TC1) - There is a public commenting role under the planning act and community outreach in flood forecast awareness. Communities may get involved due to personal property being impacted by basement flooding, therefore first hand experience with flood can be used for more community engagement and flood awareness. (TC2 & TC3) - Looking at the planning level there isn't many involvement, but work closely with like minded organizations and agencies. Local communities are involved when seeking solutions for risk reduction, where the conservation authority will go into areas identified to be at risk and consult stakeholders and other NGOS in that area. There are environmental groups that are involved in the land-use planning phase if there is proposed development project in green field areas. (TC4) **Private Organization** - There aren't a lot of flood specific NGOS independently funded. There are lots of community involvement conducting environmental assessment. NGOS are not directly involved in decision-making, but involved in conducting reports and advocating for effective change. (TPO1) - There is a variation of NGO involvement across in Canada (ex. British Colombia do an effective job), but mostly across the country NGO involvement is not as strong as it could be. NGOS need to challenge the government of what their capabilities are and ask to be invited. (TPO2) **Academic** - There a plenty of NGOS in Toronto, there is government in the city and people have a great network. There is plenty of work on smart growth, green initiatives and social issues in marginalized areas that have influenced planning and policy (based on assumption). City politicians are opening to accessible NGOS. NGOS need to work on raising their voice of opinion and useful information. (TA1) - There is community involvement, such as the source water protection act integrate stakeholders encouraging a range of different perspectives in response measures and other programs include river keepers engaged in conservation management activities. Additional preparedness response management placing emergency kits and generators will help accommodate extreme weather. (TA3) **NGO** - Specifically working on flood management initiatives there isn't community involvement, but there are plenty of volunteers and community engagement in other programs within the organization (ex. Tree planting, naturalizing watersheds) (TN1) - All our work is based on volunteers in which we work with community members, stakeholders, agencies to engage community citizens and build relationships in communities create response strategies to emergency events (TN2)
What might be some of the unique challenges faced here for urban flood planning, compared to other cities?	**Provincial Government** - The size of the city, age and money are the biggest barriers. There needs to be good political will to provide the resources for planning and be shared amongst different levels of government for long term resilience planning. (TP1)

	Municipal Government - We are not prepared for power destruction. Toronto is suppose to be one of the most resilient cities and the population increase and the aging population is also increasing therefore there needs to be effective preparedness planning in all areas. (TM1) - Toronto is unique in its geographic location being at the bottom of the watershed, the city isn't built with a lot of storm water management and flood control, aging infrastructure. The city's emergency response and response planning has a lot of resources and is able to respond to all types of events without seeking assistance. (TM2) **Conservation Authority** - Some areas in Toronto are more complicated than others and there are many groups to deal with. Unique challenges considers money challenges and economic issues for work, have other areas that require work (TC1) - Toronto watershed is very urbanized since the early settlers developed in the floodplain. As the city population grows the province has set a growth plan to prevent increasing urban sprawl. This is a challenge because existing infrastructure will not have the capacity for new development and re-development. Therefore there is a need for infrastructure upgrade and expansion and financially that is not feasible. (TC2 & TC3) - There are rapidly developing communities right up north of City of Toronto and are expecting population to increase in the Greater Toronto Area (GTA), this means increasing flow of stream creating more flashier floods as storm water flows down the watershed. (TC4) **Private Organization** - Toronto is an older municipality with older infrastructure in which development was not built according to current standards. Pressure to develop in the white belt area and other undeveloped land. (TPO1) - Urban flooding is similar across Canada, but there is a difference that during an urban flood there could be other things happening, such as riverine flooding at the same time. People need to be more sensitive to the meaning of urban flooding in comparison to other types of flooding. (TPO2) **Academic** - Toronto is a large city, old/aging and consists of a large population with a lot of foreign born. There are language and economic barriers making it difficult to understand insurance, risk perceptions and competing social and cultural conceptions. (TA1) - Toronto is a large urban city, which if an extreme event occurs there will be an economic impact. Insurance claims increase as wealthy communities make claims. There are many rivers within the city compared to other cities that may have just one river, therefore there are legacy issues a different mindset of early settlers and not thinking of storm water management at time of development. (TA2) **NGO** - the last comprehensive flood mapping occurred after Hurricane Hazel and updated about approximately twenty years ago, therefore flood mapping is out of date. Also areas that are located by a river are experiencing floods and also in the city there are buried creeks being discovered. (TN1) - The way of thinking they are safe and not exposed to any risk needs to change. Marginalized communities are stronger than others because everyone knows each other and are better at responding to extreme events. (TN2)

Do you have any other thoughts about these issues?	**Provincial Government** - Need to response more rapidly with flood/resilience planning to avoid plans getting lost in the list of priorities. Also understanding the inter-dependency of infrastructure in urban cities. (TP1) - Citizens need to make conscious decisions about their contribution to problem and make changes to reduce the impacts. (TP2) **Municipal Government** - There is a lot that can be done with the engagement of citizens and people need to think about changes they can make on their own properties like permeable driveways. (TM1) **Conservation Authority** - Concerning major issue is the integration of conservation authorities with the city and addressing water infrastructure concerns. (TC1) - Send out information in our policies to the municipality to ensure that the growing region is built resiliently and safe, looking for opportunities to redevelop and revitalize urban design and aesthetics and eliminating risks to flood hazards. (TC2 & TC3) - Municipalities need to invest in expertise to address the problem and deal with flooding problems for future climate while evolving jurisdictional problems. The conservation authority provides recommendations based on research looking at models and applications developed. (TC4) **Private Organization** - Flood regulations were created and implemented post hurricane hazel. We need to look at what lessons are learned and how to be prepared for future events and consider climate change and change in precipitation activity to enhance preparedness planning. (TPO3) - In Canada urban flooding is the leading disaster damages to property in conjunction with climate change there is a changes it may get worse and that is when this issue will be taken seriously. Most of the losses can be preventable, but this needs to be taken seriously and make more progress in responses. (TPO4) **Academic** - This is a very important topic, there needs to be more urban planning considering living things. (TA1) - The 1-100 year event is used as a reference point of extreme event, which may not be conservative enough now since we are experiencing 1-100 year floods more frequent especially where new infrastructure exist and do not have the capacity to withstand large volume of storm water (ex. Red Hill expressway, Hamilton). (TA2) **NGO** - This is a complex issues and many barriers, but there needs to be an increase understanding on weather system patterns and how floods occur. (TN1) - Building community resilience is important to reduce exposure to risk and having designated roles and knowing points of contact help to organize an effective response during an event before first responders arrive. (TN2)

Appendix F: Table 8. City of Calgary Results Table

QUESTION	RESPONSE
Is flood response planning a priority for your organization/agency? What priorities are your main ones?	**Provincial Government** - Flood response planning is a priority by setting out a plan and getting flood response centers organized and having effective communication a routine part of our work. Priorities look at how information gets delivered to the municipality in terms of river flows, getting people out on the field to validate information. Also work with municipal systems tracking and responding to flood related issues and have a flood-forecasting center. (CP1) - Looking at mitigation options and building long term resilience is a priority and has become a front line priority since the 2013 flood. (CP2) - Coordinate all provincial government supporting communities, responding to events and helping communities recover from extreme events. (CP3) **Municipal Government** - Improving resiliency in vulnerable areas, public safety and critical services (ex. Water, electricity and transport). (CM1) - Priorities focus on utility services, portable water, sanitary and storm water drainage services under the provincial, municipal government act maintaining response strategies (planning and prediction) to regions at risk in Calgary due to flooding and ice related flooding. (CM2) **Private Organiztion** - Provide technical support for the government by linking policy and technology needs of the government for industries and academic research. We focus on water policy, business, liable water supply and city and province to improve flood response. (CPO1) - Hired by external parties to conduct assessments and look at regions and what planning practices should be put in place and how well they perform. (CPO2) **Academic** - Evacuation of students, housing and providing shelter, emergency response preparedness. (CA1) - The university should make a contribution to flood response/resilience planning. (CA2) - Looking at ways the city can develop flood mitigation programs. Participated in a civil meeting to develop a report main priorities looking at stop developing in flood prone areas and reduce flood risk. (CA3) **NGO** - Priority of the organization is climate change adaptation and mitigation, but flood isn't. (CN1) - Not intimately involved in response planning but work related to watershed management planning and have little involvement in preparation for response or recovery from flood and have very little direct involvement. Since the last major flood a couple of months after, response activities were still governed by emergency principles more than watershed management and hope it will be returned to watershed management as quickly after emergency management needs are met. (CN2) - Help people gain understanding on how to make landscape more resilient with land-use changes and learn how to build resilience to climate change and adapt to climate with various land-use changes. (CN3)
How do you consider resilience in planning for	**Provincial Government** - If we get minor floods, we can develop a good capacity and routine

extreme events such as floods?	activity practicing flood response programs. Flooding is difficult to prepare for because not matter much preparedness planning is in place, do not know what the city will be hit with. Newer communities have responded will with infrastructure designed to anticipate large stream flows. So far since the major flood in 2005 there has been staff turn over working in managerial positions directing effective plans. (CP1) - Helping communities across the province build resiliency with infrastructure and public safety when extreme events occur. Working toward minimizing damages and increasing preparedness planning. In relation to the 2013 flood there could have been more prepared and since then a resilience and mitigation branch has been formed within the last year setting long term objectives. (CP2) - Resilience is a combination of partnership, preparedness, planning, training and being ready to respond when a flood event occurs and lead recovery. Planning should involve making mutual aid agreements with neighbours if there are insufficient resources. Risk assessment to understand impacts. (CP3) **Municipal Government** - Preparing for a wide range of events, range of emergency response depending on the size of an event, having a flexible system. Having land-use plans in place and structural investments useful for a board variety of situations. (CM1) - The flood resilience group main objectives address 6 main theme areas; climate change, event forecasting, storage diversion and protection, infrastructure property resilience, additional risk management of non-structural measures. (CM2) - **Private Organization** - When planning for flood need to think about extreme situations and climate variability and take a static response that the river will respond at a certain level. We look at 1000 hypothetical stream data at the Bow, Calvin and North river in Edmonton combining with past data 1000 years examining drought, climate modeling and regional models creating probabilistic models of future hydrology of a 1, 2 or 20 year flood. (CPO1) - Resilience can be looked at how responses can be improved (ex. infrastructure, communicating with the public and government and observing how effective the investments are and showing the return on the investments. Professionals unprepared for flood recovery roles (ex. Assessors, insurance) working long hours and stress environment and so resilience needs to emphasize on mental health. (CPO2) **Academic** - Resilience planning should minimize the cost, the amount of time and effort in recovery. (CA1) - There are different meanings of resilience and policies take an unquestioned definition of resilience due to entrenched practices or assumptions western scientific approaches. Resilience planning should involve adaptive management reverting to engineering model of resilience, but it is difficult to practice other holistic planning of resilience. (CA2) - Resilience in the City Calgary can be reflected on the solidarity and the coming of people together to help each other. People were over stressed, depressed and there is a need for pysochological help for those that had to leave their homes. Aside from that there is a need to focus on floods. (CA3) **NGO** - Look at engaging our citizens and communities within the municipality on climate change behavior and creating awareness

	about mitigation. (CN1) - Resilience suggests to seek environmental sensitive ways of addressing issues and solutions, such as 'room for the river', which involves looking at people moving away from water oppose to making the water stay away from the people. (CN2) - Be prepared for extreme events and varying magnitudes. (CN3)
Are there any key uncertainties in response, sustainability or resilience planning? If so what?	**Provincial Government** - Working with a large area makes it difficult to determine when and where a flood will occur, weight of weather events and designing for 1-100 year flood event and experience a 1-300 year flood. Therefore community designs are built likelihood/probability of events occurring. There is uncertainty in preparing for something that isn't frequent. (CP1) - Knowing what the impacts of climate change as we see events becoming more intense and more frequent. Uncertainty planning considers 100 year period and hydrology modeling in and update models as events occurs. (CP2) - Try to limit uncertainties by carrying out hazard impact risk assessment as a prediction tool, having plans put in rapidly for effective forecasting because never know when exactly an extreme event may occur and what amount of resources will be required. (CP3) **Municipal Government** - Climate uncertainties, predicting events in the future and understanding variability in the future. There are also uncertainties in policies both in federal and provincial government for future events and what kind of liability they will have. (CM1) - Calgary being located at the foot of two maintains it is difficult to predict and characterize types of events that cause flooding varying from peak volume to peak duration, but consistent of the time of year floods occur. Other uncertainties deals with the social and cultural decision around how much to invest around typical events. If flood event doesn't occur for a couple of years, it is forgotten and need to work on keeping cultural awareness and support of investing and defining level of investment and risk. (CM2) **Private Organization** - There are uncertainties around climate change, extreme events, increased flooding and drought. (CPO1) - Not knowing how and how well plans initiated will respond, not knowing how the next extreme event is going to be and if it is going to be similar (ex. Flood, fire, earthquake), uncertainties in cost and return investment. (CPO2) **Academic** - There are limited issues on the availability of flood maps, getting actions made by government, individuals and insurance companies to align with each other. There are multiple players in resilience planning. (CA1) - Understanding what is at stake (mitigating risks) and how it comes into play with climate change, which seems to be a lack of linking the two. Indeterminacy deals with a lot of ignorance among experts, and in a realm of uncertainty of what we do not know and how we frame the problem. (CA2) - Uncertainties can look at knowing when the flood is going to come and knowing whether their communities will be flooded or knowing if their homes will be able to survive the flood. Other areas of uncertainties looking forecasting systems, it as allowed to see when a storm will be coming, but could not predict with certainty the volume of water that will fall into the watershed. Severity of flood could depend on the amount of snow in the mountains plus rainfall known as "rain on snow". (CA3)

	NGO - Lack of coordination is a big uncertainty, but the flood that occurred in 2013 allowed to become aware of the need to preparation. There might be duplicating services or the assumption that certain services are being taken care by someone and that is also unknown. Therefore it is important to have effective communication and coordination and also in resilience planning there isn't enough money being spent on infrastructure. (CN1) - Promoting healthy and intact ecosystems and watersheds. Also preserving existing wetlands, preserving riparian landscape and also land-use practices on floodplains. (CN2) - In south western Alberta there is a lack of critical monitoring equipment and the province has decreased flow monitoring rather than increase creating gaps and uncertainties in flood forecasting and providing consistent historic mapping and accurate flood maps of flood prone areas. Inability to look at things at the landscape/watershed scale and lack of understanding of head front waters impact on flood delivery downstream. (CN3)
What urban flood resilience (planning or response) tools and approaches responses do you think work well or do not work well?	**Provincial Government** - Understanding the cycle of a disaster and how easy it is to prevent disaster and costly to fix. Flood mapping illustrating flood ways and flood fringe is a great tool and data is available online, which helps to predict where flooding will occur. Communities that understand multiple risks were able to face new challenges easier, such as anticipating different events, having larger reservoir capacity and more online tools. (CP1) - Planning approaches use flood mapping and 2 zone maps, flood way and flood fringe mapping setting designations for the municipality to put in bylaws or restrictions in vulnerable areas for future developments. Right now moving towards prohibiting development and also considering ' room for the river' strategy adopted from the Netherlands (ex. Allowing the river to occupy space it needs in the floodplain and moving development out of the way). (CP2) - Flood risk mapping is a good tool, that is still in progress but significant of the work was completed about 20 years ago and a lot of development has been done since. There are some mitigation practice to reduce risk, but still do not have appropriate land-use policies in place to restrict development in flood risk areas and need regulations to restrict development. (CN3) **Municipal Government** - Having an emergency response that is flexible and responsible to different floods and having hour by hour forecasting. Land-use bylaw is a main tool used for development in flood prone areas, but it's a long term tool. Opportunities for re-development will follow bylaw policies. (CM1) - The 6 major themes have to be all looked at along with organizational support of emergency response management. The city has an extensive emergency management network, professionals that work in the field and water business resources. Having the tools, resources, awareness and infrastructure will help make the city more resilient. (CM2) **Private Organization** - Worked with resilience tools looking at a whole watershed collaborated watershed management project, modeling of input of water demand on water in the system and the river basin brings together the water usage. This real time model develops performance level and decision making tools to observe the possibility of building a new structure (ex. Dam or tunnel), therefore this allows to view other aspects of bringing all the water

	users in the community together and build those relationships and understanding and public education. (CPO1) - Look at independent assessments indicating what went wrong and write a report and emphasize on what worked well and what worked well that wasn't planned. There needs to be longer term recovery plans. (CPO2) **Academic** - Planning measures, such as buying out property in flood areas, changing land-use regulations and building codes. Trying to get people to voluntarily change behaviors does not work well as individuals do not like change. (CA1) - Leaving things a small panel of experts does not work well due to their limited disciplinary limitations. Limiting types of experts (mainly engineers) on the panel will not allow a board holistic perspective. There needs to be more stakeholder consultation and present a range of arguments and counter arguments. Need to consider different frames of issues with a different lens. The city/people need to ask questions of who are we building resilience for and who is left out. (CA2) - Using social networks to provide updates to the public of what is happening, assisting rescue units, organizing displaced people. Reading the news papers showed a lot of evidence of what was working well and not what didn't. (CA3) **NGO** - There are really good communication tools to deliver information from the municipality and news media to citizens in a timely matter but was reactive responses. There isn't much proactive tools being practiced, but the reactive piece was coordinated, multilevel, timely and efficient. (CN1) - Flooding is not an unnatural phenomenon and resilience planning is trying to get people to plan and get aware of allowing rivers the room to be behave like river (ex. Room for the river). The east slope of the Rocky's is in the head water region and there is a lot of mobility in the watercourse and streams and the water should be able to flow on it's natural course. (CN2) - Observing past flood events, there isn't much improvement in flood resilience and see repetitive measures in organizations and agencies in flood management, insufficient monitoring and need to build resilience into our landscapes. (CN3)
How do you plan so that future events have less severe impacts? Do you try to plan to make the city more resilient and less vulnerable?	**Provincial Government** - Look at risk assessment, community operations and observe previous events and lessons learned. Applying situational learning specific to areas help to operators to understand risks in a different way. Flooding is based on probabilities; therefore get a range of different perspectives on experiences and how to respond has shown to work. Having a network and knowing where to get help in a formal and informer manner, building awareness about floods and associated risks will help people to plan. (CP1) - Improving preparedness planning, flood warning and prediction in place to project when a flood will occur. Warning will allow for get people out of floods, respond and get equipment out quickly for emergency response measures (ex. Sand bags & water dams). A lot of these tools have been in place since the flood in 2013. (CP2) - The city will not be able to eliminate all the risks, but need to use mitigation efforts and public alterning system 'Alberta altering system' for upcoming storms using traditional radio broadcasting but social networks as well. (CN3) **Municipal Government** - Expert panel report six different areas to focus to reduce future impacts, working with community members, educating awareness about flood risk in the city and personal flood risk on individual

	property and at work and preparedness planning, building infrastructures, land-use planning. Flood control needs to review level of protection or 1-100 year flood needs to be higher. (CM1) - Making sure there is integration of 6 theme areas, culture of awareness for the public, provincial and municipal government to understand risk and preparation to mitigate the problem. Also translating damage into economic cost terms to enhance understanding to investments and risk tolerance. (CM2) **Private Organization** - Reduce impacts and have flood maps in place and understand flood patterns. In Calgary development known as unique broadway prevents people from paving entire front lawn. Also best management practices will work to increase biorention and increase groundwater filtration and potentially green roofs. Snow melt is problematic causing the water system to overload causing flooding and affects water quality, therefore need to look at alternative snow removal. (CPO1) - Municipalities and the province need to conduct independent reviews to observed what has been done and what was used and determine what has worked and what hasn't, training and passing of skills to new individuals in the field, update systems and documentation of flooded areas. (CPO2) **Academic** - One of the hardest and probably one of the most effective planning will be to get policy in place to get individuals to voluntarily relocate out of flood prone areas out of dangers way. (CA1) - Planning needs to consider a board and not a narrow view of the problem observing practices not limited in the city, but upstream. Impacts have been recorded in economics, there has been increasing development in the flood areas. The city has failed voicing about the risks living in the floodplain and need to plan for the marginalized communities discuss issues of inequality and think about impacts and on whom they affect. (CA2) - Planning can look at ecological solutions in the riverbanks avoiding building in the floodplains and moving communities out of high risk areas. Currently the city is considering these strategies and also looking to improve forecasting systems. (CA3) **NGO** - We don't look at the city as a whole, but look at each of its citizens, looking at how people and communities can come together and empower each other to adapt to changes. The faces a lot of overland flooding and inadequate infrastructure so contributing factors are how individuals maintain their properties (ex. Lawns, gardens, driveways), therefore encourage citizens to mitigate the problems by de-paving and repaving with permeable surfaces, planting rain gardens, trees, shrubs, rain harvesting and things that absorb water and recharge the ground water. (CN1) - The city has been looking at riparian restoration and land-use bylaws increasing set-back distances from watercourses, which will be great for resilience planning. This would also support biodiversity and other intended benefits. Because the city is close to the mountains there isn't a lot of warning before a flood hits, but in comparison to Winnipeg warning is sent months in advance. (CN2) - There are many best management practices, some of them work in the Bow river watershed, such as helping people understand giving rivers to move (Adopted idea from the Netherlands), advising how to manage models attend flood attenuation. There isn't much practice with land-use activities and open mind thinking of alternative methods (ex. the organization has tried to convince the use of beavers as a flood mitigation tool and climate change

	adaptation tool in head water region) Preparedness planning (ex. Tanks filled with gas, home kits). (CN3)
What are the barriers faced in response planning? Can you provide an example of particular case and what kind of issues arose?	**Provincial Government** - There are so many possibilities and hard to plan for different scenarios. Looking at a community level, not having enough resources is an issue and difficult to make a priority when extreme flood events are not occurring frequently. Most of the planning happens for minor floods and the learning and planning gets updated and it's in that repetition. (CP1) - There is a lot of awareness about response planning, but having the commitment and resources to do it is a barrier. There is a two-year window after an event occurs to have the attention of decision-makers before flood priorities get shifted. Budget and understanding 1-100 year flood event is a barrier. (CP2) - Having insufficient resources, sharing information, organizations competing for resources and reluctancy to share data are barriers where this leads to delayed responses and sometime personalities get in the way in response planning. (CN3) **Municipal Government** - There are a lot of things up in the air provincially, municipally, flood mapping, land-use, investments and how to manage investments. We want to make progress, but have to wait to see other things and response from the province, so we know we are making the best decision for the city. (CM1) - Having enough resources and time, culture of risk and understanding, such that if people do not understand risk seriously then they wont plan for them seriously. Technology is something that can be leverage we use GIS and flood mapping, communication systems and state of the airk emergency response center with a policy plan back up to respond adequately. (CM2) **Private Organization** - Having individual property owners to work with the city to implement best management practices and landscaping issues. (CPO1) - Barriers in risk analysis and planning for 1-100 year floods until it happens. Costs for implementing plans and reckless spending on resilience projects where doesn't seem to be needed, communicating what is being done and why and getting plans implemented quickly. (CPO2) **Academic** - Battling with more immediate priorities at the current time, having to relocate people from their homes, dealing high costs and complexity based on where located on the floodplain map (ex. Some home may be partially marked in the flood zone and difficult to determine quantification of monetary value) - People do are not aware of the cultural changes that we need to make to build resilience, which comes down to the culture of democracy and more participatory approach. There are barriers in setting a cultural change that needs to happen to build resilience which is not limited to technology, economic or even climate, but our own cultural practices (personal contribution). (CA2) - Every city generally faces problems when dealing with catastrophic events. Issues arise when coordinating with different groups of people involved in emergency response. (CA3) **NGO** - Lack of coordination and communication are big barriers in resilience building. After the flood occurred in 2013 there was a realization for preparation training and other related programs, but has faded from consciousness since the flood occurred where it had immediate attention. (CN1) - Make sure there always an updated flood risk mapping, effort to

	keep development out of floodplain. Since there is a lot of development in floodplain it is not practical and possible to remove it all. If not replacement of vulnerable infrastructure are not made property assets can drop due to high damage costs. Diversion and reservoirs projects can also have unintended consequences of changing risk profile and help to prevent flood. (CN2) - Calgary faces major barriers structurally and metaphorically; dependency on dams on the Bow river and major tributaries as mitigation strategies, which have proven to be insufficient providing a false sense of security thinking that dames built for hydropower can be served as multipurpose structures to reduce risk. (CN3)
What types of conflict, if any have arisen with other institutions and/or government in response planning?	**Provincial Government** - We do not know everything during a flood and don't know what is going to happen. Information confidence is under question and there isn't really conflict, but there is misunderstanding and miscommunication. What is being communicated to us is captured and validated if there is action taken. On the community level, they are making their own decisions and it's during these events you realize that many things are interrelated in society. Choosing between different costs and impacts are conflicting and have been accused of presenting all kinds of information leading to mistrust. (CP1) - Conflict may arise within different levels of governance in terms of municipals wanting to implement solutions and other levels of government not agreeing and not willing to fund for it. Conflicts may arise with the government and insurance industry with expectations of who is going to pay for damage costs. (CP2) - Conflict may arise between agencies when competing for resources during quiet times, where they look to make a profit and assist during decision making with communities and developer. (CN3) **Municipal Government** - Work closely with the province, the biggest challenge is figuring out who's going to pay for projects. When both the municipality and the province agree on investments questions arise as to how much the province will cover and how much is left for the city to pay for. Other questions arise as to what level of protection is appropriate. Data is suggesting that what used to be a 1-100 year flood is now a 1-75 year flood, therefore there are disagreements on the level of protection thinking that 1-100 year might not be the level of investment needed given the population in the city might not be enough. (CM1) - In Alberta a lot of the responses are made at the municipal level, but there needs to be coordination at all levels of governance and stakeholders where there is a stake in water management or other water license holders or administrators that have been impacted by water management. (CM2) **Private Organization** - There are disagreements, but to reduce conflict there has to be a set of initial rules to work by when assessing performance measures of a specific model to get people to agree with the model works or not, so having the roles set in the beginning will help reduce conflict amongst decision-makers. (CPO1) - Conflict may arise when actors feel they are not in the loop of what is happening (ex. NGOS not being included and how plans are being excuted). Knowing where vulnerable population are and what kind of assistance they require. Use of volunteers and setting rules to ensure protection and liability. (CPO2) **Academic** - Not a lot of conflict in the planning, but conflict in the lack of

	planning. (ex. City response groups in charge of whole flood response, but did not have an organized system of how evacuees were stationed at the university), therefore lack of understanding and organization head of time on how to deal with large evacuee population. (CA1) - Assume in the case of emergency response planning there might be some conflict. (CA3) **NGO** - Issues about infrastructure always come up and it implementing what is needed comes down to priorities for the provincial, financial, municipal budget and if there is the will from the people to spend money in those areas. Not sure if it is a conflict, but it's inheritance of where there is substantial investment and if those investments are in place where it is needed or if there are other immediate concerns. Not so much conflict, but finding the resources to do something. Discussing about climate change is also a barrier. (CN1) - There is no conflict aware of. The organization is most involved in some of the long after action work and the province has seek us out as a key stakeholder in our breadth of membership, business, agriculture, environment, provincial, federal and first nations interests. (CN2) - There is no consistent approach across the board to allow appropriate development to ensure consistent approach for flood prone areas and zoning to prevent development and reduce risk for the long term. (CN3)
Is there any community or NGO involvement in the planning process? How and how involved are they? Could local communities be more involved in the planning process? If so how?	**Provincial Government** - Many NGO groups have done studies, set advisory committees who are experts and have invested interest. Most of the planning is conducted by the local municipal and when the province does planning we conduct public consultations on different issues. Working with schools, healthcare, communities is something that we do in the midst, but planning should think about stakeholders and getting community groups involved as much as possible. (CP1) - Host stakeholder meetings, build partnerships where solutions get implemented and mutual government provide funding. The municipality takes on the lead for these projects, looking at best management planning and alternatives then implementing long term goal and maintaining the operation. Communities are involved in providing feeding as the municipality conduct the environmental assessment, but there is a need for more community involvement. (CP2) - The NGO council in Alberta is an example how on the provincial level are asked to concentrate and support communities in areas that they are good at and specialize to build efficiency. There is a need to improve emergency social services framework to give better guidance to communities and NGOS. this will allow for better information sharing and collaborating amongst communities. There is a bit of friction when collaboration and sharing response measures, but it's the jurisdictional authorities decision that will go forward. (CP3) **Municipal Government** - There have been several specific community organizations formed since 2013 flood providing information and insights on their input on concerns and priorities. The province hired bigger organizations to host stakeholders sessions to allow the opportunities to hear feedback and response on 'room for the river approach'. Community groups have been will involved, but things are on hold until we hear back from the provincial level. There is also a program planned to begin a year or two from now to work community by community identifying what major priorities are

	priorities are whether structural or land-use planning of keeping citizens informed would be priorities for them. (CM1) - A lot of the NGOS we deal with are with emergency response groups or watershed oriented. These groups have a role in building community resilience and need to be engaged and leveraged. We are involved through formal management making sure organizations take part in those groups and understand their mandate and gain understanding, communications, policies and support culture of awareness and decision making. Community groups need to take strong leadership in higher levels from of government in planning and collaborate to build resiliency. (CM2) **Private Organization** - Community/NGO involvement does exist and has increased since the 2013 flood. These groups need to push their concerns and are very knowledgeable. Integrated planning with the province and municipal government allows for more discussion and common understanding of the issues and implement changes where needed. (CPO1) - There should be community involved in certain parts like identifying what is needed and local NGOS and actors can make a difference by pushing what is needed which maybe things that the government may not be familiar with. There is a need for collaborative effort building pre-established relationships working on issues on a local level. (CPO2) **Academic** - In the immediate response phase there probably was not any community of NGO involvement, but a follow up report had recommended that community and NGO involvement will benefit in the future. There is a technical knowledge that is required and experts and some people that want to get involved may not have those skill sets. (CA1) - Haven't seen a boarder involvement of stakeholders addressing these issues. Haven't seen a lot of involvement particularly with NGO or civil society groups and more attention should focus on it. Need to include a board range of frames in planning, social learning involving experts in communities. (CA2) - There are many people that are concerned with future flood risks and developments in flood zones. Interest groups and individuals are often invited to provide feedback to organizations with leading roles watershed management groups. (CA3) **NGO** - This would be a question for the municipality. We want to be involved from green infrastructure, climate change and adaptation. Many communicates what to be proactive in what they can do, with the city there are consultation processes and we have small planning projects creating awareness and imagine project pieces of how green infrastructure can be incorporated. (CN1) - The organization has 6 membership categories; commercial, industrial, medium to large consulting companies, non-profit organizations, academia and other organizations like minded organizations. The Watershed Planning and Advisory Councils (WPACs) are watershed stewardship groups that are community based and do a lot of hands on work such as bioengineering projects and community monitoring in the watershed. These groups provide policy and plans that we work on to be implemented and provide feedback from a local watershed scale of what works and doesn't in a boarder policy plans. (CN2) - There is a lot of NGO/community involvement in the Bow and Old Man Watersheds, WPACs that serve to protect and monitor watersheds. There is lack of provincial support, of resources to accomplish their goals and if these groups have the opportunity for

	responsibility and authority they already have a template. There is a failed recognition that there is citizen-based communal work on watershed management that requires more support from the province to be more effective. There are lots of local groups working in the lower watershed. (CN3)
What might be some of the unique challenges faced here for urban flood planning, compared to other cities?	**Provincial Government** - The type of flooding we get here is different from Manitoba for example because of the mountain and foot hills, it's a different type of flood looking at rainfall on top of snow and the snowmelt or expect flood when it rains the valley. Other challenge is not to develop in flood prone areas. (CP1) - The discovery that the downtown core is in the 100 year floodplain, Calgary is facing many developments at risk. The nature of storms in the foothills is detrimental to facing high rainfall in a short period of time (ex. Winnipeg providing warning weeks in advance). (CP2) - The Alberta buy out program is difficult, but is politically acceptable if it is voluntary and a small number agree. The geographic location of Calgary is close to the mountains so flooding is more severe and downtown core is built in the flood risk area. Moving the downtown out of the risk area is impossible so other mitigation options (ex. Rail yard closed). Therefore significant mitigation is needed to reduce risk in Calgary. (CP3) **Municipal Government** - Because of the recent major flood there are many things changing at the same time both at the provincial and municipal level. Another challenge is the close proximity to the Rocky Mountain, which means large floods with very little warning with just a few hours when the rain hits the city. (CM1) - The City of Calgary is growing rapidly, there is densification in vulnerable areas and this questions how do you ensure appropriate regulation and design standards are in planning processes and not after thought. Again question of culture supporting awareness, making more transparent decisions top of the line for the jurisdiction making sure there is enough money and support (CM2) **Private Organization** - One issue to look at is understanding groundwater at the top of the bow river and that rivers are not static. The Netherlands had a lot of flooding and have a very different geology, but rivers are managed more effectively and do not have extreme variability oppose to Alberta where there is very high variability of climate and extreme events. (CPO1) - Geography of the city, weather patterns and impact on flooding and it's citizens. Need to understand different types of emergencies and how it can affect the municipality. (CPO2) **Academic** - The City of Calgary one of the most richest and the most powerful people live along the river, therefore there are very expensive properties in the millions and would be difficult to buy out properties. Having a small number of powerful individuals in contrast to large number of average individuals brings a unique set of challenges for communities along the river. (CA1) - There is a lot of expensive property in the floodplain, which is the downtown core. There have been approaches to mange to live with the river, but there is a culture of resisting climate change and thinking that climate wont change. lastly the public have a misunderstanding of what 1-100 year flood means and think that a major flood wont occur for another 99 years. Need to look at what demographic the policies are support and which properties. (CA2) - Major challenges are the two rivers meeting downtown part of the

	city, the sources of the rivers are in the mountains and so when there is high volume of rainfall in the mountains it accumulates and flows downstream into the city leaving little time to prepare for a flood. In comparison to other cities flood warning can be released days in advance, where in Calgary warning is announced within a few hours. (CA3) **NGO** - The City of Calgary is unique geographically being built on a floodplain and the city goes around it and there are higher points in the city. So when a flood event occurs the city is shut down from services creating a set of challenges. The city also has two major rivers that flow into the city and there is a close proximity to the Rocky Mountain and Calgary is the first point before water flows into the Hudson and feel the immediate impacts. Floods vary year-to-year depending on snow pack in the mountains. (CN1) - The city has a lot of development in the floodplain which is a great challenge and no one is suggesting for the downtown core to be moved, trying to explore best solutions possibly combining room for the river and other methods where the program is not in effect. (CN2)
Do you have any other thoughts about these issues?	**Provincial Government** - It is hard to anticipate and put in measures that will prevent disaster because it is costly and also the low frequency of extreme floods. The flood in 2013 was less than the design flood and wonder what would happen if Calgary gets a 1-200 year flood. (CP1) - Hoping that the 'room for the river' will have success, which will be tough to accomplish because there are well developed communities. need to be more resourceful and proactive in implementing response measures (ex. Development restriction policies). (CP2) - There needs to more proactive response and less reactive, improve hazard identification, mitigate and eliminate possible risks, build collaborative partnerships and expand not just within government, but industries, NGO and communities. (CP3) **Municipal Government** - The City of Calgary has a great sense of community, in 2013 there was a huge outpour of people supporting each other. (CM1) - Need good technical tools and invest in planning. Would have expected worse outcome in the last major flood, but it was better than expected due to the fact there were plans in place with good information and good understanding within the organization which made the plans more effective. (CM2) **Private Organization** - Often times think about what last hit us, but should keep an open mind when planning for disaster and look at lessons learned from different events and transfer that to flood scenarios where there may be similarities, which can be applied to different cities. Need to build relationships, knowing who is your equivalent in another province, city or NGO. (CPO2) **Academic** - Flood insurance should put a price on risk and encourage people to be aware of how much flood risk is increasing. If we put economic incentives in the right place, it will prevent developers building in certain communities (ex. Higher flood insurance in vulnerable areas, would choose another area and pay less insurance). (CA1) - Homeless people are a very vulnerable population and it is worrisome that the policies being developed will only support the wealthy. The idea of resilience needs to consider ethics of care in practice, in practice there isn't any which may not be done

	intentionally but think there isn't enough push to voice assumptions and engage in bigger ethical conversations. (CA2) - The city is investigating expensive engineering solutions (ex. Dams, changing the flow of the elbow & bow river) **NGO** - Insurance companies are dealing with high costs and people respond better flood preparedness planning from them oppose to ENGOS sending out warning bells since there is a skeptical piece about environmental groups, but when a profit sector such as insurance companies send out warning to shareholders and supporting climate change people generally respond better when impacts are put into monetary value. (CN1) - Flooding impacts is trending in across Canada and there is no doubt that this is an important issue and urban planners and developers need to contribute to the problem and make careful decisions. Also need to keep in mind that data is not stationary and what was experienced in the last 100 years can represent what will happen in the next 100 years where we will need to plan for the worst and hope for the best. (CN2) - Climate change is a reality and there is extreme variability of future events since there is a lot of development in the floodplain, reliance on physical structures and need to improve land-use planning and activities creating a resilient landscape keeping in mind ecological health and integrity. (CN3)