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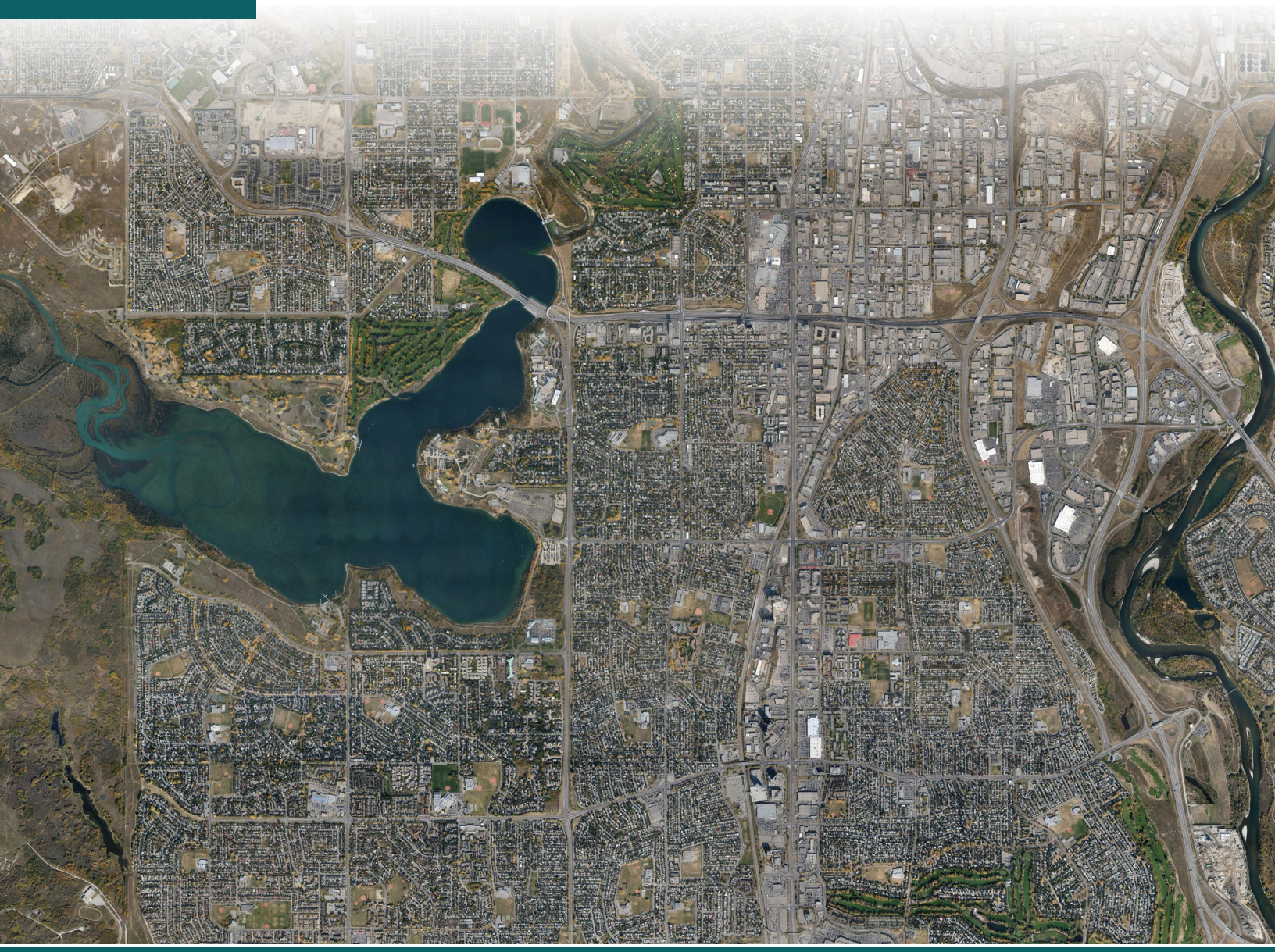

REPORT

Benefit/Cost Analysis of Flood Mitigation Projects for the City of Calgary: Glenmore Reservoir Diversion

Prepared for Government of Alberta
ESRD - Resilience and Mitigation
by IBI Group
February 18, 2015

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February 18, 2015

Ms. Heather Ziober
Project Manager, Strategic Integration and Projects
Government of Alberta
Environmental and Sustainable Resource Development
205 J.G. O'Donoghue Building
7000 - 113 Street
Edmonton, AB T6H 5T6

Dear Ms. Ziober:

BENEFIT/COST ANALYSIS OF FLOOD MITIGATION PROJECTS FOR THE CITY OF CALGARY: GLENMORE RESERVOIR DIVERSION

Enclosed please find the draft final report for the aforementioned assignment. The report describes the benefit/cost analysis undertaken for the Glenmore Reservoir Diversion Flood Mitigation Project in relation to ameliorating the City of Calgary flood damages. This analysis culminates with a comparison of the benefit/cost ratios for the three major mitigation projects under consideration of which the Glenmore Reservoir Diversion ranks third.

Should you have any questions or require additional information please do not hesitate to contact the undersigned.

Yours truly,

IBI GROUP

Stephen Shawcross
Director

Augusto Ribeiro, P.Eng.

SS/mp

cc: Cathy Maniego, Government of Alberta, Environment and Sustainable Resource Development
Andrew Wilson, Government of Alberta, Environment and Sustainable Resource Development

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Benefit/Cost Analysis for Flood Mitigation Projects for the City of Calgary: Glenmore Reservoir Diversion

Submitted to Government of Alberta
ESRD - Resilience and Mitigation
by IBI Group

February 2015

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Executive Summary

Key Metrics

Project Costs

Item	Cost
Project Construction	$458,600,000
Upstream Mitigation	$8,900,000
Total 1:100 Year Protection	**$467,500,000**
Additional Cost for 1:200 Year Protection	$39,600,000
Total 1:200 Year Protection	**$507,100,000**
Annual Operation and Maintenance	$1,800,000

Benefit/Cost Analysis

Indicator	High Damage Scenario		Low Damage Scenario	
	1:100 Year Protection	1:200 Year Protection	1:100 Year Protection	1:200 Year Protection
PV Benefits (average annual damages)	$621,715,000	$664,189,000	$416,313,000	$458,787,000
PV Costs (development & operating total cost)	$512,465,000	$551,960,000	$512,465,000	$551,960,000
Benefit/Cost Ratio	1.21	1.20	0.81	0.83
Net Present Value	$109,250,000	$112,229,000	-$96,152,000	-$93,173,000
Average Annual Damages	$25,370,933	$27,104,222	$16,988,895	$18,722,184

Benefit/Cost Comparison

Mitigation Project	High Damage Scenario		Low Damage Scenario	
	1:100 Year Protection	1:200 Year Protection	1:100 Year Protection	1:200 Year Protection
SR1	1.87	2.07	1.32	1.32
MC1	1.43	1.65	1.01	1.05
Glenmore	1.21	1.20	0.81	0.83

1 Introduction

1.1 Background

The flood of 2013 was a devastating event for Southern Alberta and the City of Calgary. The flood event had the largest economic impact of any extreme weather event in Canada to date. As part of the response to protect communities from future flood damage, the Province of Alberta commissioned a study through the Flood Mitigation Advisory Panel to provide engineering assessments and practical solutions on possible flood mitigation measures.

In March of 2014 the City of Calgary retained Hatch Mott MacDonald (HMM) to prepare a detailed feasibility study to provide recommendations on a preferred tunnel diversion from Glenmore Reservoir aimed at routing flood flows away from that portion of the Elbow River between Glenmore Reservoir and the confluence with the Bow River.

As part of the subsequent Provincial Flood Damage Assessment Study, IBI Group was commissioned by the Government of Alberta ESRD Operations, Resilience and Mitigation Branch to undertake a benefit/cost analysis of the recommended Glenmore Reservoir Diversion.

1.2 Purpose

The purpose of the benefit/cost analysis is to provide a comparison of project benefits, in terms of damages averted to project costs, including capital and operating costs to determine if the project under consideration is economically viable.

1.3 Scope

For the purposes of this study, benefits are restricted to economic benefits accruing within the study area, which is defined as the flood risk area within the City of Calgary boundaries. The study utilizes current damage estimates based on updated stage-damage curves and the Provincial Rapid Flood Damage Assessment Model. Project costs are based on the estimates prepared as part of the Glenmore Reservoir Diversion Feasibility Study dated July18, 2014.

2 Context

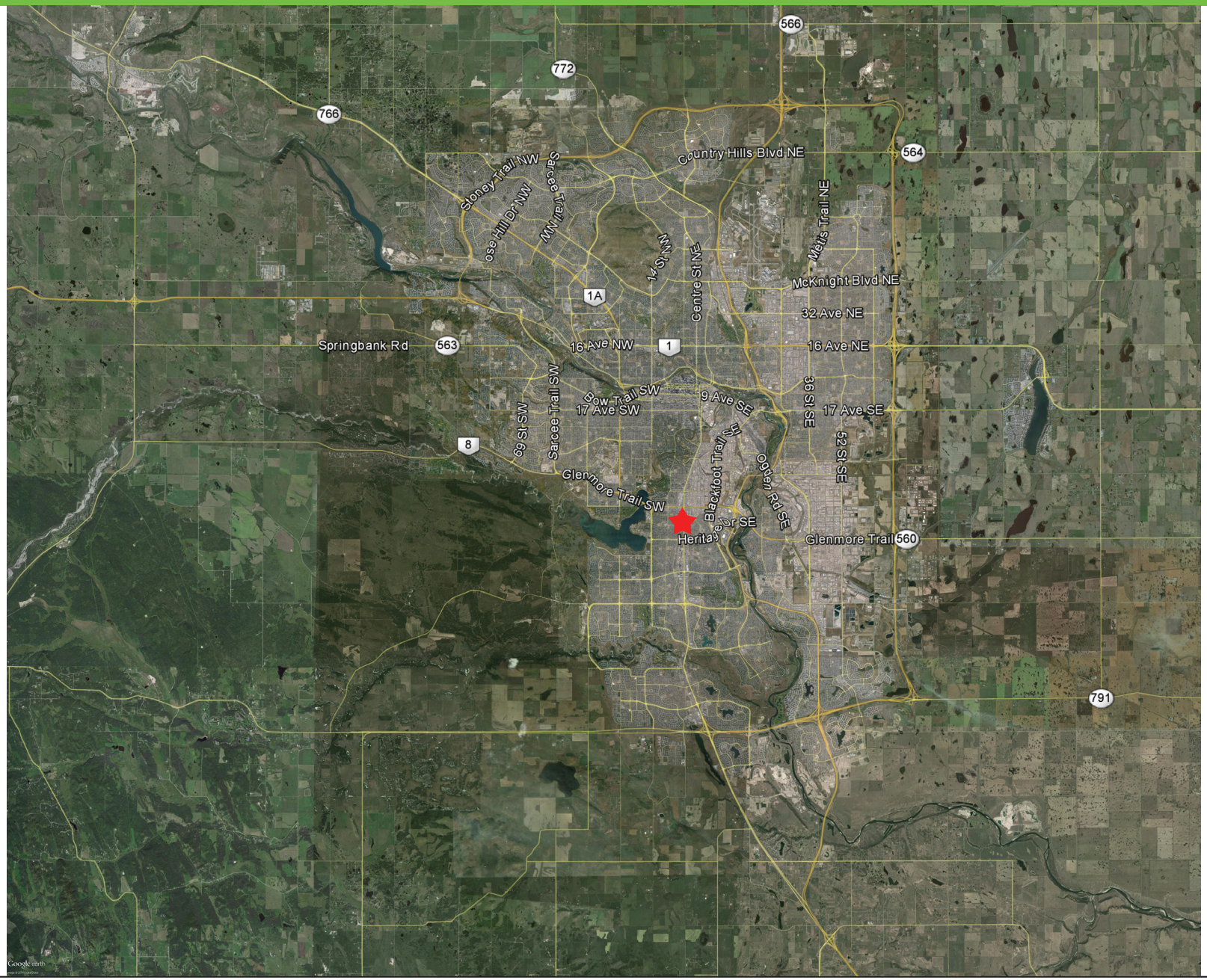
Exhibit 2.1 illustrates the study area, while **Exhibit 2.2** illustrates the location of the preferred alignment.

3 Project Description

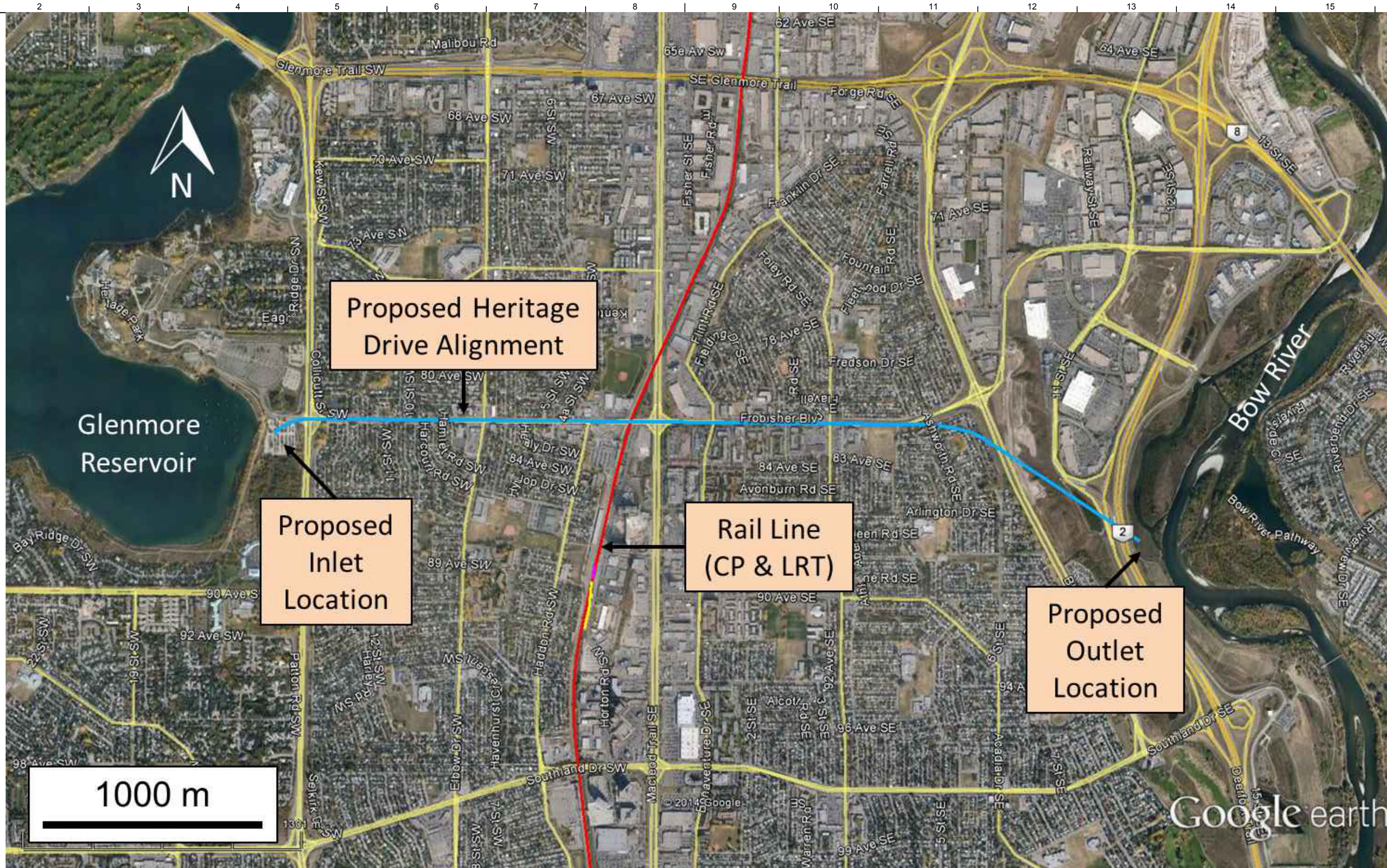
Essentially, floodwater exceeding a 1:10 year event will be conveyed from the inlet structure to the outlet structure through a tunnel measuring approximately 4.2 km in length along the preferred Heritage Drive alignment. The geometry of the proposed flood diversion tunnel has been established based on two flow cases: 500 cm/s and 700 cm/s. The flow velocity is anticipated to be 10 m/s for both cases, meaning a tunnel cross-sectional area of 50 m^2 and 70 m^2 would be required for each flow case, respectively.

Exhibit 3.1 illustrates some of the details of the proposed tunnel structure.

Context - City of Calgary



Glenmore Reservoir Diversion Tunnel



FILE NAME: C:\Users\bro51532\Desktop\PDF\Misc\20140529 - Glenmore Diversion Tunnel - Sketch\334731-SK-01.dwg

USER NAME: Brockway, Chris

PLOT DATE: Monday, June 02, 2014 12:22:02

REF.	DRAWING NUMBER	DRAWING TITLE

REFERENCE DRAWINGS

This document is issued for the party which commissioned it and for specific purposes connected with the captioned project only. It should not be relied upon by any other party or used for any other purpose. We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties. This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

ENGINEER STAMP:

NO.	DESCRIPTION	BY	YYYY/MM/DD
A	ISSUED FOR DISCUSSION	CL	2014/06/02

REVISIONS

Hatch Mott MacDonald

	INITIALS	SIGNATURE	YYYY/MM/DD
DRAWN:	CSB		2014/06/02
DESIGN:	CL		2014/06/02
CHECK:			
REVIEW:			

SCALE: AS NOTED AT ANSI D

CLIENT REF. DWG. No.: -

CLIENT: The City of Calgary — Glenmore Reservoir Diversion Tunnel

GLENMORE DIVERSION TUNNEL
HERITAGE DRIVE TUNNEL PROFILE

D — PROJECT/DWG No.: 334731-SK-01 — REV No: A

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Alberta Government

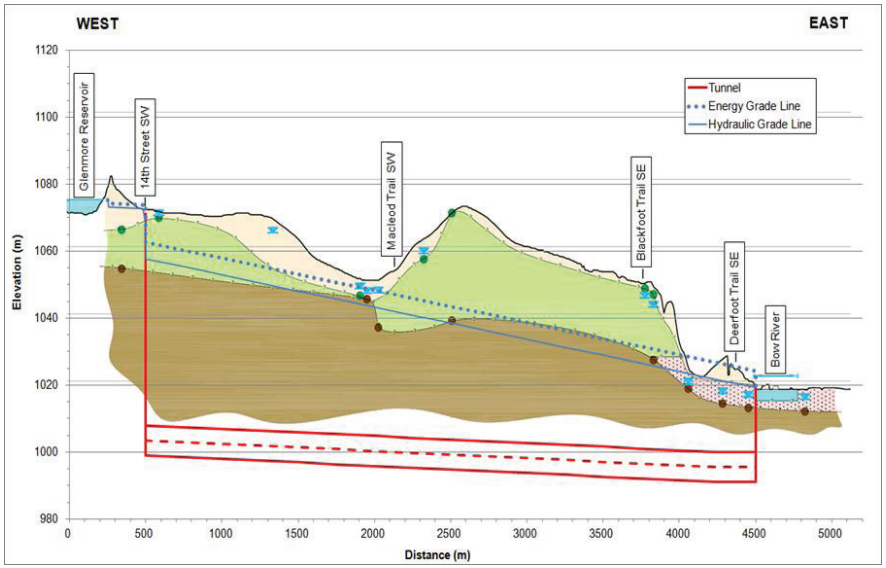
Benefit/Cost Analysis for Flood Mitigation Projects for the City of Calgary: Glenmore Reservoir Diversion

February 2015

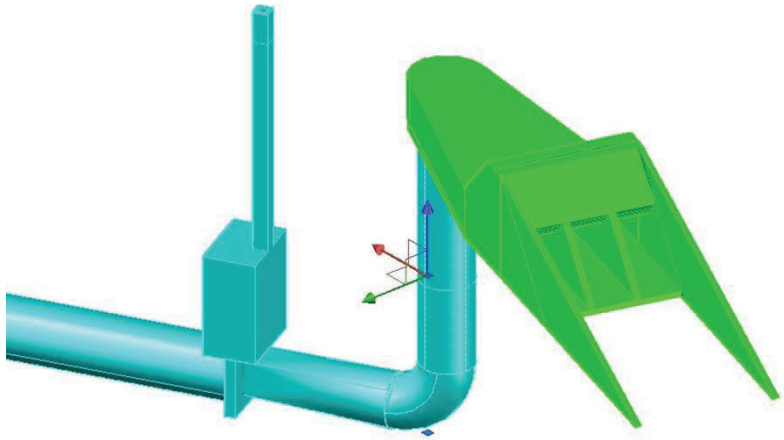
EXHIBIT 2.2

City of Calgary - Glenmore Reservoir Diversion Feasibility Study

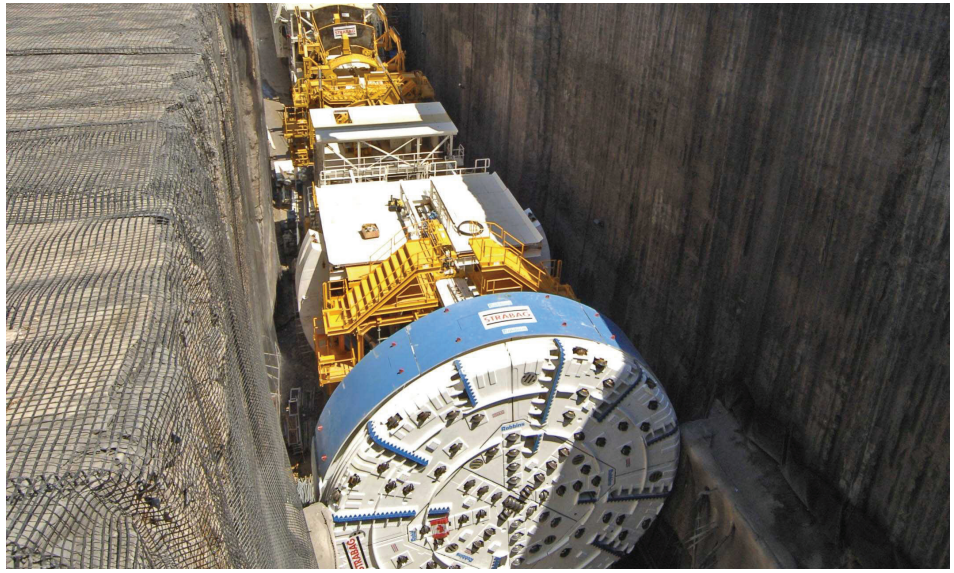
HYDRAULIC GRADE LINE PLOT: HERITAGE DRIVE (500 m3/s)



ISOMETRIC VIEW OF TUNNEL AND INLET



TBM LAUNCH BOX FOR THE NIAGARA HYDROELECTRIC PROJECT IN ONTARIO



4 Cost Estimate

This estimate was prepared in Canadian dollars assuming a mid-2014 bid date. The focus of the estimate was placed primarily on the tunnelling and underground components as they dominate the overall cost and risk provisions. These costs were estimated, drawing from the HMM proprietary cost estimating method TED (tunnel estimating database), which adopts estimating methods similar to those used by tunnelling contractors.

4.1 Basis of Estimate/Assumptions

The cost estimate includes the following elements:

- Procurement and mobilization of equipment & materials.
- Site setup.
- Outlet launch box excavation in soil and rock (includes secant pile wall).
- Shield TBM bored tunnel (includes assemble and disassemble costs) with precast concrete tunnel lining.
- Inlet shaft excavation (includes secant pile wall).
- Inlet transition section.
- Control shaft excavation (includes secant pile wall).
- Control gate area excavation.
- Construction water (tunnel inflows) treatment facilities and disposables.
- Final concrete lining for inlet and control shafts.
- Transport and disposal of excavation muck.
- Excavation including topsoil removal.
- Construction of concrete inlet/outlet structures.
- Fabrication, installation and commissioning of all gates (includes guides, provisions for hydraulic and control system).
- Service shaft (includes consideration of ladder, dewatering system, air circulation fan and a housing).
- Indirect costs.
- Construction contingency.

A summary of the cost estimate for the Heritage Drive alignment is provided in the table below.

Summary of Total Project Costs for the Deep Tunnel Option Along the Heritage Drive Tunnel Alignment (millions of dollars)[1]

FLOW CASE	CONSTRUCTION CAPITAL COSTS	ENVIRONMENTAL MITIGATION	PROFESSIONAL SERVICES	RIGHT OF WAY	TOTAL
500 m^3/s	$ 362.4	$ 5.4	$ 90.6	$ 0.1	$ 458.6
700 m^3/s	$ 393.8	$ 5.9	$ 98.4	$ 0.1	$ 498.2

Notes:

1. All costs in millions of Canadian dollars and assume a mid-2014 bid date (excluding GST).
2. Operational and maintenance costs are expected to be between $1.8 to $2.0 million per year.
3. Refer to Appendix G of the HMM report for a breakdown of Construction Capital Costs.
4. Environmental mitigation costs are assumed to be 1.5% of the construction capital costs.
5. Professional services are assumed to be 25% of the construction capital costs and include final design services, construction management and additional costs to the owner (e.g., permit and agency fees for plan check, inspections and testing, and engineering fees for design consultants retained by city agencies or project stakeholders). This is based in part on The American Society of Civil Engineers Manual of Practice 45 “How to work effectively with consulting engineers”.
6. Right of Way costs for a temporary construction easement are assumed to be 5% of the assessed land value. This will need to be confirmed with the City of Calgary. The total area of subsurface easement is estimated at 3,000 m^2.

4.2 Flood Defences at Bragg Creek

The flood mitigation measures study for the Bow, Elbow and Old Man River basins recommended flood defences at Bragg Creek if flood protection infrastructure for the City of Calgary was located downstream of Bragg Creek. Protection of the Hamlet via dykes was proposed with a further recommendation that if a decision was made to proceed with a project located downstream of Bragg Creek, then the detailed design and planning for the dykes of Bragg Creek should be initiated as soon as possible.[2] Costs for the dyke system were estimated at $6.2 million (see **Appendix A**).

5 Flood Damages

5.1 Without Mitigation Alternative

5.1.1 City of Calgary

Flood damage estimates were generated for the City of Calgary employing updated stage-damage curves and the Provincial Rapid Flood Damage Assessment Model. Damage assessments were generated for nine return frequencies including: 1:2 year, 1:5 year, 1:10 year, 1:20 year, 1:50 year, 1:100 year, 1:200 year, 1:500 year and 1:1000 year, which allowed for the computation of average annual damages. Damage estimates were also assessed under two cases: a higher or “worst case” condition and a lower or “anticipated case” condition.

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1 Hatch, Mott, MacDonald Ltd., Glenmore Reservoir Diversion Feasibility Study – Final Report, July 18, 2014.
2 AMEC Environmental & Infrastructure, *Southern Alberta Flood Recovery Task Force, Flood Mitigation Measures for the Bow, Elbow and Oldman River Basins, Volume 1 – Summary Recommendations Report – Final,* June 2014.

The detailed analysis of City of Calgary flood damages is contained under separate cover; however, summary tables are contained in **Appendix B**. For the 1:100 year flood under the higher damage case, total damages on the Elbow are estimated at $741,005,000. Average annual damages for the Elbow River under the higher case equate to $30,110,965.

For the 1:100 year flood under the lower case assumptions, total damages on the Elbow River are estimated at $538,369,000 with average annual damages estimated at $21,728,927.

5.1.2 Other Damages

Flood damage studies, akin to the detailed assessment undertaken for the City of Calgary have not been generated for areas upstream of the Glenmore Reservoir Diversion project including Bragg Creek, Redwood Meadows and infrastructure within Rocky View County which would not be protected by the proposed Glenmore Reservoir Diversion project. These damages constitute costs over and above those accruing to the City of Calgary and should be taken into consideration as part of the benefit/cost analysis.

A variety of secondary sources were employed to determine damages, including the damage claims submitted under the 2013 Southern Alberta Disaster Recovery Program along with a previous study of Bragg Creek completed for Alberta Environment Planning Division in 1987[3].

In terms of the 2013 Southern Alberta Disaster Recovery Program, the total estimated amount for flood recovery projects between the McLean Creek dam site and the City of Calgary is approximately $5.6 million. This amount is made up of $1.084 million for recovery projects in Rocky View County (including Bragg Creek), $2.657 million for recovery projects in the Townsite of Redwood Meadows, and $1.901 million for recovery projects in the Tsuu T'ina First Nation. Details are contained in **Appendix C**.

5.1.2.1 1987 Bragg Creek Floodplain Management Study

The 1987 Bragg Creek Floodplain Management Study identified 37 residential units and 21 commercial units within the flood hazard area. This has increased to 51 residential units and 29 commercial units, representing an increase of 27% for residential and 28% for commercial. A very cursory assessment of potential damages employing values from the updated stage-damage curves suggests total damages in the order of $12.7 million for the Bragg Creek flood study area for the 1:100 year event.

5.1.2.2 Cost Implications

At this juncture it is not possible to accurately calculate average annual damages for the areas upstream of the Glenmore Reservoir Diversion project. Notwithstanding, in order to account for the other damages, and therefore additional costs that will be incurred by the Glenmore Reservoir Diversion project over the MC1 project (McLean Creek Flood Storage), an additional $8.9 million in total costs are proposed to be added to the Glenmore project.

5.2 With Mitigation Alternative

Implementation of the Glenmore Reservoir Diversion project results in a reduction of average annual damages under the four cases as follows:

- 1:100 year level of protection under the higher damage scenario = $25,370,933
- 1:200 year level of protection under the higher damage scenario = $27,104,222

[3] *Bragg Creek Floodplain Management Study – Final Report*, J.N. MacKenzie Engineering Ltd. in association with W-E-R Engineering Ltd., IBI Group and Ecos Engineering Services Ltd., January 1987.

- 1:100 year level of protection under the lower damage scenario = $16,988,895
- 1:200 year level of protection under the lower damage scenario = $18,722,184

6 Benefit/Cost Analysis

6.1 Benefit/Cost Analysis for Flood Mitigation Projects

For flood mitigation projects, economic evaluation requires a comparison between the events predicted to occur if the project is built and those predicted to occur if the project is not built. This is called the “with and without principle”. For flood control one cannot directly equate an exchange in the market, however flood control benefits can be estimated by assuming they are equivalent to the flood damage prevented.

For flood mitigation projects the probabilistic approach to benefit/cost estimates is used. To reiterate, within the defined flood risk area, flood damages were estimated with the application of depth-damage curves applied to the various return flood events (probability). The flood damage probability distribution was then plotted and the average annual damage (AAD) estimated for project evaluation purposes.

With the updated average annual damages and cost estimates of the diversion alternative, an economic efficiency evaluation was performed. This evaluation is based upon the net present value (NPV) of respective benefits and costs. The net present value of any project is governed by three variables: the average annual cost or benefit, discount rate, and discount period. To provide a consistent economic evaluation of flood mitigation projects across the Province, a common discount rate of 4% was agreed upon and applied. The discount period is the estimate of the alternative’s project life.

The benefit/cost (B/C) ratio of a project is the ratio of net present value of the benefits (average annual damages) over the net present value of the costs. This value is the indicator of economic efficiency. Where the benefits exceed costs, the ratio would be greater than 1.0, and where benefits are less than costs then the ratio would be less than 1.0. An economically-efficient project would have a B/C ratio greater than 1.0. At a B/C ratio of 1.0, the project is at a breakeven point.

6.2 Assumptions/Methodology

The following assumptions were employed in the benefit/cost analysis:

- Costs are based on the estimated capital and operational/maintenance costs presented in Section 4.
- $8.9 million in capital costs was added to the Glenmore Reservoir Diversion scenario to account for required mitigation measures upstream.
- Benefits are based on the quantification of flood damages averted as outlined in Section 5.
- The benefit/cost analysis has been carried out using a net present value analysis.
- A 100 year economic analysis.
- Annual operating and maintenance costs of $1.8 million.

6.2.1 MC1 (McLean Creek Flood Storage Project) and SR1 (Springbank Off-Stream Flood Storage Project)

Net benefits for MC1 and SR1 were computed on the basis that the projects will provide protection downstream of Glenmore Dam to the 1:100 and 1:200 year flood events. When these events are exceeded, the damages will start to increase rapidly as the peak discharge passes through the flood hazard area within the City of Calgary. Without additional hydrologic routing, it was assumed that once the design event is exceeded, full damages are incurred. With additional hydrologic routing it is possible that the benefit/cost ratios of these schemes will improve somewhat.

6.2.2 Glenmore Reservoir Diversion

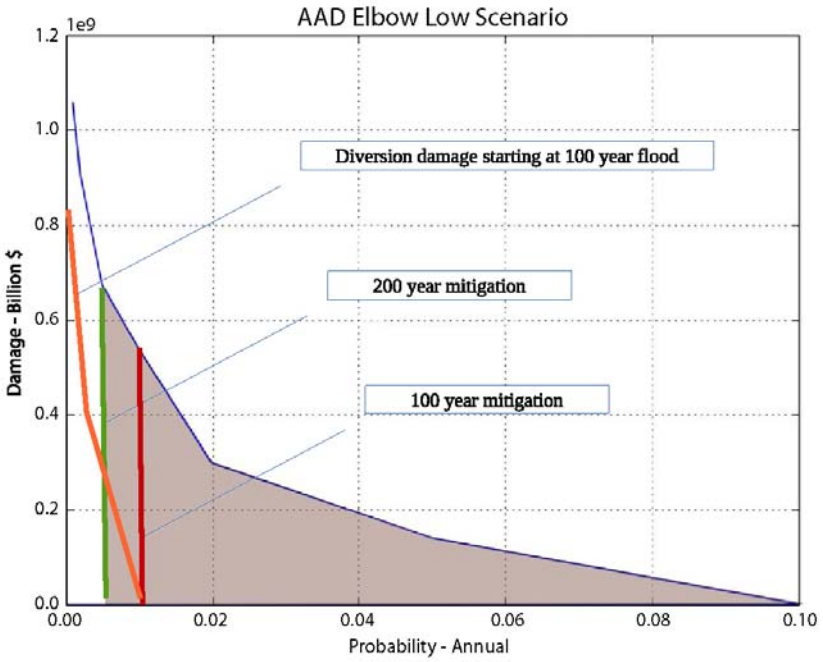
With respect to the Glenmore Reservoir Diversion it was possible to calculate the reduced damages that would be achieved as a result of the 500 and 700 CMS diversion. The incremental flow was passed downstream and damages based on the reduced flood flow were computed to determine the net benefits. Consequently, a higher benefit can be attributed to the diversion scheme based on this higher level of analysis. Notwithstanding the higher overall benefits, the actual benefit/cost ratio as illustrated in the next section is lower than the MC1 and SR1 schemes due to the much higher cost base of the Glenmore Reservoir Diversion.

Exhibit 6.1 illustrates this principle considering the average annual damage on the Elbow under the low damage scenario. If all flood damage can be eliminated then the average annual damage is equal to the area under the curve from the Y to the X axis. This is the total average annual damage.

If a dyke is constructed to a 100 year flood protection, the area right of the red line is subtracted from the total average annual damage. This is the value of the average annual damage averted. However, when the 100 year flood is exceeded then all the properties are flooded instantaneously (area to the left of the red line). Similarly, for a dyke built to the 200 year level of protection.

Conversely, in the case of the diversion tunnel, the mitigation is the area right of the orange line. In this case, when the diverted flow is exceeded, then the damage occurs gradually (slope of the orange curve) rather than vertically, like the dyke situation.

Exhibit 6.1: Affect of Mitigation on Average Annual Damage



6.3 Discussion of Results

Exhibit 6.2 highlights the key results of the benefit/cost analysis of the Glenmore Reservoir Diversion project under the four cases as discussed.

For the 1:100 year level of protection under the high damage scenario, the present value of benefits is some $622 million versus $512 million in costs, rendering a positive benefit/cost ratio of 1.21.

At the 1:200 year level of protection under the high damage scenario, the benefit/cost ratio decreases slightly to 1.20, illustrating the economic viability of both alternatives.

For the lower damage scenarios, the 1:100 year present value of benefits is $416 million versus $512 million in costs, rendering a benefit/cost ratio of 0.81. At the 1:200 year level of protection, the benefit/cost ratio increases slightly to 0.83.

In summary, this project demonstrates economic viability under only two of the four cases considered.

Exhibit 6.2: Benefit/Cost Analysis

Indicator	High Damage Scenario		Low Damage Scenario	
	1:100 Year Protection	1:200 Year Protection	1:100 Year Protection	1:200 Year Protection
PV Benefits (average annual damages)	$621,715,000	$664,189,000	$416,313,000	$458,787,000
PV Costs (development & operating total cost)	$512,465,000	$551,960,000	$512,465,000	$551,960,000
Benefit/Cost Ratio	1.21	1.20	0.81	0.83
Net Present Value	$109,250,000	$112,229,000	-$96,152,000	-$93,173,000
Average Annual Damages	$25,370,933	$27,104,222	$16,988,895	$18,722,184

6.4 Benefits Beyond the Study Area

Of the three mitigation projects under consideration, only one – the McLean Creek Flood Storage project (MC1) – provides benefits beyond the primary study area, the City of Calgary. An analysis of any potential benefits downstream of the City was outside the scope of this analysis. Needless to say, it is anticipated that benefits downstream of the City would be marginal in any event.

6.5 Triple Bottom Line Considerations

Traditional economic analyses of flood mitigation alternatives have generally assumed a straightforward objective of maximizing the net benefits (total benefits minus total costs) that accrue to a project. Society however, has other goals besides economic efficiency. These goals or objectives are the results of outcomes that society desires and have more recently been described as triple bottom line objectives which include, in addition to economic objectives, considerations of environmental and social impacts. In relation to flood mitigation projects, the following criteria are often considered in the evaluation process:

- Disaster prevention:
  - reduces current losses
  - reduces future losses
  - potential residential loss of life
  - potential non-residential loss of life
- Environmental impact:
  - biophysical impacts
  - social impacts
  - aesthetic impacts
- Implementation:
  - complexity
  - flexibility of integration with other measures
- Incidental benefits:
  - recreation
  - drought mitigation
  - other

This study was concerned solely with economic efficiency and consequently does not include analysis of the aforementioned non-commensurable criteria.

6.6 Summary and Conclusions

Exhibit 6.3 below illustrates the relative ranking of the flood mitigation projects.

Exhibit 6.3: Benefit/Cost Ratio

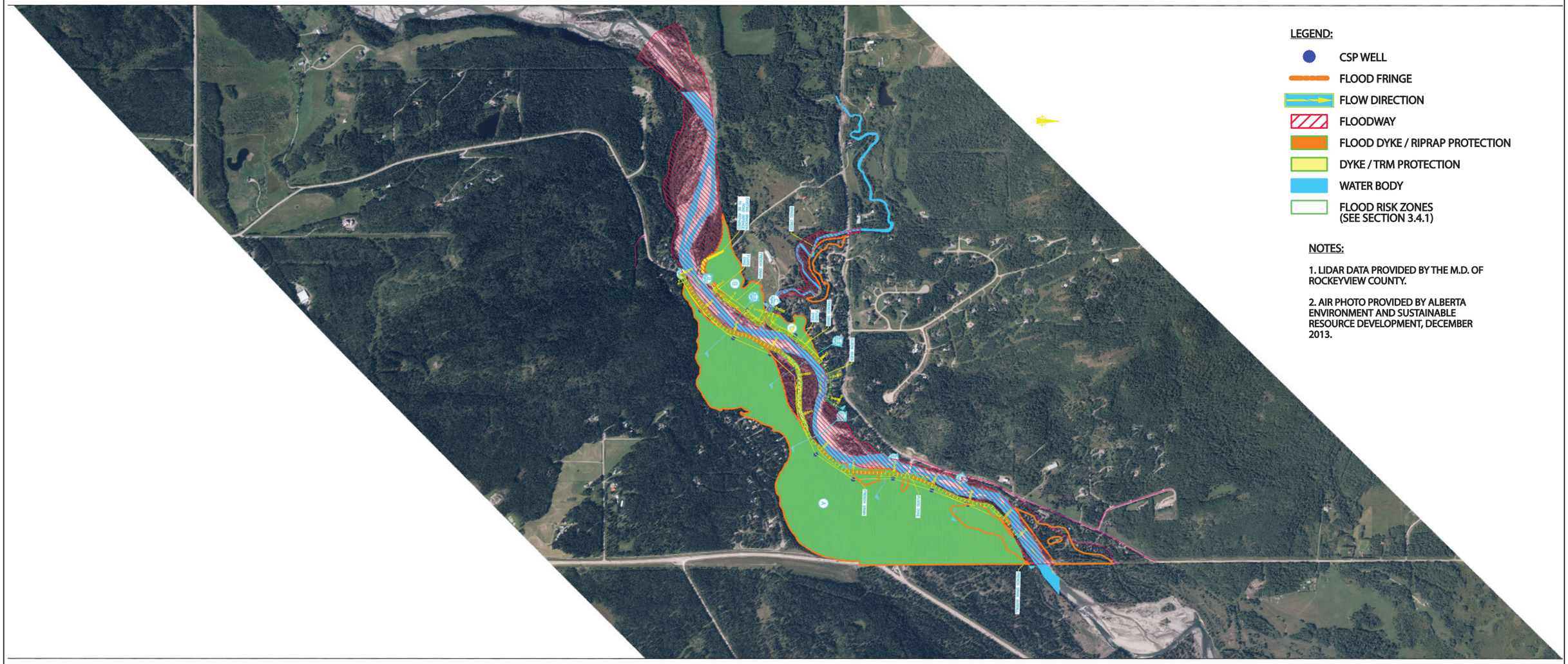
Mitigation Project	High Damage Scenario		Low Damage Scenario	
	1:100 Year Protection	1:200 Year Protection	1:100 Year Protection	1:200 Year Protection
SR1	1.87	2.07	1.32	1.32
MC1	1.43	1.65	1.01	1.05
Glenmore	1.21	1.20	0.81	0.83

The Glenmore Reservoir Diversion achieves a positive benefit/cost ratio in only two of the four scenarios and ranks third behind the other two mitigation projects.[4] In addition, of the three scenarios considered, the diversion project appears to have the highest level of uncertainty relative to costs. It relies upon new and relatively untested technology in the Alberta context versus the alternative storage solutions. The recent cost escalations associated with the City of Calgary airport runway tunnel (greater than two times the original estimate) provides a good example of the latter concern.

[4] Refer to IBI Group Reports: *Benefit/Cost Analysis of Flood Mitigation Projects for the City of Calgary: Springbank Off-Stream Flood Storage (February 2015)* and *Benefit/Cost Analysis of Flood Mitigation Projects for the City of Calgary: McLean Creek Flood Storage (February 2015).*

Appendix A – Bragg Creek Proposed Dyke System

Bragg Creek Flood Risk Area and Proposed Dyke System



LEGEND:

- CSP WELL
- FLOOD FRINGE
- FLOW DIRECTION
- FLOODWAY
- FLOOD DYKE / RIPRAP PROTECTION
- DYKE / TRM PROTECTION
- WATER BODY
- FLOOD RISK ZONES (SEE SECTION 3.4.1)

NOTES:

1. LIDAR DATA PROVIDED BY THE M.D. OF ROCKEYVIEW COUNTY.

2. AIR PHOTO PROVIDED BY ALBERTA ENVIRONMENT AND SUSTAINABLE RESOURCE DEVELOPMENT, DECEMBER 2013.

Source:
amec - Southern Alberta Flood Recovery Task Force
Flood Mitigation Measures for the Bow, Elbow and Oldman River Basins
Volume 4 - Flood Mitigation Measures - Final
June 2014

N

Elbow River at Banff Creek f

Source:
amec - Southern Alberta Flood Recovery Task Force
Flood Mitigation Measures for the Bow, Elbow and Oldman River Basins
Volume 4 - Flood Mitigation Measures - Final
June 2014

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Conceptual Cost Estimate - Bragg Creek Flood Defence Dykes & French Drain

Item No.	Item Description	Unit	Quantity	Unit Price	Extension
	ALLOWANCES				
1	Larger Riprap sizing	Allow.	Allowance		$200,000
	TEMPORARY FACILITIES				
2	Mobilization and Demobilization	L.S.	1	Lump Sum	$50,000
3	Existing and Temporary Roads	L.S.	1	Lump Sum	$10,000
	SITE PREPARATION				
4	Clearing & Grubbing	ha	3	$2,000.00	$6,251
5	Topsoil & Subsoil Stripping	m^3	11315	$5.00	$56,577
6	Care of Water	L.S.	1	Lump Sum	$75,000
	EXCAVATION				
7	Common Excavation	m^3	13820	$6.50	$89,831
	FILL PLACEMENT				
8	Low Permeable Fill	m^3	56263	$10.00	$562,628
9	Common Fill	m^3	9577	$6.00	$57,461
	GRANULAR AND RIPRAP MATERIALS				
10	Granular Drain Rock	tonnes	5456	$35.00	$190,966
11	Riprap Zone 6B	tonnes	14770	$130.00	$1,920,103
12	Riprap Zone 6A	tonnes	202	$110.00	$22,176
13	Gravel Armour	tonnes	9231	$40.00	$369,251
14	Non-Woven Geotextile	m^2	15385	$3.00	$46,156
	SITE CONSTRUCTION				
15	600 Dia. Perforated HDPE Pipe	m	2947	$120.00	$353,606
16	CSP Well Supply and Installation	L.S.	12	$15,000.00	$180,000
	LANDSCAPING				
17	Topsoil & Subsoil Placement	m^2	15390	$1.50	$23,084
18	Turf Reinforcement Mat	m^2	30779	$6.00	$184,674
19	Hydroseeding	m^2	30779	$3.50	$107,727
	SUBTOTAL				**$4,505,490**
	CONTINGENCIES @ 25%				**$1,126,373**
	ENGINEERING @ 12%				**$540,659**
	ESTIMATED TOTAL COST				**$6,173,000**

Source:
amec - Southern Alberta Flood Recovery Task Force
Flood Mitigation Measures for the Bow, Elbow and Oldman River Basins
Volume 4 - Flood Mitigation Measures - Final
June 2014

Appendix B – City of Calgary Flood Damage Estimates

Total Damages, Bow and Elbow Rivers, With Sewer Backup

Categories of damage		Return frequency, in years								
		2 *	5 *	10 **	20	50	100	200	500	1,000
Residential	Direct	$0	$0	$0	$268,753,000	$414,798,000	$686,791,000	$947,786,000	$1,329,201,000	$1,496,364,000
	Indirect 15%	$0	$0	$0	$40,313,000	$62,220,000	$103,019,000	$142,168,000	$199,380,000	$224,455,000
	Total	$0	$0	$0	$309,066,000	$477,018,000	$789,810,000	$1,089,954,000	$1,528,581,000	$1,720,819,000
Commercial	Direct	$0	$0	$0	$15,210,000	$37,446,000	$111,079,000	$271,990,000	$493,824,000	$572,607,000
	Indirect 323%	$0	$0	$0	$49,128,000	$120,951,000	$358,785,000	$878,528,000	$1,595,052,000	$1,849,521,000
	Total	$0	$0	$0	$64,338,000	$158,397,000	$469,864,000	$1,150,518,000	$2,088,876,000	$2,422,128,000
Infrastructure	Direct	$0	$0	$0	$101,508,000	$170,620,000	$299,100,000	$452,626,000	$686,656,000	$780,711,000
	Indirect 20%	$0	$0	$0	$20,302,000	$34,124,000	$59,820,000	$90,525,000	$137,331,000	$156,142,000
	Total	$0	$0	$0	$121,810,000	$204,744,000	$358,920,000	$543,151,000	$823,987,000	$936,853,000
Stampede	Direct	$0	$0	$0	$10,200,000	$42,200,000	$68,900,000	$91,900,000	$166,853,000	$193,472,000
	Indirect 185%	$0	$0	$0	$18,860,000	$78,030,000	$127,400,000	$169,928,000	$308,521,000	$357,741,000
	Total	$0	$0	$0	$29,060,000	$120,230,000	$196,300,000	$261,828,000	$475,374,000	$551,213,000
Total	Direct	$0	$0	$0	$395,671,000	$665,064,000	$1,165,870,000	$1,764,302,000	$2,676,534,000	$3,043,154,000
	Indirect 73%	$0	$0	$0	$128,603,000	$295,325,000	$649,024,000	$1,281,149,000	$2,240,284,000	$2,587,859,000
	Total	$0	$0	$0	$524,274,000	$960,389,000	$1,814,894,000	$3,045,451,000	$4,916,818,000	$5,631,013,000

* No Actual damages occur at these flow levels
** Flood Flow primarily contained within the river

Total Damages, Bow River, With Sewer Backup

Categories of damage		Return frequency, in years								
		2 *	5 *	10 **	20	50	100	200	500	1,000
Residential	Direct	$0	$0	$0	$167,738,000	$247,549,000	$387,075,000	$582,482,000	$891,235,000	$991,311,000
	Indirect 15%	$0	$0	$0	$25,161,000	$37,133,000	$58,062,000	$87,372,000	$133,685,000	$148,697,000
	Total	$0	$0	$0	$192,899,000	$284,682,000	$445,137,000	$669,854,000	$1,024,920,000	$1,140,008,000
Commercial	Direct	$0	$0	$0	$15,128,000	$36,965,000	$100,874,000	$256,774,000	$471,284,000	$539,790,000
	Indirect 323%	$0	$0	$0	$48,863,000	$119,397,000	$325,823,000	$829,380,000	$1,522,248,000	$1,743,522,000
	Total	$0	$0	$0	$63,991,000	$156,362,000	$426,697,000	$1,086,154,000	$1,993,532,000	$2,283,312,000
Infrastructure	Direct	$0	$0	$0	$63,102,000	$98,179,000	$168,379,000	$289,606,000	$470,170,000	$528,344,000
	Indirect 20%	$0	$0	$0	$12,621,000	$19,636,000	$33,676,000	$57,921,000	$94,034,000	$105,669,000
	Total	$0	$0	$0	$75,723,000	$117,815,000	$202,055,000	$347,527,000	$564,204,000	$634,013,000
Stampede	Direct	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Indirect 185%	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	Direct	$0	$0	$0	$245,968,000	$382,693,000	$656,328,000	$1,128,862,000	$1,832,689,000	$2,059,445,000
	Indirect 84%	$0	$0	$0	$86,645,000	$176,166,000	$417,561,000	$974,673,000	$1,749,967,000	$1,997,888,000
	Total	$0	$0	$0	$332,613,000	$558,859,000	$1,073,889,000	$2,103,535,000	$3,582,656,000	$4,057,333,000

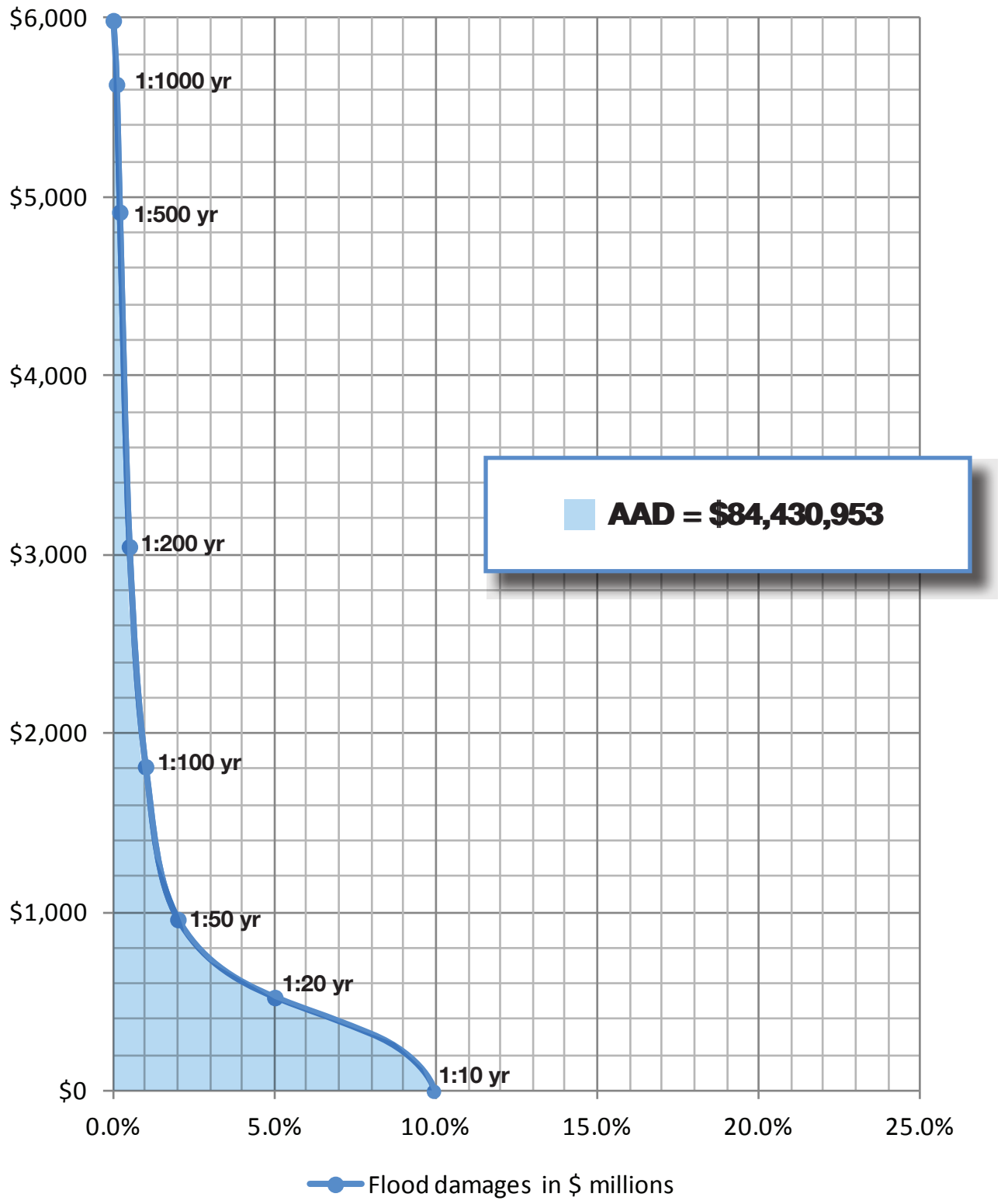
* No Actual damages occur at these flow levels
** Flood Flow primarily contained within the river

Total Damages, Elbow River, With Sewer Backup

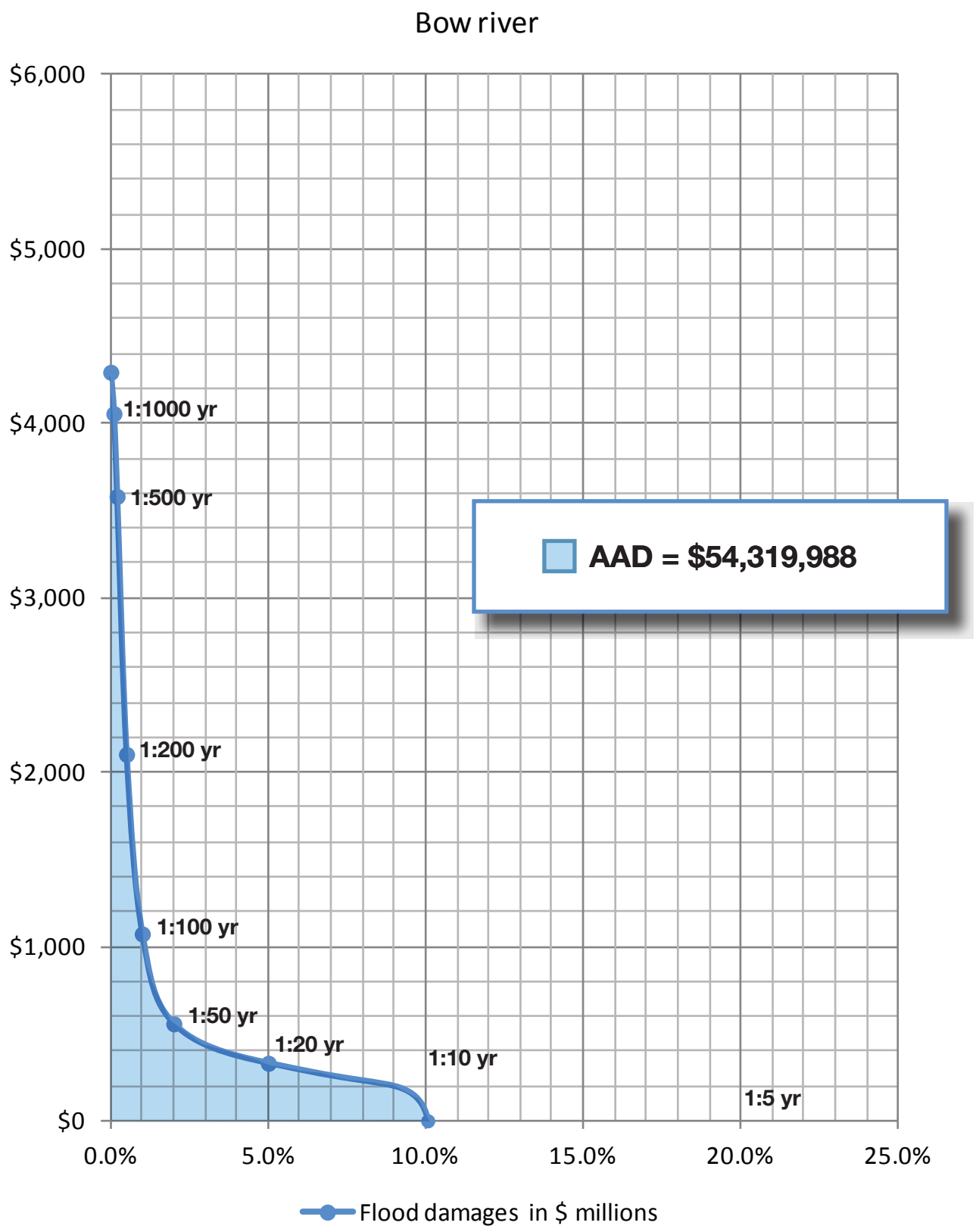
Categories of damage		Return frequency, in years								
		2 *	5 *	10 **	20	50	100	200	500	1,000
Residential	Direct	$0	$0	$0	$101,015,000	$167,249,000	$299,716,000	$365,304,000	$437,966,000	$505,053,000
	Indirect 15%	$0	$0	$0	$15,152,000	$25,087,000	$44,957,000	$54,796,000	$65,695,000	$75,758,000
	Total	$0	$0	$0	$116,167,000	$192,336,000	$344,673,000	$420,100,000	$503,661,000	$580,811,000
Commercial	Direct	$0	$0	$0	$82,000	$481,000	$10,205,000	$15,216,000	$22,540,000	$32,817,000
	Indirect 323%	$0	$0	$0	$265,000	$1,554,000	$32,962,000	$49,148,000	$72,804,000	$105,999,000
	Total	$0	$0	$0	$347,000	$2,035,000	$43,167,000	$64,364,000	$95,344,000	$138,816,000
Infrastructure	Direct	$0	$0	$0	$38,406,000	$72,441,000	$130,721,000	$163,020,000	$216,486,000	$252,367,000
	Indirect 20%	$0	$0	$0	$7,681,000	$14,488,000	$26,144,000	$32,604,000	$43,297,000	$50,473,000
	Total	$0	$0	$0	$46,087,000	$86,929,000	$156,865,000	$195,624,000	$259,783,000	$302,840,000
Stampede	Direct	$0	$0	$0	$10,200,000	$42,200,000	$68,900,000	$91,900,000	$166,853,000	$193,472,000
	Indirect 185%	$0	$0	$0	$18,860,000	$78,030,000	$127,400,000	$169,928,000	$308,521,000	$357,741,000
	Total	$0	$0	$0	$29,060,000	$120,230,000	$196,300,000	$261,828,000	$475,374,000	$551,213,000
Total	Direct	$0	$0	$0	$149,703,000	$282,371,000	$509,542,000	$635,440,000	$843,845,000	$983,709,000
	Indirect 52%	$0	$0	$0	$41,958,000	$119,159,000	$231,463,000	$306,476,000	$490,317,000	$589,971,000
	Total	$0	$0	$0	$191,661,000	$401,530,000	$741,005,000	$941,916,000	$1,334,162,000	$1,573,680,000

* No Actual damages occur at these flow levels
** Flood Flow primarily contained within the river

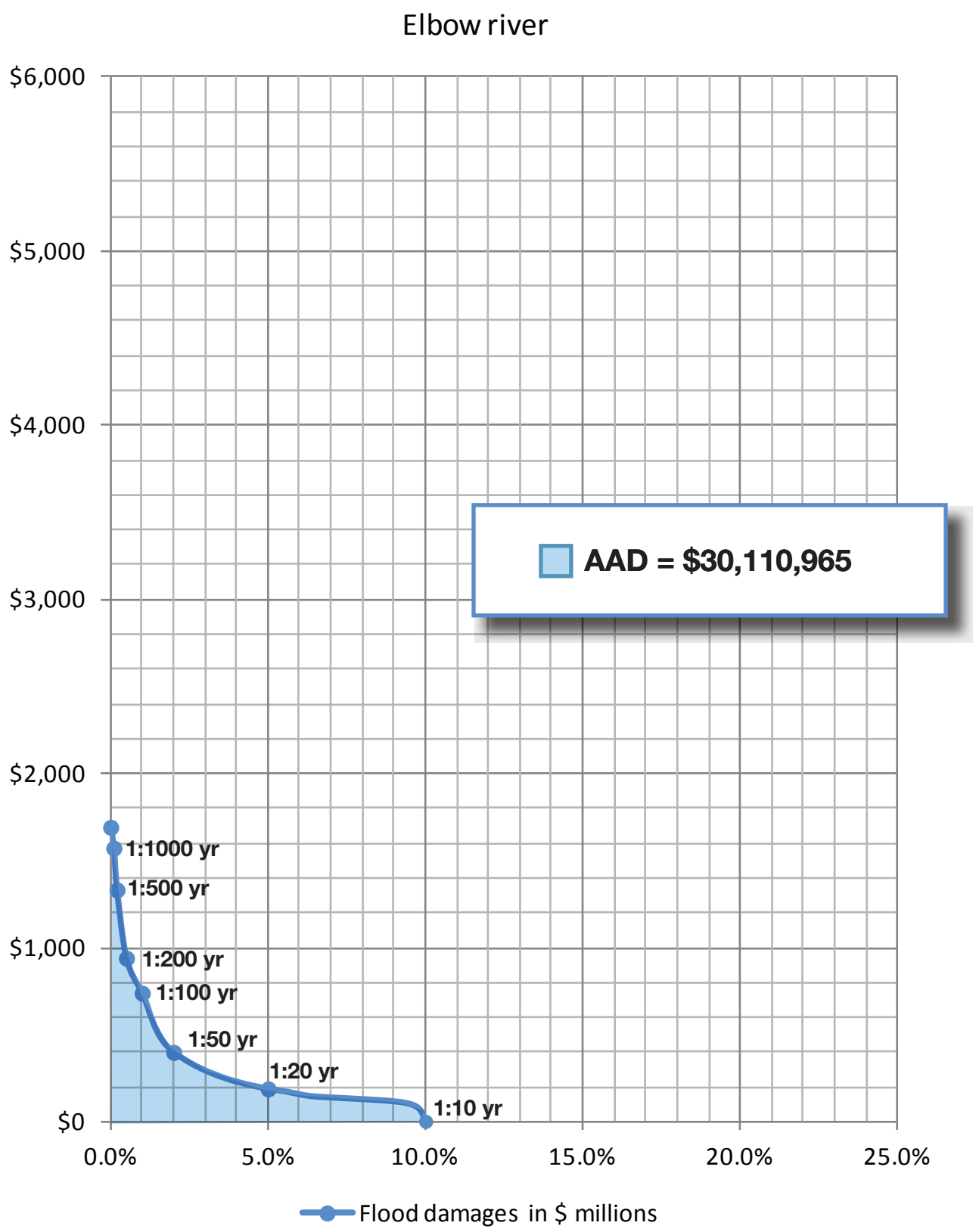
Flood Damages Probability Distribution, Bow and Elbow Rivers



Flood Damages Probability Distribution, Bow River



Flood Damages Probability Distribution, Elbow River



Alternative Damage Scenario - Total Damages, Bow and Elbow Rivers, With Sewer Backup

Categories of damage		Return frequency, in years								
		2 *	5 *	10 **	20	50	100	200	500	1,000
Residential	Direct	$0	$0	$0	$268,753,000	$414,798,000	$686,791,000	$947,786,000	$1,329,201,000	$1,496,364,000
	Indirect 15%	$0	$0	$0	$40,313,000	$62,220,000	$103,019,000	$142,168,000	$199,380,000	$224,455,000
	Total	$0	$0	$0	$309,066,000	$477,018,000	$789,810,000	$1,089,954,000	$1,528,581,000	$1,720,819,000
Commercial	Direct	$0	$0	$0	$15,210,000	$37,446,000	$111,079,000	$271,990,000	$493,824,000	$572,607,000
	Indirect 45%	$0	$0	$0	$0	$16,851,000	$49,986,000	$122,396,000	$222,221,000	$257,673,000
	Total	$0	$0	$0	$15,210,000	$54,297,000	$161,065,000	$394,386,000	$716,045,000	$830,280,000
Infrastructure	Direct	$0	$0	$0	$21,639,000	$90,929,000	$159,400,000	$241,219,000	$365,941,000	$416,066,000
	Indirect 20%	$0	$0	$0	$4,328,000	$18,186,000	$31,880,000	$48,244,000	$73,188,000	$83,213,000
	Total	$0	$0	$0	$25,967,000	$109,115,000	$191,280,000	$289,463,000	$439,129,000	$499,279,000
Stampede	Direct	$0	$0	$0	$10,200,000	$42,200,000	$68,900,000	$91,900,000	$166,853,000	$193,472,000
	Indirect 38%	$0	$0	$0	$3,908,000	$16,170,000	$26,400,000	$35,213,000	$63,932,000	$74,132,000
	Total	$0	$0	$0	$14,108,000	$58,370,000	$95,300,000	$127,113,000	$230,785,000	$267,604,000
Total	Direct	$0	$0	$0	$315,802,000	$585,373,000	$1,026,170,000	$1,552,895,000	$2,355,819,000	$2,678,509,000
	Indirect 22%	$0	$0	$0	$48,549,000	$113,427,000	$211,285,000	$348,021,000	$558,721,000	$639,473,000
	Total	$0	$0	$0	$364,351,000	$698,800,000	$1,237,455,000	$1,900,916,000	$2,914,540,000	$3,317,982,000

* No Actual damages occur at these flow levels
** Flood Flow primarily contained within the river

Alternative Damage Scenario - Total Damages, Bow River, With Sewer Backup

Categories of damage		Return frequency, in years								
		2 *	5 *	10 **	20	50	100	200	500	1,000
Residential	Direct	$0	$0	$0	$167,738,000	$247,549,000	$387,075,000	$582,482,000	$891,235,000	$991,311,000
	Indirect 15%	$0	$0	$0	$25,161,000	$37,133,000	$58,062,000	$87,372,000	$133,685,000	$148,697,000
	Total	$0	$0	$0	$192,899,000	$284,682,000	$445,137,000	$669,854,000	$1,024,920,000	$1,140,008,000
Commercial	Direct	$0	$0	$0	$15,128,000	$36,965,000	$100,874,000	$256,774,000	$471,284,000	$539,790,000
	Indirect 45%	$0	$0	$0	$0	$16,635,000	$45,394,000	$115,549,000	$212,078,000	$242,905,000
	Total	$0	$0	$0	$15,128,000	$53,600,000	$146,268,000	$372,323,000	$683,362,000	$782,695,000
Infrastructure	Direct	$0	$0	$0	$13,452,000	$52,323,000	$89,734,000	$154,340,000	$250,569,000	$281,571,000
	Indirect 20%	$0	$0	$0	$2,691,000	$10,465,000	$17,947,000	$30,868,000	$50,114,000	$56,314,000
	Total	$0	$0	$0	$16,143,000	$62,788,000	$107,681,000	$185,208,000	$300,683,000	$337,885,000
Stampede	Direct	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Indirect 38%	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Total	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	Direct	$0	$0	$0	$196,318,000	$336,837,000	$577,683,000	$993,596,000	$1,613,088,000	$1,812,672,000
	Indirect 23%	$0	$0	$0	$27,852,000	$64,233,000	$121,403,000	$233,789,000	$395,877,000	$447,916,000
	Total	$0	$0	$0	$224,170,000	$401,070,000	$699,086,000	$1,227,385,000	$2,008,965,000	$2,260,588,000

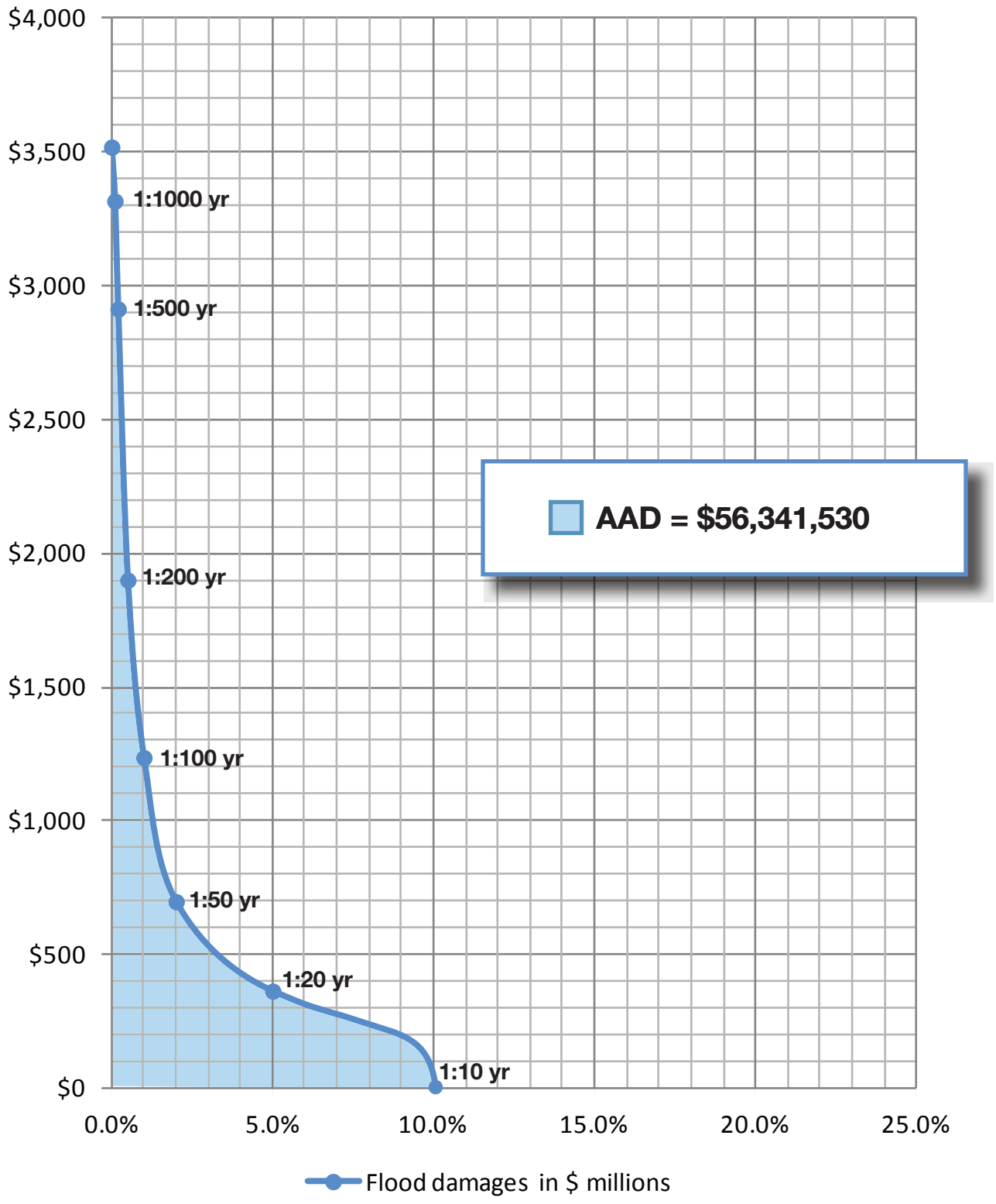
* No Actual damages occur at these flow levels
** Flood Flow primarily contained within the river

Alternative Damage Scenario - Total Damages, Elbow River, With Sewer Backup

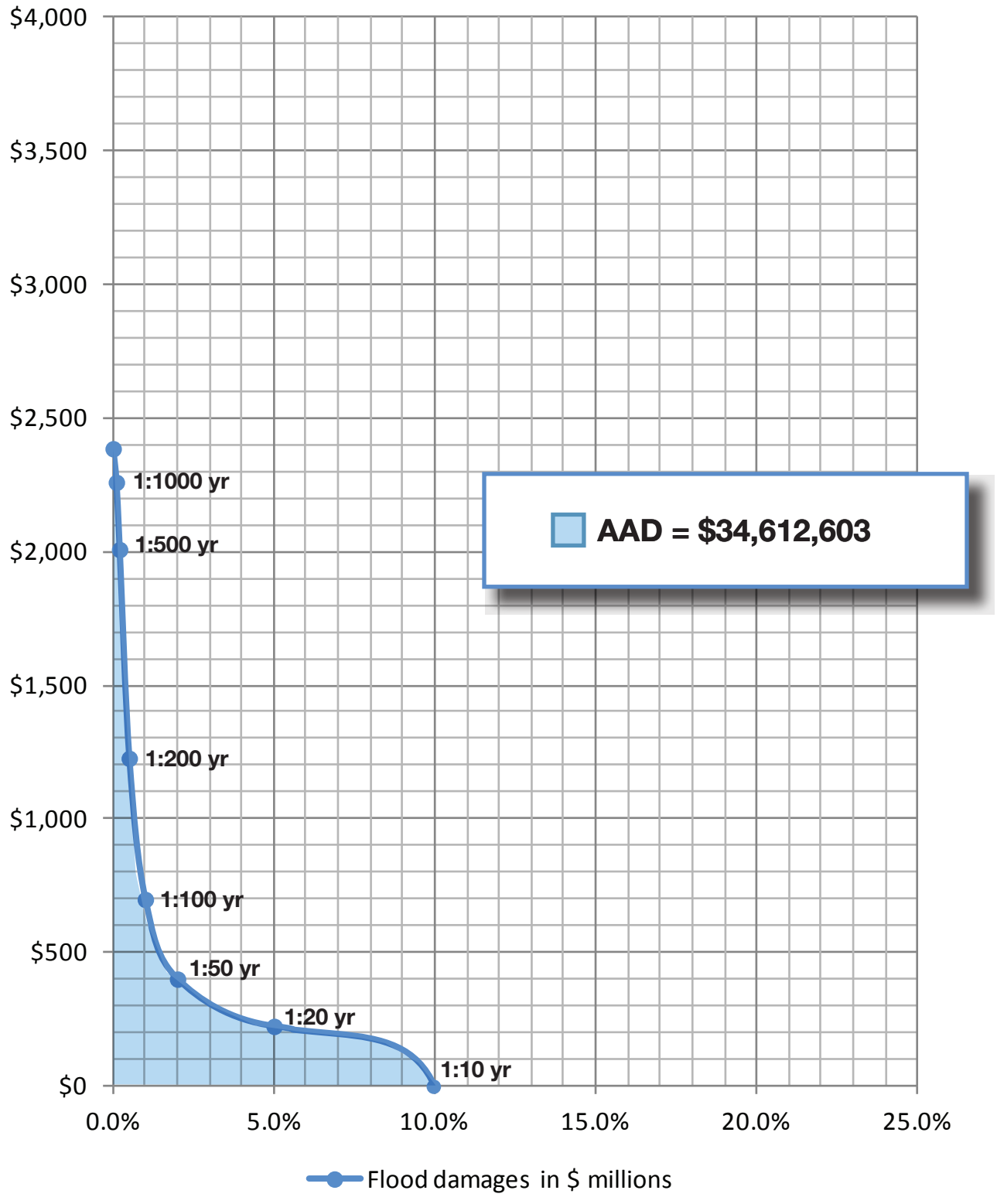
Categories of damage		Return frequency, in years								
		2 *	5 *	10 **	20	50	100	200	500	1,000
Residential	Direct	$0	$0	$0	$101,015,000	$167,249,000	$299,716,000	$365,304,000	$437,966,000	$505,053,000
	Indirect 15%	$0	$0	$0	$15,152,000	$25,087,000	$44,957,000	$54,796,000	$65,695,000	$75,758,000
	Total	$0	$0	$0	$116,167,000	$192,336,000	$344,673,000	$420,100,000	$503,661,000	$580,811,000
Commercial	Direct	$0	$0	$0	$82,000	$481,000	$10,205,000	$15,216,000	$22,540,000	$32,817,000
	Indirect 45%	$0	$0	$0	$0	$216,000	$4,592,000	$6,847,000	$10,143,000	$14,768,000
	Total	$0	$0	$0	$82,000	$697,000	$14,797,000	$22,063,000	$32,683,000	$47,585,000
Infrastructure	Direct	$0	$0	$0	$8,187,000	$38,606,000	$69,666,000	$86,879,000	$115,372,000	$134,495,000
	Indirect 20%	$0	$0	$0	$1,637,000	$7,721,000	$13,933,000	$17,376,000	$23,074,000	$26,899,000
	Total	$0	$0	$0	$9,824,000	$46,327,000	$83,599,000	$104,255,000	$138,446,000	$161,394,000
Stampede	Direct	$0	$0	$0	$10,200,000	$42,200,000	$68,900,000	$91,900,000	$166,853,000	$193,472,000
	Indirect 38%	$0	$0	$0	$3,908,000	$16,170,000	$26,400,000	$35,213,000	$63,932,000	$74,132,000
	Total	$0	$0	$0	$14,108,000	$58,370,000	$95,300,000	$127,113,000	$230,785,000	$267,604,000
Total	Direct	$0	$0	$0	$119,484,000	$248,536,000	$448,487,000	$559,299,000	$742,731,000	$865,837,000
	Indirect 21%	$0	$0	$0	$20,697,000	$49,194,000	$89,882,000	$114,232,000	$162,844,000	$191,557,000
	Total	$0	$0	$0	$140,181,000	$297,730,000	$538,369,000	$673,531,000	$905,575,000	$1,057,394,000

* No Actual damages occur at these flow levels
** Flood Flow primarily contained within the river

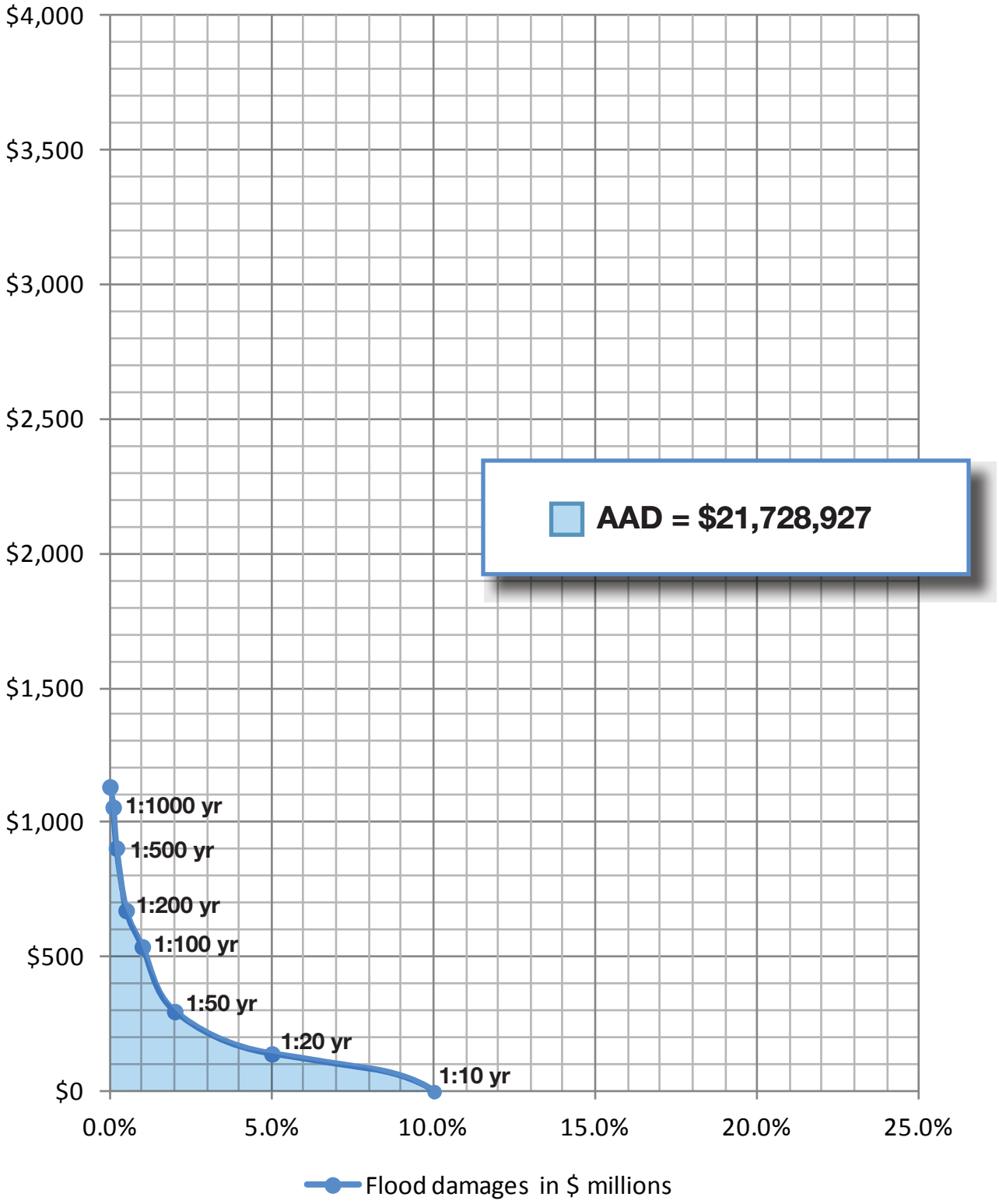
Alternative Damage Scenario - Flood Damages Probability Distribution, Bow and Elbow Rivers



Alternative Damage Scenario - Flood Damages Probability Distribution, Bow River



Alternative Damage Scenario - Flood Damages Probability Distribution, Elbow River



Appendix C – Southern Alberta Disaster Recovery Program

Rocky View County Ongoing Project Estimates

Project Number	Project Name	Status	Approved Estimate (Y/N)	Latest Estimate Date	Estimate ($)	Comments
1	Emergency Operations	Ongoing	Y	Sept. 19, 2013	450000.00	Approved inspection estimate
2	Hamlet of Bragg Creek water intake	Ongoing	Y	Sept. 19, 2013	110000.00	Approved inspection estimate
3	Hamlet of Bragg Creek road damage	Ongoing	Y	Sept. 19, 2013	20000.00	Approved inspection estimate
4	Balsam Ave Erosion	Ongoing	Y	Sept. 19, 2013	25000.00	Approved inspection estimate
5	Access to Hamlet of Bragg Creek Snowbirds Chalet	Ongoing	Y	Sept. 19, 2013	5000.00	Approved inspection estimate
6	Hamlet of Bragg Creek Community Centre	Ongoing	Y	Sept. 19, 2013	35000.00	Approved inspection estimate
7	Wood debris site	Ongoing	Y	Sept. 19, 2013	25000.00	Approved inspection estimate
8	Wintergreen road	Ongoing	Y	Sept. 19, 2013	10000.00	Approved inspection estimate
9	Slapping Tail Pond	Ongoing	Y	Sept. 19, 2013	75000.00	Approved inspection estimate
12	RR 54, S of TWP road 234	Ongoing	Y	Sept. 19, 2013	10000.00	Approved inspection estimate
14	Bracken Road gate and spillway	Ongoing	Y	Sept. 19, 2013	15000.00	Approved inspection estimate
15	Bracken Road	Ongoing	Y	Sept. 19, 2013	25000.00	Approved inspection estimate
16	Bracken Road S TWP Rd 232, Bragg Creek BF72292	Ongoing	Y	Sept. 19, 2013	29000.00	Approved inspection estimate
18	RR 41, S of Springbank Road, Gross Creek BF74057	Ongoing	Y	Sept. 19, 2013	15000.00	Approved inspection estimate
19	Springbank road W of RR 35, Springbank Creek BF9024	Ongoing	Y	Sept. 19, 2013	20770.00	Approved inspection estimate
33	Bragg Creek Municipal Park	Ongoing	Y	Sept. 19, 2013	20000.00	Approved inspection estimate
34	Springbank Park for All Seasons	Ongoing	N	Dec. 9, 2013	194000.00	Applicant initial estimate only
TOTAL BUDGET ESTIMATES FOR ROCKY VIEW COUNTY ONGOING PROJECTS					$1,083,770.00	

2013 Southern Alberta Disaster Recovery Program - Ongoing Project Estimate Tracking - As of February 4, 2014

Townsite of Redwood Meadows Ongoing Project Estimates

Project Number	Project Name	Status	Approved Estimate (Y/N)	Latest Estimate Date	Estimate ($)	Comments
1	Northern berm breach	Ongoing	Y	Sept. 10, 2013	838000.00	Approved inspection estimate
2	Sleigh Drive berm breach	Ongoing	Y	Sept. 10, 2013	75000.00	Approved inspection estimate
3	Use of existing rip rap for flood protection	Ongoing	Y	Sept. 10, 2013	465000.00	Approved inspection estimate
4	Water treatment plant	Ongoing	Y	Sept. 10, 2013	75000.00	Approved inspection estimate
5	Playground berm breach	Ongoing	Y	Sept. 10, 2013	690000.00	Approved inspection estimate
6	Berm breach, #18 Redwood Meadows Drive	Ongoing	Y	Sept. 10, 2013	444000.00	Approved inspection estimate
7	Sanitary sewer pumping station	Ongoing	Y	Sept. 10, 2013	70000.00	Approved inspection estimate
TOTAL BUDGET ESTIMATES FOR TOWNSITE OF REDWOOD MEADOWS ONGOING PROJECTS					$2,657,000.00	

Tsuu T'ina Ongoing Project Estimates

Project Number	Project Name	Status	Approved Estimate (Y/N)	Latest Estimate Date	Estimate ($)	Comments
1	Emergency Operations	Ongoing	N	Sept. 25, 2013	60384.22	Applicant initial estimate only
2	Infrastructure Damage	Ongoing	N	Sept. 25, 2013	211611.26	Applicant initial estimate only
3	Housing	Ongoing	N	Sept. 25, 2013	29914.77	Applicant initial estimate only
4	Band Works	Ongoing	Y	Nov. 11, 2013	800000.00	Approved inspection estimate
5	Redwood Meadows Golf Course	Ongoing	Y	Nov. 11, 2013	800000.00	Approved inspection estimate
TOTAL BUDGET ESTIMATES FOR TSUU T'INA FIRST NATION ONGOING PROJECTS					$1,901,910.25	

TOTAL ESTIMATE OF ONGOING PROJECTS **$5,642,680.25**