LAW, Legal Services (8053)

Lawyer: Melissa Senek
Direct Line: (403) 268-2404
Email: Melissa.Senek@calgary.ca
Legal Assistant: Denise Caron
Direct Line: (403) 268-2452
Fax No.: (403) 268-4634
Our File: ENV0718

February 26, 2021

Natural Resources Conservation Board
250 – 5 Street SW
Calgary, AB T2P 0R4
via Email: laura.friend@nrcb.ca

Attention: Laura Friend
Manager, Board Reviews

Dear Ms. Friend

Re: Alberta Transportation Springbank Off-Stream Reservoir Project (SR1)
NRCB Application No. 1701 - Notice of Hearing
City of Calgary Submission

Dear Ms. Friend,

On behalf of The City of Calgary (The City), please find attached The City of Calgary's written submission, to accompany its participation as an intervener in the above noted application. The City's written submission directly reflects the topic-based hearing approach adopted by the Board and re-iterates The City's support of the SR1 project. The City's exhibits, being large files, will be provided to the Board separately, but will also be hyperlinked for ease of reference where publicly available. Please note that most of the City hosted links will go live on Monday, March 1, 2021.

Yours truly,

Melissa Senek
Barrister & Solicitor

Encl.

cc: Frank Frigo, P.Eng., Leader, Watershed Analysis, Water Resources
Justin Lo, Business Strategist, Water Resources
David Mercer, Manager, Planning & Real Estate, Law & Legal Services
Sara Munkittrick, Barrister & Solicitor, Law & Legal Services
Francois Bouchart, P.Eng., PhD, Director, Water Resources
Michael Thompson P.Eng., MBA, General Manager, Infrastructure & Engineering Services
David Duckworth, P.Eng., MBA, City Manager

The City of Calgary

NRCB Application No. 1701

Public Hearing Written Submission

March 22, 2021

Contents

Attendance

Mr. Frank Frigo, P.Eng., Leader of Watershed Analysis, will represent The City of Calgary (The City) at the hearing. Mr. Frigo is a Water Resources Engineer with a career spanning over 24 years in applied hydrology, flood forecasting, river hydraulics, river morphology, flood and erosion protection, floodplain modelling, dam safety, water quality, water control structures design and construction and drainage analyses.

Since 2008, Mr. Frigo has been involved with the River and Drainage portfolios within The City's Water Resources business unit. As Leader of the Watershed Analysis group, Mr. Frigo leads The City's hydraulic modeling, flood mitigation, river flood preparedness planning and response, watershed monitoring, and bank restoration programs. He was directly involved in the preparation, emergency response, and recovery related to the June 2013 floods. Mr. Frigo is heavily involved in The City's flood resilience program, having supported its strategic development and leading the delivery of key parts of the program. He also works closely with other experts in water supply and source water protection. He holds a BSc. Eng. from University of Guelph 1995 and previously worked as an engineering consultant with firms based in Ontario and Alberta.

The City's Law department will also be in attendance.

Overview of Submission

City Position

River flood mitigation is a critical priority for The City and its citizens. Since 2013, The City has studied its flood risk and assessed mitigation measures to reduce its flood risk as effectively as possible. As part of its comprehensive flood resilience strategy[1], the Springbank Off-Stream Reservoir (SR1) is a cornerstone of The City's ability to mitigate flooding on the Elbow River.

The City, its public infrastructure, emergency operations and citizens are directly affected by SR1. The City is responsible for the operation and maintenance of roads, bridges, transit systems, water supply, wastewater treatment, and stormwater management infrastructure within the city of Calgary, including the Glenmore Dam. The City is also responsible for enacting emergency response to ensure the safety of Calgarians during events such as a floods on the Elbow River.

The 2013 floods caused widespread impacts throughout Calgary, including:

- The displacement of at least 88,000 Calgarians[2]
- Damage to 14,500 homes[3]
- The flooding of 4,000 businesses[4]
- Damage to numerous pieces of public infrastructure including roads, power transformers, water, wastewater, and stormwater systems, parks, pathways, and public transit, including $400M in insurable losses to city-owned infrastructure.[5]

[1] City Exhibit A
[2] Alberta Transportation, Exhibit #20, p. 6.24.
[3] Alberta Transportation, Exhibit #56, p. 17.2
[4] Alberta Transportation, Exhibit #56, p. 17.2
[5] City Exhibit A

- Calgary's downtown core being left inaccessible for days due to power outages, damaged access routes, and public safety risks due to pooled water on roadways and pathways.

The City supports Alberta Transportation's application to the Board for approval of SR1. SR1 is in the public interest and should be expeditiously constructed as proposed.

The accompanying written submission includes comments and conclusions informing The City's position. Failure to approve this project will potentially lead to further delays on flood mitigation efforts on the Elbow River, and leave Calgary and the surrounding region exposed to significant public safety risk, economic losses, widespread property damage, and environmental impacts due to flooding.

Major Topics Addressed

This submission is organized by the NRCB's hearing topic list. A conclusion is provided for each topic. Specific comments are mentioned in the appropriate sub-topic.

Any technical studies referenced in this submission are hyperlinked, where publicly available, for ease of reference and will be supplied to the Board as exhibits and listed accordingly in Appendix A. In addition, The City's watershed experts have prepared a technical analysis of SR1, which is enclosed as Appendix B. The City's submission is focused on two of the five hearing topics:

- Project Need and Justification; and
- SR1 Design, Safety, and Risk.

The City submits that SR1 is vitally needed by Calgary and its citizens, and provides considerable social and economic benefits. The City and the Government of Alberta have extensively studied both in-city and upstream alternatives to the SR1 project. The City concludes that SR1 presents a practical, timely, adaptive, and environmentally responsible mitigation option that will work with existing and planned mitigation within Calgary to reduce flood-related risks on the Elbow River. In addition to reduced flood damages, the presence of SR1 will also enhance The City's emergency response capacity by delaying the arrival of floodwater through Calgary and concentrating emergency response resources in areas of highest risk.

SR1 is preferred by The City to other alternatives based on the reliability of its design, lower environmental impact, and lower risk to Calgary as an off-stream reservoir. The City believes SR1 achieves the target outcome of reducing flood risk on the Elbow River through Calgary as intended by the Applicant.

In terms of SR1's design, it is The City's view that the Applicant has undertaken the necessary analysis to assess dam safety and risk management. The City has no concerns respecting any potential risk to public safety; on the contrary, The City believes that SR1 provides a net benefit to public safety in Calgary, providing adequate reservoir capacity and benefits of coordinated operation with city-owned flood mitigation infrastructure.

Areas of No Position

The City takes no position on the topic of Crown consultation and land use. The City supports Alberta Transportation's position and offers no additional comments or submissions on the following topics and sub-topic areas:

- Aquatics;

- Hydrogeology;
- Sensitivity of project water elements to changes or variability in climate parameters; and
- Air Quality, Human Health, and Terrestrial (including all sub-topics).

Oral Submissions

The City intends to provide oral submissions for the major topic areas discussed below. The City does not anticipate requiring any more than the 20 minutes provided for each of the relevant topic areas (Project Need and Justification; SR1 Design, Safety and Risk; and Water).

Topic 1: Project need and justification

Summary

The City supports the Applicant's conclusion that SR1 achieves its main intended outcome, which is to reduce the risk of flooding on the Elbow River for Calgary and other downstream communities. SR1 is critical to The City's flood mitigation efforts on the Elbow River and increases Calgary's resilience to flooding amidst anticipated increase to the intensity and frequency of flooding due to climate change. The Applicant estimates that SR1 will reduce potential damages by nearly $1.5B based on the design flood.[6]

Current mitigation undertaken and completed by The City cannot mitigate a 2013-sized flood event on the Elbow River on its own. SR1 presents a practical, timely, adaptive, environmentally responsible mitigation option that will work with mitigation undertaken by The City to provide additional mitigation the Elbow River. SR1 is preferred by The City to other alternatives based on the maturity of its design and study, and The City believes SR1 achieves the main function and target outcome better than any of the potential alternatives.

The City submits that SR1 has greater benefit than cost, with an estimated ratio of 5:1 of damages avoided over the project's asset lifecycle versus the current capital cost estimate.[7] SR1 will significantly reduce the risk of flooding on the Elbow River. It will reduce potential flood damages in key areas including the Downtown Core, which serves as Calgary's central business district. Elbow River communities include numerous historical sites, cultural amenities, and neighbouring residential communities, all of which are also at risk of flooding.

1.1 Project purpose and need

The main function of SR1 is to reduce the risk of flooding on the Elbow River, including Calgary and other downstream communities. The City's Flood Mitigation Measures Assessment,[8] completed in 2017, used data from the Government of Alberta's 2015 Provincial Flood Damage Assessment Study[9] to assess the effectiveness of various measures at mitigating flooding in Calgary. The assessment concluded that upstream storage, especially on the Elbow River, is critical to mitigating flood risk on the Elbow River for Calgary. While the Glenmore Dam provides some mitigation against flooding on the Elbow River, it possesses only a portion of the necessary storage capacity to fully mitigate a 2013-sized event.[10]

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[6] Alberta Transportation, Exhibit #56, p. 17.10 (see Table 17-6)
[7] Appendix A, Pg. 13-14
[8] City Exhibit B
[9] City Exhibit C
[10] Appendix A, Pg. 13

The City anticipates that SR1, on its own, has the capacity to manage an event similar to the 2013 flood. In tandem with the recently upgraded Glenmore Dam, the available storage capacity on the Elbow River will mitigate damages of an approximated 200-year flood event,[11] by reducing flows downstream of the Glenmore Reservoir below the safe flow target of 160 m^3/s,[12] resulting in minimal damage and disruption in Calgary, if any. The City views this as an acceptable target level of service, considering the uncertainty around the severity of future floods due to increased urban development and climate change.

The mostly-mountainous catchment upstream of Calgary is one of the steepest in Alberta. [13] This topography can cause rapid runoff, limiting the time available for The City to enact its emergency response. In 2013, The City had under 15 hours to enact its emergency response plan and conduct evacuations.[14] SR1, in addition to minimizing flood damages through Calgary, affords The City greater time to enact emergency response measures, giving The City the flexibility to concentrate emergency resources in areas at highest risk. This will help ensure the safety of Calgarians and other communities downstream of the reservoir. SR1 also provides greater control of flood attenuation than other proposed alternatives that may be located farther from Calgary as it can accommodate water entering downstream of other proposed alternatives, providing greater mitigation for Calgary.[15]

1.2 Social and economic project costs and benefits

The Applicant states that SR1 has an estimated a cost-benefit return on the project greater than 1.24:1.[16] In The City's submission, the benefits are even greater than the cost-benefit stated by the Applicant. Regardless of methodology, The City submits that it is clear that SR1 provides significant social and economic benefits.

Based on data provided by IBI Group, The City estimates that SR1 will provide an average annualized reduction in potential flood damages in Calgary of approximately $28M per year, totaling benefits of nearly $3B over 100 years.[17] This number is derived from The City's modeling of flood damages for a variety of return periods from a 2-year event to a 1000-year event and estimating damages based on the probability of occurrence of each event over 100 years.[18] Based on this approach and taking the average annualized damage reduction relative to the current cited cost estimate of the project from the Applicant, The City estimates a 5:1 return on capital cost over SR1's lifecycle.

The City's estimate does not consider discounting, capital depreciation, or operations and maintenance costs. This is due to uncertainty in future costs and other factors like economic growth and population growth, or increases in potential risk due to growth, that would effectively raise the total damages averted by SR1.

To put the economic benefits in perspective, The City incurred $400M in insurable losses to City-owned infrastructure such as roads, water, wastewater, and stormwater systems, parks, pathways, and public

[11] Alberta Transportation, Exhibit #20, Pg. 3.1
[12] Alberta Transportation, Exhibit #20, Pg. 1.3
[13] Alberta Transportation, Exhibit #159, Pg. 4
[14] City Exhibit B, Pg. 53
[15] Alberta Transportation, Exhibit #20, Pg. 2.9
[16] Alberta Transportation, Exhibit #100, Pg. 8
[17] City Exhibit D
[18] City Exhibit B, Pg. 9

transit[19] – costs that would not have otherwise been incurred had SR1 been constructed and functioning during that flood.[20] This suggests that one flood equivalent to 2013 would result in an immediate near-payback of SR1 from damages avoided in Calgary alone, given the Applicant's current estimated cost of $432M.[21]

Flooding on the Elbow River carries significant social and economic costs to Calgarians. The 2013 flood, which was approximately a 1:200-year flood event above Calgary,[22] had significant impacts on both business and residential districts located near the Elbow River.

The 2013 floods affected 4,000 businesses in Calgary.[23] Such flooding significantly impacts Calgary's downtown core, which acts as Calgary's central business district. In 2013, Calgary's downtown core was left inaccessible for days due to property damage, power outages, damaged access routes, and public safety risks due to pooled water on roadways and pathways. SR1 will significantly reduce the risk of business interruption, supply chain interruption, and the likelihood of business total loss due to flood damages for businesses on the Elbow River that were affected by the 2013 floods.

In 2013, at least 88,000[24] Calgarians were displaced by the devastating floods, with 14,500 homes being damaged.[25] Construction of SR1 will also reduce flooding for residential neighbourhoods located near the Elbow River, and the likelihood of damages to private residences and critical infrastructure. The City expects that SR1 will support The City's emergency response by reducing potential disruption to emergency access routes, increasing likelihood of successful evacuation.

Figure 1 below shows the extent of flooding from a 200-year flood event in Calgary with existing conditions (i.e., without SR1) versus the expected flood inundation area with SR1 in place. Overall, The City estimates that SR1, once completed, will store more than half the volume of a 2013 sized flood along the Elbow River.[26] Attenuation provided by SR1 will ensure that floods up to a 200-year event will be contained within the banks of the Elbow River.

[19] City Exhibit A
[20] Appendix A, Pg. 13
[21] Alberta Transportation, Exhibit #100, Pg. 4 (Exhibit 2.4)
[22] Alberta Transportation, Exhibit #159, Pg. 22
[23] Alberta Transportation, Exhibit #56, Pg. 17.2
[24] Alberta Transportation, Exhibit #56, Pg. 17.2
[25] Alberta Transportation, Exhibit #56, Pg. 17.2
[26] Appendix A, Pg. 8

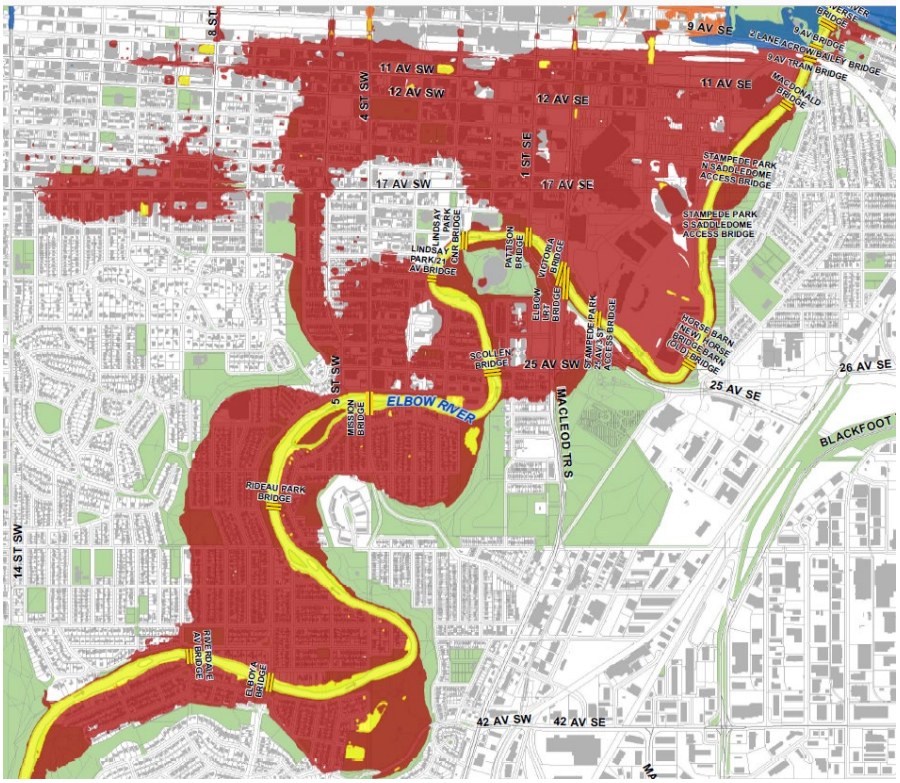

Figure 1: SR1 Flood Mitigation during a 200 Year Flood Event. Source: The City of Calgary (Appendix A, Section 2.1).

An added benefit of SR1 is lower inflows from the Elbow River entering the Bow River during flood events, providing some flood mitigation benefits for Bow River communities downstream of the confluence of the two rivers.[27]

1.3 Alternatives considered

Following the 2013 floods, The City conducted analyses of in-city mitigation options for Calgary on the Elbow River and worked closely with the Government of Alberta as it examined upstream flood mitigation possibilities. In-city alternatives to SR1 were extensively examined including:

- Modifications to Glenmore Dam's gate system[28]
- Community level flood barriers, walls and berms[29]
- Diversion of the Elbow River to Fish Creek[30]
- Diversion of flows from the Glenmore Reservoir to Bow River by conveyance tunnel[31]
- Dredging of the Glenmore Reservoir[32]
- Modification of gravel bars and bridges to increase hydraulic capacity[33]

[27] Appendix A, Pg. 13
[28] City Exhibit E
[29] City Exhibit F
[30] City Exhibit G
[31] City Exhibit H
[32] City Exhibit E
[33] Appendix A Pg. 5

Upgrades to Glenmore Dam's gate system were undertaken in order to pursue flood mitigation within The City's control on the Elbow River. The upgrades were intended to maximize the Glenmore Reservoir's ability to reduce flood risk on the Elbow River, considering the practical limitations of the Reservoir's footprint and its main purpose as a water supply reservoir. The City completed the upgrades in 2020, and the gate system is now fully operational. By itself, even with the upgrades, the Glenmore Dam cannot reduce flows from a 2013-sized flood event to the targeted flow of 160 m^3/s, and only provides a portion of the storage necessary for a 2013-sized flood event.[34] However, SR1, working in tandem with the upgraded Glenmore Dam, can mitigate damages above a 200-year event.

Permanent community flood barriers within Calgary were evaluated, including 14 km of barriers along the Elbow River. Given the height and cost of barriers required to achieve 1:200 flood protection, they were not considered feasible.[35] SR1 is preferred over other options listed due to estimated cost-benefit return, lower risk to public safety, and technical feasibility.

The City agrees with the Applicant's conclusions respecting the McLean Creek Dam (MC1) alternative, which notes the timescale uncertainty associated with the project.[36] The onstream nature of MC1 adds an additional level of potential operational risk not expected with SR1, which, instead of being continuously operational, will be constructed as off-stream structure and only operated when necessary. SR1's location will also allow it to potentially capture more rainfall from a larger catchment area and manage water entering further downstream compared to MC1.[37]

In addition to structural mitigation and river works, The City also examined a number of non-infrastructure changes to reduce flood risk:

- Land use regulation changes and floodproofing for buildings in the Flood Hazard Area
- Community-wide property buy-out and long-term land use change[38]
- Financial risk management through private insurance[39]

Prior to introduction of flood hazard regulation zones in the 1980s, development in the floodway occurred in Calgary. Development in the floodway is now significantly restricted by The City of Calgary's Land Use Bylaw (Land Use Bylaw), which prohibits new buildings and limits alterations to, replacement of, and additions to existing residential development to the existing footprint.[40] When faced with redevelopment applications for residential properties in the flood fringe, the Land Use Bylaw requires building design to meet standards for flood damage mitigation, including requiring major utilities and mechanical to be raised above the designated flood level.[41] The City is currently in the process of reviewing its development policies, including the Land Use Bylaw, and identifying potential changes to further reduce flood risk.

The City has updated its hydrology and inundation mapping since the 1983 Flood Hazard Area maps were released by the Government of Alberta and provides recommendations on development permit

[34] Appendix A, Pg. 10
[35] Appendix A, Pg. 16
[36] Alberta Transportation, Exhibit #100, Pg. 2
[37] Alberta Transportation, Exhibit #20, Pg. 2.9
[38] City Exhibit B, Pg. 22, Pg. 96
[39] City Exhibit B, Pg. 117
[40] City Exhibit I, Part 3, Division 3, s. 57
[41] City Exhibit I, Part 3, Division 3, s. 60

applications based on its latest understanding of flood risk in Calgary.[42] The City's relevant policies and mapping are expected to be updated again after the Government of Alberta releases updated inundation maps, anticipated in 2021, which will likely be followed by subsequent updated Flood Hazard Area maps. Any changes to The City's development policies will reflect any Flood Hazard Area mapping updates released by the Government of Alberta.

Buyouts were not considered financially feasible due to the significant number of high-value properties within the 200-year floodplain (980)[43], as well as the associated cost of relocating businesses from the floodplain, which is in excess of the cost of SR1's cost estimate.[44] Flood insurance is a reasonable mechanism where residual risk can be clearly and reliably be reduced and potentially discourages development in the floodplain. However, insurance does not reduce damages and availability at this time appears to be inconsistent, in part due to the risk level of properties near the river in Calgary.[45]

The City also continues to undertake the following actions to improve its flood readiness and response:

- Annual review and update of its flood emergency response procedures;
- Development of additional public education and awareness program materials; and
- Investments in additional watershed instrumentation, forecasting capabilities, and study of the influence of climate change on Calgary's flood risk

While readiness and response improvements provide valuable risk-reduction and are a necessary part of The City's flood resilience strategy, none of these measures provide sufficient scale or reliability to reduce the potential exposure from flooding on the Elbow River to the same magnitude as SR1.

1.4 Crown engagement with public

The City recognizes that individual stakeholders may be citizens of Calgary and hold a different position than The City's corporate position regarding SR1. The City recognizes the Applicant's engagement efforts with The City to date and feels the level of engagement and response from the Applicant to any inquiries or concerns raised by The City has been adequate. The City looks forward to continuing to work with the Applicant should the project move forward.

Topic 2: Crown consultation and land use

The City takes no position respecting the subjects outlined in Topic 2. The City recognizes other stakeholders and municipalities in the region are affected by the SR1 project and fully supports ongoing consultation by the applicant with these stakeholders, including ongoing consultation with affected indigenous groups to ensure consultation requirements are met and areas of concern are addressed as necessary.

Topic 3: SR1 Design, Safety, and Risk

Summary

The City supports the Applicant's conclusions and mitigation proposals respecting the proposed design, safety measures, and capacity of SR1. The proposed project is required to comply with all necessary

[42] City Exhibit J
[43] City Exhibit B, Pg. 96
[44] City Exhibit B, Pg. 96
[45] City Exhibit B, Pg. 7

Canadian Dam Association (CDA) guidelines and Alberta Dam Safety requirements in order to be constructed.[46]

While The City is broadly supportive of the risk mitigation measures proposed, The City requests that the Applicant continue to communicate and work with The City respecting dam safety and potential risk to Calgary related to SR1. The City recommends any concerns related to dam safety and risk be addressed through ongoing coordinated communications between the Applicant and The City. This will ensure that any unforeseen concerns that may occur during flood events can be actively managed and surface water quality risks can be minimized during normal operation.

The combined storage of SR1 and the Glenmore Dam is sufficient to mitigate all overland flooding on the Elbow River from a 200-year flood event downstream of the Glenmore Dam through Calgary. It is The City's position that SR1 provides significant reduction to Calgary's flood risk and potential flood damage, will reduce flood risk beyond the Provincial minimum standard when considering the Glenmore Dam, and remains in the public interest.

3.1 Project description (including operating plan, flood water management, and reservoir capacity)

The City has reviewed SR1's proposed Water Management Plan[47] and has no concerns. The Applicant's operating threshold and safe target flow of 160 m^3/s provides The City a clear reference for decision-making and operation of its flood mitigation structures, including the Glenmore Dam.

The City recommends that post-flood operations be approached with the intention of providing maximum flexibility to account for unforeseen conditions such as back-to-back floods or a water quality contamination event. Continual monitoring of conditions and data collection will facilitate SR1's ability to respond to such events from an operating standpoint.

The City has had a positive relationship with the Applicant to date and anticipates continued coordination between The City and the Applicant will ensure that any unforeseen concerns that may occur during flood events can be actively managed and surface water quality risks can be minimized during normal operation. Ongoing collaboration between The City and the Applicant will also facilitate coordination of public messaging to minimize risks to the public during at times when SR1 is operational.

3.2 Dam safety

SR1 is classified as an Extreme Consequence dam.[48] This consequence classification requires the most stringent of engineering design, surveillance, operation and maintenance standards with significant margins of error to minimize the risk of catastrophic failure. SR1's large storage capacity, designed freeboard capacity, service spillway designed to pass the Probable Maximum Flow (PMF), and redundant debris management are critical safety aspects of the project and subject to Dam Safety requirements. Unlike other extreme consequence structures in Alberta, including existing hydropower reservoirs on the Bow River upstream of Calgary, SR1 will only contain water following major floods. In combination with the high design and operational standards, this significantly limits the potential for failure. Regular performance monitoring and condition assessment should also be less challenging than other dams since the reservoir will not be operated constantly, facilitating access when not in use. The proposed MC1 alternative would be similarly classified, subject to the same risks, but would be operated

[46] Alberta Transportation, Exhibit #20, Pg. 5.1.
[47] Alberta Transportation, Exhibit #20, Attachment A
[48] Alberta Transportation, Exhibit #20, Pg. 5.6

onstream. This onstream operation contributes additional potential risks due to year-round operating versus SR1, which as a dry reservoir will operate only when necessary.

The Glenmore Dam is located downstream of SR1 on the Elbow River, is also classified as Extreme Consequence, and is capable of passing the design PMF. SR1, during a significant flood event, will divert and attenuate flows on the Elbow River before entering the Glenmore Reservoir. This should result in a greater safety at the Glenmore Reservoir as peak water levels, flow velocities, scour potential and groundwater pressures should be less due to the flow reduction provided by SR1. Though the possibility of dam failure is present, the likelihood of this is remote and The City submits that the risk of dam failure is far outweighed by the benefits in flood mitigation provided.

The City agrees with the Applicant's proposed mitigations for dam failure[49] and looks forward to continuing to work with the Applicant to further mitigate risks to dam safety as they arise.

3.3 Risk management

The applicant has identified safety concerns as part of the project's construction and operation, as well as preventative and reactive measures to mitigate the identified safety risks such appropriate geotechnical instrumentation with the dam monitoring of data to ensure performance.[50] The Applicant has also conducted breach analyses as part of its submission and The City has not identified any concerns with the Applicant's analysis.[51] The City remains a close partner with the Government of Alberta and will continue to coordinate operations efforts between SR1 and the Glenmore Dam.[52]

The Applicant's proposed configuration of SR1 as a dry operated, off-stream structure means that it will be infrequently loaded with stored water. Structural fair-weather failure can only occur in short periods after a major event. This makes risk of failure far more remote than onstream reservoirs like those on the Bow or the proposed MC1 alternative.

3.4 Public safety, including emergency response

Large river floods on the Elbow River remain one of Calgary's top disaster risks.[53] As noted above, during the 2013 floods, numerous households were evacuated and Calgary's downtown access was restricted for days following the event due to after effects such as downed transformers, deep surface pooling, and damaged roadways. The 2013 flood caused an estimated $400M in insurable damages to city-owned infrastructure alone,[54] displaced 88,000 Calgarians, and closed hundreds of businesses and government services for several days. Additionally, the potential of flooding continues to have a significant mental health impact on Calgarians who were impacted in 2013, with over half of Calgarians living within the 200 year flood zone and a quarter of those living outside, reported feeling emotional or psychological distress form the 2013 flood event.[55] A disruption of the scale seen in 2013 would be avoided with the presence of SR1. SR1 would also support The City's emergency response capacity, affording The City longer time to respond on the Elbow River and the flexibility to potentially divert emergency response resources to the Bow River, where less flood mitigation infrastructure has been constructed.

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[49] Alberta Transportation, Exhibit #20, Pg. 5.1-5.5
[50] Alberta Transportation, Exhibit #20, Pg. 5.6-5.8
[51] Alberta Transportation, Exhibit #20, Pg. 5.6-5.8
[52] Alberta Transportation, Exhibit #20, Pg. 3.34
[53] City Exhibit K, Pg. 18
[54] City Exhibit A
[55] Appendix A, Pg. 3

Though The City has continued to improve its forecasting and monitoring capabilities since 2013, advanced warning for impending floods is still limited due to the natural topography of the watershed. SR1's ability to mitigate flows before reaching Calgary will provide The City with a longer timeframe to enact its emergency response and increase the likelihood of successful evacuation. Due to the unpredictability and unique nature of each flood and rainfall, The City does not have exact estimates on additional evacuation time provided. However, the presence of any structure holding water back upstream will afford The City greater time to respond.

SR1 will allow The City to redirect emergency response resources to more vulnerable areas that lack the same level of structural protection, as overland flood impacts on the Elbow River will be eliminated for floods up to a 200-year flood and will be reduced on the Bow River below the confluence.[56] SR1 will also maintain public safety during and after a major flood event as it minimizes the likelihood that critical infrastructure including bridges, roads, water, sanitary and stormwater utilities, and electrical and natural gas distribution and control systems will be impacted.

For the above reasons, The City submits that SR1 is beneficial to public safety.

3.5 Sensitivity of project design, operation, and safety elements to changes or variability in climate parameters

Flows in the Elbow River have been increasing due to increased snowmelt from higher temperatures and increased rainfall.[57] SR1, through the mitigation provided, would reduce the potential damages from increased frequency of flows largely due to climate change. Reservoirs such as SR1 can also provide mitigation of the peak flow of flood events larger than their design capacity, reducing potential damages from flooding of any size. With a design PMF of 2770 m^3/s,[58] well in excess of a 200-year flood event, The City submits that SR1's design is resilient to potential failure from climate change that would cause increased frequency and intensity of flooding.

The mitigation provided by SR1 in combination with Glenmore Dam exceeds the 200-year flood event, which is higher than the current provincial standard of 1:100. An increase in the frequency and scale of major floods due to climate change would reinforce SR1's benefits and increase the total estimated damages avoided.

3.6 Reservoir capacity

The estimated full supply level of SR1 is estimated at 77.2M m^3.[59] Combined with the Glenmore Dam, The City estimates that the total nominal flood storage for Calgary on the Elbow River is 97.2 M m^3,[60] which together provides enough storage to mitigate a 200-year flood event,[61] suggesting that a similar event would pass through Calgary safely with minimal disruption or damages with both reservoirs in place.

The City's internal hydraulic routing analysis in Table 1 shows that SR1, with the Glenmore Dam, will reduce downstream flows to the damage threshold of 160 m^3/s for events up to the 200-year flood

[56] Appendix A, Pg. 13
[57] City Exhibit L
[58] Alberta Transportation, Exhibit #20, Pg. 3.2
[59] Alberta Transportation, Exhibit #20, Pg. 1.3
[60] Appendix A, Pg. 5-8
[61] Alberta Transportation, Exhibit #20, Pg. 3.1

event. This meets the Applicant's safe flow target of 160 m^3/s.[62] Upstream structures such as reservoirs are beneficial as they can provide mitigation in events exceeding their design. For larger events, The City estimates that SR1 would continue to offer benefit by reducing downstream flows in events exceeding the 200-year event, with reduction to flow rates by as much as an estimated 79 per cent in a 350-year event to 45 per cent at a 1000-year return period, thereby reducing the potential severity of damages incurred in Calgary even during floods larger than the design flood.[63]

Flood Event	Hydrograph Peak Flow (unattenuated)	Estimated peak flow downstream of Glenmore Reservoir (combined attenuation of SR1 and GM reservoir)
(years)	**(m^3/s)**	**(m^3/s)**
100	**841**	**160**
200	**1140**	**160**
350	1440	295
500	1660	455
1000	2150	1165

Table 1: City of Calgary Estimated flow routing through SR1 and Glenmore Reservoir, Elbow River. Source: Stantec, The City of Calgary (See Appendix A, Section 2.1)

Topic 4: Water

Summary

The City agrees with the Applicant's analysis of SR1 and relevant level of impacts on water and hydrology in the Elbow River watershed. The City also concurs with the Impact Assessment Agency of Canada (IAAC)'s conclusion that SR1 groundwater effects from SR1 are anticipated to be short-lived, reversible, and of low to moderate severity and significance[64] and the proposed mitigation measures to manage residual effects on surface water quality.[65]

4.1 Hydrology

As noted above, based on the design flood of 2013[66] it is expected that SR1, in tandem with the Glenmore Dam will attenuate a 200-year flood event above Glenmore to the 160 m^3/s safe flow threshold. The City does not anticipate flooding through Calgary during lesser events. Potential damages from events exceeding a 200-year event would be reduced (see section 3.6).

[62] Alberta Transportation, Exhibit #20, Pg. 3.1
[63] Appendix A, Pg. 8
[64] Impact Assessment Agency of Canada, Exhibit #163, Pg. 56
[65] Impact Assessment Agency of Canada, Exhibit #163, Pg. 62-66
[66] Alberta Transportation, Exhibit #20, Pg. 1.3

The City does not expect appreciable changes to the timing and availability of water in the Elbow River basin with SR1 in place. As an off-stream, intermittently operated structure, SR1 will only impact hydrology during periods of flood operations.

The City does not anticipate SR1 will cause significant groundwater-related impacts based on its operation.

4.2 Surface water quality

The City accepts the Applicant's analysis and proposed mitigations to manage residual effects on surface water quality. As an off-stream, intermittently operated structure, SR1 will only impact water quality dynamics during periods of flood operations. During periods of normal operation, The City does not anticipate any appreciable effects to the Elbow River's water quality.

SR1 is a dry reservoir not intended for drinking water sources, providing greater latitude for sediment management at SR1 than within Glenmore Reservoir. SR1's proposed design thus limits downstream transport when in operation.[67] When not in operation, SR1 is not anticipated to affect flows in the Elbow River based on its design. The City anticipates the operation of SR1 during a flood will reduce loading of materials associated with sediment (nutrients, adsorbed metals) to the Glenmore Dam during a flood and have no effect under normal conditions. The City acknowledges that operations of both SR1 and Glenmore Water Treatment Plant will need to be coordinated in order to ensure maximum operational flexibility for flood attenuation and maintenance of surface water quality for environmental and public health purposes.

Based on extensive consultation with the Applicant, The City understands that it will be engaged in seasonal operations for SR1[68], including:

- reviewing seasonal flood forecasting;
- reviewing flood operations;
- water quality and quantity measurement and monitoring; and
- reviewing land uses in the project area that could impact downstream water quality

As part of this work, The City expects that the Applicant will work with The City to monitor surface water quality to address any potential risks or concerns as they occur, such as evidence of contamination. This will include providing The City access to SR1's sites and facilities to conduct water quality sampling and analysis to support the Glenmore Water Treatment Plant's ability to meet regulatory and operational needs.

4.3 Aquatics

The City has no comments and is supportive of the Applicant's position and analysis on this topic.

4.4 Hydrogeology

The City has no comments and is supportive of the Applicant's position and analysis on this topic.

4.5 Sensitivity of project water elements to changes or variability in climate parameters

The City has no comments and is supportive of the Applicant's position and analysis on this topic.

[67] Alberta Transportation, Exhibit #27, Pg. 6.4.1
[68] Alberta Transportation, Exhibit #20, 3.34

Topic 5: Air Quality, Human Health, and Terrestrial

The City has no comments on this topic, and is supportive of the applicant's analysis of SR1 and relevant level of impacts on air quality, human health, and terrestrial impacts on the Elbow River watershed. The applicant's conclusions are further supported by the IAAC, which concludes that air quality effects are local and reversible long-term.[69]

Conclusion

The City of Calgary is grateful for the opportunity to participate in SR1's NRCB hearing and submits that SR1 is in the public interest and should be constructed as proposed.

[69] Impact Assessment Agency of Canada, Exhibit #163, Pg. 50

Appendix A – List of Exhibits (The City of Calgary)

Exhibit	Document	Author	Date
City Exhibit A	*Reducing Calgary's Flood Risk* LINK	The City of Calgary	Not Dated
City Exhibit B	*City of Calgary Flood Mitigation Options Assessment* LINK	IBI Group Inc.	February 2017
City Exhibit C	*Provincial Flood Damage Assessment Study City of Calgary: Assessment of Flood Damages* LINK	IBI Group Inc.	February 2015
City Exhibit D	*City of Calgary – Flood Scenarios 2 (Baseline, Full Plan, SR1)*. Memorandum. LINK	IBI Group Inc.	September 2020
City Exhibit E	*Glenmore Dam and Reservoir Improvement – Glenmore Reservoir Dredging* LINK	Klohn Crippen Berger	2014
City Exhibit F	*Permanent Flood Barrier Protection Assessment* LINK	Associated Engineering	2018
City Exhibit G	*Glenmore Reservoir Fish Creek Flood Diversion – Feasibility Assessment* LINK	Stantec	2015
City Exhibit H	*City of Calgary Glenmore Reservoir Diversion Feasibility Study* LINK	Hatch Mott MacDonald	2014
City Exhibit I	Excerpt from Land Use Bylaw 1P2007 LINK TO FULL BYLAW	The City of Calgary	June 2008, Last Amended January 2021
City Exhibit J	City of Calgary Flood Mapping (online only, see flood maps tab)	The City of Calgary	Not Dated
City Exhibit K	*Disaster Risk Report* LINK	The City of Calgary	2018
City Exhibit L	*Climate Change Impacts in the Elbow River Watershed* LINK	C. Valeo, Z. Xiang, F. J-C. Bouchart, P. Yeung and M.C. Ryan	October 2007
City Exhibit M	*2019 Citizen Flood Risk Research Telephone Survey Key Findings Report* LINK	Advanis	2019
City Exhibit N	*Calgary's Flood Resilient Future: Report from the Expert Management Panel on River Flood Mitigation* LINK	City of Calgary	June 2014

City Exhibit O	*Flood Mitigation Options Assessment Summary – Summary of full report prepared by IBI Group and Golder Associates* LINK	City of Calgary	December 2017
City Exhibit P	*The Riparian Action Program: A Blueprint for Resilience* LINK	City of Calgary	2017
City Exhibit Q	*Climate Resilience Strategy: Mitigation & Adaptation Action Plans* LINK	City of Calgary	March 2017
City Exhibit R	*Basin-Wide Hydrology Assessment and 2013 Flood Documentation* LINK	Golder Associates	September 2014
City Exhibit S	*Bow and Elbow Rivers Hydraulic Model and Flood Inundation Mapping Updated Study* LINK	Golder Associates	July 2015
City Exhibit T	*Bow, Elbow, Highwood, and Sheep River Hydrology Assessment* LINK	Golder Associates	September 2020
City Exhibit U	*2016 Flood Mitigation Research – Key Findings Report* LINK	Ipsos Public Affairs	April 2016
City Exhibit V	*Fall 2020 Quality of Life and Citizen Satisfaction Survey – Final Report* LINK	Ipsos Public Affairs	September 2020
City Exhibit W	*Public health surveillance response following the southern Alberta floods, 2013* LINK	M. Beliveau, D.C. Dover, V. Sahni, A.N. Scott, J. Talbot & M. Varuhgese	2016

Appendix B – SR1 Technical Memo (The City of Calgary)

Memo

DATE Feb 25, 2021

TO Carolyn Bowen
Manager, Watershed Planning
The City of Calgary

FROM Sandra Davis, M.Sc., P.Eng.
Team Lead, River Engineering
The City of Calgary

Frank Frigo, P.Eng.
Leader, Watershed Analysis
The City of Calgary

Landon Evans, E.I.T.
Engineer in Training, River Engineering
The City of Calgary

SUBJECT: **City of Calgary technical assessment related to the Springbank Off-Stream Reservoir**

Executive Summary

Springbank Off-Stream Reservoir

The concept for water detention in a reservoir along the Elbow River basin was first explored after the 2013 flood in Calgary. After further studies and a benefit cost analysis by the IBI Group in 2015, SR1 was proposed as a flood mitigation solution.

SR1 with the completed Glenmore Dam gate upgrades will attenuate a 2013 sized flood to below the 160 m^3/s damage threshold on the Elbow River through Calgary and substantially reduce flood risk on the Bow River downstream of the Elbow River confluence. SR1 and Glenmore can avert almost all of the potential damages and life safety risk in Elbow River communities for events up to the 1:200 flood (0.5% annual exceedance probability) and substantially reduce damages for more severe floods.

Economic Benefits

SR1 is a critical investment that will deliver an overwhelming positive return.

According to an updated flood damage study for The City of Calgary (IBI Group, 2020), SR1 will reduce potential flood damages in Calgary by an annual average of $27.7M per year. This equates to almost $3 billion over the next century, which is a conservative estimation. These savings are in the order of five times the $432M estimated capital cost of the project. For a single flood event of 1:100 severity, (1% annual exceedance probability), which is highly likely within the next century and without accounting for changes in climate, SR1 would avert $1.14 billion in potential

damages on the Elbow River alone accounting for current mitigation infrastructure (IBI Group, 2020), or 2.6 times the estimated $432M capital cost. During this same period, several other events exceeding Glenmore reservoir's 1:30 flood event attenuation capacity are statistically expected to occur.

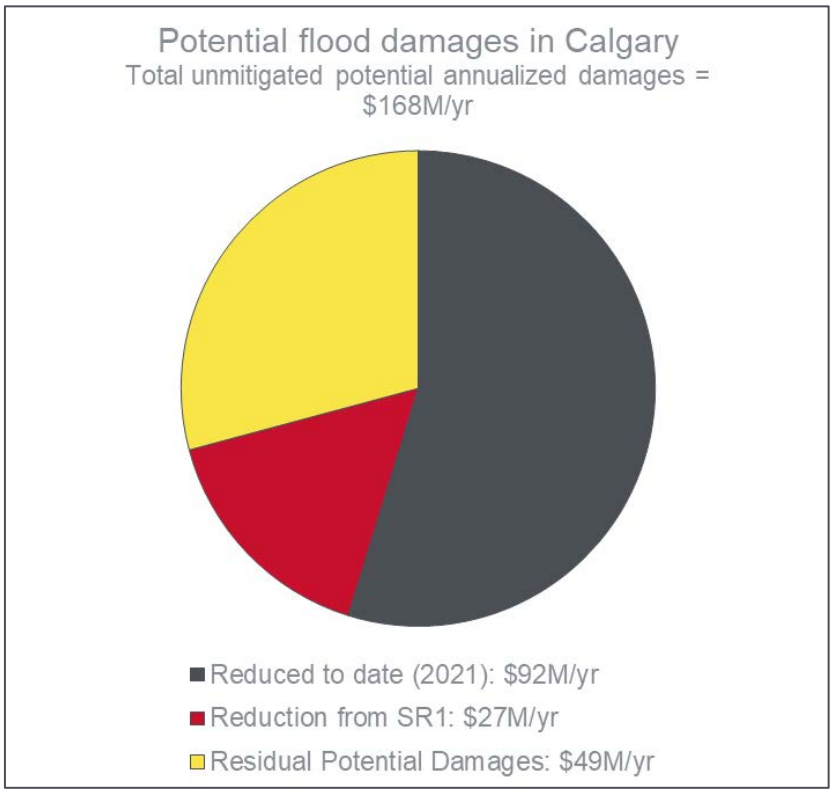


Figure 1: AAD Mitigated by SR1

SR1 is crucial for protecting the downtown core and surrounding commercial areas, which are vital economic drivers for Calgary and the region. The reservoir will also protect several historic sites and critical transportation network nodes.

Public Safety

SR1 is critical for protecting the public from the impacts of a large flood event in Calgary. It will reduce the risk of major flooding along the Elbow River from a 1:30 or 3.3% chance to less than 1:200 or 0.5% chance in any year. Over a period of 25 years, this reduces the probability of damaging events from a 57% chance to less than 12%.

Over 1.3 million residents rely on the completion of the Springbank Reservoir project to protect public safety, critical infrastructure, vital services, private property, and safeguard Calgary's downtown core, the economic engine and social and cultural centre of the region. This includes over 4,000 property parcels, 400 businesses, vital transportation and utility infrastructure, 2,000 residences, and several social, historical, and cultural assets.

During a flood The City prioritizes evacuations, outfall closures, and temporary barrier installations among other emergency operations. Mitigation provided by SR1 will avert the need for about 40% of the planned response actions in the municipal Flood Emergency Reference Manual, allowing reallocation of flood response resources, and improving resilience beyond the direct benefit area.

Environment and Climate Change

The City has adopted the Climate Action Plan and is committed to watershed resilience. This means creating a resilient city, reducing emissions, and improving the health of Calgary's watersheds (City of Calgary, 2018).

When completed, SR1 will support these goals by attenuating flood peaks above a 1:200 flood event. Attenuated flood peaks decrease flow velocity and elevation in floodwaters, leading to less environmental harm. This includes: reduction in potential erosion of pipelines, bridges, less contact of river water with the urban environment, construction materials, waste, less potential erosion of riparian parks, open spaces and natural areas, and decreased potential for mixing with sanitary sewer flows or infiltration of river water into sanitary sewers which can overload wastewater treatment facilities and decrease effluent quality during and following flood events.

Climate change is expected to increase extreme weather events in the Elbow River watershed (C. Valeo et al, 2007). Increased spring freshets and more severe rain on snow events will lead to a higher variability in future flooding. Over the coming century flow rates for flood events in the 1:100 severity range are expected to increase by 20% or more. SR1 will create a more resilient city that is facing increased climate change risks, by reliably attenuating damaging peak flow rates.

Council Direction and Community Engagement

As part of *Flood Mitigations Options Assessment* (IBI Group, 2017), Calgary City Council adopted the recommendations of the flood resilience strategy. The two key structural mitigation investments to manage the damaging flood flows generated by the Elbow River are the Glenmore Dam gate improvements and the Springbank Off-Stream Reservoir. Investing in flood mitigation measures continues to be a priority.

Public support remains strong for flood mitigation measures. Over half of Calgarians living within the 1:200 flood zone and a quarter of those living outside, reported feeling emotional or psychological distress form the 2013 flood event (Advanis, 2019). A recent Citizen Satisfaction Survey found 85% of Calgarians believe that protection from river flooding is important (Ipsos Public Affairs, 2020). A majority of residents, business owners, and users near the river are concerned about flooding and wish to see continued investment in flood mitigation measures.

Regulatory Guidance and Land Use Bylaw Impacts

The City's Land Use Bylaw is being reviewed to ensure it reflects the current hydrology and new flood protection infrastructure to balance land use and development with: public safety, vital service continuity, environmental sustainability, and property damage risks. Development is currently regulated to reduce the incremental accrual of flood risk and to reflect on existing flood protection infrastructure.

1.0 The City of Calgary's Commitment to Flood Resilience

1.1 Flood Resilience Plan

The City of Calgary has made climate and flood resiliency a top priority. After the 2013 flood, The City convened an Expert Management Panel to make recommendations on building flood resiliency (City of Calgary, 2014). The report contained 27 recommendations, all of which are complete or underway.

Based on those recommendations, significant investment has been made by The City and The Province into understanding the flood damage risk and potential mitigation options for Calgary. Completed studies include updated hydraulic models and flood inundation mapping, assessment of potential flood damages, and conceptual level assessment of mitigation measures.

The City's flood resilience plan was based on several technical studies and public engagement, and includes flood mitigation to a 1:200 flood level. A flood damage study, combined with conceptual assessments of several mitigation options and including a triple-bottom line sustainability analysis, allowed the optimal combination of mitigation measures to be determined from a social, environmental, and economic perspective. Through this analysis, it is clear that a single mitigation measure is insufficient to reduce flood risk to acceptable levels in Calgary. As such, The City has adopted a collective of measures that are required to address flood risk, including:

- reservoirs
- barriers
- property-level measures
- policy and development regulation
- public education
- emergency response

The City's current flood resilience plan and related links can be viewed here:
https://www.calgary.ca/uep/water/flood-info/mitigation-and-resilience/flood-projects.html

On the Elbow River, the plan includes improvements to the Glenmore Dam (completed in 2020), and the Springbank Off-Stream Reservoir (SR1), which is an Alberta Transportation project currently under regulatory review.

1.2 Mitigation Measures

The City's flood resilience plan incorporates local and regional, structural and non-structural measures. These work collectively to provide protection for private and public assets, while balancing social and environmental needs.

Permanent flood barriers are common, visible flood mitigation measures constructed primarily within Bow River communities. Since 2013, several barriers have been constructed. Most based on analyses of *Permanent Flood Barrier Protection Assessment* (Associated Engineering, 2018). Barriers completed in the past several years include, but are not limited to:

- Montgomery flood barrier improvement.
- Sunnyside flood barrier (underway, expected completion 2023).
- Centre Street flood barrier.

- Downtown flood barrier (underway, expected completion 2022).
- West Eau Claire flood barrier.
- Inglewood Flood barrier.
- Deane House Inglewood Barrier.
- St George's Island and Calgary Zoo barrier.
- The Bonnybrook Industrial flood barrier.
- Heritage Drive/Glenmore Trail flood barrier.
- Stampede flood protection improvements.

Several other shorter, lower barrier improvements and grading modifications have been implemented to improve resilience. Additional barriers are being studied and assessed.

Based on the *Permanent Flood Barrier Protection Assessment* (Associated Engineering, 2018), permanent barriers along much of the Elbow River and within several communities along the Bow were found to be impractical. High barrier heights, overland and stormwater drainage system impacts, river encroachment, community aesthetics, high costs, significant erosion protection requirements, geotechnical conditions and proximity/conflict with existing infrastructure and utilities singly or in combination, yield costs, and impacts that exceeded benefits, exclude these from resilience plans.

Streambank and riparian erosion protection improvements, bridge replacements with higher flow capacity structures, drainage system improvements to alleviate river water backup, stormwater and sanitary lift station improvements, improvements to water treatment and wastewater treatment plants as well as gravel bar modifications have also been completed (City of Calgary, 2021).

Glenmore Dam's active flood storage capacity doubled in 2020. The extra capacity was enabled by dam structure improvements and installation of operable spillway crest gates. This improvement ensures Calgary has further protection from droughts and floods. The expanded flood handling capacity increases live storage to about 20 million m^3 which is sufficient to attenuate flood events of almost 1:30 severity to the 160 m^3/s damage threshold for Elbow River communities.

SR1 will work in conjunction with the Glenmore Dam to attenuate severe floods. Further details about SR1 are found in Section 2.

The Ghost Reservoir, upstream of Calgary on the Bow River, can aid in reducing flood peaks in The City. TransAlta operates the Ghost Reservoir and an agreement with the Government of Alberta, to manage reservoir levels for enhanced flood attenuation capacity, has been in place since 2016.

Calgary's emergency flood response includes, but is not limited to: hydrologic forecasting and communications, closing and evacuation of roads, parks, bridges and transportation networks, shutdown or modification of utilities, erosion response, construction of temporary barriers, temporary pumping, modified water and wastewater treatment operations, and forecasting risk zones.

The City's land use and flood hazard area building design requirements forming Part 3, Division 3 of the Land Use Bylaw were updated in 2014 to refine flood zone regulation that has been in place since the 1980s and reduce damage during a disaster. Currently, the 1:100 flood event is the designated flood event outlined and mapped within the Land Use Bylaw (1P2007); however, the provincial mapping referred to in the bylaws is soon to be updated. New flood approaches and refinements to current bylaws are being assessed, in conjunction with updated mapping from Alberta Environment and Parks (AEP), as discussed in Section 3 of this memo.

1.3 Environment and Climate Change

The City is committed to mitigating and adapting to our changing climate, and has adopted the Climate Action Plan (City of Calgary, 2018). The plan aims to reduce greenhouse gas emissions and implement risk management measures to reduce impacts of extreme weather events. A link to the plan and other climate change initiatives is found here:
https://www.calgary.ca/uep/esm/energy-savings/climate-change.html?redirect=/climateprogram

The City is committed to watershed resilience; having four watershed management goals: providing secure drinking water for the region, using water wisely, keeping rivers healthy, and reducing impacts from flooding. All of our flood mitigation, infrastructure and water management decisions are evaluated against these goals.

Recent flood events in Calgary include the 2005 and 2013 floods. Heavy rainfall in 2005 resulted in flooding across the city, two river related fatalities and became one of Alberta's most costly disasters. More severe flooding occurred in 2013. Flows displaced over 80,000 Calgarians, damaged numerous properties, and resulted in life safety risks, including multiple fatalities. This was Canada's most costly natural disaster at the time. Flows during these flood events, are within the natural variability of the Bow and Elbow rivers, and were exceeded by events in 1879 and 1897 (Golder, 2014).

The Bow and Elbow River basins have highly variable climates and rapidly responding hydrology. A study of the Elbow River watershed showed that the average annual temperatures in the watershed were rising and snowfall in the western portion of the watershed was increasing (C. Valeo et al., 2007). Higher precipitation will lead to increased spring freshet flows. Climate change is complex and is expected to shift temperature and precipitation patterns, changing the frequency and magnitude of flooding in the region. Higher flood frequencies means that larger floods will become more common.

1.4 Council and Community Support

Calgary City Council adopted the recommendations of a flood resilience strategy, as presented in the *Flood Mitigations Options Assessment* (IBI Group, 2017). The two key structural mitigation investments to manage the damaging flood flows generated by the Elbow River are the Glenmore Dam gate improvements and SR1 Investing in flood mitigation measures continues to be a priority and City Council continues to advocate for SR1.

Public support for flood mitigation work has not wavered since the 2013 flood. A telephone survey in 2016 demonstrated that 49% of Calgarians were impacted appreciably during the 2013 flood through: work or utility disruptions, evacuation, or damage to property (Ipsos Public Affairs, 2016). 67% and 47% of Calgarians living within and outside the 1:200 flood zone, respectively, reported disruption to commuting or recreation routes (Advanis, 2019). Flooding remains a mental health concern for Calgarians; half of all Calgarians living in the 1:200 flood zone and a quarter living outside reported suffering from emotional or psychological distress due to the 2013 flood, according to a 2019 survey conducted by Advanis on behalf of The City of Calgary (Advanis, 2019). According to the same survey, almost half of people living in the flood zone still did not feel safe from river flooding six years after the 2013 flood. A recent Citizen Satisfaction Survey found 85% of Calgarians believe that protection from river flooding is important (City of Calgary, 2020).

Flood mitigation continues to be a priority for Calgarians and City Council, vital to sustaining economic, cultural and historical assets and enabling community prosperity and citizen well-being.

2.0 Springbank Off-Stream Reservoir

SR1 will be located off-stream of the Elbow River, between Calgary and Bragg Creek, east of Highway 22 and to the south of the Trans-Canada Highway. Construction has not begun to date. The City has completed several studies and internal analyses to assess the impact of SR1 on City flood response and resilience.

2.1 Hydrologic Performance and Flood Attenuation Potential

Flows vary along river reaches and can be measured at flow monitoring stations. These measurements can be used to estimate flood flows and frequencies. The SR1 site is in between Bragg Creek and Glenmore Dam, where no flow monitoring occurs, so the flows at the site have been interpolated. Stantec's *Springbank Off-Stream Reservoir Project Hydrology Flood Frequency Analysis* (Stantec, 2015) memo estimated this data and is presented in Table 1 below. The instantaneous peak discharge and 7-day volumes for a 1:200 flood event are important to note, as the 2013 flood was a slightly larger event (i.e., 140,000 dam^3).

Table 1: Estimated Discharge and Volumes at SR1 Location (Stantec)

Flood Event	Instantaneous Elbow River Peak Discharge at SR1 (m^3/s)	7-Day Volume (dam^3)
500	1,800	174,000
200	1,110	132,000
100	765	107,000
50	530	86,600
20	330	65,600
10	200	53,100
5	140	38,100
2	70	20,000

Note, that the hydrology of the Elbow River basin has been updated for AEP (Golder, 2020). Due to refinements in statistical and analytical approaches, peak discharges for a 1:200 event is slightly lower than the 2015 Stantec estimates. Similarly, 1:100 and 1:50 return period flows are slightly lower, while flows for smaller return periods are slightly increased. This does not significantly alter estimated attenuation by SR1.

The City completed flood routing calculations to estimate the combined flood attenuation from SR1 and Glenmore Dam (Table 2). As shown, SR1 with Glenmore Dam can attenuate floods slightly greater than a 1:200 return period to the 160 m^3/s damage threshold of the lower Elbow River. The combined capacity will be 97,200 dam^3.

Methodology for The City's routing analysis:

- AEP 2020 peak flow rates were used for Elbow River at Sarcee Bridge (Glenmore Dam inflow).
- Elbow River hydrographs (Golder, 2016) were scaled to the AEP 2020 hydrology peaks.
- SR1 volume is assumed to be 77,200 dam^3.
- SR1 diversion capacity is 600 m^3/s.
- SR1 begins diversion when Elbow River flows rise above 160 m^3/s.
- SR1 stops diversions when SR1 storage reaches full supply level (FSL).

- Routing through Glenmore Dam follows the current gate flood operating procedure, including the upgraded gates and increased reservoir flood mitigation capacity.
- Glenmore flood mitigation volume capacity is assumed to be 20,000 dam^3.
- Flows downstream of Glenmore Dam are kept to a maximum of 160 m^3/s.

Table 2: The City of Calgary's Flood Routing Estimate with SR1 and Glenmore Dam*

Flood Event	**Hydrograph Flow Peak (unattenuated)**	**Flow Peak into SR1**	**Volume stored in SR1**	**Flow peak into GM**	**Equivalent Return Period Above GM**	**Flow Peak below GM**	**Equivalent Return Period Below GM**
	(m^3/s)	(m^3/s)	(dam^3)	(m^3/s)	(years)	**(m^3/s)**	(years)
1:100	841	600	50562	241	9	**160**	5
1:200	1140	600	75332	540	40	**160**	5
1:350	1440	600	77200	840	100	**295**	13
1:500	1660	600	77200	1060	173	**455**	29
1:1000	2150	600	77200	1550	425	**1165**	213

*This data is still preliminary and should only be used as an estimate of the combined flood attenuation feasible with SR1 and Glenmore Dam.

SR1 will work in conjunction with the Glenmore Dam to mitigate a 2013 sized flood. As per Figure 2, SR1 will be able to store more than half the volume of a 2013 sized flood along the Elbow River. The planned capacity for the reservoir 77,200 dam^3. The remaining volume will be stored by the Glenmore Dam as it continuously releases a safe flow volume downstream, at a flow rate that will not cause overland flooding. This safe flow amount was determined based on current flood inundation mapping, and is estimated to be 160 m^3/s, downstream of Glenmore Dam.

The mitigation capacity of SR1 also has the potential to significantly attenuate floods larger than a 1:200 event, even though overland flooding cannot be completely eliminated. The combined mitigation of SR1 and Glenmore Reservoir can achieve downstream peak flow reductions of 79% and 45% for the 1:350 and 1:1000 flood events, respectively. This provides significant benefit for these events, reducing property damage and decreasing the impacted area with associated decreases in impacts to access, egress, infrastructure, and evacuations.

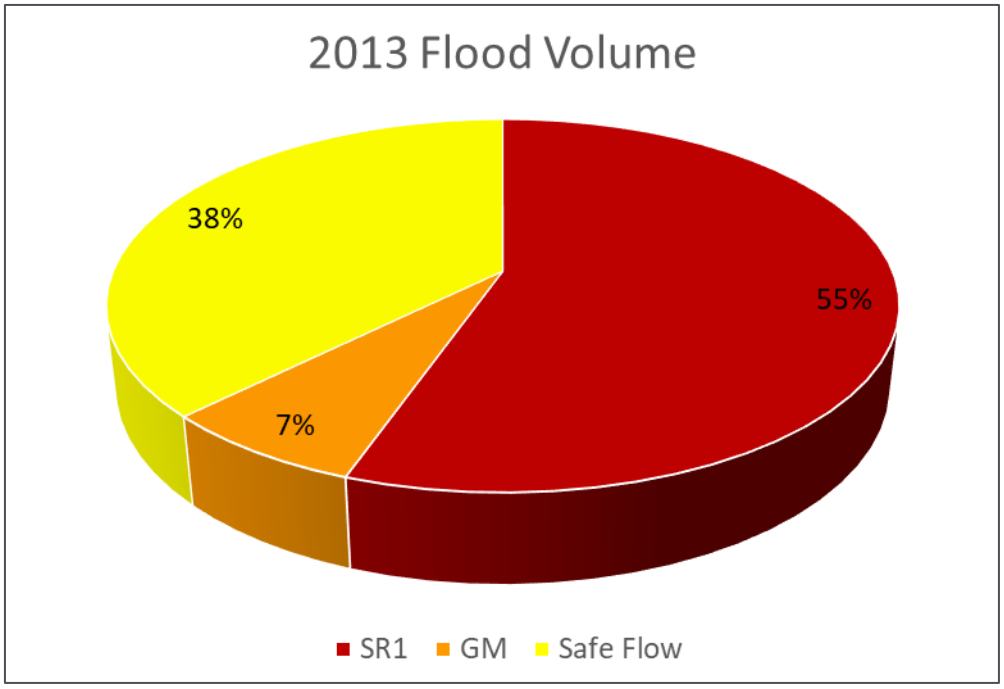


Figure 2: 2013 Flood Volume Mitigation with SR1 and Glenmore Dam

In Calgary, a 1:200 flood event on the Elbow River, without attenuation, would impact numerous communities situated near the Elbow and Bow rivers, including parts of downtown. Figure 3 shows the inundated extents of a 1:200 flood along the Elbow River with and without SR1's impact. Inundation extents decrease from community wide to an average width of about 50 m, comprising the main river channel. The extents are based on draft inundation mapping by AEP using recently updated hydrology (Golder, 2020). The maps are found here: https://floods.alberta.ca/?app_code=FI&mapType=Draft

Figure 3 also depicts effects of existing or underway permanent flood barriers. Barriers along the Elbow River and downstream on the Bow River work in conjunction with SR1, Glenmore Dam, and other mitigation measures to reduce flood impacts. See Appendix A for full maps, which include benefit areas along the Bow River downstream of the Elbow River.

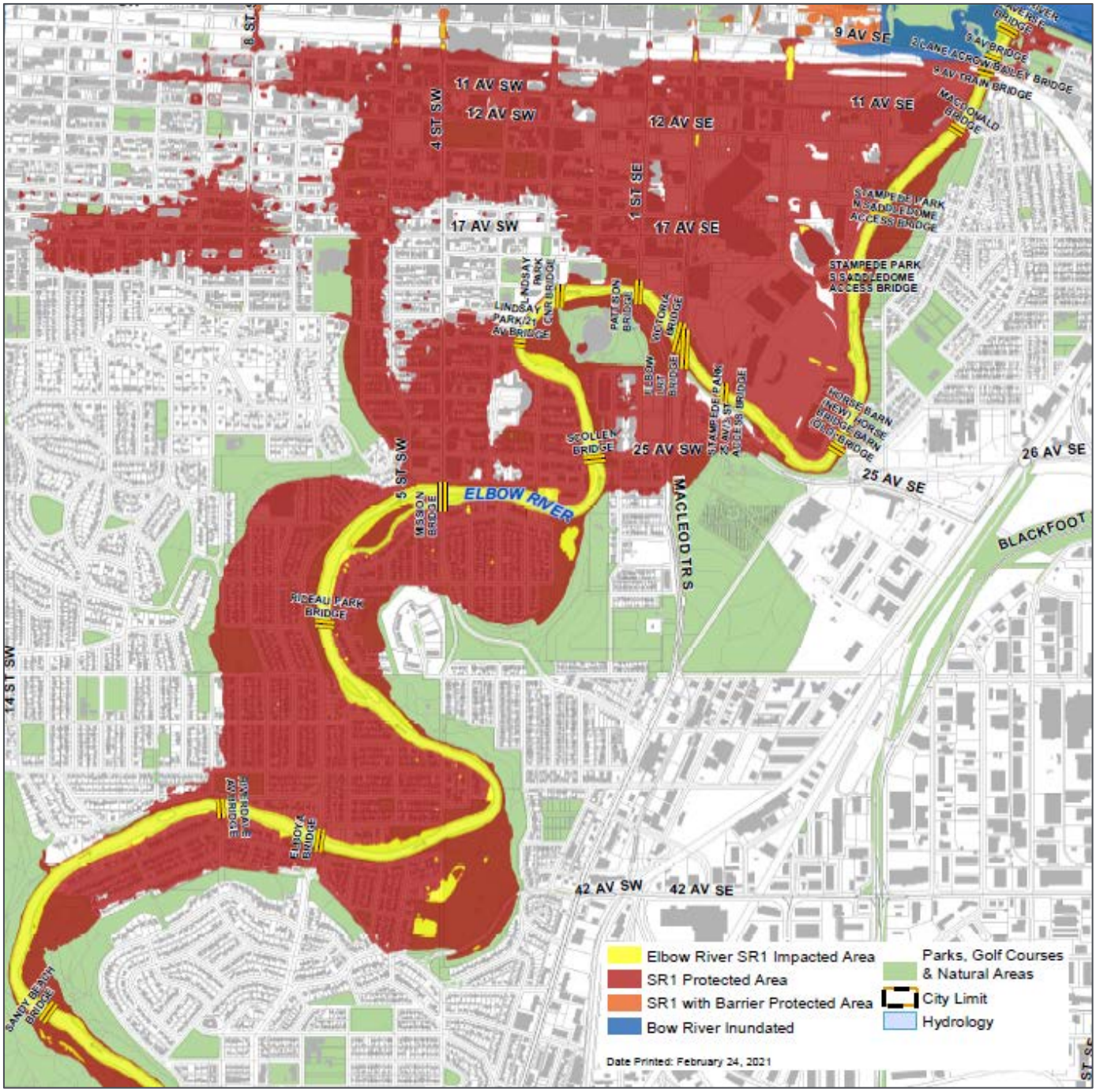


Figure 3: SR1 Flood Mitigation during a 1:200 Flood Event

SR1 reduces the risk of major flooding along the Elbow River from a 1:30 or 3.3% chance to less than 1:200 or 0.5% chance annually. Over a period of 25 years, this reduces the probability of damaging events from a 57% chance to less than 12%.

Currently, Calgary has protection from a flood event on the Elbow River up to a 1:30 return period, due to the Glenmore Dam gates upgrade. When SR1 is constructed, this protection will extend to a 2013 sized event (slightly greater than a 1:200 flood). The Calgary Stampede grounds, 17th Avenue corridor, Fort Calgary, and communities

from Elboya to Beltline, will benefit from this level of protection. SR1 and Glenmore Dam will reduce a 2013 size flood to a 1:5 flow, with no overland flooding.

2.2 Groundwater

The Bow and Elbow rivers are underlain by a permeable alluvial aquifer that allows groundwater to rise with river water levels. High groundwater may impact properties in and beyond the overland inundation extents. It is a concern for properties with developed basements in these zones, and represents a significant proportion of total flood damages, although the proportion of total flood damages attributable to groundwater decreases as the flood size increases (IBI, 2017).

High groundwater levels can persist weeks after a flood event and flood protected areas, such as parcels behind flood barriers, are still at risk for groundwater seepage. SR1 will provide wide-scale groundwater protection. SR1 will prevent large groundwater fluctuations by reducing the elevation of the river water surface during a flood. Lower water surface levels will decrease the groundwater table.

Flood events that may not overtop banks throughout the Elbow River with SR1, will still increase the groundwater table nearby. There will still be risk of foundation damage, basement seepage, and storm system backups where backflow prevention valves are not present. As a local solution to groundwater seepage, all below grade developments at risk of flooding during a large event (i.e. 1:200), are advised to build using flood proof materials, install backflow prevention valves, and have a sump pump (regulation and policy discussed further in Section 3). Developers are advised to build at risk structures to be flood resilient.

2.3 Environmental Benefits

Floods have a significant environmental cost. Small floods, or typical higher spring flows, can have a positive impact on the biodiversity of a watershed, recharge groundwater, and trigger breeding or migration events for aquatic animals; however, large flood flows are detrimental to the environment and are even more harmful near urban-natural interfaces. Sediment loading from erosion of river beds, unprotected banks, or banks with unhealthy riparian areas (City of Calgary, 2017) reduce the water quality downstream and can suffocate aquatic biota. When overland flooding pulls pollutants from developed land into the river, the effects can also be detrimental.

Attenuated flood peaks decrease flow velocity and elevation in floodwaters, leading to less environmental harm. This includes:

- Reduction in potential erosion of: pipelines, utilities, and bridges.
- Less potential erosion of: riparian parks, open spaces and natural areas.
- Less contact of river water with the urban environment, which may contain: fuels, construction materials, and waste.
- Less potential erosion of riparian parks, open spaces, and natural areas.
- Decreased potential for mixing with sanitary sewer flows or infiltration of river water into sanitary sewers, which can overload wastewater treatment facilities and decrease effluent quality during and following flood events.

SR1 will have a positive environmental impact within Calgary during a flood event.

2.4 Public Safety

Flooding has a tangible impact on the life and safety or Calgarians. During the 2013 flood, over 80,000 people were evacuated, four fatalities were recorded (Public Safety Canada, 2013), and the number of emergency department visits the week of the flood increased by 1.3 times (M. Beliveau, 2016).

Currently, there are over 3,000 parcels at risk of a 1:200 flood on the Elbow River. Additionally, over 2,000 more parcels are at risk of a 1:200 flood on the Bow River below the Elbow. Barriers on the Bow River downstream of the Elbow River will work collectively with SR1 to protect these properties up to a 1:200 flood event. Overall, thousands of buildings will no longer be flooded in deep, fast moving flood waters along the Elbow River and Bow River once SR1 is complete.

The protection extents and statistics are presented in Table 3 below. The following statistics were gathered using available geographic information system (GIS) data from the City's data repository (2021), and are subject to the limitations of the data available. The full table, comments, and methodology is found in Appendix B and is in direct correlation to the SR1 Impact maps in Appendix A.

Table 3: Estimated SR1 Impact Statistics form 2021 City Analysis

	Area Categories	Area (km2)	Population (2019 census)	Parcels*	Assessed Value (Billions) (2019 values)	Buildings - Total	Buildings - Residential	Buildings - Com/Indu /Inst**
Elbow River Downstream of GM	SR1 Protected Area	4.5	20228	2795	$ 84.041	2263	1749	336
Bow River Downstream of Elbow River	SR1 Protected Area	4.4	1735	1330	$ 1.883	913	622	136
	Total SR1 Protected	8.9	21963	4125	$ 85.924	3176	2371	472

* Parcel count does not include parks, natural areas, open spaces or public golf courses.
** Commercial, industrial, and institutional buildings.

During severe flooding on the Elbow River, low lying infrastructure will be at risk. Not only buildings, but transit stations, fences, light posts, etc., and several bridges will be at risk of flood water forces, including debris strikes. The 2013 flood overtopped several bridges along the Elbow River. Property and infrastructure damages can result in debris flows downstream, which can become lodged or impact other infrastructure. Bridge overtopping and debris flows will be minimized with SR1 in place by attenuating severe floods.

Having an operable SR1 and Glenmore Dam will allow The City to focus more of its resources for emergency response on the Bow River, where some communities remain at higher risk of flooding. SR1 will eliminate overland flooding along the Elbow River in Calgary during floods up to 2013 sized event, which will sustain access and egress routes and allow first responder and emergency response services to be maintained. It will also delay the peak of larger events, increasing the time available for response actions and evacuation.

The Flood Emergency Reference Manual (FERM) is The City's plan and prioritization of emergency response measures in case of a flood event. These measures include closing outfall gates, installing temporary barriers, protecting lift stations, evacuating areas, and other measures. Mitigation provided by SR1 will avert the need for about 40% of the planned response actions in the municipal Flood Emergency Reference Manual, allowing reallocation of flood response resources, and improving resilience beyond the direct benefit area. During a 1:100 flood, The City's emergency response actions on the Elbow River alone will be reduced by: 21 outfall gate closures,

construction of 7 temporary flood barriers totalling 1,200 m of length, protection of 12 lift stations, and evacuation of 10 communities would be averted (FERM, 2020). Similar or greater reductions in response effort are associated with less severe flood events.

SR1 will become an integral part of creating a city that is resilient to flooding, by protecting the livelihoods and safety of the public.

This includes all existing mititgation

2.5 Economic Benefits

The 2013 flood was one of Canada's costliest disasters and was approximately equivalent to a 1:75 flood event in Calgary. The cost estimate of direct damages in a 1:75 flood event from the *Flood Mitigation Options Assessment* report along the Bow and Elbow is $1.8 billion (IBI Group, 2017). This does not include damage to infrastructure, traffic, habitat, emergency ops costs or waste disposal. About 33% of this cost is for the Elbow River; therefore, SR1 would have averted more than $600 million in damages from this event if it had been completed and functioning.

Based on the flood damage model created by IBI Group for the Government of Alberta and updated for The City of Calgary, which was based on the 2015 inundation maps for Calgary (Golder, 2015), the current Average Annual Damages (AAD) in Calgary from potential flooding Bow and Elbow rivers was estimated at $75.3 million per year (IBI Group, 2020). The estimated capital cost of SR1 is $432 million (Stantec, 2019). The capital cost of SR1 will be recouped by the cost of potential damages if a 1:75 flood event or greater were to occur on the Elbow River, as seen in Table 4.

Table 4: Potential Damages Averted from Flood Events on Elbow River with SR1

Flood Event	1:10	1:50	1:75	1:100	1:200
Annual Probability	10.00%	2.00%	1.33%	1.00%	0.50%
Total (millions)	**$9.8**	**$349.2**	**$613.6**	**$1,196.2**	**$1,971.5**

Data provided as part of analyses for IBI Group's 2020 *City of Calgary - Flood Scenarios 2 (Baseline, Full, SR1)*) memorandum.

The report captured this AAD using a Triple Bottom Line (TBL) policy framework in the damage assessment. This calculation includes all existing mitigation and barriers currently under construction, as well as the mitigation provided by the recent Glenmore Dam gate improvements and the Government of Alberta's agreement with TransAlta at the Ghost Reservoir. AAD is the aggregate damages from a range of flood sizes that could occur over the next 100 years, based on the probability that such a flood will occur. These potential future damages are then expressed as an annualized amount. Potential damages or AAD include flood impacts from both overland flooding and basement flooding from flood related high groundwater and storm and sanitary sewer backup.

The total unmitigated potential damages from flooding in in Calgary is estimated to be $168 million per year. About $92 million of this has been mitigated to date. The potential flood damages on the Elbow River in Calgary as of 2020 is $31.6 million per year. Potential flood damages avoided with SR1 will be $27 million per year, of which about $20 million is savings along the Elbow River and $7M along the Bow River. Over 100 years, this benefit accumulates to almost $3 billion in avoided damages due to SR1. This assumes a zero discount rate or that the inflation and interest rate are the same. Compared to the current estimated capital cost of SR1 of $432 million, this represents a benefit to capital cost ratio of more than 5:1. For a single event of 1:100 severity, (1% annual exceedance probability), which is highly likely within the next century (63% chance of occurrence without accounting for changes in climate), SR1 would avert $1.14 billion in potential damages on the Elbow River alone accounting for current mitigation infrastructure (IBI Group, 2020), or 2.6 times the estimated $432M capital cost.

During this same period, several other events exceeding Glenmore reservoir's 1:30 flood event attenuation capacity are statistically expected to occur.

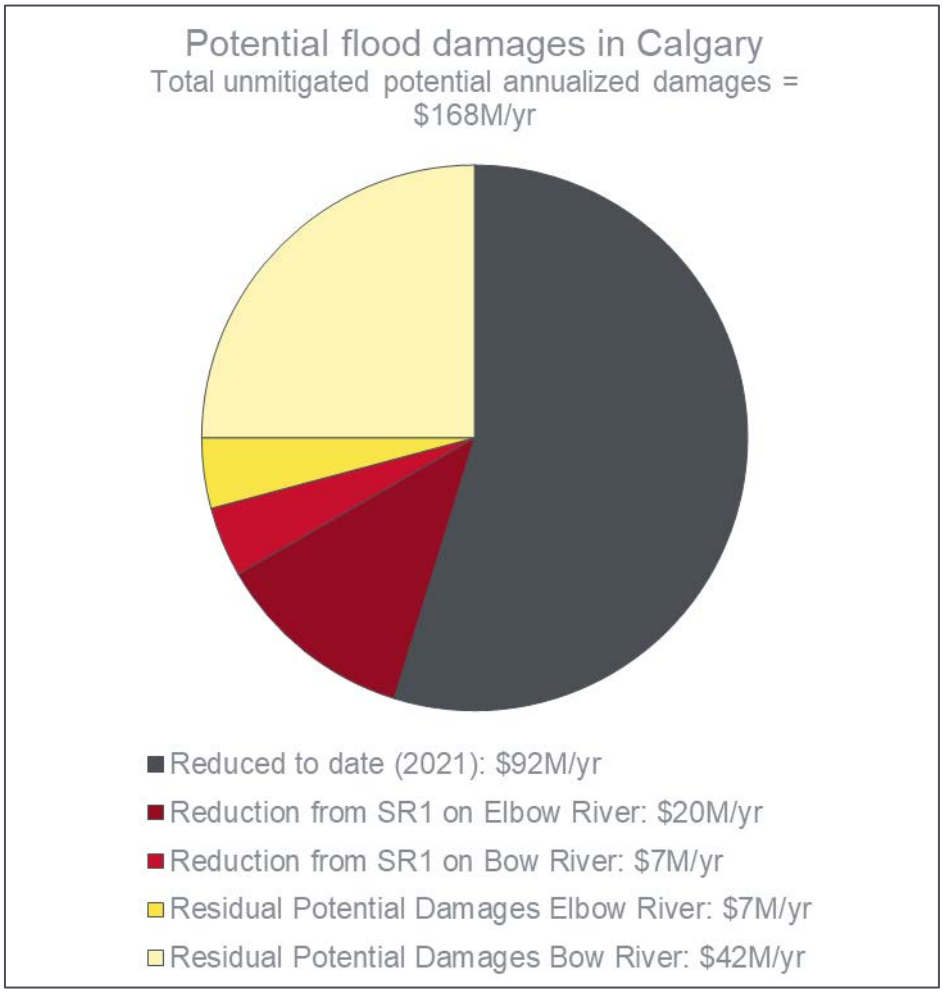


Figure 4: AAD Mitigated by SR1 per Major River

Assuming a discount rate of zero and directly comparing the benefits accrued over 100 years to the capital costs is a simplified approach to the benefit to cost ratio that demonstrates the project's robust positive benefit. The main benefit of SR1 is its ability to avert damage to real estate and economic productivity within the benefit area. A zero discount rate assumes there is no time value multiplier to long term city assets, like real estate. Calgary will likely increase its private and public assets, and they will be continuously revaluated, reused, and invested independent of SR1. It is expected that assets, such as real estate, will accrue inflation at a higher rate than interest; therefore the estimate of a zero discount rate is conservative. The 5:1 ratio is therefore likely conservative, as are cost to benefit estimates for the SR1 project that assume a higher discount rate. The City acknowledges that in this rough calculation, there are costs that have not been captured, although there is uncertainty in the future costs of operation and maintenance there is also corresponding uncertainty around benefits of the project, and not all benefits have been captured in the flood damage model. Operational and maintenance costs that are excluded from this calculation are considered to be small relative to the capital cost, and may be offset by corresponding benefits. For example, operation and maintenance costs will increase if the frequency of diversions to SR1 increase due to operational decisions or refinement, or climate change, which will also increase the benefits accrued to SR1.

Other potential costs may be offset by benefits that have not been captured in the calculation of the benefit, such as the potential open space use of the reservoir footprint.

Studies to date have produced a range of benefit to cost ratios for SR1, ranging from 1.24 (Stantec, 2019) to 3.22 (IBI, 2017). These ratios vary based on the assumptions used (such as capital and operational costs), and were applicable for the purposes for which they were designed, which, in most cases, were comparative analyses to compare between mitigation options or scenarios, and not to calculate an exhaustive and accurate benefit-cost ratio for the specific SR1 project. It is acknowledged by The City that the benefit to cost ratio over the lifespan of the infrastructure will vary depending on how it is calculated, and that all benefit-cost calculations have inherent assumptions, inclusions and omissions and are best used for the specific purpose for which the calculation was intended. It is The City's opinion that the benefits have been sufficiently demonstrated to be positive for a range of assumptions.

Flood protection from SR1 will save commercial, residential, industrial, and institutional buildings from extensive damage. As depicted in Table 3, the assessed value of the properties that would be protected by SR1 during a 1:200 flood in Calgary is estimated to be over $85 billon. This value is derived from over 3000 buildings over the 8.9 km^2 area.

As western Canada's business centre and the fourth largest city in Canada, having a downtown that is protected from flood risk is a critical measure in safeguarding our economy, by helping to sustain and attract future investment and activity that delivers widespread economic benefits regionally. Calgary is a vital business centre with more head offices per capita than any other Canadian city, the second highest small business concentration of major cities in Canada, and is a host multiple international events including the Calgary Stampede.

SR1 will benefit many of the city's historic neighbourhoods, cultural landmarks, and destinations that shape our regional community and attract interest from around the world, including the Calgary Stampede, Fort Calgary, Saddledome and Entertainment District, historic Deane House and the Calgary Zoo. The completion of SR1 will build resilience in areas zoned for sustainable growth. High flood resilience would allow responsible growth and density in the city centre. City centre has core infrastructure such as transit systems already in place that are within walking distance to commercial and entertainment districts. SR1 will help keep Calgary connected and increase its economic resilience.

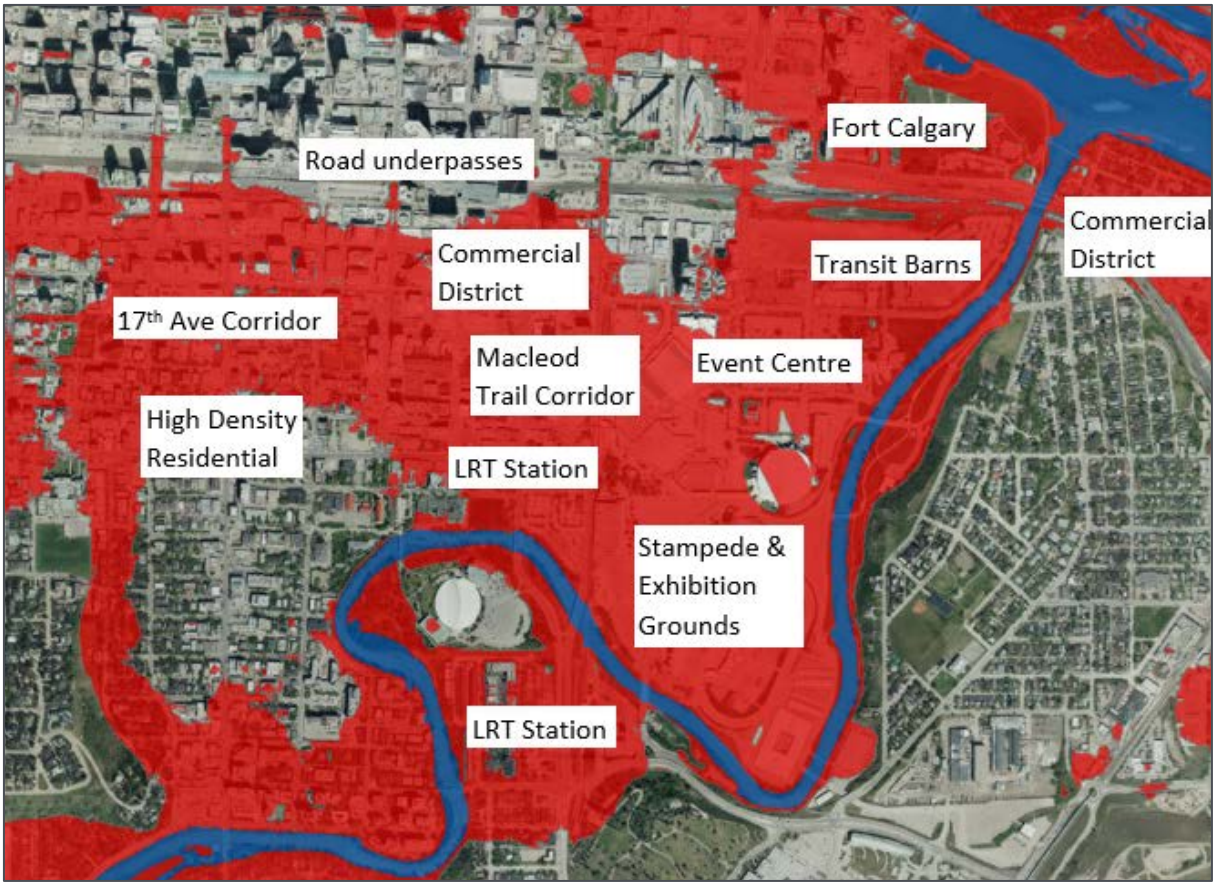


Figure 5: Sample of SR1 Protected Infrastructure, Landmarks and Commercial Areas

2.6 Alternatives

In 2013, the City convened an Expert Management Panel on River Flooding (City of Calgary, 2014). The panel organized according to six topic areas and engaged local, regional, and national experts on each. The panel's report included 27 recommendations, which became a guide for the City's background technical study, community and stakeholder engagement, listing and screening resilience concept alternatives, conceptual configuration of resilience measures, combination of measures into mitigation scenarios, and comparative evaluation of the scenarios and their effects. This included developing software and computational tools to assess flood damages (IBI Group, 2017). The flood damage estimation and evaluation process was then used to evaluate risk for various alternative mitigation scenarios. Public engagement was conducted to inform the interpretation and evaluation of resilience scenario alternatives. The engagement included eight community open house workshops and input from a Community Advisory Group formed of citizens within and outside river valleys. For the Elbow River, some of the key resilience components or options that were investigated, screened or evaluated are:

Glenmore to Bow River Diversion Tunnel:
In 2014, The City evaluated concepts to create a diversion tunnel from Glenmore Dam to the Bow River (Hatch Mott MacDonald, 2014). A 7-9 m diameter large concrete tunnel, drilled through bedrock 80 m underground was considered along two alignments. The concept was considered to involve significant construction complexity and cost uncertainty due to deep underground construction needing customized boring equipment and complex care of water measures with both the inlet and outlet being within active water bodies. The diversion would not appreciably attenuate flood flow peaks. Instead, damaging flows would be translated downstream without

reduction in rate. Debris management challenges at the inlet could complicate flood operations at the Glenmore dam and spillway, and the scale and underground nature of the diversion conduit would lead to appreciable life cycle replacement cost and complexity. Though considered engineering-wise plausible to construct, the option was not a preferred flood resilience measure.

Fish Creek diversion:
A study was completed in 2015 to assess the feasibility of diverting flows from Elbow River to Fish Creek (Stantec, 2015). The concept involved excavating an open channel from the Elbow River near Glenmore Dam to Fish Creek, lined with rock or concrete. Despite straightforward, extensive excavation being the main element of construction, this option was not preferred based on: the irreversible morphologic change likely to Fish Creek, scale of the right of way width, lack of peak attenuation for downstream communities, conflicts with existing utilities and roads, and significant costs.

Large Scale Land Use Change and Property buy-out:
Community wide land use change and property buy-outs have been assessed by The City as a flood resilience measure, both in lieu of structural mitigation and in combination. While removing properties entirely from the floodplain removes all future potential flood damages for that property (except for potential damages to park and public infrastructure that might replace the current use), the concept of large-scale buy-outs in Calgary's existing developed communities have not been found to be feasible, as many of the communities at flood risk are Calgary's most historic, and comprise mixed residential and commercial districts. According to The City's data, the assessed value alone of the properties benefiting from SR1 are over $85 billion (2019 tax assessed values). The cost of buying out a portion of the properties along the Elbow River nearest to the river, where the water would be deepest and fastest during a 1:200 flood, was also assessed. The tax-assessed value of these 980 properties was about $1.81 billion (IBI Group, 2017). The cost of buying out these properties, demolition and abandonment of embedded roads, utilities, and infrastructure, loss of social, historical, and cultural resources, costs and impacts of providing replacement community footprint elsewhere, and conversion to open space, would be additive, exceeding the scale of expected costs of other mitigation alternatives.

Permanent Flood barriers:
Conceptual designs for community wide permanent flood barriers along the Elbow River below the Glenmore Dam were evaluated (IBI, 2017 and Associated Engineering, 2018). Over 14 km of barriers would be required, ranging from 1.6 m to 3.0 m in height. Barriers would require erosion protection components, complex buried utility and roadway system conflicts, and considerable stormwater and overland drainage system complexity, due largely to the height and utility/road conflict and right of way width requirements. The extent of riverfront property conceptual designs would cost about $800 million. Unlike flood storage and attenuation measures, barriers provide no benefit for events that exceed their design service level, so damages for events exceeding barrier crest elevations would remain as residual risks, as would some of the damage exposure arising from elevated groundwater seepage and sewer backup mechanisms.

Glenmore Reservoir dredging:
As a structure primarily functioning for municipal water supply, the Glenmore Reservoir has insufficient storage capacity to offer appreciable flood peak attenuation for floods more severe than the 1:50 range. Glenmore offers approximately 20 million m^3 of storage, where at least 3 to 4 times this amount would be needed to reduce peak flow rates to downstream damage thresholds. Despite this, routine bathymetric surveys are conducted within the reservoir and conceptual engineering evaluation of reservoir dredging was evaluated in 2014 (KCB, 2014). Bathymetry suggested only about 10% of the reservoir storage capacity, based on comparison with records from the time of dam construction in 1932 had been filled with sediment, with much of the deposition at levels that would not be relevant to the elevation range of live flood storage. Changes in peak attenuation associated with dredging were minor (2-4% differences) and impacts to water supply, along with environmental and care of water complexities led to the recommendation against dredging. Dredging has not been considered further, as the

limited incremental storage volume would be depleted over time, and expected impacts to water supply were considerable.

Technical studies and internal analyses concluded that SR1 is a key element of option for flood mitigation in Calgary. A decision was made in 2015 by The Province and The City to support the SR1. Several benefits of SR1 include:

- Fully attenuate a 2013 sized flood with Glenmore Dam.
- Better benefit to cost ratio than other alternatives.
- Captures floodwaters close to Calgary, increasing effectiveness for a range of potential rainfall events.
- No impact to habitat or river flow under normal conditions.
- Minimal environmental impact compared to an on-stream reservoir.
- Potential to develop recreational opportunities on the site when reservoir not in use.

SR1 integrates and synergizes with resilience measures the City of Calgary has or is implementing, such as: upgrades to the Glenmore Dam gates, improvements to the storm and sanitary systems, improvements to riparian habitat and riverbanks, updates to land use regulations, education programs for citizens, and refinement of forecasting and flood response plans. All these measures can work together to provide reliable, adaptive, timely and cost effective resilience.

3.0 Flood Policy, Land Use and Development Regulation

The City has policies and a regulatory framework in place to guide land use and development in flood hazard areas (FHA). SR1 will protect a large portion of properties within the current regulatory FHA from the Elbow River. The City acknowledges that while SR1 will reduce flood risk in many communities, it will not eliminate river flood risk in those communities. Further risk assessment and stakeholder engagement must determine the appropriate level of land use and development regulation to address the residual risk with structural flood mitigation infrastructure in place.

3.1 Policies

The City's 1983 Calgary River Valleys Plan set out the policy direction for development in Calgary's river valleys, with the intention of reducing accrual of flood risk. After the 2013 flood, the Municipal Development Plan and Land Use Bylaw were updated to strengthen flood policy and regulation. Since that time, The City has developed a Riparian Strategy and Riparian Action Program (City of Calgary, 2017), and a Climate Action Plan (City of Calgary, 2018).

The City currently requires development to be flood resilient up to at least a 1:100 flood level, and recommends that higher levels be considered, especially for critical infrastructure. In greenfield communities, a higher level of resilience is achieved through application of Environmental Reserve setbacks and a combined river and stormwater flood design criteria.

The City is currently reviewing flood related policies and regulation, in anticipation of new Provincial Flood Hazard Mapping. This work will confirm alignment of City policies with current direction and understanding of flood risk, reflect built flood mitigation infrastructure and work together with structural mitigation to increase Calgary's flood resilience.

3.2 Current Land Use Bylaw

The current Land Use Bylaw (1P2007) defines the designated flood elevation as the regulatory 1:100 flood event elevation. Regulatory FHA maps were established in 1983 and do not display the current hydrology or protections from permanent flood barriers. The will also not reflect the protections from SR1 when it is constructed. The City continues to regulate according to existing mitigation and policies until new maps and/or regulation are adopted.

Recommendations are provided to applicants that provide the most up-to-date flood information available, included updated 1:100 flood elevations from subsequent studies, where available.

3.3 Floodway

The floodway refers to the area of river where velocities and depths will equal or exceed 1 m/s velocity and/or 1 m depth during a 1:100 flood event. This is the area where the greatest amount of flow is concentrated during a flood and the flow is considered the most erosive and damaging. Regulations within the floodway include:

- No new buildings are allowed within the floodway or a 6 m setback from the floodway.
- Re-development in the floodway is restricted to the replacement of existing buildings that were in place prior to the bylaw coming into force, on the same footprint.
- Buildings must be setback 60 m from the Bow and 30 m from the Elbow, Nose Creek, or West Nose Creek – when a parcel was vacant on July 22, 1985.

The definition of buildings includes: berms, decks, docks, fences, gates, patios, rip-rap, and retaining walls or anything placed on or within the land.

New structures are not permitted in the floodway because:

- They are susceptible to significant damage due to the fast flowing water and depth of inundation.
- It ensures future protection in the event the river channel shifts during a flood.
- Upstream water levels may rise from a reduction in the hydraulic conveyance of the river due to the obstruction.

3.4 Flood Fringe

The flood fringe is the section of river where the flood waters are below 1 m/s velocity and 1 m depth during a 1:100 flood event. New developments in the flood fringe must be designed for the following:

- To prevent structural damage by floodwaters.
- The first floor of all buildings must be constructed at or above the designated flood level.
- Electrical and mechanical equipment in a building must be located at or above the designated flood level.
- Buildings must have a sewer back-up valve installed.

As well, no easily movable objects are allowed to be stored outside of a building within the flood fringe.

3.5 Overland Flow

Overland flow zones are areas which become inundated by shallow overland floodwater during a 1:100 flood event, where water flows through the streets back into the river further downstream. Development in these areas has similar restrictions as the flood fringe as they must be designed:

- To prevent structural damage by floodwaters.

- The first floor of all buildings must be constructed at or above the designated flood level.
- Electrical and mechanical equipment in a building must be located at or above the designated flood level.
- Buildings must have a sewer back-up valve installed.

As well, no easily movable objects are allowed to be stored outside of a building within the overland flood zone.

As floodwater in the overland flood zone generally flows through the streets back to the river, the flood depth is typically governed in these areas by the street grade rather than by the water surface elevation in the river. The designated flood level for development is calculated by finding the highest bottom of curb street grade adjacent to the development property, then adding 300 mm.

3.6 Updating Calgary's flood policy and regulations

The City's flood policies and regulations are under review to ensure they reflect the current hydrology and structural protection in place, and balance land use and development with public safety, vital community services, environmental sustainability, and property damage risks.

Utilizing updated hydrology and hydraulic modelling for flood resilience is important. The City currently provides applicants with the most up to date information on flood risks as advisory comments on relevant development applications.

The City is working with AEP to develop a process to update maps when new flood protection infrastructure is brought into operation, including flood barriers and reservoirs that provide flood mitigation such as SR1. Flood maps and policies around appropriate development in protected areas will be determined in consultation with AEP, City, external stakeholders and the public, and will consider safety, economic, social, and environmental factors.

4.0 References

1. Advanis, 2019. *2019 Citizen Flood Risk Research Telephone Survey Key Findings Report*. Prepared for The City of Calgary. Link: https://publicaccess.calgary.ca/lldm01/livelink.exe?func=ccpa.general&msgAction=Download&msgID=STcgsTgeAqU

2. Associated Engineering, 2018. *Permanent Flood Barrier Protection Assessment*. Prepared for The City of Calgary, April 2018. Link: http://publicaccess.calgary.ca/lldm01/livelink.exe?func=ccpa.general&msgID=GTTKTgKecrE&msgAction=Download

3. C. Valeo, Z. Xiang, FJC. Bouchart, P. Yeung, MC. Ryan, 2007. *Climate Change Impacts in the Elbow River Watershed*. Canadian Water Resources Association, submitted May 2007. Vol. 32(4): 285-302. LINK

4. City of Calgary, 2014. *Calgary's Flood Resilient Future: Report from the Expert management Panel on River Flood Mitigation.* June 2014. Link: http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Flood-Info-Documents/Expert-Management-Panel-Report-to-Council.pdf

5. City of Calgary, 2017. *Flood Mitigation Options Assessment Summary.* Summary of full report prepared by IBI Group and Golder Associates. December 2017. http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Flood-Mitigation-Options-Assessment-Summary.pdf

6. City of Calgary, 2017. *The Riparian Action Program: A Blueprint for Resilience.* March 2017. Link: http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Riparian-Action-Program-Report.pdf

7. City of Calgary, 2018. *Climate Resilience Strategy: Mitigation & Adaptation Action Plans*. Link: http://www.calgary.ca/UEP/ESM/Documents/ESM-Documents/Climate_Resilience_Plan.PDF

8. City of Calgary, 2021 [webpage]. *Flood Projects – Water Services*. Accessed February 23, 2021. Link: https://www.calgary.ca/uep/water/construction-projects/flood-projects-water-services.html

9. City of Calgary, 2021. *Land Use Bylaw 1P2007.* Bylaw available on-line: https://www.calgary.ca/content/dam/www/pda/pd/documents/calgary-land-use-bylaw-1p2007/land-use-bylaw-1p2007.pdf

10. Golder Associates Ltd., 2014. *Basin-Wide Hydrology Assessment and 2013 Flood Documentation*. Prepared for Alberta Environment and Parks and The City of Calgary, September 2014. LINK

11. Golder Associates Ltd., 2015. *Bow and Elbow Rivers Hydraulic Model and Flood Inundation Mapping Updated Study.* Report prepared for The City of Calgary and Alberta Environment and Parks, July 2015. LINK

12. Golder Associates Ltd., 2016. Hydrology of Flood Events in Elbow River. Report prepared for The City of Calgary, January 2016. LINK

13. Golder Associates Ltd., 2020. *Bow, Elbow, Highwood, and Sheep River Hydrology Assessment*. Prepared for Alberta Environment and Parks, September 2020. LINK

14. Hatch Mott MacDonald, 2014. *City of Calgary Glenmore Reservoir Diversion Feasibility Study*. Prepared for The City of Calgary, July 2014. LINK

15. IBI Group, 2017. *Flood Mitigation Options Assessment.* Prepared for the City of Calgary by IBI Group and Golder Associates Ltd., February 2017. LINK or https://cityonline.calgary.ca/Pages/Product.aspx?category=Unlisted&cat=CITYonlineDefault&id=8092-12527-14294-00002-P

16. IBI Group, 2020. *City of Calgary – Flood Scenarios 2 (Baseline, Full Plan, SR1)*. Memorandum. Prepared for City of Calgary, September 2020. Project number 119424. LINK

17. Ipsos Public Affairs, 2016. *2016 Flood Mitigation Research – Key Findings Report*. Prepared for The City of Calgary, April 2016. LINK

18. Ipsos Public Affairs, 2020. *Fall 2020 Quality of Life and Citizen Satisfaction Survey – Final Report*. Prepared for The City of Calgary, September 2020. Link: https://www.calgary.ca/content/dam/www/cfod/csc/documents/fall2020-cssr/Report-FINAL-Detailed-2020-Fall-Citizen-Satisfaction-Survey-Sept-30.pdf

19. Klohn Cripper Berger, 2014. *Glenmore Dam and Reservoir Improvement – Glenmore Reservoir Dredging*. Prepared for The City of Calgary, January 2014. LINK

20. M. Beliveau, DC. Dover, V. Sahni, AN. Scott, J. Talbot, and M. Varuhgese, 2016. *Public health surveillance response following the southern Alberta floods, 2013*. Canadian Journal of Public Health. 107(2): e142–e148. Published online 2016 March 1. doi: 10.17269/cjph.107.5188. Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6972453/

21. Public Safety Canada, 2013. *Canadian Disaster Database - Southern Alberta Flood*. Modified September 12, 2013. Accessed February 24, 2021. Link: https://cdd.publicsafety.gc.ca/dtpg-eng.aspx?cultureCode=en-Ca&eventTypes=%27FL%27&eventStartDate=%2719200101%27%2C%2720181231%27&normalizedCostYear=1&dynamic=false&eventId=1056

22. Stantec, 2015. *Glenmore Reservoir Fish Creek Flood Diversion – Feasibility Assessment*. Prepared for The City of Calgary, October 2015. LINK

23. Stantec, 2015. *Springbank Off-Stream Reservoir Project Hydrology Flood Frequency Analysis*. Prepared for Alberta Transportation, December 2015. Rev. 1.0, Dec 14, 2015. Link: 124337E.pdf (iaac-aeic.gc.ca)

24. Stantec, 2019. *Appendix IR6-1 SR1 & MC1 Option Benefit/Cost Analysis – April 2019*. Prepared for Alberta Transportation, May 2019. LINK

5.0 Closure

The information contained in this memo summarizes The City of Calgary's analyses pertaining to SR1. If you would like to discuss any aspects of this memo further, please do not hesitate to contact the undersigned.

Written by:

X

Landon Evans, E.I.T.
River Engineering

Approved by:

25-02-2021

X

Frank Frigo, P.Eng.
Leader, Watershed Analysis

Reviewed by:

PROFESSIONAL ENGINEER ALBERTA
SANDRA DAVIS

X Feb 25, 2021

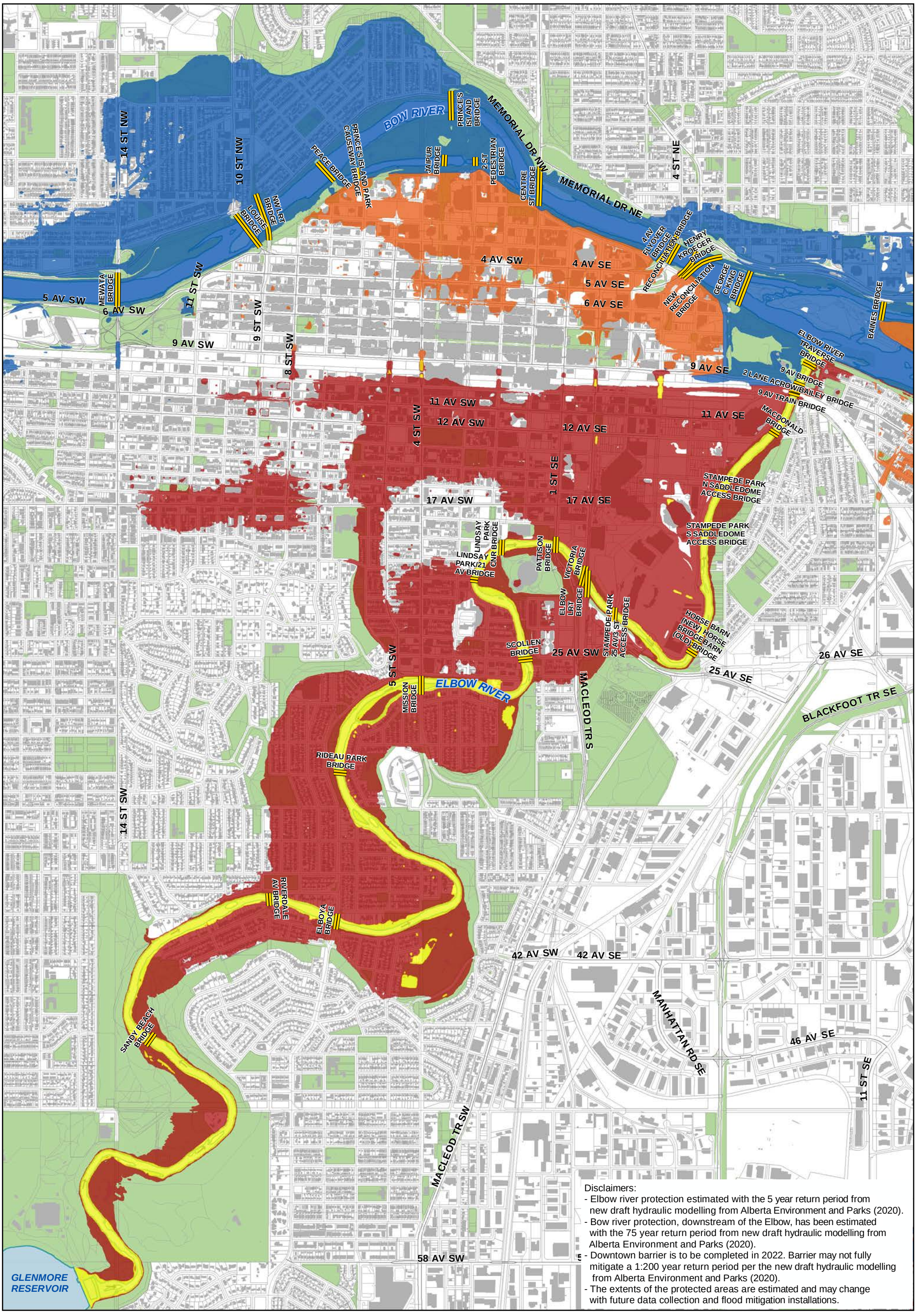
Sandra Davis, M.Sc., P.Eng.
Team Lead, River Engineering

Permit to Practice:

PERMIT TO PRACTICE
CITY OF CALGARY
RM SIGNATURE: F.Frigo
RM APEGA ID #: 66191
DATE: 25-02-2021
PERMIT NUMBER: P004426
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

APPENDIX A

Springbank Off-Stream Reservoir Calgary Impact Maps (1-4)



Disclaimers:
- Elbow river protection estimated with the 5 year return period from new draft hydraulic modelling from Alberta Environment and Parks (2020).
- Bow river protection, downstream of the Elbow, has been estimated with the 75 year return period from new draft hydraulic modelling from Alberta Environment and Parks (2020).
- Downtown barrier is to be completed in 2022. Barrier may not fully mitigate a 1:200 year return period per the new draft hydraulic modelling from Alberta Environment and Parks (2020).
- The extents of the protected areas are estimated and may change with future data collection and flood mitigation installations.

Legend

- Elbow River SR1 Impacted Area
- SR1 Protected Area
- SR1 with Barrier Protected Area
- Bow River Inundated
- Parks, Golf Courses & Natural Areas
- City Limit
- Hydrology

Elbow River 1:200 Flood with SR1 Impact Map 1 from Glenmore Reservoir to Bow River

0 175 350 700
Metres

N

Projection: Calgary 3TM WGS 1984 W114

Date Printed: February 24, 2021

File Location: \\gis_mappinmg\Flood_Mapping\Provincial_FHA\SR1_Impact\Pdf\Elbow_SR1_Impact_Map1.pdf

Bow River 1:200 Flood with SR1 Impact Map 2
Bow River below Elbow River

Disclaimers:
- Bow river protection, downstream of the Elbow, has been estimated with the 75 year return period from new draft hydraulic modelling from Alberta Environment and Parks (2020).
- The extents of the protected areas are estimated and may change with future data collection and flood mitigation installations.

Legend

- Elbow River SR1 Protected Area
- Flood Barrier Protection
- Bow River SR1 Impacted Area
- Elbow River SR1 Impacted Area
- Bow River Above Elbow River
- Parks, Golf Courses & Natural Areas
- Hydrology
- City Limit

Date Printed: February 24, 2021

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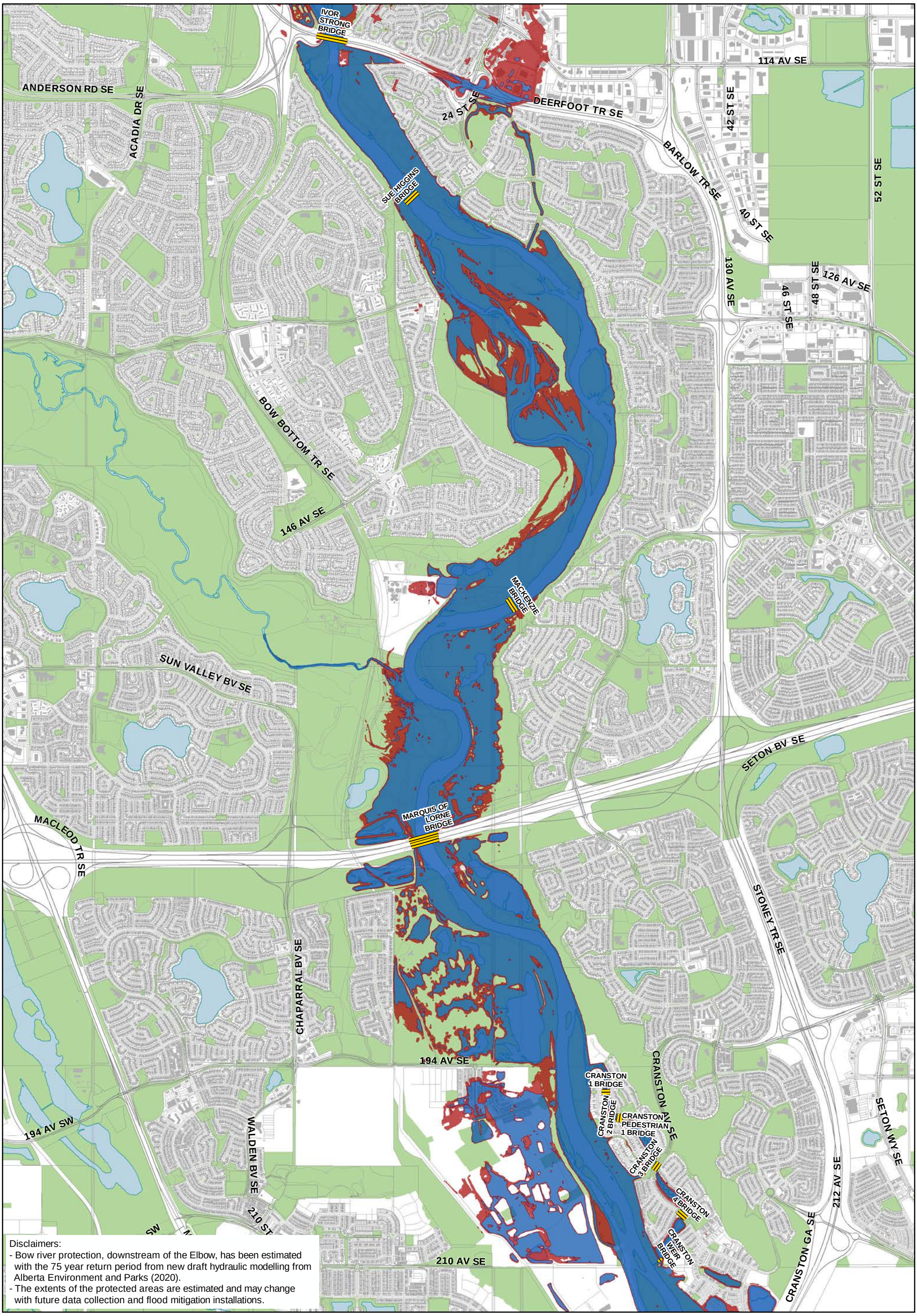
0 250 500 1,000
Metres

Projection: Calgary 3TM WGS 1984 W114

N



Disclaimers:
- Bow river protection, downstream of the Elbow, has been estimated with the 75 year return period from new draft hydraulic modelling from Alberta Environment and Parks (2020).
- The extents of the protected areas are estimated and may change with future data collection and flood mitigation installations.

Legend

- SR1 Protected Area
- SR1 with Barrier Protected Area
- Bow River SR1 Impacted Area
- Parks, Golf Courses & Natural Areas
- Hydrology
- City Limit

Bow River 1:200 Flood with SR1 Impact Map 3
Bow River below Elbow River

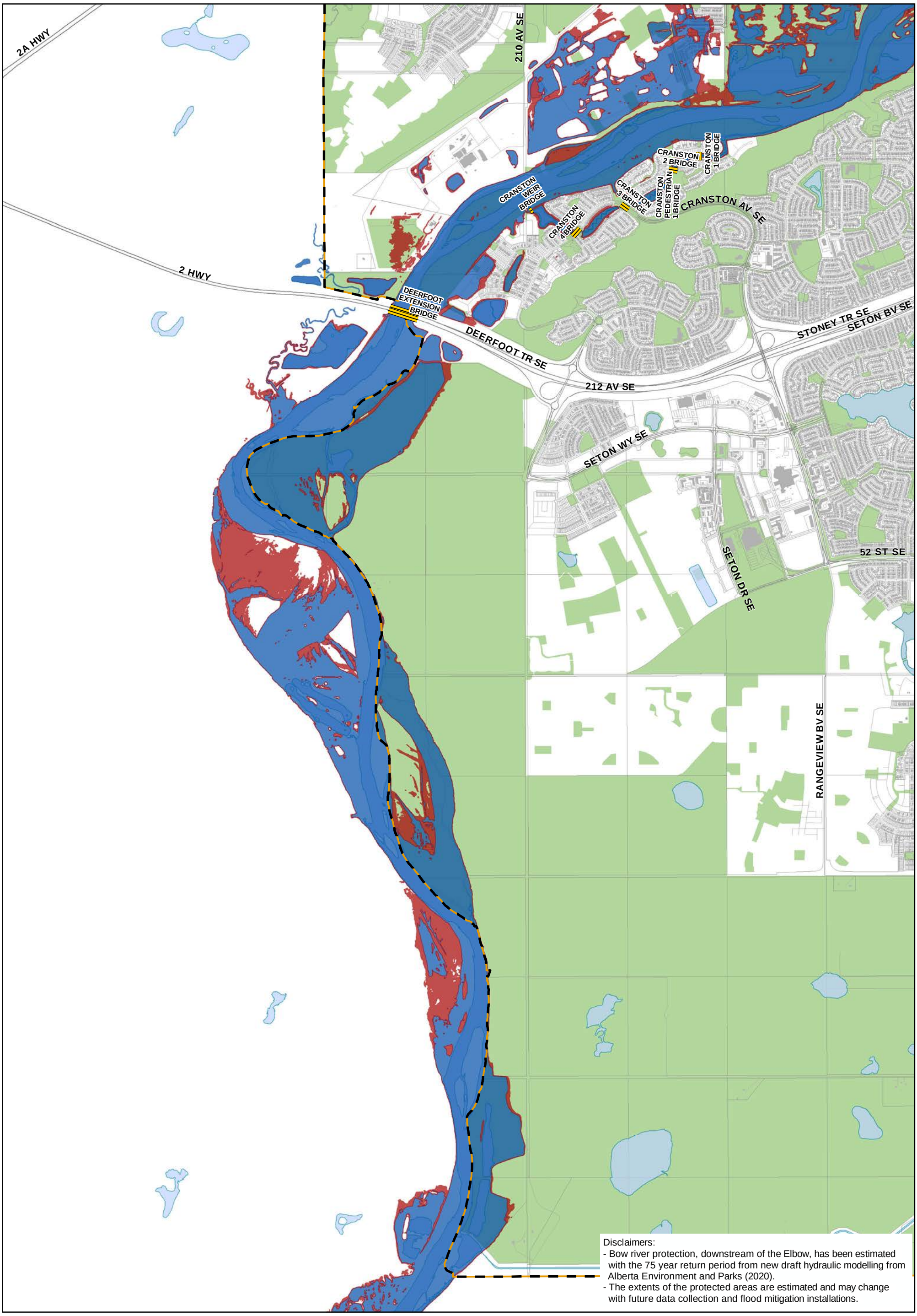
0 250 500 1,000
Metres

N

Projection: Calgary 3TM WGS 1984 W114

Date Printed: February 24, 2021

File Location: \\gis_mappinmg\Flood_Mapping\Provincial_FHA\SR1_Impact\Pdf\Bow_Below_Elbow_SR1_Impact_Map3 .pdf



Disclaimers:
- Bow river protection, downstream of the Elbow, has been estimated with the 75 year return period from new draft hydraulic modelling from Alberta Environment and Parks (2020).
- The extents of the protected areas are estimated and may change with future data collection and flood mitigation installations.

Legend

- SR1 Protected Area
- SR1 with Barrier Protected Area
- Bow River SR1 Impacted Area
- Parks, Golf Courses & Natural Areas
- Hydrology
- City Limit

Bow River 1:200 Flood with SR1 Impact Map 4
Bow River below Elbow River

0 250 500 1,000
Metres

N

Projection: Calgary 3TM WGS 1984 W114

Date Printed: February 24, 2021
File Location: \\gis_mappinmg\Flood_Mapping\Provincial_FHA\SR1_Impact\Pdf\Bow_Below_Elbow_SR1_Impact_Map4 .pdf

APPENDIX B

Impact Statistics from Springbank Off-Stream Reservoir

SR1 Protection for 1:200 flood event on Bow and Elbow Rivers

	Area Categories	Area (km^2)	Population[3] (2019 census)	Parcels θ Ω	Assessed Value θ Ω ** (2019 values)	Dwellings[3] (2019 census)	Buildings θ °° - Total	Suites θ ††	Buildings θ °° Low Density Residential‡ ‡	Buildings θ °° High Density Residential¶ ¶	Buildings θ °°Commercial §§	Buildings θ °° Inudstrial §§	Buildings θ °° Institutional §§
Elbow River*	SR1 Protected Area¶	4.46	20228	2795	$ 84,040,867,157	14103	2263	31843	1394	355	317	5	14
	Residual Impacted Area‡	0.60	50	211	$ 4,219,190,710	38	17	54	11	2	0	0	1
	Total	**5.06**	**20279**	**3006**	**$ 88,260,057,867**	**14141**	**2280**	**31897**	**1405**	**357**	**317**	**5**	**15**
Bow River°	SR1 Protected Area‖	3.21	220	499	$ 860,737,639	105	161	1146	67	5	21	21	1
	Area protected by SR1 plus a Flood Barrier	1.22	1515	831	$ 1,022,214,876	800	752	1790	541	9	48	40	5
	Impacted Area§ (residual)	16.39	49	748	$ 1,912,448,622	25	232	596	105	4	28	12	1
	Total	**19.60**	**269**	**1,246**	**$ 2,773,186,261**	**130**	**393**	**1742**	**172**	**9**	**49**	**33**	**2**
	Total residual impact (after SR1)	**16.99**	**100**	**959**	**$ 6,131,639,332**	**63**	**249**	**650**	**116**	**6**	**28**	**12**	**2**
	Total SR1 protected	**8.89**	**21963**	**4,125**	**$ 85,923,819,672**	**15008**	**3176**	**34779**	**2002**	**369**	**386**	**66**	**20**

Source: 2020 draft inundation maps for Calgary from Alberta Environment and Parks, and data in City Respository as of February 2021.

Numbers are draft and subject to change.

* Elbow River consists of the area downstream of Glenmore Dam

° Bow River consists of the area within the City of Calgary boundary downstream of the Elbow River confluence

‡ Elbow Residual Impacted Area estimated using the 1:5 year return period from the new draft hydraulic modelling from Alberta Environment and Parks (2020)

‡ Elbow Residual Impacted Area estimated using the 1:5 year return period from the new draft hydraulic modelling from Alberta Environment and Parks (2020)

¶ Elbow SR1 Protected Area estimated using the 1:200 year return period from the new draft hydraulic modelling from Alberta Environment and Parks (2020) and have the Elbow Impacted areas removed
‖ Bow River (downstream of Elbow River confluence) SR1 Protected Area estimated using the 1:200 return period from the new draft hydraulic modelling from Alberta Environment and Parks (2020) with the Bow River Impacted Area (residual) removed. Numbers do not include additional areas protected by flood barriers.

§ Bow River (downstream of Elbow River confluence) Residual Impacted Area estimated using the 1:75 return period from the new draft hydraulic modelling from Alberta Environment and Parks (2020)
ˣ Areas protected by SR1 Plus Flood Barrier consist of additional area within the draft 1:200 return period (Alberta Environment and Parks 2020) that are protected by the Zoo Flood Barrier, the Inglewood Flood Barrier, and the Bonnybrook Wastewater Treatment Plant Barrier. Numbers are exclusive of area protected only by SR1.

[3] Population and Dwelling counts are based on point features
θ Building, Parcel, Assessed Value, and Suite counts are assigned to areas in the following hierarchy: impacted > SR1 protected > barrier protected. E.g. if a polygon intersects both, the Elbow impacted and the Elbow SR1 protected area, it is counted into the impacted category.

Ω Parks, Natural Areas, Open Spaces, and Public Golf Courses based on a combination of SDE Layer CALGIS.PARIS_SITE_C_V and the CALGIS.OPF_PARCEL were removed from the OPF Parcels and Assessed Values

** Assessed Values do not extend over the whole Nose Creek area present in the draft hydraulic modelling data from Alberta Environment and Parks (2020)
°° Buildings based on CALGIS.BLDG_BUILDING SDE Layer copied on Jan 22nd, 2021 only containing Stages "CONSTRUCTED", "UNDER CONSTRUCTION", and "UNDER RENOVATION" and having buildings identified as 'Garage' or 'Greenhouse' removed

†† Building Suites based on CALGIS.BLDG_ASMT_PROPERTY_USE SDE Layer copied on Jan 22nd, 2021. Not all buildings from CALGIS.BLDG_BUILDING are found in CALGIS.BLDG_ASMT_PROPERTY_USE

‡‡ Low Density Residential Buildings based on CALGIS.BLDG_BUILDING SUBCLASS categories 'Duplex', 'Fourplex', 'House', 'Townhouse (more than 4 units)', 'Triplex'

¶¶ High Density Residential Buildings based on CALGIS.BLDG_BUILDING SUBLCASS category 'Apartment Building'
§§ Commercial, Industrial, and Institutional Building Counts based on CALGIS.BLDG_ASMT_PROPERTY_USE_TBL joined to CALGIS.BLDG_BUILDING and using the PROPERTY_USE_CODE attribute. Not all buildings from CALGIS.BLDG_BUILDING are found in CALGIS.BLDG_ASMT_PROPERTY_USE_TBL