along the Elbow River. The overall flood inundation extent throughout Calgary was reduced from ~40 km^2 in the 2013 base case to ~34 km^2 in the 2014 run (Figure 57).[15] Recall that the total area covered in water includes the river channels, so the reduction in flooded area is 6 km^2 out of 40 km^2 but that all 6 km^2 are lands not normally under water. Although the percent reduction may appear small, that is not an accurate statistic because stream channels are included in both calculations – that is, stream channels are included in both the 40 km^2 in the 2013 base case and the 34 km^2 in the 2014 run. This statement also applies to similar calculations of area flooded described later in this report for other scenarios.

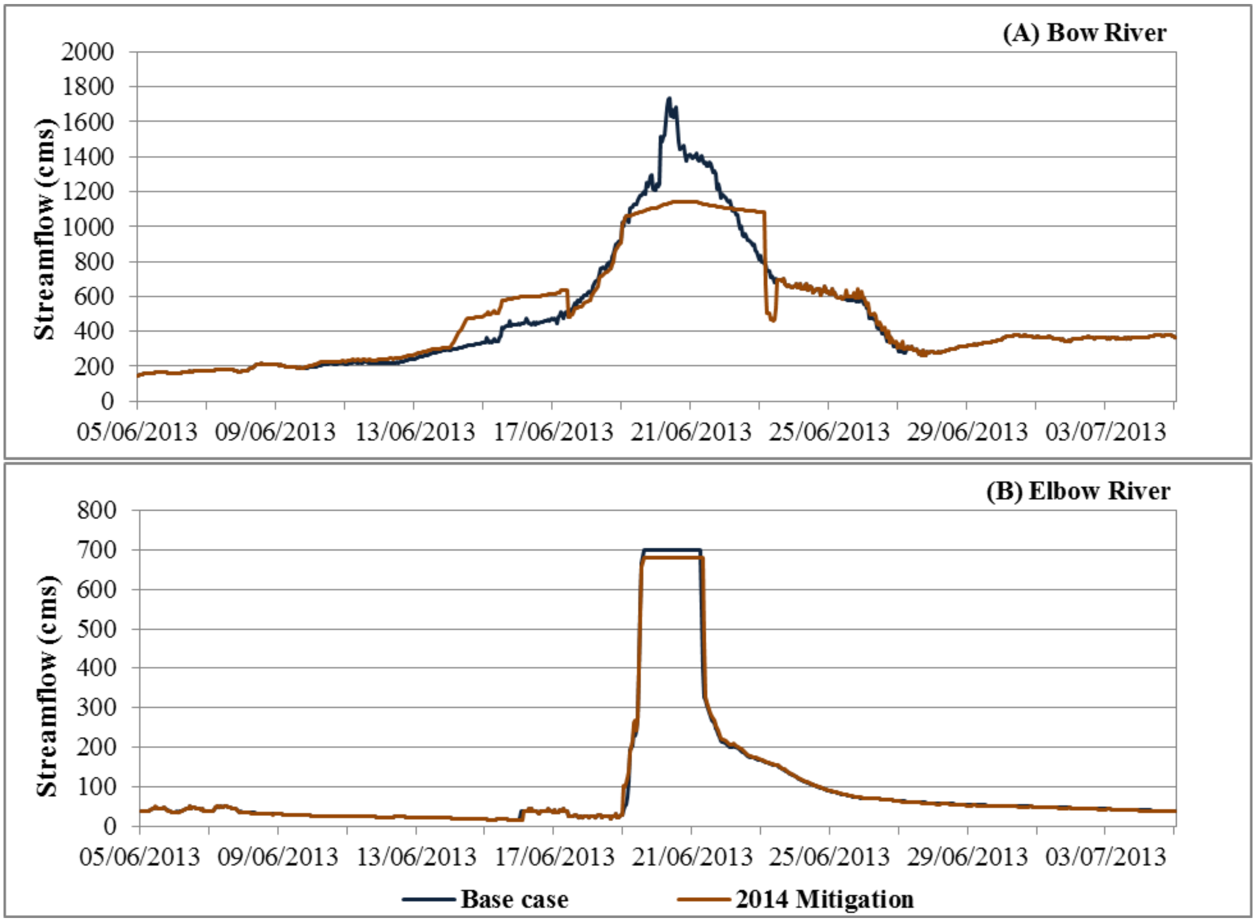

Figure 56: Comparison of streamflow in the (A) Bow and (B) Elbow Rivers assuming the 2013 flood reoccurred in 2014 and was mitigated as described above

[15] The 1:100 values from the City of Calgary that were used in the flood visualization tool are based on the following reference and differ from values shown in this report: Golder Associates Ltd. 2010. *Hydrology Study, Bow and Elbow River Updated Hydraulic Model Project, Revision A.* Prepared for Alberta Environment. Report No. 09-1326-1040.

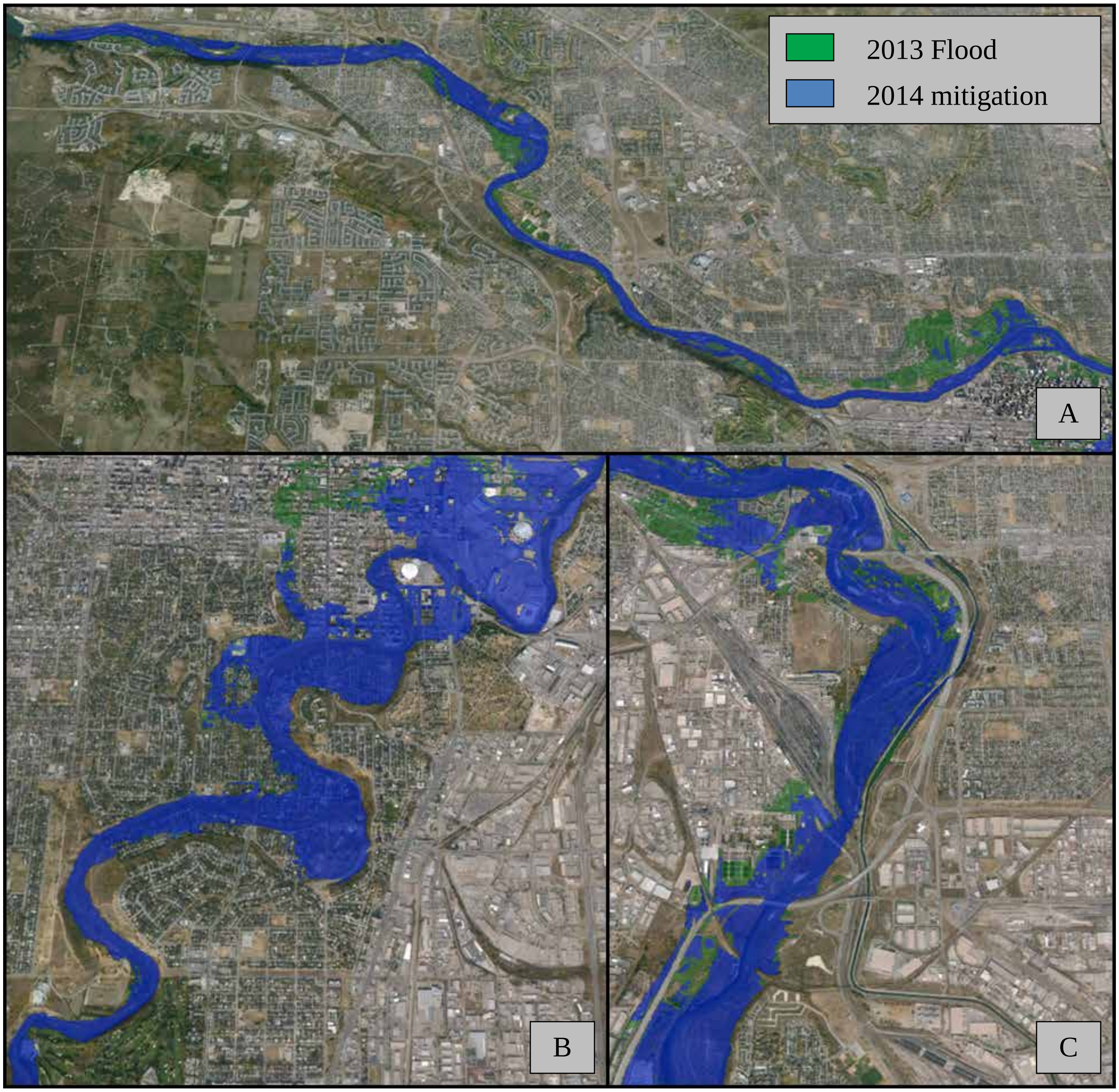

Figure 57: Visualization of the estimated 2013 flood extent and mitigation in 2014 for the Bow River upstream in Calgary (A), the Elbow River downstream of Glenmore Reservoir (B), and the Bow River downstream in Calgary (C)

The benefits and any concerns related to potential changes in operation of TransAlta reservoirs were described in Section 7.1. As noted in Section 7.2, Glenmore Reservoir was operated very well in 2013 for flood mitigation. Additional benefits might be secured by operating TransAlta facilities even more aggressively for flood control but would require a management agreement with the company or some form of government or collaborative operational control under flood forecast conditions, with appropriate compensation.

Flood mitigation actions upstream have implications for downstream users. In the Bow River Basin, downstream users include municipalities (e.g., Medicine Hat), First Nations (e.g., Siksika

First Nation), irrigation districts (EID, BRID), and other users into Saskatchewan. These downstream users need to understand the impacts of upstream mitigation activities on the speed and timing of future flood flows and take appropriate mitigation action themselves. And those putting the upstream measures in place must identify and address the downstream impacts.

A primary example of this is downstream irrigation infrastructure: Carseland diversion, Bassano Dam, and Travers Dam. The consequence of dam failure in any of these cases would be catastrophic. Berming and diking upstream to prevent municipal flooding means less upstream detention therefore more flow downstream during the peak event. Diversions, overland or underground, to reroute flows away from infrastructure reduces local flooding but gives higher peak flow downstream. Dry dams that detain high flows during the peak events should mean reduced peak flow downstream. Changing operations to detain high flows should mean reduced peak flow downstream. The effects of any of these activities upstream is additive.

Table 7 shows how upstream mitigation activities might accumulate to create significantly higher peak flows at Bassano Dam. The starting point is the ~4300 cms flow that was estimated at Bassano Dam in the 2013 flood event. The flow impacts of upstream mitigation actions are then added or subtracted to see the accumulating effect on the flow at Bassano Dam. As an example, berms through High River will send an additional 300 cms downstream in Spring 2014, increasing the flow at Bassano to 4600 cms. Protection along the Elbow could add another 100 cms for a cumulative total of 4700 cms at Bassano. The rest of the table can be interpreted similarly for each of the four scenarios across the top and the variety of mitigation options down the side. The bottom line of revised flow at Bassano can then be compared to the 2013 estimated peak flow to see the accumulated effect of the mitigation options.

Table 7: Examples of the additive downstream impacts of upstream mitigation activities

	Spring 2014		**With High River Channelization**		**With Additional Diversions**		**With a Dry Dam on the Elbow**	
2013 Peak Flow at Bassano Dam *(EID estimate)*	**~4300 cms**		**~4300 cms**		**~4300 cms**		**~4300 cms**	
Upstream Mitigation	***Impact (cms)***	***Flow (cms)***	***Impact (cms)***	***Flow (cms)***	***Impact (cms)***	***Flow (cms)***	***Impact (cms)***	***Flow (cms)***
Repeat 2013 Glenmore flood operations	0	4300	0	4300	0	4300	0	4300
Build berms through/ around High River	+ 300	4600	+ 750	5050	+ 300	4600	+ 300	4600
Build protection along Elbow *(illustrative estimate)*	+ 100	4700	+ 150	5200	+ 150	4750	+ 150	4750
Build protection along Bow *(illustrative estimate)*	+ 50	4750	+ 100	5300	+ 100	4850	+ 100	4850
Repeat 2014 TransAlta flood operations	0	4750	0	5300	0	4850	0	4850
Further operate TransAlta for flood control *(modelled ~ 600cms)*	- 300	4450	0	5300	0	4850	0	4850
Calgary tunnel *(500cms)*	n/a	n/a	n/a	n/a	+ 150	5000	n/a	n/a
Dry dam on Elbow *(modelled)*	n/a	n/a	n/a	n/a	n/a	n/a	- 300	4550
Revised Flow at Bassano	**4450**		**5300**		**5000**		**4550**	

This accumulative effect reinforces the need to implement and manage flood mitigation as a system and to find and take advantage of opportunities to offset negative impacts downstream. Downstream municipal and infrastructure planners need to prepare for the full range of future flood events as well as whether upstream flood mitigation measures will operate successfully. It is critical that existing downstream infrastructure be reinforced to comply with full safety standards, given potentially higher future flows.

8.2 What can be done for 2015?

This combination focuses on mitigation options that could be applied for spring 2015 in the Bow, Elbow, Highwood, and Sheep river watersheds. It includes:

- Building on 2014 activities described in Section 8.1
  - Implement agreement to operate TransAlta facilities for water management improvements including flood control
  - Operate Glenmore for flood control.
- Adding some new infrastructure
  - Rebuild and increase diversion from Ghost River to Minnewanka to 100 cms during flood
  - Divert 300 cms from the Highwood River north around High River or south into Little Bow
  - Divert 20 cms from the Elbow River into Priddis Creek or alternative route (20 cms, or 10% of the 2013 flow, was estimated by participants as a manageable addition to what would naturally spill into Priddis Creek from the Elbow River).
- Continuing to develop additional components:
  - Ongoing flood preparedness efforts
  - Continued local berming and diking, informed by impacts assessment
  - Improved emergency communications and scalable alert systems, backcountry advisories, and others, as well as continued public education and awareness around water management
  - Wetland and riparian restoration, land management enforcement and activities
  - Established and tested ensemble and integrated weather risk forecasting system in place
  - Collaborative governance watershed advisory board in place and operational.

The BROM was applied to simulate TransAlta and Glenmore Reservoir operations, a reconstructed 100 cms diversion into Lake Minnewanka, a 20 cms Priddis Region diversion, and augmenting flow into the Little Bow by 300 cms. Local diking and berming are also assumed to be implemented, but these were not captured in the BROM.

The peak hourly streamflow was reduced to 1060 cms and 660 cms in the Bow and Elbow rivers, respectively for the 2013 modelled event (Figure 58). Implementing a 100 cms diversion into Lake Minnewanka further reduced the flood extent along the Bow River relative to 2013. The Priddis diversion only resulted in a small flow reduction and did not substantially decrease the extent of flooding relative to 2013. The overall flood inundation extent throughout Calgary was reduced from ~40 km^2 in the 2013 base case to ~32 km^2 in the 2015 run (Figure 59).

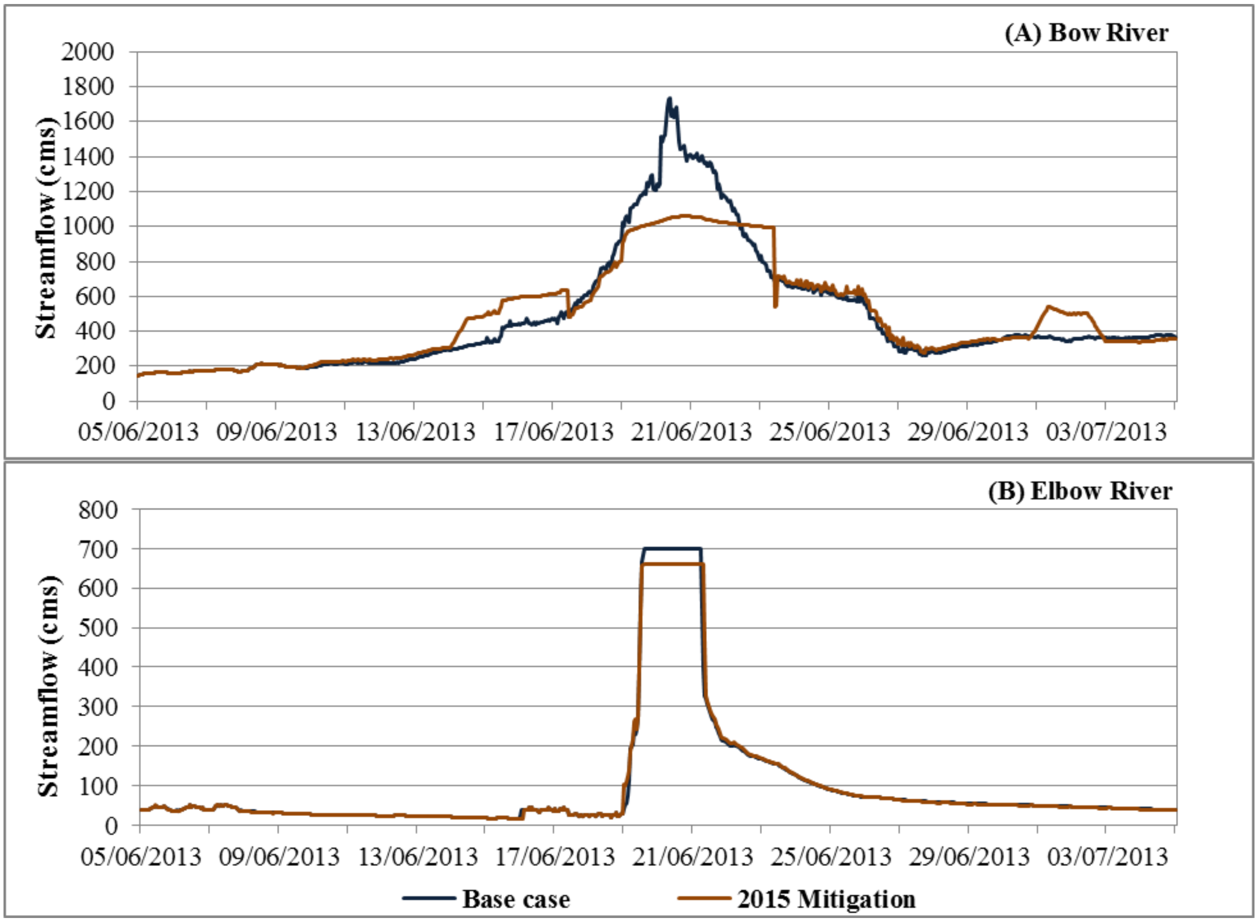

Figure 58: Comparison of streamflow in the (A) Bow and (B) Elbow Rivers assuming the 2013 flood occurred in 2015 and could be mitigated

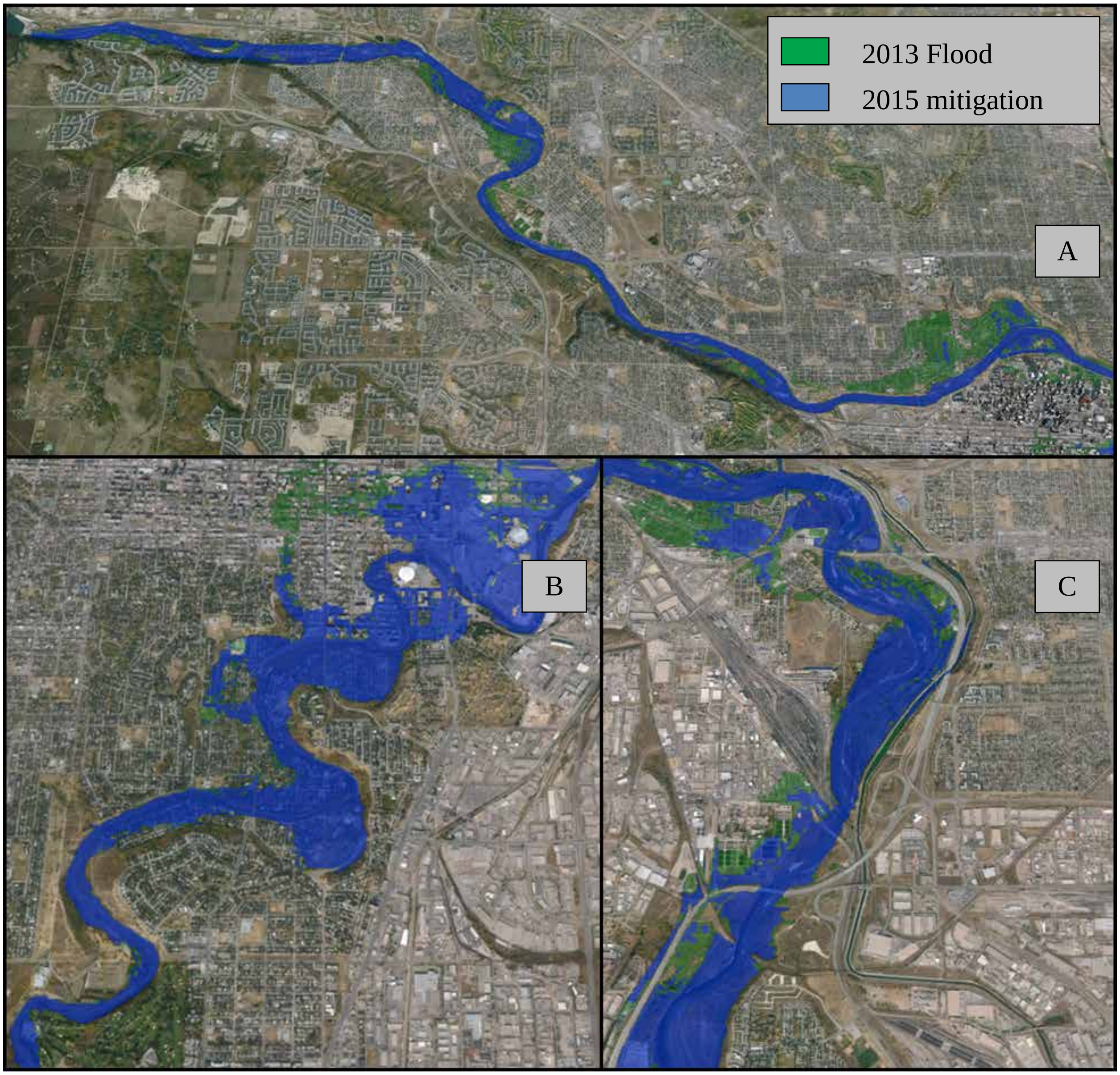

Figure 59: Visualization of the estimated 2013 flood extent and mitigation in 2015 for the Bow River upstream in Calgary (A), the Elbow River downstream of Glenmore Reservoir (B), and the Bow River downstream in Calgary (C)

Augmenting natural overland flow into the Little Bow resulted in a peak hourly flow reduction to 1538 cms in the Highwood River at High River for the modelled 2013 event (Figure 60). There was no flow reduction in the Sheep River.

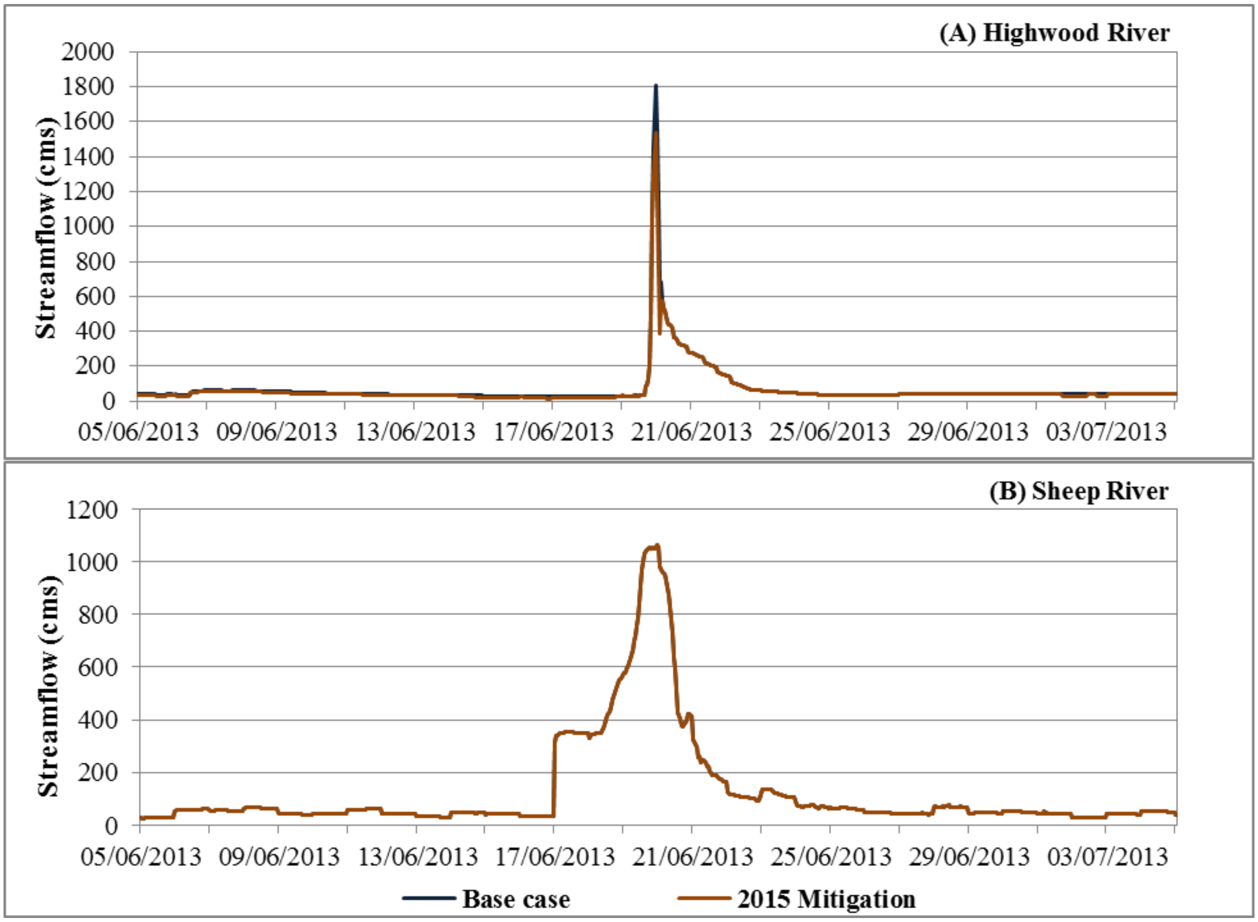

Figure 60: Comparison of streamflow in the (A) Highwood and (B) Sheep Rivers assuming the 2013 flood occurred in 2015 and could be mitigated. Note: Local mitigation (berming, diking) were not accounted for in these model runs; black line is largely hidden behind brown line on these charts.

Questions and issues related to implementation and risks of the North and South diversions around High River, particularly with respect to the South diversion into the Little Bow, were discussed in Section 7.3.

8.3 Mitigation Target Scenarios

A broader range of mitigation options could be implemented and made operational in the longer term beyond 2015. The decision as to which options to implement should be driven by the social policy question of what we are trying to mitigate to. The three mitigation target scenarios described in Sections 8.4, 8.5, and 8.6 were done to determine what infrastructure and other mitigation actions would be necessary to meet the three hourly mitigation targets shown in Table 8.

Table 8: Bow Basin mitigation targets

Location	Peak Hourly Mitigation Target 1 (cms)	Peak Hourly Mitigation Target 2 (cms)	Peak Hourly Mitigation Target 3 (cms)	1:100 Event (cms)
Bow River upstream of the confluence with the Elbow	~1050	~825	~540	1970
Elbow River downstream of Glenmore Reservoir	~450	~300	~180	758
Highwood River at High River	~1500	~1300	~1100	750
Sheep River at Okotoks	~850	~750	~650	954

Source: 1:100 Event values provided by the Government of Alberta Flood Recovery Task Force, November 2013

The 1:100 event values used as a reference in the figures in this report are based on flood frequency analyses conducted prior to the 2013 event. They are the currently-official design discharges used in the provincial flood hazard mapping. The values were provided by the Government of Alberta Flood Recovery Task Force. More recent studies are updating the 1:100 event values but these are in preliminary stages and not yet published. These design discharge values differ from the 1:100 event values provided by the City of Calgary and used in the flood visualization tool.

These mitigation targets are not set in stone and in some instances are already being increased by local actions such as the floodway through High River, relocation of infrastructure, protective actions for the water treatment plant in Okotoks, temporary and permanent berming in Medicine Hat and other locations, and many other local and regional flood damage reduction activities. The target scenarios are intended to inform the nature and extent of infrastructure changes needed to attain reduced peak flow levels through varying degrees of mitigation targets. In addition to mitigation targets, the threshold flows for downstream structures must be considered (Table 9).

Table 9: Flow thresholds for downstream structures

Location	Flow above which safety of structure is of concern
Bow River flow at Carseland Dam	3200
Bow River flow at Bassano Dam	3450
Little Bow flow into Travers Reservoir	250

8.4 Mitigation Target Scenario 1

Mitigation Target Scenario 1 was designed to achieve the Target 1 hourly mitigation target (MT1), as shown in Table 8 in the Bow, Elbow, Highwood, and Sheep river watersheds.

Operational, infrastructure, and natural mitigation options were used in combination to achieve this target and a functional governance decision-making process is assumed to be in place:

- Implement agreement to operate TransAlta facilities for flood control
- Operate Glenmore Reservoir for flood control
- Increase diversion from Ghost River to Minnewanka to 100 cms during flood
- Divert 300 cms from Highwood River north around High River (or south into Little Bow)
- Divert 345 cms from the Elbow River into Priddis Creek (or alternative options, as previously described)
- Build a dry dam on Threepoint Creek
- Basin-wide land management
- Basin-wide wetlands storage
- Improved probability forecasts for floods and reservoir management
- System in place for collaborative management of entire watershed

The BROM was applied to simulate TransAlta and Glenmore Reservoir operations, a reconstructed 100 cms diversion into Lake Minnewanka, a 300 cms diversion north of High River, a 345 cms Priddis region diversion, the Threepoint Creek dry dam, a 1% reduction in streamflow as a function of land management practices, and wetland restoration. Local diking and berming were also assumed to be implemented.

Implementing these options reduced peak hourly streamflow in the Bow and Elbow rivers at Calgary to 1059 cms and 375 cms, respectively for the modelled 2013 event (Figure 61). The flood inundation extent was reduced throughout Calgary along the Bow and Elbow rivers from ~40 km^2 in the 2013 base case to ~29 km^2. The greatest change relative to 2013 was along the Elbow River, due largely to the Priddis regional diversion being substantially increased (Figure 62).

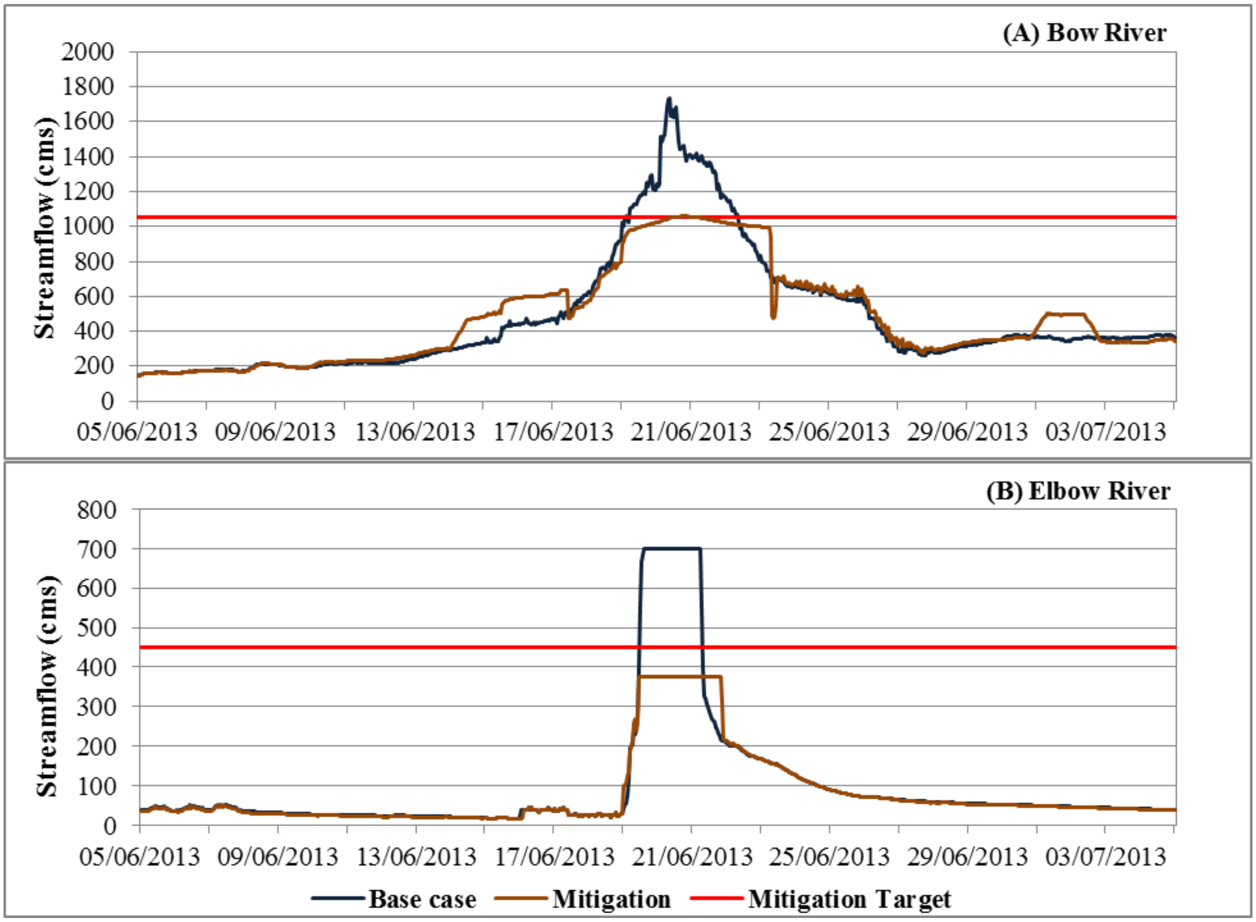

Figure 61: Comparison of streamflow in the (A) Bow and (B) Elbow Rivers in 2013 and applying infrastructural and natural mitigation to attempt to reach the mitigation target (MT1)

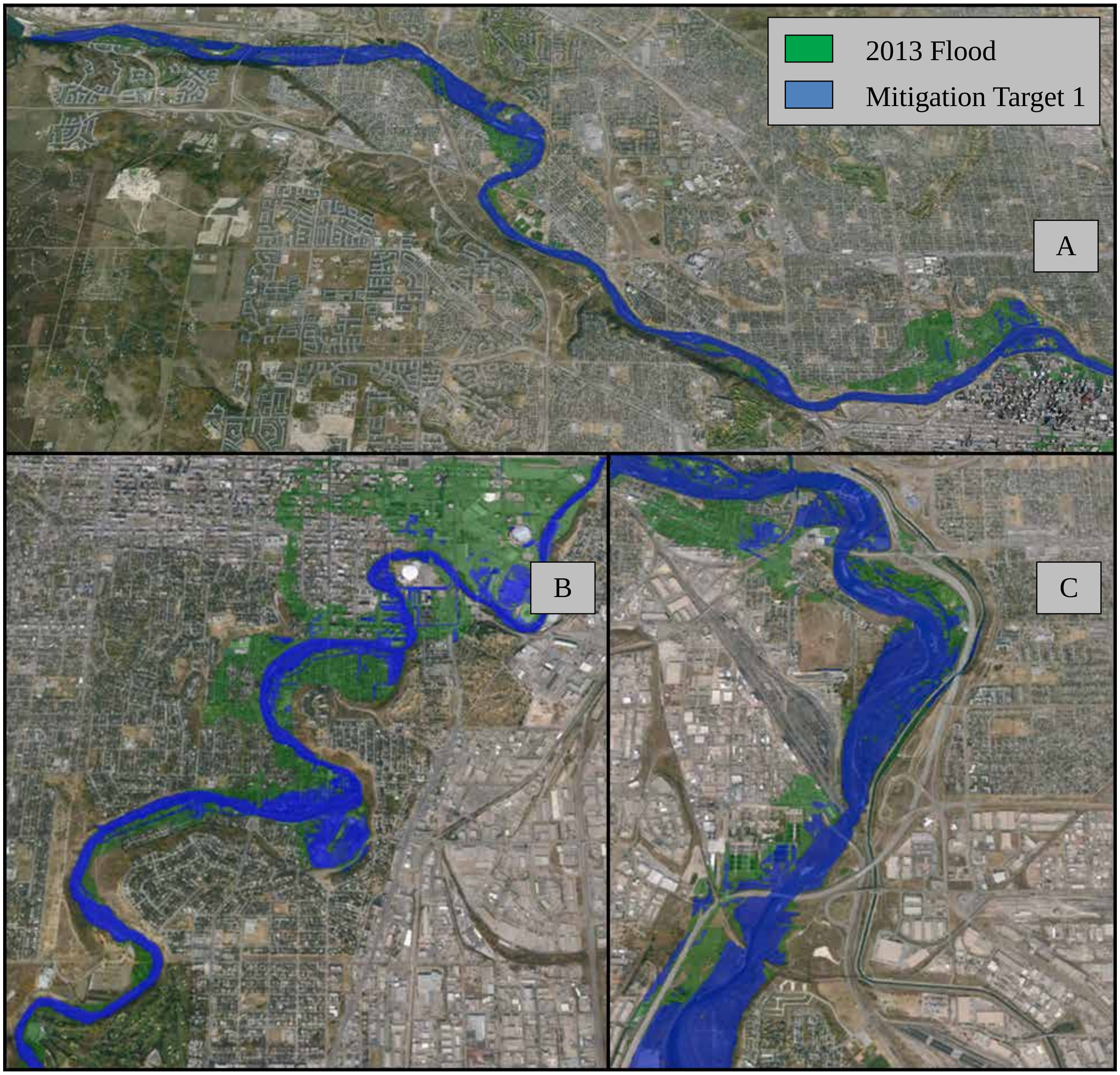

Figure 62: Visualization of the estimated 2013 flood extent and Mitigation Target 1 for the Bow River upstream in Calgary (A), the Elbow River downstream of Glenmore Reservoir (B), and the Bow River downstream in Calgary (C)

Peak hourly flow in the Highwood River was reduced to the 1500 cms mitigation target by implementing a 300 cms North diversion in the modelled 2013 event. The peak hourly flow in the Sheep River was reduced to 836 cms as a result of the Threepoint Creek dry dam (Figure 63).

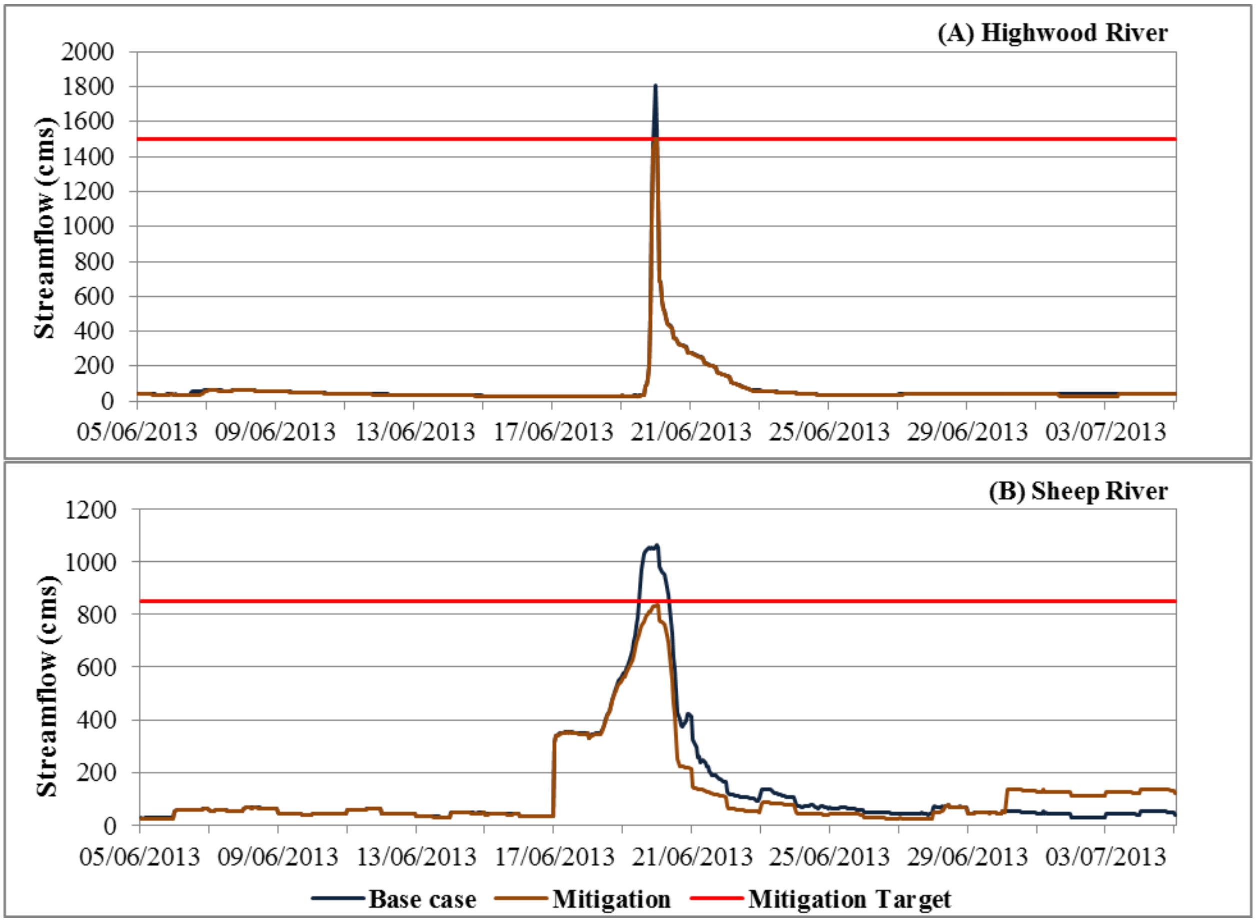

Figure 63: Comparison of streamflow in the (A) Highwood and (B) Sheep Rivers in 2013 and applying infrastructural and natural mitigation to attempt to reach the mitigation target (MT1)

The results show that the Threepoint Creek dry dam alone can reduce the peak flow through Okotoks to the MT1 target. Additional berming or other protection in the townsite may achieve the flood mitigation goal without the need for additional control structures upstream.

8.5 Mitigation Target Scenario 2

This combination was designed to achieve the second hourly mitigation target (MT2), excerpted from Table 8; these targets are:

Bow River upstream of Elbow = 825 cms
Elbow River downstream of Glenmore = 300 cms
Highwood River at High River = 1300 cms
Sheep River at Okotoks = 750 cms

Operational, infrastructure, and natural mitigation options were applied in combination to achieve this target, specifically:

- All of Scenario 1 (TransAlta flood control; Glenmore flood control; Minnewanka 100cms diversion; Highwood 300cms diversion; 345 cms Elbow diversion; dry dam on Threepoint Creek; land management; wetland storage)
- Improved probability forecasts for floods and reservoir management
- System in place for collaborative management of entire watershed

PLUS

- More Elbow diversion OR EQ1 dry dam on Quirk Creek above Elbow Falls
- Expanded Highwood diversion of 500 cms instead of 300 cms
- Two upstream dry dams on the Bow (BG1-Ghost River and BW1-Waiparous Creek)
- The S2 dry dam on the Sheep River

To meet these targets in the Bow, Elbow, Highwood, and Sheep rivers a series of natural, operational, and infrastructure mitigation measures were required. The BROM was applied to simulate TransAlta and Glenmore Reservoir operations, wetland restoration, an inflow reduction of 1% as a result of best land management practices, the BG1 and BW1 dry dams, a 100 cms Minnewanka diversion, a 345 cms Priddis diversion plus another diversion with ~80 cms capacity to handle the remaining flow to reach the mitigation target, S2 and Threepoint Creek dry dams, and a 500 cms North diversion around High River. Local diking and berming were also assumed to be implemented for the 2013 modelled event.

The addition of large dry dam infrastructures resulted in peak hourly streamflow in the Bow and Elbow rivers being reduced to 804 cms and 300 cms, respectively (Figure 64). The flood inundation extent was substantially reduced along the Bow and Elbow rivers. The overall change in flood extent throughout Calgary was a reduction from ~40 km^2 in the 2013 base case to ~26 km^2 (Figure 65).

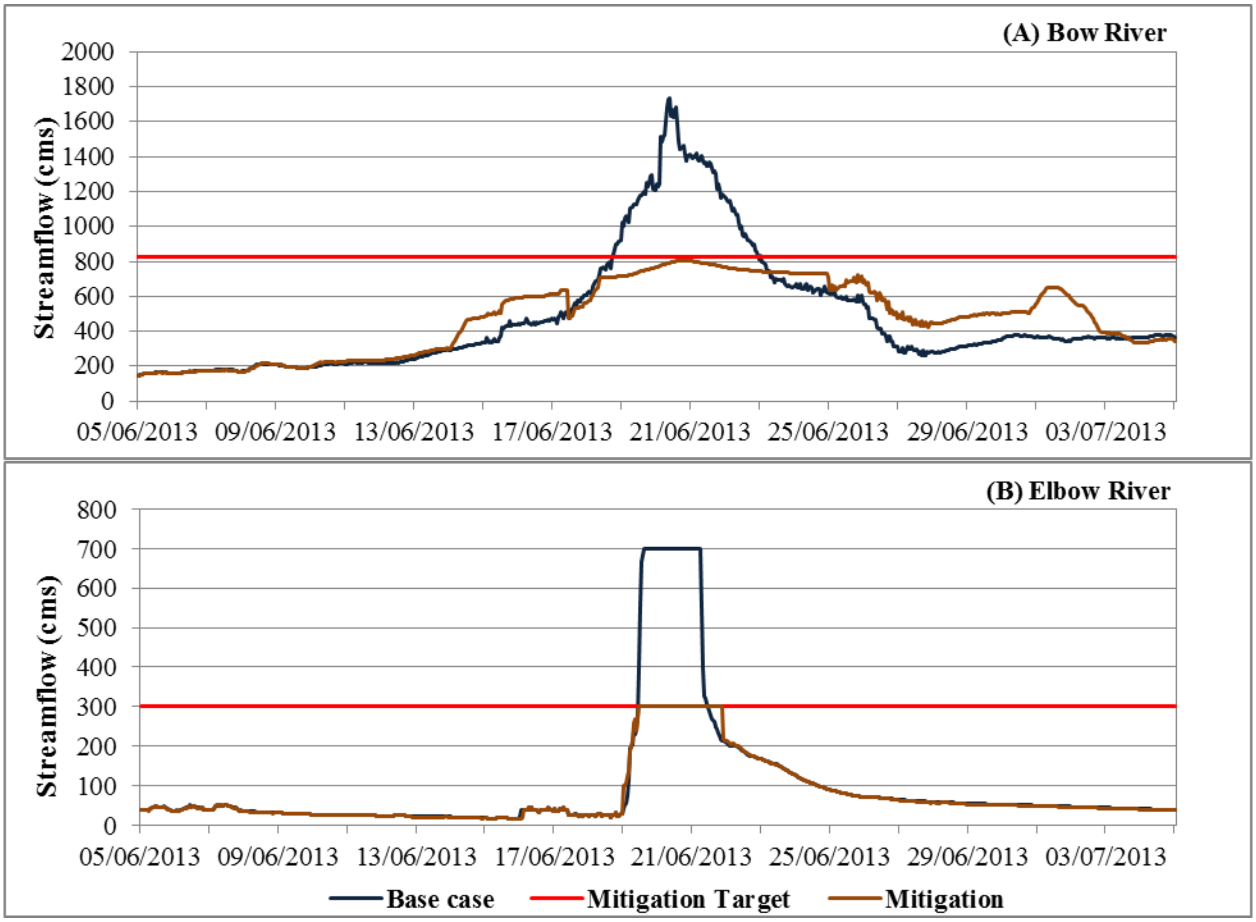

Figure 64: Comparison of streamflow in the (A) Bow and (B) Elbow Rivers in 2013 and applying infrastructural and natural mitigation to attempt to reach the mitigation target (MT2)

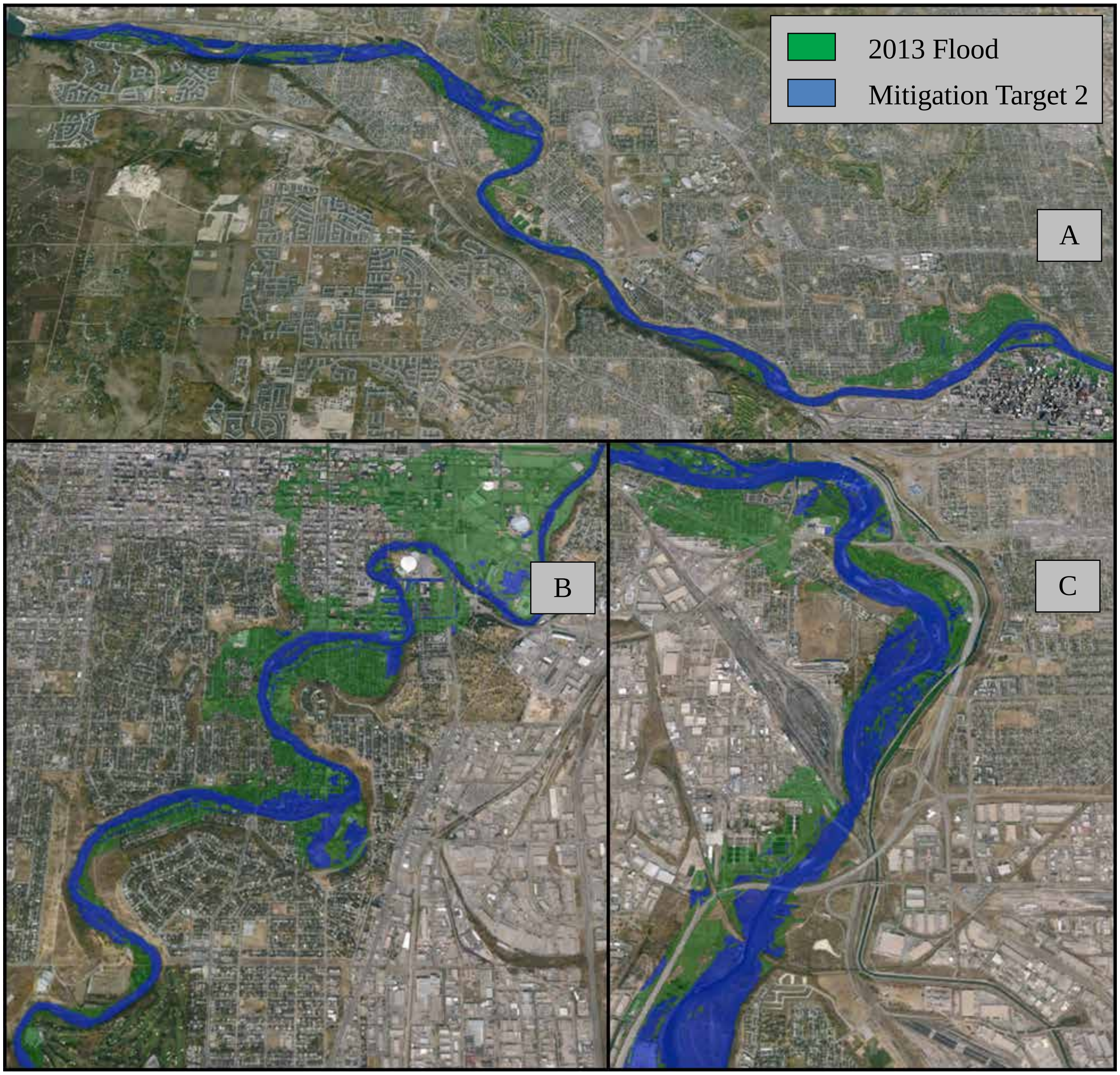

Figure 65: Visualization of the estimated 2013 flood extent and Mitigation Target 2 for the Bow River upstream in Calgary (A), the Elbow River downstream of Glenmore Reservoir (B), and the Bow River downstream in Calgary (C)

Increasing the North diversion around High River to 500 cms resulted in a peak hourly flow of 1300 cms for the 2013 modelled event. The peak hourly flow in the Sheep River was reduced to 748 cms as a result of the S2 and Threepoint Creek dry dams (Figure 66).

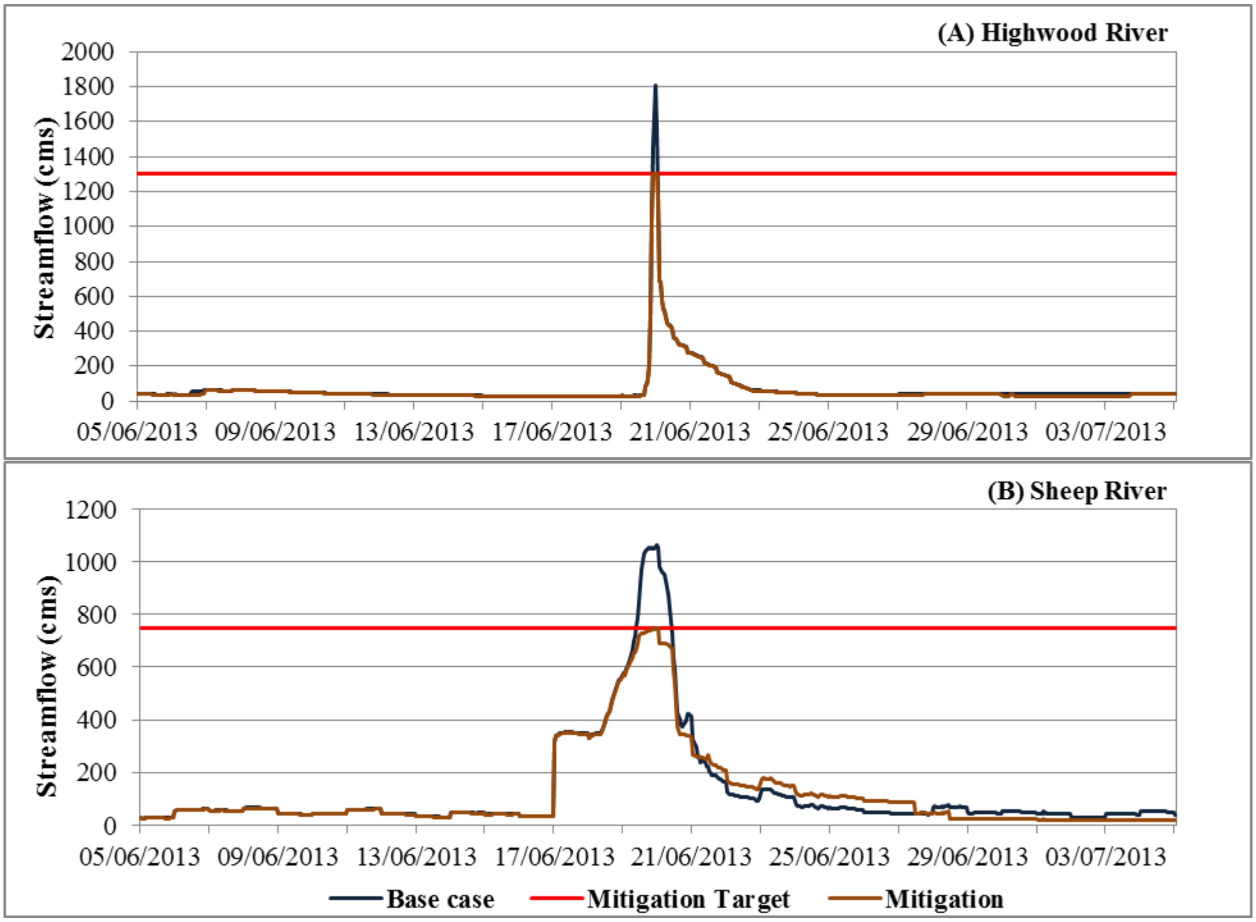

Figure 66: Comparison of streamflow in the (A) Highwood and (B) Sheep Rivers in 2013 and applying infrastructural and natural mitigation to attempt to reach the mitigation target (MT2)

Achieving the targets set in MT2 would require a considerable array of expensive and environmentally impactful new infrastructure. The targets for the Bow River through Calgary, and the Highwood and Sheep rivers through High River and Okotoks respectively are probably at or beyond what is required to protect life and most property and ensure safety under conditions of lesser flood flows than were experienced in 2013. It is more of a challenge to mitigate damages to existing homes and infrastructure along the Elbow River; that said, this run showed a substantial reduction in flooded area (~26 km^2 instead of ~40 km^2 in the 2013 base case) as visible in Figure 65.

The Elbow River has the greatest percent reduction targets of all the river systems and is shown to reach the 300 cms MT2 target in this run, down about 60% from the 700 cms which was already reduced by 40% by applying proactive flood management tactics on Glenmore Reservoir operations. The total percentage reduction in peak flow on the Elbow from inflow to Glenmore to below Glenmore Reservoir would have to reach 75% to achieve the MT2 scenario.

Some of the targeted peak flows reductions in MT2 may already have been raised due to regional and local actions to reduce flood damage. High River may need to reach only 1500 cms as a maximum flow target and Okotoks may be able to withstand a higher peak flow than 573 cms (approximately 750 cms). The actual mitigation targets will vary according to local initiatives such as relocation, permanent and temporary berming, armouring, raising essential infrastructure, pumping, and other less expensive and less environmentally disruptive actions. All of these local and regional activities can substantially reduce the overall costs (social, economic, and environmental) of mitigating flood damage given the relatively low annual probability of another flood of the size and extent of the 2013 event. As described in the introduction, human safety is the first priority followed by protecting the economic core of Alberta represented by downtown Calgary, and then reducing damage to homes and other infrastructure at least cost while minimizing negative environmental and other unintended consequences.

8.6 Mitigation Target Scenario 3

This combination was designed to achieve the third hourly mitigation target (MT3), excerpted from Table 7; these targets are:

Bow River upstream of Elbow = 540 cms
Elbow River downstream of Glenmore = 180 cms
Highwood River at High River = 1100 cms
Sheep River at Okotoks = 650 cms

Operational, infrastructure, and natural mitigation options were used in combination to achieve this target, specifically:

- All of Scenario 2 (TransAlta flood control; Glenmore flood control; Minnewanka 100cms diversion; Highwood 500cms diversion; 345 cms Elbow diversion; additional Elbow diversion or EQ1 dry dam; dry dams on S2 and Threepoint Creek; dry dams on Ghost River-BG1 and Waiparous Creek-BW1; land management; wetland storage)
- Improved probability forecasts for floods and reservoir management
- System in place for collaborative management of entire watershed.

PLUS

- Dry dam on Bow main stem above Bearspaw (BR1)
- The 500 cms 58th Ave tunnel OR more overland diversion OR dry dam EQ1
- Expanded Highwood diversion of 700 cms instead of 500 cms
- Increased flood flow retention by the S2 and Threepoint Creek dry dams

The BROM was used to simulate TransAlta and Glenmore Reservoir operations, wetland restoration, an inflow reduction of 1% as a result of best land management practices, the BG1, BR1, and BW1 dry dams, a 100 cms Minnewanka diversion, a 345 cms Priddis diversion plus another diversion (Fish Creek or ring road) with the capacity to handle the remaining flow to get down to target, S2 and Threepoint Creek dry dams, and a 700 cms North diversion around High River for the 2013 model event.

The addition of another dry dam (BR1) resulted in peak hourly streamflow in the Bow River being reduced to 674 cms, still short of the 540 cms target. Larger diversions (specific locations not identified) in the Elbow watershed resulted in a peak hourly streamflow of the targeted 180 cms (Figure 67). The flooded extent was further reduced along the Bow and Elbow rivers, with a very small amount of flooding. The overall change in flood extent was from ~40 km^2 in the 2013 base case to ~25 km^2 (Figure 68).

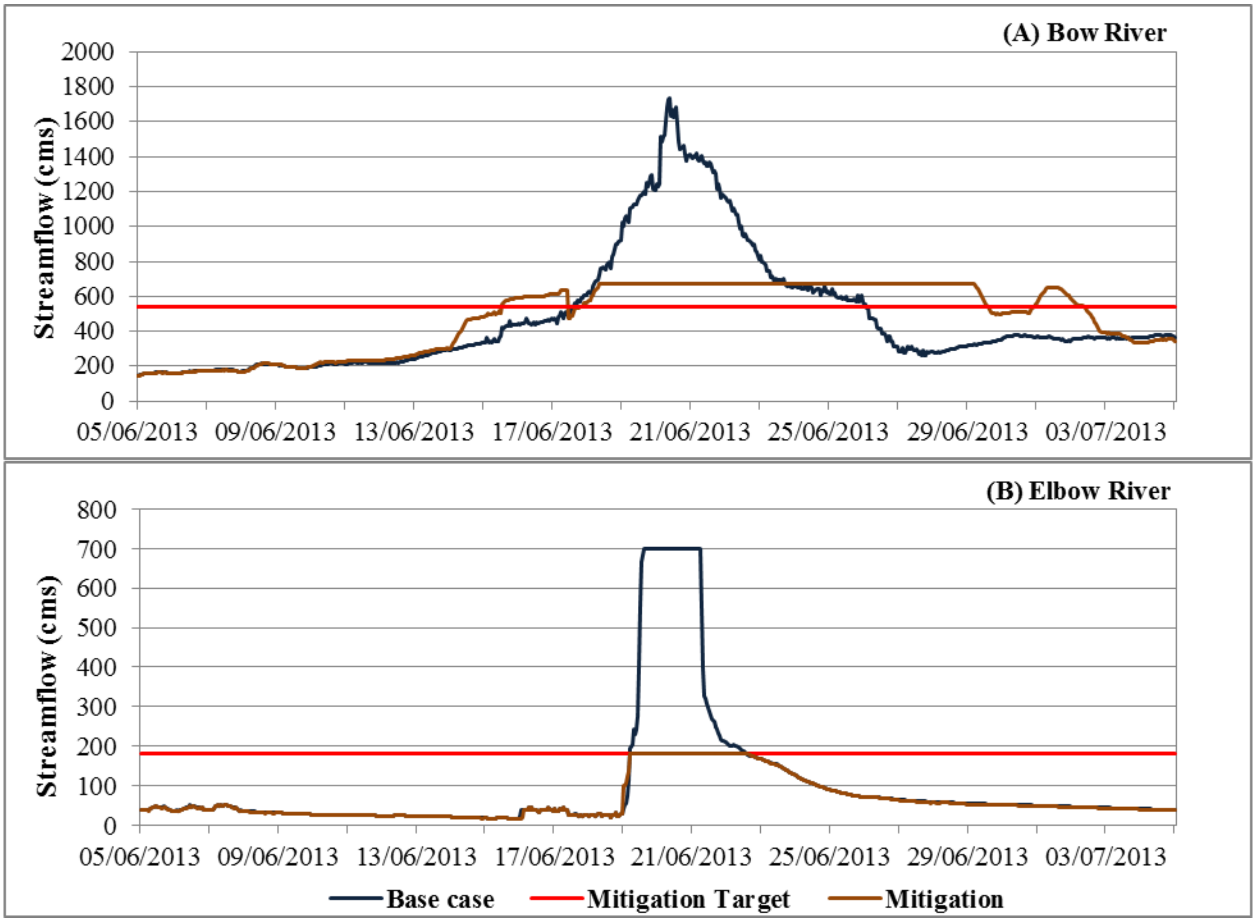

Figure 67: Comparison of streamflow in the (A) Bow and (B) Elbow Rivers in 2013 and applying infrastructural and natural mitigation to attempt to reach the mitigation target (MT3)

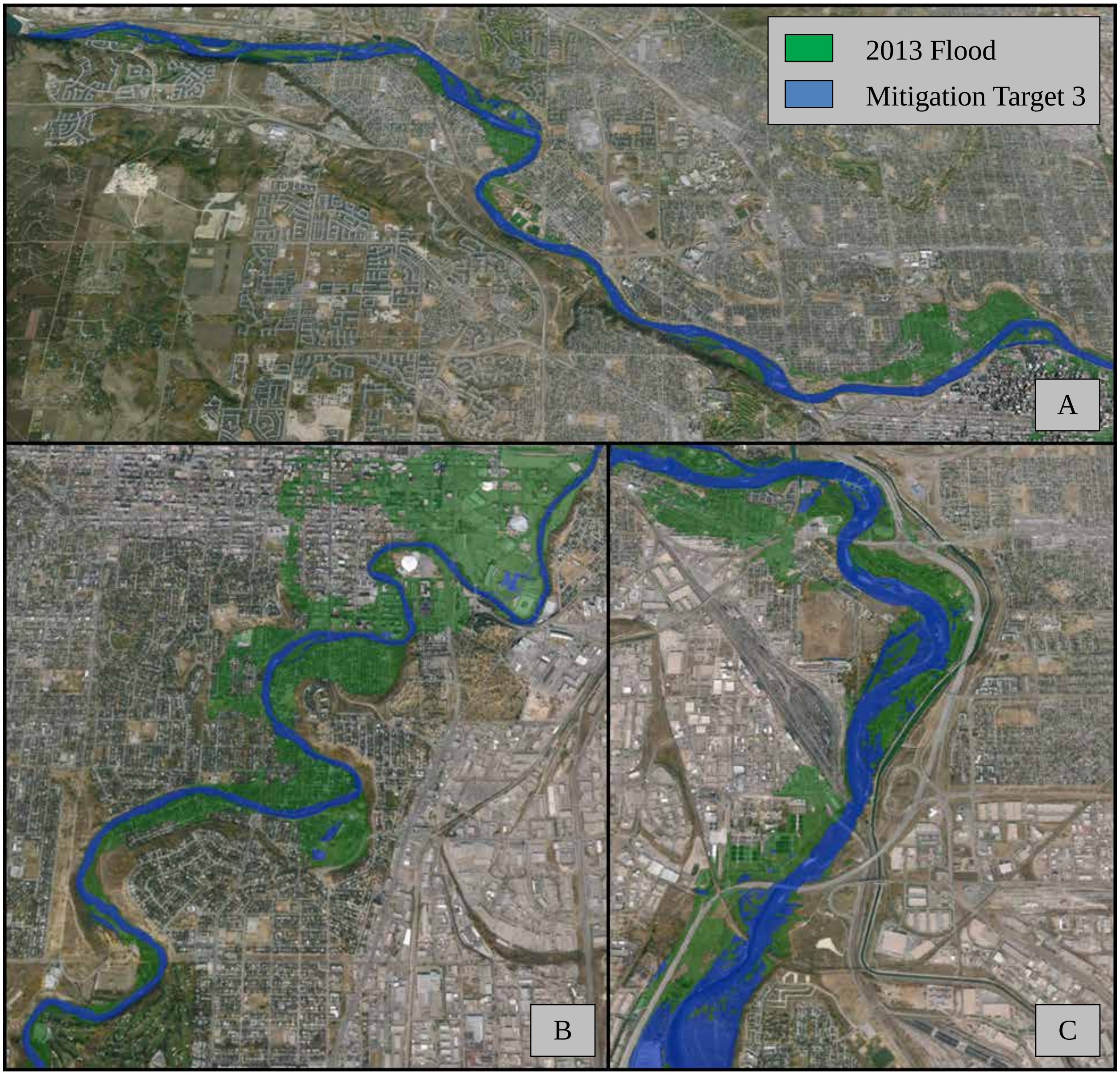

Figure 68: Visualization of the estimated 2013 flood extent and Mitigation Target 3 for the Bow River upstream in Calgary (A), the Elbow River downstream of Glenmore Reservoir (B), and the Bow River downstream in Calgary (C)

Increasing the North diversion around High River to 700 cms resulted in a peak hourly flow of 1100 cms for the modelled 2013 event. The peak hourly flow in the Sheep River was reduced to 573 cms as a result of the S2 and Threepoint Creek dry dams (Figure 69).

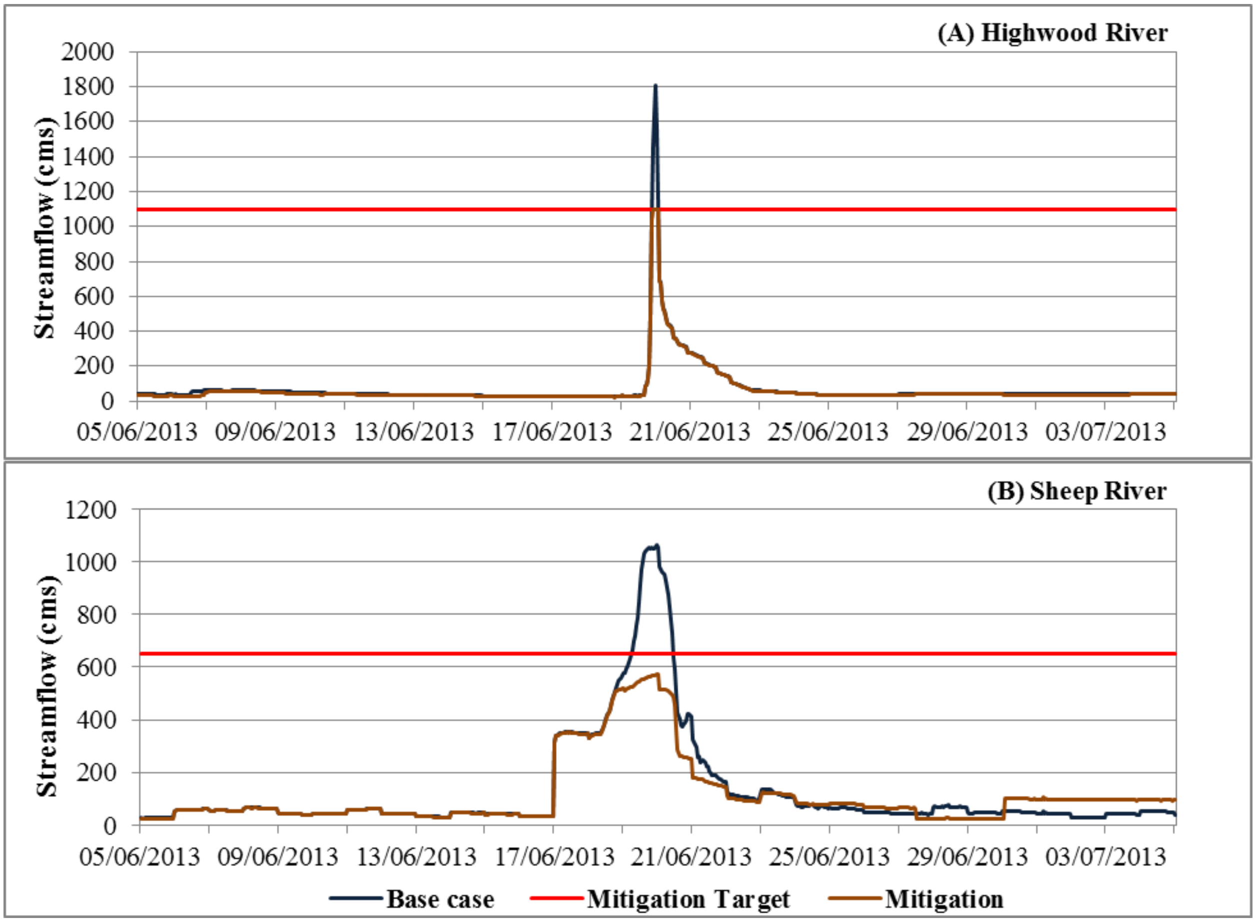

Figure 69: Comparison of streamflow in the (A) Highwood and (B) Sheep Rivers in 2013 and applying infrastructural and natural mitigation to attempt to reach the flow target (MT3)

This run illustrates that herculean efforts may achieve the minimization of flood flow on each of the river systems. But for many participants this raised the issue of too much control. Flood flows up to the point of serious safety threats or severe negative economic consequences are necessary for healthy functioning river ecosystems. This scenario also triggered a good deal of discussion about how much ordinary citizens are willing to pay in terms of pure financial costs as well as environmental and recreational costs needed to protect a relatively small number of homes, businesses, and infrastructure. The additional infrastructure for this third scenario only reduced flooding by another 1 km^2 compared with 11 km^2 for Mitigation Target 1, and 3 km^2 for Mitigation Target 2. Clearly there are diminishing returns as current proposals for additional infrastructure are added in. The all-in costs including environmental and social issues versus the benefits of flood protection against relatively low probability flooding would have to be carefully considered by decision makers before proceeding down the path to these particular mitigation targets.

The three Mitigation Target categories can be mixed and matched and do not have to proceed together for each river system. For example, if one doesn't have to mitigate to such rigorous targets on the Bow, Highwood, and Sheep rivers, perhaps an alternative is to spend more resources examining and implementing a variety of damage reduction options for the Elbow system.

9 Key Messages

A flexible, adaptive, and resilient approach to flood mitigation is needed since the next flood will no doubt have different characteristics than previous flood events. Planning to fight and win the last battle is rarely a successful strategy particularly with infinitely variable climate and weather patterns. Protecting against such a severe and massive flood will require some potentially severe and massive trade-offs among a variety of mitigation options, none of which are pleasant to contemplate nor beneficial to everyone. This report has laid out some of the options available to us, on the assumption that we as a society must not allow a recurrence of the human and economic damages suffered in the flood of 2013.

We cannot prevent floods or droughts. However, we can achieve some level of flood mitigation through a coordinated combination of operational, infrastructure, and natural options. These must be operated in an integrated manner with appropriate governance, involving water managers and applying other expertise throughout the system. All of these elements must be carefully considered in thorough and comparative cost-benefit analyses and in light of sound water management.

Effective watershed management cannot respond only to specific flood events such as 2013, but must build the resiliency of the watershed to adapt to the full potential range of hydrological and climatic conditions. Understanding how flood mitigation measures affect low flows, water supply, and ecosystem conditions is of paramount importance to ensuring long-lasting watershed health. Despite the risks and damage of large floods, flooding is a natural occurrence and has beneficial impacts for humans and the environment that should not be completely lost.

Moving people and infrastructure out of the flood plain is the only sure way to avoid flood damage. Even with the buyouts already underway, it is recognized that much of the existing infrastructure will remain in the flood plain. To prepare for the spring of 2014, municipalities are already implementing local flood mitigation measures, and these measures need to be considered within basin-scale mitigation plans. Longer term development restrictions throughout the flood plain, possibly as a prerequisite for provincial mitigation investments, are only prudent as a part of the government's approach to flood mitigation for the basin.

Some degree of long-term cost-effective flood and drought mitigation is available by ensuring a basin-scale perspective on existing reservoir operations. An agreement should be implemented prior to this flood season between the Province of Alberta and TransAlta that supports and governs TransAlta in operating its reservoirs for flood control when needed; this is essential in implementing some of the quick and effective measures for the 2014 flood season. In parallel, effort must be put into compiling the best meteorological and hydrological forecasting possible to inform operational decision making and enable a collaboration-based integrated management system for both flood and drought in the best interest of the whole basin.

Diversions on different scales and using different methods offer the opportunity to route flows away from infrastructure and, in some cases, these diversions build on natural flow pathways. How the diverted flow rejoins the river system needs to be carefully managed. It is critical that these diversions do not simply transfer flood risk from one community to another without fairly derived and complete compensation. All the trade-offs involved in this type of mitigation, social, economic, environmental and psychological need to be carefully assessed, but difficult decisions do need to be made.

Dry dams are a massive and expensive undertaking with many complexities: full safety standards, possibly gated spillways and culvert operations, debris management, ongoing maintenance and management, and river function impacts. There was little support among participants for dry dams, even in the Elbow River system where this type of infrastructure may play the greatest role in reducing flood flows for Calgary. The many environmental, social, and economic factors and risks associated with dry dams need to be understood and assessed in a detailed and comparative cost-benefit analysis.

Maximizing natural resiliency by improving wetland management, implementing best management practices on the landscape, and restoring natural river function are crucial to any flood mitigation solution. There are a number of practical and reliable means of doing this, including:

- Set aside some percentage of the costs of the engineered infrastructure developments being proposed and built. This percentage, proposed by many participants to be approximately 10% of the total, would be used exclusively to retain and improve healthy functioning ecosystems and for a collaborative governance function to make decisions in support of overall watershed management.
- Identify high priority locations for the establishment of wetland conservation or restoration programs.
- In combination with the GoA's purchase of flood-prone properties, provide support and incentives (cash or enhanced tax treatment) for voluntary conservation of riparian areas and flood hazard areas within both urban and rural reaches.
- As an extension to the above, engage landowners in the river valleys in voluntary land conservation, leading to perpetual and term agreements that would set aside natural areas and allow riparian enhancement activities to occur.

The most promising near-term options for flood mitigation throughout the Bow River Basin that were identified through this project are:

1. Operate TransAlta facilities for flood control when needed. This should be implemented immediately for relatively low cost and maintained over the long term to achieve overall water management improvements as described in the Bow River Project results.
2. Construct a channel for the Highwood River through the Town of High River capable of handling 1300 cms or more. If needed, construct a channel north around High River to mitigate flood impacts on the town without increasing flood flows down the Little Bow system south of the town.
3. Operate Glenmore Reservoir in the same manner as in 2013. It was acknowledged that Glenmore Reservoir was operated optimally for flood peak attenuation during the 2013 flood event.
4. Apply existing wetland, riparian, and land management policies and plans to stop further loss and achieve a level of wetland and riparian restoration throughout the headwaters, foothills, and prairie reaches of the Bow System. This includes implementing the new Wetland Policy, making all wetland impacts subject to the mitigation process, implementing watershed and land management plans, and enforcing existing legislation.

5. Reinforce existing downstream infrastructure as soon as possible with spillways conforming to full safety standards, given potentially higher future flows; in particular, Bassano Dam and Travers Dam.
6. Improve resourcing for forecasting systems and better integration of communications to the first responders and the public if and as severe flood risk potential increases and becomes imminent.

Next steps in flood mitigation decision making, including implementation of the short term options described above, should include:

1. Social policy decisions on what flow rate and elevation level we want to target mitigation to in each basin.
2. Comparative cost-benefit analyses of what it would take to achieve the desired mitigation targets, including consideration of these measures in terms of their ecological, social, recreational, downstream, and upstream impacts.
3. Analysis of the level and location of risk associated with these mitigation measures including upstream and downstream consequences, transfer of risk, and the cost of mitigating the negative impacts of the mitigation.
4. Setting aside some percentage of the costs of the infrastructure being engineered and built, proposed to be approximately 5-10% of the total, which would be used exclusively to retain and improve healthy functioning ecosystems and to establish and operate a collaborative governance function to administer and support watershed management.
5. Broad and full communication of the flood mitigation information, analyses and decisions to all communities and residents in the Bow River Basin.

Any mitigation involves trade-offs. The hope is that a balanced suite of mitigation options will be pursued to increase safety and reduce risk of damage while enhancing the long term health and resiliency of our watershed.

Appendix A: Project Participants

Organization	Representative(s)
Alberta Agriculture and Rural Development	Andrea Gonzalez Roger Hohm
Alberta Environment and Sustainable Resource Development	Andrew Paul David DePape Derek Lovlin Jenny Earle Jon Jorgenson Paul Christensen Peter Onyshko Satvinder Mangat Werner Herrera
Alberta Innovates – Energy and Environment Solutions	Jon Sweetman
Alberta Tourism, Parks and Recreation	Joey Young Melanie Percy Scott Jevons
Bow River Basin Council	Mark Bennett Mike Murray
Bow River Irrigation District	Richard Phillips
City of Calgary	Deighen Blakely Edith Philips Frank Frigo Harpreet Sandhu Rick Valdarchi Wolf Keller
Ducks Unlimited Canada	Tracy Scott
Eastern Irrigation District	Earl Wilson
Fisheries and Oceans Canada	Marek Janowicz
Highwood Management Plan – Public Advisory Committee	Shirley Pickering
Kananaskis Improvement District	Arnold Hoffman
MD of Bighorn	Erik Butters
MD of Foothills	Hugh Pettigrew Julie McLean Suzanne Oel
Rocky View County	Jorie McKenzie
Spray Lakes Sawmills	Gord Lehn
Town of High River	Douglas Holmes Reiley McKerracher
Town of Okotoks	Rick Quail
TransAlta	Don Thomas Roger Drury Scott Taylor
Trout Unlimited Canada	Brian Meagher
Western Irrigation District	Erwin Braun
Western Sky Land Trust	Jerry Brunen
Flood Recovery Task Force (as observers)	Andre Corbould Andrew Wilson Cathy Maniego

Organization	Representative(s)
Alberta WaterSMART	Colin Savoy Kim Sturgess Megan Van Ham Mike Kelly Mike Nemeth Ryan MacDonald
GranDuke Geomatics Ltd.	Guy Duke Kevin Grant
HydroLogics Inc.	Casey Caldwell Dan Sheer A. Mike Sheer