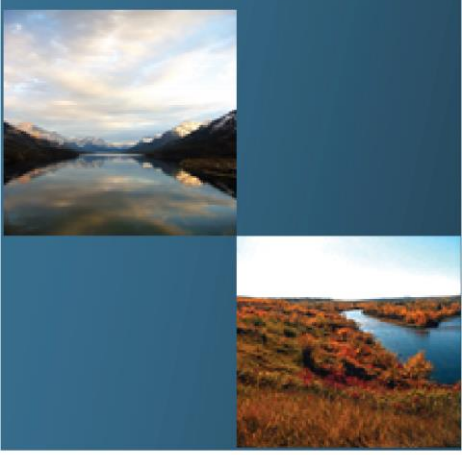

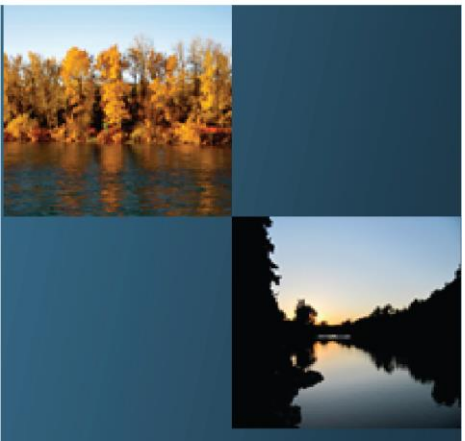

The 2013 Great Alberta Flood: Actions to Mitigate, Manage and Control Future Floods

ALBERTA waterSMART Water Management Solutions

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Executive Summary

June 2013 will be remembered across Alberta as the month of the Great Flood which resulted in the loss of four lives, displaced thousands from their homes, disrupted hundreds of businesses, and caused significant damage to private and public property, land and infrastructure. The immediate responses of municipal, provincial, and federal governments and particularly the people of Alberta to help those impacted by these flood events have been exemplary. However, as the recovery efforts begin to wind-down, the daunting task of rebuilding our communities looms large on the horizon. The rebuilding program must be based on a solid understanding of the confluence of events that caused the flood, the likelihood of recurrence, the efficacy of the proposed mitigation strategies, and the impact of these strategies on the entire South Saskatchewan River Basin.

While we cannot prevent extreme weather, we believe that the weather can be better understood and that actions can be taken to reduce the likelihood of such large-scale destruction resulting from future extreme events. There is a series of logical, science-based, proactive actions that can be taken to strengthen our capacity to respond to these types of natural disasters. The purpose of this paper is to outline these specific actions to inform the policy discussions currently underway in committee rooms across the province.

A broad group of water practitioners from across Alberta, Canada and the world have participated in developing this paper. Collectively they have identified specific actions that can be taken to mitigate, manage, and control the impacts of extreme weather events resulting in floods and the inevitable opposite condition of severe drought. These are summarized into six recommendations:

1. Anticipate and plan for more extreme weather events, including both flood and drought.
2. Improve our operational capacity to deal with potential extreme weather scenarios through better modelling and data management.
3. Investigate the cost/benefit balance of investing in physical infrastructure such as on and off-stream storage, diversions, and natural infrastructure such as wetlands.
4. Consider flood risks in municipal planning and strengthen building codes for new developments in flood plains.
5. Evaluate options for overland flood insurance.
6. Manage our water resources collaboratively, following the examples of the Bow River Consortium and the Cooperative Stormwater Management Initiative, and ensure Watershed Planning and Advisory Councils (WPACs) across the province have proper authority and funding.

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Introduction

June 2013 will be remembered across Alberta as the month of the Great Flood. In late June a major rain event caused massive flooding in the South Saskatchewan River Basin (SSRB), affecting tens of thousands of families throughout the region, resulting in the loss of four lives, displacing thousands from their homes, disrupting hundreds of businesses, and causing significant damage to private and public property, land and infrastructure.

The immediate responses of the municipal, provincial and federal governments and particularly the people of Alberta to help those impacted by these flood events have been exemplary. In particular in Calgary, where 26 communities were affected, the excellent cooperation and collaboration between City officials, businesses, emergency response services, and the public prevented many possible deaths (only one person died in Calgary) and ensured minimal disruption in services. The Government of Alberta (GOA) responded to the flood by pledging $1 billion in disaster recovery assistance, and the Government of Canada promised full support for flood relief. The stories of heroism and sacrifice from ordinary Albertans are abundant.

However, as the immediate response and recovery efforts begin to wind down, the daunting task of rebuilding our communities looms large on the horizon. Decisions on priorities for investment must be made by individual home and business owners, the councils of the affected municipalities and counties, and the provincial and federal governments. The preliminary estimates of the total cost of Alberta's recovery efforts range from three to five billion dollars.

The rebuilding program must be based on a solid understanding of the confluence of events that caused the flood, the likelihood of recurrence, the efficacy of the proposed mitigation strategies, and the impact of these strategies on the entire river basin. Our analysis shows that Albertans from all parts of the province should be prepared to experience more frequent and severe weather events, including floods and droughts. Due to the urgent need for action our recommendations focus on the South Saskatchewan and Bow River basins. However the conclusions from our work have implications for the rest of Alberta and Canada.

While we cannot prevent extreme weather, we believe that the weather can be better understood and that actions can be taken to reduce the likelihood of such large-scale destruction resulting from future extreme events. There is a series of logical, science-based, proactive actions that can be taken to strengthen our capacity to respond to these types of natural disasters. The purpose of this paper is to outline these specific actions to inform the policy discussions currently underway in committee rooms across the province. As this paper was written, the goal was to engage as many thought leaders as possible in this important discussion. The contributors to this paper (listed in Appendix A) ensured that the recommendations herein represent clear, consistent, implementable, and fundable solutions.

Background

The idea for this White Paper arose from a discussion group at the Canadian Water Summit, which was held in Calgary on June 27, 2013. The discussion was hosted by IBM, and was designed and conducted by Alberta WaterSMART. Thirty water experts from across Canada and around the world participated in the discussion group.

The first draft of the White Paper was distributed to the discussion group participants, the Western Irrigation District (WID) executive, the Bow River Basin Council (BRBC) executive, the South East Alberta Watershed Alliance (SEAWA) Director, the Scientific Director of Alberta Innovates – Energy and Environment Solutions (AIEES), a small number of GOA staff members, the Chief Executive Officer of the Association of Professional Engineers and Geoscientists of Alberta (APEGA), members of the Canadian Academy of Engineering (CAE), the Hydrologics modelling team, and the Alberta WaterSMART team and board. In addition, a summary of the recommendations was posted on the Alberta WaterPortal for input and comments from the public.

This final version of the White Paper represents the contributions of several dozen water practitioners and interested members of the environment community and the public. Every effort was made by the authors to include the comments received. The contributors to this paper are listed in Appendix A. Any errors or omissions in this document are the responsibility of the authors and not the contributors.

Summary of Recommendations

There are actions that can be taken to mitigate, manage, and control the impacts of extreme weather events resulting in floods and the inevitable opposite condition of severe drought. These are summarized into six recommendations:

1. Anticipate and plan for more extreme weather events, including both flood and drought.
2. Improve our operational capacity to deal with potential extreme weather scenarios through better modelling and data management.
3. Investigate the cost/benefit balance of investing in physical infrastructure such as on and off-stream storage, diversions, and natural infrastructure such as wetlands.
4. Consider flood risks in municipal planning and strengthen building codes for new developments in flood plains.
5. Evaluate options for overland flood insurance.
6. Manage our water resources collaboratively, following the examples of the Bow River Consortium and the Cooperative Stormwater Management Initiative, and ensure Watershed Planning and Advisory Councils (WPACs) across the province have proper authority and funding.

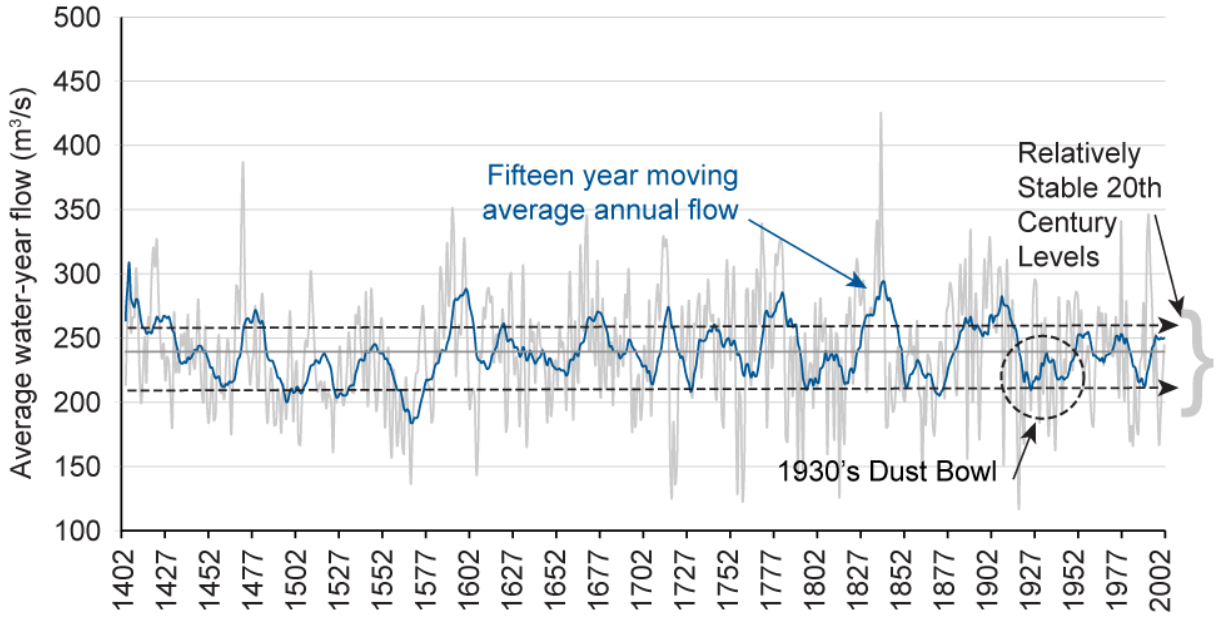
This White Paper expands on these recommendations and provides a summary of short-term actions that can be taken immediately to begin implementing these recommendations. It is hoped that all of these recommendations will help to inform the policy discussions currently underway in committee rooms across the province, as well as to educate those impacted by the flood event and anyone involved in water management activities.

1. Anticipate and plan for more extreme weather events.

Alberta, and specifically southern Alberta, should be prepared to experience larger and more frequent extreme weather events in the future, including both floods and droughts. This is important because these events have huge impacts on people and on our economy. These impacts are costly and are likely to become more costly as Alberta's population grows.

Detailed studies of historical tree ring data in southern Alberta show a remarkably consistent trend in the SSRB flows over the last 600 years. This data indicates that flood and drought events in the past were far more severe than we have experienced during the mid to late 20th century. The pre-historic record (Figure 1) suggests that we should be prepared for extreme weather events that are worse in terms of severity and frequency than the ones we have experienced in recent history. For example, the 2013 flood was one of five similar sized flood events on the Bow River in 130 years (Figure 2).

Figure 1: SSRB Flows (Bow River + Oldman River)

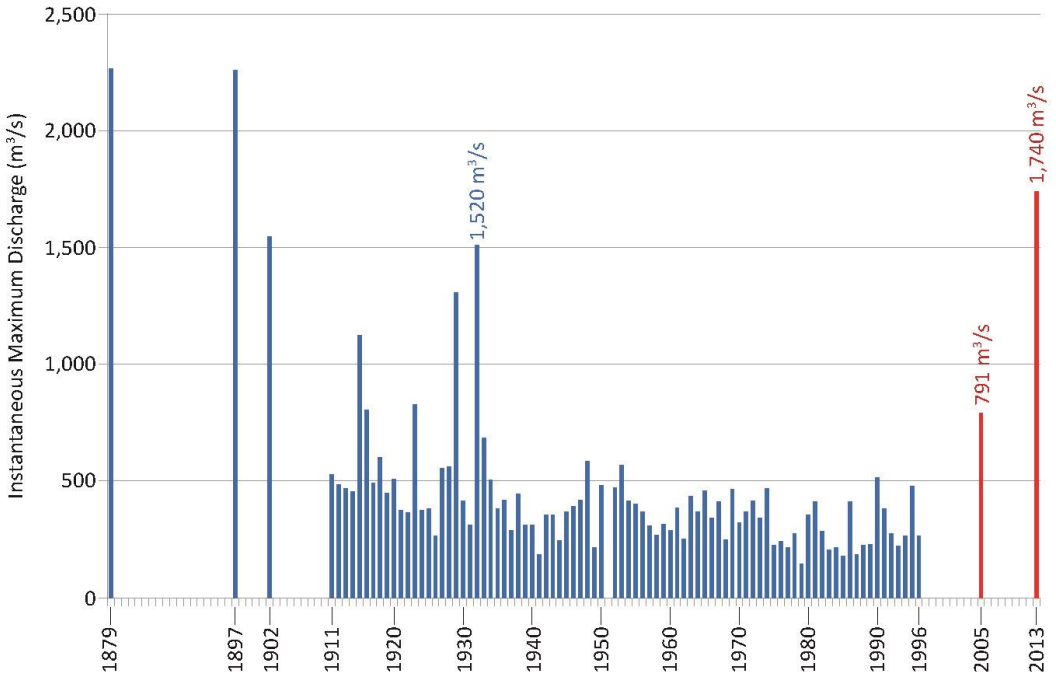


Source: David Sauchyn, PARC, University of Regina

History would suggest that we should consider the recorded maximum and minimum flow levels in our infrastructure and response planning. As a further complication, this planning must take drought into

account, as flooding and drought can occur right after one another (e.g. 2001 and 2002 were major drought years, while 1995, 2005, 2011 and 2013 were major flood years) or even in the same year.

Figure 2: Maximum Water Discharge in the Bow River at Calgary between 1879 – 2013



Source: Modified from Neill, C.R. and Watt, W.E., 2001. Report on Six Case Studies of Flood Frequency Analysis. Prepared for Alberta Transportation and Civil Engineering Division Civil Projects. April 2001. Figure 5.1 p44

Although the Great Flood of 2013 did not have the highest flow rate in the history of the SSRB, it very likely has caused the most damage and had the largest economic impact of any extreme weather event in Canada to date. The costs of this flood will surpass the ice storm of January 1998 in Ontario and Quebec, which totalled $1.9 billion according to the Insurance Bureau of Canada (IBC).

The population of southern Alberta is currently projected to grow by sixty percent over the next thirty years (Alberta Treasury Board & Finance 2012). If development continues according to the same patterns as has occurred over the last thirty years, it is likely that damage from another major flood incident would be even more significant in terms of financial costs and physical impact than in 2013. Anticipating and planning for more extreme weather events is an important factor to consider in planning at all levels of government, as these events have a significant impact on the economy.

Before the flooding had subsided discussion had already entered the media around whether or not man made climate change contributed to the severity of the flood. Climate change is a contentious issue in Alberta that will continue to generate heated debate. However, based on the historical record as noted above, there is clearly a natural variance of the climate which requires adaptation in the short term. This paper focusses on adaptive actions to be made around water management in response to

extreme events, providing space for ongoing conversations, actions, and policies regarding climate change.

Understanding the relationships between weather, river flows, population growth, and potential economic impacts is essential to planning for the future. Therefore, we make the following recommendations to better understand and plan for more extreme weather events.

- **Analyze the confluence of events that resulted in the 2013 flood.** This flood event closely resembled pre-1933 flood events. There are several theories why the maximum water discharge in the Bow River remained so low from 1933 until 2005. One theory is that there were severe forest fires in the foothills and mountains in the late 1800s and early 1900s, which could have resulted in more rapid runoff, ultimately resulting in high peak water flows. Another theory is that as the TransAlta hydro reservoirs came on-stream, they increasingly blunted the flood flows. However, neither of these theories explains the 2005 and 2013 rain events. Some work has already been done to explain changes in southern Alberta river flows based on climate variations, including the Pacific Decadal Oscillation (Alberta Innovates – Energy and Environment Solutions and WaterSMART Solutions Ltd. 2013). However more work needs to be done to understand other factors that are influencing the weather. The key meteorological, landscape, land use, and urban design factors that caused or contributed to this event in conjunction with the likely changes in frequency and magnitude of these events in future decades must be studied and debated. This analysis can then be used to signal how frequently we can expect these events in the future and their potential magnitude, allowing for better planning. The modelling work done as part of the Bow River Project and SSRB Adaptation Project is an excellent starting point and can be used to assess the impacts of flood flows, land cover, and changing weather patterns as well as the effects of various mitigation options.

- **Overlay potential development scenarios on the weather scenarios**. Land use in the South Saskatchewan watershed will change over the next thirty years as the population increases. Models such as the ALCES tool run by the ALCES Group can be used to understand how development will alter the landscape, which has a major impact on stormwater management, flood mitigation, and watershed saturation. This type of analysis is being incorporated in the current Alberta Innovates – Energy and Environment Solutions (AI-EES)-funded studies on river management in the SSRB.

- **Determine the magnitude of potential economic loss from another flood event.** As the 2013 flood has demonstrated, floods are extremely costly. An analysis of the physical and economic losses incurred in this flood, as well as other recent floods, would provide a baseline for assessing the magnitude of losses from potential future events. This type of analysis is being considered by the IBC, and they would be an excellent resource for this work. The results of this analysis would support and justify the necessary investments in planning and infrastructure that are needed to reduce the impacts of another flood.

- **Take a holistic approach when analyzing storm, flood, and drought data.** When analyzing storm, flood, and drought data, a holistic approach to hydrology assessment is required that includes data from watersheds outside of the watershed where the weather event occurred. In the case of southern Alberta, the flood history for all of the river basins with headwaters along the east slope of the Rockies needs to be examined to get a complete view of the frequency and magnitude of potential floods resulting from severe storm events along the eastern slopes. These storms are regional, not basin specific, as was shown in the 2005 event where the final rain dropped in the Red Deer basin, not the Bow basin. In addition, it would be extremely beneficial if meteorological data from across the North American continent could be shared between experts to improve monitoring capabilities. The Delft Flood Early Warning System (FEWS) program has been used in other parts of the world to assemble and analyze this type of data and could provide some guidance for Alberta.

2. Improve our operational capacity to deal with potential extreme weather scenarios through better modelling and data management.

Improving our operational capacity is integral to ensuring that the most appropriate mitigation strategies have been analyzed, developed and implemented before the next flood or drought occurs. This includes increasing modelling efforts and ensuring that drought and flood planning receive equal attention from policy-makers. Modelling should be based on the best data available. Efforts to collect more water-related data such as snowpack, precipitation, evapotranspiration, and sublimation and their effects on streamflow should be a high priority. Where possible, it is important to include the quantitative evaluation of natural ecosystem functions and services in the form of flood mitigation from forests and other natural land cover in the headwaters, wetlands and healthy riparian areas.

Considerable work is already underway in this area, but can be accelerated and improved through the following actions.

- **Ensure that data is available and easily accessible so that it can be used in modelling and planning by researchers, municipalities, provincial officials, and private property owners.** Historical and current data should be used to better understand and model the long-term trends referenced above. Researchers and planners should utilize the data from the new provincial monitoring agency to ensure consistency. The GOA has data that should be made available either through the monitoring agency or through public websites. In particular, increased data on groundwater is required for flood potential forecasts. Monitoring and research that is funded by the GOA (e.g. snowpack monitoring) should continue. When known, flood and drought risk and vulnerability should be clearly communicated to researchers and accurately portrayed. Impacts of a changing climate should be accounted for, including changing precipitation patterns, drought and heat waves.

- **Investigate back-up systems for Water Survey of Canada gauging systems to maintain data continuity during large events.** During the 2013 flood, every Water Survey of Canada gauge

between Banff and Calgary went out of service prior to the peak flows occurring. TransAlta, the City of Calgary, the irrigation districts and the GOA need real-time data to operate their water retention systems. Currently a standard stream gauging system is built on the bank of the stream and is prone to being damaged or flooded. A realistic short-term action is to ensure that real-time data stations maintain integrity during the flood event. This could involve adding more gauges in more secure locations, and researching alternate systems that could initiate operation when the existing gauges are overwhelmed.

- **Improve predictive capacity through increased modelling and data management.** Models that run a variety of scenarios, using in some cases well over 80 years of gauge data, can help decision-makers understand the possible outcomes and impacts of a flood or drought event. Decision-makers should increase their use of modelling capacity to ensure that a variety of extreme weather scenarios have been taken into account in policy planning, and so that specific mitigation measures and plans can be identified, properly analyzed and implemented. Publicly available models have already been developed for some parts of Alberta (e.g. the OASIS model has been developed by the University of Lethbridge and Hydrologics, and is being applied by Alberta WaterSMART in the SSRB). Improved operational capacity can be achieved by:

    - Developing flood potential forecasts. Hydrometeorlogic data can be used to investigate the nature and extent of flood risk. The magnitude and frequency of major floods can be estimated in order to identify where funding should be allocated to support adaptation measures. As an example, Red River basin managers have developed these kinds of tools (see Warkentin1999) and some of their work should be adopted in Alberta.
    - Increasing flood risk mapping. Flood mapping for 1:200 year, 1:500 year, 1:1000 year or possibly Probable Maximum Flood events should be considered and vulnerable areas should be identified. This needs to be kept up to date, as mapping precision can decrease with time resulting in increasingly less reliable statistics.
    - Utilizing the best available technologies. Remote sensing tools should be developed and incorporated into Alberta's flood planning and response. Alberta has some of the best LIDAR inventories (remote sensing technology that uses lasers to measure distance) in the world, but there is a need for new digital elevation models to be built. Options like the American GRACE satellite and the new Canadian RADARSAT constellation satellite can be used for better surface groundwater mapping. GRACE could play a big role in understanding flooding and groundwater relationships.
    - Developing communication tools. Publicly available and user friendly tools can be developed to help engage and educate the public with respect to high flood risk areas. These tools could show the high water level mark associated with a given flooding event and outline which communities would be affected by flooding at different flow rates. Mitigation and damage reduction options can then be designed to meet each specific risk profile.
    - Increasing basin-specific modelling. Current models such as the Bow River Operational Model (BROM) should continue to be upgraded to incorporate new data and inputs such

as groundwater and smaller streams. Land cover and use, water quality, wetland, and riparian habitat data should be incorporated into the BROM.

- Using BROM as an operational support tool. BROM should be used by water managers and reservoir operators in training exercises to help them prepare for a variety of flood and drought scenarios. This was demonstrated as part of the Bow River Project (see www.albertawater.com/Bow River Project).

- **Recognize that flood and drought planning are interconnected, and that both should receive an equal amount of attention.** Over the last decade in the SSRB the majority of water management strategies have been drought-related. Flood-related water management strategies should receive an equal amount of attention. Drought and flood mitigation strategies can be used to benefit each other; for example implementing the Bow River Project recommendations, including flexible and collaborative management, can improve environmental conditions under normal circumstances and ensure adaptive responses to either drought or flood conditions.

- **Develop a better understanding of the relationship between flooding and groundwater.** Alluvial aquifers (shallow groundwater-bearing channels connected to surface water bodies such as rivers) are vital natural infrastructure. Further investigations should be conducted in order to understand the effects of flooding on groundwater, and vice versa. Some work has been done in this area specifically by Alberta Environment and Sustainable Resource Development (ESRD), and this work should be leveraged and the data made available publicly. More specifically:

  - In the City of Calgary, there should be a detailed review of the alluvial aquifer around the Bow and Elbow Rivers to map the groundwater levels and the sensitivity to rises in river levels. This work is essential to understanding the risks to office buildings, residential homes, businesses and condominiums close to the rivers, and to determine appropriate building standards. Work that has been done to date should be made publicly available and easily accessible.
  - The hydrological cycle should be better understood in its entirety on a regional scale with respect to the SSRB. This includes a detailed understanding of the interactions and relationships between groundwater, surface water, precipitation, snow pack and related factors such as sublimation and evapotranspiration, snowmelt, aquifer recharge/discharge and variations in climate. There are academic studies of many of these elements that could support a larger integrated study. The current AIEES-funded study of The Future of Water in Alberta could perhaps use the Bow River Basin as a case study for its integrative work on water issues in Alberta.

- **Re-evaluate the potential for slumps and mudslides during flooding events.** Numerous communities in the municipalities affected by the 2013 flood are situated near the edge of steep slopes that were formed by river erosion. Steep slopes that consist of large quantities of glacial and lake sediments become unstable and may fail when materials are removed from the base of these slopes or when the ground becomes saturated. Although major slumping and mudslides did

not occur in Calgary, they occurred in Canmore and other areas. The potential for these to occur in the future throughout the region should be assessed and preventive measures implemented.

- **Build upon work that has already been done.** Current and future policy should build upon work that has already been done, such as the 2006 Groeneveld Provincial Flood Mitigation Report. Unfortunately that report was not released until 2012 and is now somewhat out of date. However the basic tenets and recommendations still apply and the report should be updated and analyzed for effectiveness using the latest data and modelling techniques and then implemented where needed most. In addition, during the past decade the ALCES Group has completed several projects along the east slope drainage basins from the U.S. border, through the Oldman Basin, to the Bow River Basin upstream of Calgary. All of these projects have examined elements of water flow and water quality, among a broader suite of indicators. Other work currently underway has been identified elsewhere in this paper, including the IBC reports, the SSRB projects, and projects underway at the Universities of Alberta (Goss *et al*), Regina (Sauchyn *et al*) and Saskatchewan (Pomeroy *et al*).

- **Engage public health professionals in assessing mitigation measures.** Floods create immediate public health risks to drinking water supplies, a risk that has been mainly dealt with by means of precautionary boil water advisories. Given the experience of the 2005 and 2013 floods, additional risk management measures for protecting drinking water and assessment of the effectiveness of boil water advisories, particularly when power outages and/or natural gas shut-offs also exist, should be pursued. There are also public health concerns with remediation efforts from flooding, including exposure to sewage contamination, growth of toxic molds and dealing with food spoilage. Public health professionals should be engaged in assessing mitigation measures to determine if better health practises and/or advice is needed for future events.

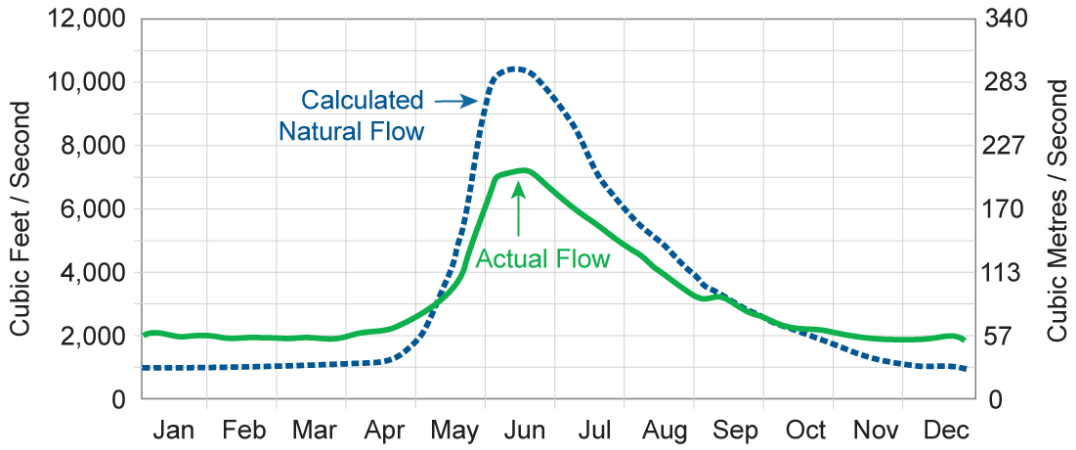
3. Investigate the cost/benefit balance of investing in physical and natural infrastructure.

Extreme weather events often catalyze discussion on the resiliency and adequacy of water infrastructure such as dams, canals, diversions, reservoirs, and natural features such as wetlands. A conversation about water infrastructure opportunities in Alberta is needed now. Billions of dollars will be spent on flood recovery and rebuilding efforts and some of this money should be invested in infrastructure to mitigate the impacts of future extreme weather events. It is important to remember that there is no one single infrastructure solution that will resolve all issues in the SSRB. The recommendations included here should be viewed as tools in a toolkit rather than either/or options. Even with properly planned and implemented infrastructure, the risks of building in flood-prone areas and the cost of recovering from a flood need to be carefully balanced.

- **Conduct cost-benefit and risk analyses to assess the best use of capital funds to support infrastructure spending decisions.** Obviously public funds are scarce and must be directed to the use which maximizes the benefits to society. After recovery from the current flood event,

preventative physical and natural infrastructure initiatives should be identified, evaluated, and where justified, planned and implemented. An excellent example of how infrastructure is already being utilized to manage water flows is the management of the Bow River through the City of Calgary by the TransAlta hydro dam infrastructure during normal times (Figure 3). The benefit of this infrastructure is that it ensures a stable and steady flow of water in the Bow River; the managed flow is double the natural flow in the winter months, which ensures that the City of Calgary can operate its water treatment plants within the legislative parameters set out by the GOA. A stable flow in the winter also helps prevent ice jams and floods, and the lower than natural flow in the summer months can mitigate minor to moderate flooding. Other examples include the Glenmore Dam on the Elbow River, operated by the City of Calgary, and the Oldman Dam on the Oldman River, operated by ESRD. Other opportunities have been explored, and some new ideas are noted in this section.

Figure 3: Bow River at Calgary - Natural vs. Managed Flows (38 years data)



Source: BRBC State of Watershed Plan 2010

- **Consider all available infrastructure options**. Unnecessary impacts to natural infrastructure should be avoided wherever and whenever possible. Where pipes, intakes and outfalls are needed for municipal water, wastewater, and stormwater infrastructure, the value of natural resources that may be affected by their implementation should be considered. Decision-makers should take advantage of opportunities to retrofit river shorelines using soft engineering practises; that is the use of ecological principles and practises to reduce erosion and achieve stability of shorelines, while enhancing habitat and improving aesthetics. The redevelopment of the Detroit River shoreline is often cited as an example of successful soft engineering practise. In addition, other low-impact developments, such as porous/pervious pavement, should be considered.

- **Use the best available risk assessment tools.** Over recent years new tools have been developed to assess risk more broadly for public infrastructure. Groups such as the World Federation of Engineering Organizations look broadly and systematically at infrastructure vulnerability to climate

change from an engineering perspective. Tools like the PIEVC infrastructure vulnerability protocol, developed by Engineers Canada and Natural Resources Canada and used across Canada and internationally, provide a proven approach to understanding the risks and vulnerabilities of existing infrastructures to the threats of extreme climatic events. The standards and practices developed by the PIEVC have already been tested in Alberta and could inform investment decisions as the GOA and municipal governments consider new infrastructure investments.

- **Implement the recommendations of the Bow River Project.** Over the last four years, the major water license holders on the Bow River have collaborated on developing water management protocols for the Bow River that incorporate many of the recommendations included in this White Paper. The GOA should work together with the Bow River Consortium and TransAlta to flexibly implement these recommendations. This agreement on future water management is an essential first step toward on-going, systematic improvement to the Bow River watershed, and will facilitate planning and implementation of damage reduction strategies for both future floods and droughts.

- **Utilize on-stream storage for flood control.** The Bow, the Elbow and the Oldman Rivers all have existing on-stream storage behind dams built primarily for power generation for the Bow, and water supply management for the Elbow and Oldman. Better integration of this storage capacity to embrace broader objectives of flood and drought management could significantly increase the capacity to manage extreme weather events and improve environmental conditions under normal circumstances. Current SSRB modelling can provide the structure for assessing these options. Some specific recommendations include:

    - Investigating opportunities and costs of using TransAlta storage for flood control and drought mitigation. The BROM model should be used to evaluate the extent to which reservoir capacity can be used to manage extreme weather events. The model provides for the assessment of the opportunity costs of lost power generation compared to the capacity to reduce peak flood flow. The velocity in the level of peak flood flow and elevation and the period of time in which flows are reduced can then be translated into flood flow maps to show areas where action can be taken to reduce flooding. This modelling exercise must include the downside risk of lowering reservoir levels if the expected rain/flood event does not occur or occurs at a lower than forecast amount. The key to improved risk management for flood and drought is an agreement on risk sharing and risk management among water users, taking into account maintaining appropriate environmental base flows.
    - Developing a flow/flood damage relationship for Banff, Canmore, Morley, Cochrane, Calgary, Carseland, Siksika, Medicine Hat and other significant communities and infrastructure. This information would be based on water flow rates and would demonstrate the amount of land that could be covered by water and the resulting potential economic damage at various peak flow rates. A hydrodynamic flood model should be developed and used to test flood operating strategies and trade-offs between location of available storage and potential damage.

- Evaluating multi-purpose storage and operations on the Highwood and Sheep Rivers. Some work has already been done to model the Highwood/Sheep system, and this could be the basis for assessing storage and operating options.
- Evaluating increased storage for flood control at the Glenmore Reservoir and upstream of the Elbow River for storage and power generation.
- Evaluating the potential impact of gradual accumulation of sediment in reservoirs and implementing an active reservoir sediment management plan.

- **Utilize off-stream storage more effectively for flood mitigation.** The irrigation districts have made use of man-made lakes for water storage for decades. Watershed management can be made more resilient by diversifying off-stream storage options, including increasing storage volumes or altering operating conditions. The Western, Bow River and Eastern Irrigation Districts should be engaged in a discussion as to how they can further utilize their infrastructure to help mitigate flood risks, while ensuring a robust response to drought conditions.

- **Improve management of headwater areas so that natural wetlands and riparian zones continue to act as a buffer for heavy rainfall.** The ability of the headwaters to capture and retain snowmelt and spring run-off should be optimized. The current development of the South Saskatchewan Regional Plan (SSRP) presents an opportunity to enhance flood avoidance and mitigation in southern Alberta. Headwater management should be addressed in the SSRP and could include, for example:

  - Making headwater landscape health a management priority for prairie rivers to naturally optimize water production and water quality, and to moderate the release of water throughout the spring and summer seasons.
  - Shifting from clear-cut logging to canopy-retention logging. This will help to reduce canopy snow loss while spreading out the snow melt over a longer period, and retaining the ability of the forest canopy and groundcover to intercept and retain rain.
  - Supporting high population densities of beavers in some headwaters to maximize their free ecosystem services.
  - Limiting off-road vehicles and industrial vehicles to trails and roads designed to minimize gullying and sedimentation and to avoid water source areas such as fen meadows and wetlands.
  - Investing public funds in the purchase of ecosystem services such as small check dams in coulees, wetland restoration, and/or revegetation of exposed or eroded soil from landowners in source water areas.

- **Incorporate natural infrastructure such as wetlands, riparian areas, natural storage conditions and land cover into flood and drought mitigation planning.** Utilized properly, natural infrastructure can be used as an effective long-term solution to ensure that people, infrastructure and natural systems are less vulnerable to flooding. In addition to flood control, ecosystems provide many economically beneficial services that support and protect humans and nature such as filtering pollutants, controlling erosion, producing fish and providing clean drinking water.

Moreover, natural infrastructure can have lower long-term maintenance costs than physical infrastructure. However the functions of the natural infrastructure such as wetlands must be understood to avoid unintended consequences elsewhere in the basin. The provincial wetlands strategy is needed to help guide the effective use of wetlands. In addition, the BRBC recently published the Bow Basin Management Plan (2012) which addresses wetlands, riparian areas, land use and headwaters protection. This document is in the process of being endorsed by a large number of Bow Basin stakeholders. The other WPACs in the SSRB, including the Oldman Watershed Council (OWC) and the South East Alberta Watershed Alliance (SEAWA), are also exploring natural infrastructure opportunities. Non-traditional opportunities such as gravel bed storage and aquifer storage and recovery should also be examined.

- **Investigate and identify sparsely habited or uninhabited areas that could be potentially flooded with minimal economic and environmental impact.** This measure applies to rural areas where there are large, unoccupied pieces of land. Areas where floodwaters can be diverted using an engineered system should be identified, and a system should be put in place to compensate any land or property owners for lost revenue and inconvenience. Intentional flooding did occur in some areas during the 2013 flood (e.g. in the Bow River Irrigation District) and has occurred in other jurisdictions. While flood impacts still occur, they are often not as large as they would have been if the flood waters reached more populated areas. A specific example is the Portage Diversion where channel banks (dikes) were intentionally breached in the 2011 Manitoba flood event. The dikes were breached in order to increase the capacity of the diversion channel, protecting the weir (see Manitoba 2011 Flood Review Task Force Report). This protected the urban areas by sacrificing two farms, whose owners were compensated for their losses and inconvenience. This option must be modelled and understood thoroughly to avoid unintended consequences, and requires the agreement and participation of those impacted. Intentional flooding should be more broadly considered by all parties in flood management.

4. Consider flood risks in municipal planning and strengthen building codes for new developments in flood plains.

The recent flood event revealed several weaknesses in current development practises in the urban areas in southern Alberta. Some of these practises can be addressed reasonably quickly, while others will take more time. However, all are possible within the current municipal planning structure.

- **Conduct cost-benefit and risk analyses to assess the best use of capital funds to support municipal planning and land use decisions.** As decisions are made on rebuilding existing and building new developments in flood-risk areas, it would be prudent to conduct cost-benefit and risk analyses on the costs of changing building and/or zoning codes. These costs would likely be borne by governments, as well as developers, owners and tenants. There should be some basis for evaluating the benefits of enhanced building codes and zoning plans against the costs of their implementation.

- **New municipal development in potentially flood-prone areas must be reconsidered.** Increased flood plain mapping is needed to better inform decision-makers at all levels on whether building should go ahead in flood plain areas. This mapping should include groundwater mapping as well as surface water. Much of this mapping has been done, but its existence is not widely known and not all is publicly available. In addition, as noted previously, maps must be kept current by incorporating new experience. If new development is to be discouraged in flood-prone areas, then incentives and disincentives will need to be provided in order to change the land use habits of urban developers. Examples of disincentives are higher property taxes for new developments or a requirement to have overland flood insurance for those choosing to build in a flood-prone area. Examples of incentives include provision of costs of relocation outside the flood zone. This appears to be the policy direction of the GOA in response to the 2013 event. Purchasing back lands in flood-prone areas and establishing parks and other public use spaces could provide a societal benefit for the larger community.

- **Land use planning should be connected to watershed planning.** Flood plain development is primarily an urban issue. The broader issue of land use must also be considered, particularly in rural municipalities and farming and public lands, including the effect this land has on flooding in the urban centres. It is important to model potential land cover changes that could result from threats of pine bark beetle or forest fires reducing water retention, and what improvements to water retention might result from enhanced riparian or wetlands functions. Models such as the BROM and ALCES could be used here. Some specific areas that should be considered in land use planning include:

    - Headwater basins. Headwater basins are incrementally (slowly in some, faster in others) losing their water-holding and aquifer-recharging capacity because of overlapping land uses that encourage faster overland flow of precipitation or snowmelt. Key land uses reducing groundwater infiltration and increasing overland flow are forestry, agriculture, residential construction, and the transportation network associated with forestry and energy.
    - Construction of built capital close to surface water. High levels of built capital (roads, residences, utilities, tourism, oil and gas, agriculture) have been and are being constructed close to all levels of surface water. As noted above, municipal development, as well as the construction of other capital, in potentially flood-prone areas should be reconsidered.

- **Refine our zoning and building codes.** A review of world class zoning and building code practises for office towers, condominiums, residential homes, and businesses should be undertaken. In many new office towers and condominiums in Calgary, electrical and mechanical systems are located in the lowest parking or basement levels along with the back-up generators. In this major flood, many of the parking structures and basements were flooded after the power was cut, which disabled the sump pumps. The flooding damaged or destroyed electrical and mechanical systems located at the lowest levels. Some basic redesign and relocation of these systems and addition of back-up generators above the flood line should result in less damage and faster recovery. The

location of critical information infrastructure should also be based on a clear understanding of possible water penetration during a major flood event. One specific recommendation is that multi-story buildings (commercial and residential) impacted by the flood should be required to test their sump pumps to ensure that these pumps are adequately sized to remove the water that penetrated their parking structures. These sump pumps should also be placed on a separate circuit from the electrical system of the remainder of the building and linked to a backup generator that will allow the sump pumps to keep working in the event of a power shut-down. Another recommendation is that building codes should be changed to allow flood-prone residences to relocate basement density to a third floor (i.e. current codes allow for two storeys to be built, so moving the home up one storey is a possibility). Homes in flood-prone areas could be designed without basements and possibly on static or adjustable stiles (e.g. hydraulic jacks or manually operated systems). Flood-prone subdivisions could be designed with engineered walls that could be raised or lowered to desired heights around the community.

- **Recognize the importance of urban stormwater run-off management.** Flooding can have an impact on municipal stormwater and sanitary sewer systems. For example, in the community of Sunnyside in Calgary the flood protection levee largely prevented overland flooding from the Bow River, yet many houses suffered damage due to storm and/or sanitary sewer back-up. The management of urban run-off is as important as rural run-off, and the system must be designed to cope with simultaneous high rainfall and high river conditions.

- **Encourage APEGA to revise and update their practice standards to include assessment of risks due to natural disasters.** Engineers and geoscientists practice their profession under a provincial act that is administered by the Association of Professional Engineers and Geoscientists (APEGA). Many of the recommendations made above involve engineering and geology practice. A tangible action item for APEGA would be to ask its Practice Standards Committee to include an assessment of risk due to natural disasters in their risk management practice standard. This can be done either by updating the 2006 Risk Management document to include substantially greater emphasis on risk management for natural disasters, or to develop an additional document that focuses on risk management for natural disasters. This involves identifying hazards, applying risk assessment to analyze the evidence about the magnitude and probability of risks, and then developing viable alternatives to prevent or mitigate damages arising from risks. As a participant in this White Paper, the CEO of APEGA would welcome constructive suggestions about how best to harness the large volunteer professional capacity and experience that APEGA can access to make a meaningful contribution towards improved flood risk management in Alberta. This same request should be made of the other professional associations that oversee architecture, planning and installation practices in Alberta.

- **Make a variety of tools widely available to all Albertans to inform them about a future flood.** The majority of communication on the 2013 flood was carried out through social media. Many Albertans received information from Twitter, as Premier Redford, City of Calgary, Calgary Police, Mayor Nenshi, ESRD, and many others, provided constant updates. It would be worthwhile for the

GOA to consider how it could use social media as well as traditional avenues of communication as effective public communications tools both leading up to and during natural disasters.

5. Evaluate our insurance options.

Currently, overland flood insurance is not available in Canada. Historically, the provincial government, backstopped by the federal government, stepped in to provide assistance for rebuilding when overland flood damage occurred during a flood event. For a variety of valid reasons including the magnitude of the damage, the GOA appears to be reconsidering this past practice for those wanting to rebuild the same home in the same location. There is some public support for putting conditions on payouts to reduce future tax burden to the general public from another flood. It is clear that many in the most affected areas are experiencing uncertainty and very likely significant financial hardship, especially if they are retired and were depending on their home value to support their income.

The issue is whether the affected homeowners have an option to rebuild. One idea that has been noted repeatedly since the flood occurred is offering overland flood insurance for the areas in the flood plain. Overland flood insurance potentially provides an option for homeowners who can afford it to rebuild their homes along the river's edge, ensuring that these homeowners continue to pay municipal taxes. In 2010, a study (see Sandink et al 2010) was conducted by the Institute for Catastrophic Loss Reduction and Swiss Re which concluded that overland flood is insurable for Canadian homeowners. They provided a proposal to put this insurance into place. The GOA should consider whether overland flood insurance should be brought into the province. Flood insurance programs provide important economic signals about the use and management of flood plains. At a minimum, rates for flood insurance in repetitive loss areas should be actuarially sound and reflect the true risk of flooding. Higher rates could help to guide development out of some of these high value, high repetitive loss areas. This is an area that is outside our area of expertise, and more investigation needs to be done to determine if this is a concept worth pursuing.

6. Manage our water resources collaboratively.

There are a variety of players involved in water management in Alberta, including the federal, provincial and municipal governments, as well as local watershed groups, irrigation districts, hydro power companies, non-government organizations, and others. Each has a valuable role to play in water management. Improved collaboration and information sharing between these groups is required to improve flood mitigation measures, and the following recommendations support these points. It should be noted that in the aftermath of the 2013 floods there has been great cooperation between emergency organizations at all levels of government. From local volunteer fire services to regional departments responsible for roads or electrical infrastructure to the RCMP and military, all were pitching in and cooperating with acknowledged on-scene commanders. Similarly, the transportation agencies and organizations responsible for pipeline security were cooperating to manage specific crisis situations. Politicians appeared to support each other without shifting blame or

raising questions of jurisdiction. These positive demonstrations of cooperation should continue through the following recommendations.

- **Support WPACs to work with their memberships to assess flood risk, consequences, and mitigation strategies, and to provide advice to GOA.** Under the *Water for Life* strategy, the WPACs have been given a specific role to play in managing water in the watershed. WPACs including the BRBC, the OWC, and SEAWA can and should take a leadership role in analyzing, evaluating, and advising on adaptation strategies to address future flood and drought circumstances. These organizations have the balanced membership and the neutral forum to convene and enable collaborative assessment of the data, to identify an array of mitigation options, and to provide leadership and advice on future water management in the Bow, Oldman and South Saskatchewan River systems. They are ready, willing and able to perform this vital function.

- **Consider creating a Provincial Water Authority.** In 2011, the Premier's Council for Economic Strategy recommended that an Alberta Water Authority be created. The driver behind this recommendation was the acknowledged risk that "within our thirty-year horizon, Alberta's current water management structure will be unable to effectively manage our water resources …" If an Authority was created as originally planned, it would be responsible for:

    - Water Information. The Authority would create and maintain a fully integrated and accessible water information system to support planning and decision-making. The need for more easily accessible data for modelling and planning purposes could be met through this central entity.
    - Water Infrastructure. The Authority would develop a long-term infrastructure plan to support effective water management, which would include on and off-stream storage facilities and natural infrastructure. The need for a review of infrastructure requirements that are appropriate for both flood and drought management could be met through the Authority.

- **Support and provide increased capacity to smaller municipalities to respond to natural disasters.** The cities of Calgary, Lethbridge and Medicine Hat were all well-equipped and ready to respond to the flood. However, smaller municipalities have less capacity to respond to natural disasters. The GOA should work with these small communities to coordinate emergency response plans and to determine where capacity gaps exist prior to the next natural disaster.

  Federal and provincial agencies should provide local governments with training, up-to-date science and data, and decision support tools to properly guide decision-making. In particular, local communities need to be informed about the full range of solutions to protect their communities, including the benefits of using natural infrastructure. This information should inform hazard mitigation, land use plans and local ordinances.

The Short-Term Response to the 2013 Great Alberta Flood

Over the next six months significant progress can be made on several of the recommendations noted above. These actions can provide evidence of tangible progress toward mitigating, managing, and controlling future floods.

1. **Anticipate and plan for more extreme weather events**

- Engage one of the research teams currently working on understanding weather impacts on stream flows to analyze weather patterns and trends to propose a workable theory for the occurrence of the flood. Translate this work into specific guidance that can inform weather warning systems.
- Engage existing models such as BROM to understand the specific impacts and streamflow rates generated by specific flood events.

2. **Improve our operational capacity to deal with a variety of potential extreme weather scenarios through better modelling and data management.**

- Open the doors to the data rooms so that all relevant data is easily accessible for modelling and planning throughout the SSRB.
- Implement the recommendations of the Bow River Project, including engaging TransAlta in the project through an economic arrangement with GOA.
- Engage one of the research teams currently working on groundwater mapping to map the alluvial aquifers around the Bow and Elbow Rivers to provide information on the interaction between the rivers and the aquifers. This will provide some guidance on the extent of the flood plain for various flood levels.
- Investigate the use of risk management tools such as PIEVC to incorporate flood risks into investment decisions on infrastructure.
- Research specific hydrometeorlogic indicators used by other jurisdictions that are used to understand the nature and extent of flood risk. Identify five indicators that Alberta should be monitoring now and in the future.

3. **Investigate the cost/benefit balance of investing in physical and natural infrastructure.**

- Use existing models to begin assessing engineered and natural infrastructure options for flood management and mitigation.

4. **Consider flood risks in municipal planning and strengthen building codes for new development in flood plains.**

- Fund a project to review and summarize best zoning and building code practises in North America, Europe and Australia related to flooding and how those can be applied to Alberta.
- Place a moratorium on new development in potentially flood-prone areas until the analyses outlined above are completed.
- Encourage APEGA to revise and update their practice standards to include consideration of risks in a flood event. Encourage other professional associations (e.g. architects, planners) to do the same.

5. **Evaluate our insurance options.**

- Investigate the potential for overland insurance to deal with those property owners who wish to build or rebuild in the flood plain.

6. Manage our water resources collaboratively.

- Incorporate the recommendations contained in this report into the South Saskatchewan Regional Plan.
- Support WPACs to assess flood and drought risk, consequences, and mitigation strategies.
- Consider the consolidation of water-related functions (e.g. fish, energy, irrigation) into Watershed-based Authorities to support implementation of the various Regional Land Use Plans.
- Provide increased capacity and support to smaller municipalities to deal with natural disasters.

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APPENDIX A

WHITE PAPER CONTRIBUTORS

The following is a list of individuals from Alberta, Canada and the world who engaged in consultation with Alberta WaterSMART on this White Paper. Contributors were not asked to provide an endorsement of the White Paper, or of the recommended flood mitigation actions outlined within. Rather, respondents were asked to share their insights and feedback to ensure that our work adequately captured and reflected elements of the current conversation about flood mitigation and adaptation measures in the water policy community. Every effort was made to ensure that this White Paper reflected the comments received from the contributors. However, any errors and omissions in this paper are the responsibility of the authors and not the contributors.

A Compendium document has been prepared that includes the comments and discussion as received from the contributors to the extent possible and as agreed to by the contributors. Some of these contributions have already been featured on the Alberta WaterPortal to generate more conversations on the flood event and possible actions. Hopefully the excellent suggestions contained in the Compendium will be of value to the policy and decision makers in committee rooms across the province. While there are well-regarded experts that we have no doubt missed in our consultation, such exclusion was not intentional.

Expert Group	Last Name	First Name	Position	Institution or Organization
Canadian Water Summit Discussion Group	Braun	Erwin	General Manager	Western Irrigation District
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