MEDICINE HAT RIVER HAZARD STUDY

HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

FINAL REPORT

Prepared for:

Alberta Government

04 April 2022

NHC Ref. No. 1003094

nhc
northwest hydraulic consultants
water resource specialists

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Alberta Environment and Parks
Edmonton, Alberta

Prepared by:

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This report has been prepared by Northwest Hydraulic Consultants Ltd. (NHC) in accordance with generally accepted engineering practices, for the benefit of Alberta Environment and Parks for specific application to the Medicine Hat River Hazard Study in Alberta. The information and data contained herein represent the best professional judgment of NHC, based on the knowledge and information available to NHC at the time of preparation.

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EXECUTIVE SUMMARY

Alberta Environment and Parks retained Northwest Hydraulic Consultants Ltd. in August 2017 to complete a river hazard study for the City of Medicine Hat and surrounding areas of Cypress County, including the Town of Redcliff and the Hamlet of Desert Blume. The river hazard study area includes 26 km of the South Saskatchewan River below Ross Creek, 19 km of the South Saskatchewan River above Ross Creek, 24 km of Ross Creek above the confluence with the South Saskatchewan River, 24 km of Seven Persons Creek above the confluence with Ross Creek, and 9.6 km of Bullshead Creek above the confluence with Ross Creek.

The study is being conducted under the provincial Flood Hazard Identification Program. The overall objectives of the study are to enhance public safety and to reduce potential future flood damages and disaster assistance costs.

The Medicine Hat River Hazard Study is comprised of eight major project components. This report summarizes the work of the third (***Hydraulic Model Creation and Calibration***) and fourth (***Open Water Flood Inundation Mapping***) components. Together, these components include construction and calibration of the hydraulic model, a sensitivity analysis, computation of flood frequency water levels and the associated inundation mapping.

The model was calibrated by adjusting channel roughness so that the computed flood levels agreed well with the observed flood levels for recorded historical floods. The South Saskatchewan River was calibrated to the 1975, 1995 and 2013 historic flood events. Seven Persons Creek and Ross Creek were calibrated to the June 2010 flood event. There was no historic flood level information available to calibrate the Bullshead Creek model reach. Computed stage-discharge rating curves were compared to the published rating curves for Water Survey Canada (WSC) gauge stations located along the study reaches. The computed rating curves agreed well with the published rating curves.

The calibrated hydraulic model was used to calculate water surface profiles for the 13 flood frequency return periods. The computed flood frequency levels were then used to determine the extent of inundation for all return periods. The results of the inundation analysis are presented as the open water flood inundation map library, provided as an appendix to this report. A total of 13 flood scenarios based on the calibrated open water flood frequency profiles were mapped individually for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1000-year events.

The open water flood inundation maps provide information that can be used by provincial and local authorities to assist in emergency preparedness planning for future flood events.

CREDITS AND ACKNOWLEDGEMENTS

Northwest Hydraulic Consultants Ltd. would like to express appreciation to Alberta Environment and Parks for initiating this project, making extensive background information available, and providing the project team with valuable technical input throughout the project. James Choles, P.Eng., CFM managed and directed the Medicine Hat River Hazard Study on behalf of Alberta Environment and Parks.

The following NHC personnel were part of the study team and participated in the hydraulic model creation and calibration component of the study:

- Robyn Andrishak (Project Manager) – responsible for the overall direction of the project and provided advice and senior review throughout the model construction and calibration work.
- Dan Healy (Hydraulic Modelling Lead) – co-author of this report and responsible for model development, model calibration, and inundation mapping development.
- Michael Brayall (Hydraulic Modelling Specialist) – co-author of this report and support in compiling and analysing model input data.
- Makamum Mahmood (Project Engineer) – co-author this report and support in hydraulic model development, flood history documentation, and model sensitivity analysis.
- Rebecca Himsl and Jerry Yan (GIS Analyst) – inundation mapping development and GIS deliverables.

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1 INTRODUCTION

1.1 Study Objectives

The overall objective of the Medicine Hat River Hazard Study is to identify and assess river and flood hazards along the South Saskatchewan River, Ross Creek, Seven Persons Creek, and Bullshead Creek within the City of Medicine Hat and surrounding areas of Cypress County, including the Town of Redcliff and the Hamlet of Desert Blume. Results from this study are designed to inform local land use planning decisions, flood mitigation projects, and emergency response planning. This study is being undertaken as part of the Flood Hazard Identification Program (FHIP) with the intent of enhancing public safety and reducing future flood damages within the Province of Alberta.

This river hazard study is comprised of the eight major study components listed below. A report and associated deliverables have been prepared for each individual study component.

1) Survey and Base Data Collection
2) Open Water Hydrology Assessment
3) Hydraulic Model Creation and Calibration
4) Open Water Flood Inundation Map Production
5) Open Water Flood Hazard Identification
6) Governing Flood Hazard Map Production
7) Flood Risk Assessment and Inventory
8) Channel Stability Investigation

This report summarizes the work of the third and fourth components: ***Hydraulic Model Creation and Calibration, and Open Water Flood Inundation Map Production***. The primary tasks, services, and deliverables associated with this report are:

- Documentation of open water flood history.
- Creation, calibration, and validation of a HEC-RAS hydraulic model.
- Simulation of selected return-period floods and creation of water surface profiles throughout the study reach.
- A sensitivity analysis of the model inputs.
- Production of flood inundation maps.

The development of the hydraulic model and the production of the inundation maps are foundational to the overall study and are required for the identification of flood hazard areas along the study reach.

1.2 Study Area and Reach

The City of Medicine Hat is located approximately 290 km southeast of Calgary and approximately 45 km west of the Alberta-Saskatchewan border. **Figure 1** shows the location and boundaries of the river hazard study area and contributing river basins. The river hazard study area includes the following reaches: 26 km of the South Saskatchewan River below Ross Creek; 19 km of the South Saskatchewan River above Ross Creek; 24 km of Ross Creek above the confluence with the South Saskatchewan River; 24 km of Seven Persons Creek above the confluence with Ross Creek; and 9.6 km of Bullshead Creek above the confluence with Ross Creek. Municipalities along these study reaches include the City of Medicine Hat, the Town of Redcliff, the Hamlet of Desert Blume, and Cypress County.

The contributing river basins cover an area of about 61,500 km^2, extending from the headwaters in the Rocky Mountains to the downstream boundary of the river hazard study area. Major upstream rivers include the Bow and Oldman rivers, which join together approximately 100 km upstream of Medicine Hat to form the South Saskatchewan River. The gross drainage areas of the Bow River and Oldman River basins are 25,600 km^2 and 28,300 km^2, respectively. The Bow and Oldman rivers generally flow southeast and east through the Foothills and Grassland natural regions. Most of the runoff from these two sub-basins is typically derived from spring snowmelt augmented by rainfall within the Rocky Mountain and Foothills portions of the basin. The Grassland Region is the largest region within the South Saskatchewan River basin in Alberta, extending from just west of Calgary to the Saskatchewan border. It is the warmest and driest region in Alberta.

The Ross Creek sub-basin has a gross drainage area of 4,790 km^2 and includes Ross Creek, Seven Persons Creek, and Bullshead Creek. The headwaters of the sub-basin are located in the Cypress Hills, southeast of Medicine Hat. While high flows in this sub-basin more commonly occur in the spring due to snowmelt runoff with or without rainfall, intense summer rainstorm events can often result in high annual peak flows.

A number of dams and flow diversion structures have been developed throughout the South Saskatchewan River basin for various purposes including: irrigation; low-flow augmentation; water supply for industrial, municipal, and domestic users; and hydropower. These developments have altered the natural flow regime in the South Saskatchewan River basin since the beginning of the twentieth century. It is important to note, however, that the existing system was not designed to mitigate floods.

2 FLOOD HISTORY

A description of local flood history has been prepared to provide context for the hydraulic model creation and calibration. The flood history documentation includes observational information and historical records for both open water and ice jam related flooding. Photography documenting the historic and recorded floods is provided in Appendix A.

2.1 Open Water Floods

2.1.1 Historic and Observed Open Water Floods

Historic floods refer to major floods that occurred prior to the period of hydrometric data collection and systematic recording of water level and discharge. The magnitude of historic floods can be estimated based on observations or even anecdotal information.

The available historic observations found in this study are summarized in **Table 1**. The historical floods listed in the table occurred prior to any systematic streamflow gauging. Details on the systematic record of stream gauges within the study reach are documented in the ***Open Water Hydrology Assessment*** study report (NHC, 2019a).

2.1.2 Recent and Recorded Open Water Floods

The WSC gauge for South Saskatchewan River at Medicine Hat (Station 05AJ001) provides the most representative estimate of flows for the South Saskatchewan River upstream of the confluence of Ross Creek. The WSC gauge for Seven Persons Creek at Medicine Hat (Station 05AH005) provides a relatively complete and long-term record of flows above the confluence of Ross Creek. Flows for the upper portion of Ross Creek can be obtained from the WSC gauge at Highway 41 (Station 05AH052), and the WSC gauge near Irvine (Station 05AH003) may be used to extend the period of record. Flows for Ross Creek near the mouth can obtained from the WSC gauge at Medicine Hat (Station 05AH049); however, these are only available for the period of 1985 to 1995. Flows on Bullshead Creek have been measured at the WSC gauge at Black and White Trail (Station 05AH053) – located upstream of the study reach – since 1995. **Table 2** summarizes the recent and recorded open water floods relevant to the study area.

Table 3 lists the recorded flood peak discharges for the largest open water floods. Salient information describing each recent and recorded flood event is provided in the sections that follow. On the South Saskatchewan River, three recorded open water flood events (1975, 1995, and 2013) had highwater mark data sufficient for model calibration. On Seven Persons Creek and Ross Creek, highwater marks were measured during the 2010 flood. No highwater mark data was available for the Bullshead Creek study reach.

Table 1 Historic and observed open water floods in the study area

Watercourse	Date	Details
South Saskatchewan River	June 24, 1897	The flood was believed to be caused by heavy rainfall in the mountains (Medicine Hat News, June 24, 1897). The water reached the highest point ever known in the town, though the damage at the town was believed to be minimal.[1]
	1902	Worst historical flood in Medicine Hat. The river was running very quickly and carrying all kinds of debris (Medicine Hat News, June 24, 1902). The water rose as far as the hospital grounds and the exhibition grounds. The wooden bridge over Seven Persons Creek was washed away and there was danger of the east approach to the CPR Bridge being washed out. [1] A peak instantaneous discharge of [5,660 m^3/s] was estimated by Water Survey Canada (WSC).[2]
	August, 1908	River Flats was inundated including Woolen Mills and Western Canneries (See **Figure A-1** at Appendix A). A peak instantaneous discharge of [5,240 m^3/s] was estimated by WSC.[2]
Ross Creek	1898	A local bridge at Ross Creek was washed out.[3]
	1903	The east end of Medicine Hat as well as Woolen Mills were affected by the flood (See **Figure A-2** at Appendix A). [4]
	1947	The railway bridge, surrounding properties, farm houses and transportation routes were impacted by this spring flood. (See **Figure A-3** at Appendix A). [4]
Seven Persons Creek	1899	Highwater was observed over the deck of a local bridge. [5]
	1960	Flooding was reported on 6th Ave SW, 7th Ave SW, Ball Park and 1st St NW (See **Figure A-4** at Appendix A). [4]
Bullshead Creek	1906	Trans Canada Highway WB Bridge approach was washed out.[6]
	1951	Flood occurred during Trans Canada Highway Bridge reconstruction.[6]
	1994	Spring highwater was 2.3 m above the streambed and caused localized flooding and some erosion issues.[6]

Notes:

1. Flood Over the Years by Grace Christie (Medicine Hat Museum Flood Documentation).
2. AENV (1986). Medicine Hat Floodplain Study, Main Report. Alberta Department of Environment, Water Resources Management Services, Technical Division, May 1986.
3. Alberta Transportation, Bridge File 00658.
4. Historical Imagery at Esplanade Arts and Heritage Centre Archive (http://archives.esplanade.ca/images).
5. Alberta Transportation, Bridge File 00659.
6. Alberta Transportation, Bridge File 00493W, Trans Canada Highway West Bound Bridge at Bullshead Creek.

Table 2 Recent and recorded open water floods observations in the study area

Watercourse	Date	Details
South Saskatchewan River	June 3, 1923	Flooding at Medicine Hat (see **Figure A-5**, Appendix A).[1] A peak instantaneous discharge of [4,110 m^3/s] was recorded by WSC for South Saskatchewan River gauge at Medicine Hat (Station 05AJ001).
	June 5, 1929	1929 flood was documented in previous Flood Hazard Study.[1] A peak instantaneous discharge of [3,450 m^3/s] was recorded for South Saskatchewan River gauge at Medicine Hat (Station 05AJ001) by WSC.
	June 5, 1932	Industrial Area and Railway Tracks were flooded (See **Figure A-6** at Appendix A).[2] A peak instantaneous discharge of [2,940 m^3/s] was recorded for South Saskatchewan River gauge at Medicine Hat (Station 05AJ001) by WSC.
	June 11, 1953	The City's power plant and water works system was damaged during the 1953 flood. The backwater from Seven Persons Creek contributed to flooding problems (See **Figure A-7** at Appendix A). Athletic baseball park was inundated.[3] Sections of the City hardest hit were the old Purmal subdivision and the industrial area east of the CPR main line.[1]
	June 23, 1975	The flood was well documented by Alberta Environment. Lion's Park along the South Saskatchewan River east of the Green House was inundated (See **Figure A-8** at Appendix A).[1]
	June 9-10, 1995	The flood caused $30.5 million damage at Medicine Hat. The flooding started in the Flats and Riverside (See **Figure A-9** at Appendix A). Both the Medicine Hat Arena and Athletic Park were affected. Water didn't go overtop the bridges at South Saskatchewan River but there was a fear that the floating debris could damage the bridge. Both Medicine Hat City Hall and the police station escaped the flooding.[3]
	June 10, 2005	The City of Medicine Hat declared State of Local Emergency during the 2005 flood. While notifications of possible evacuations were issued to residents of Harlow, Riverside and the South Flats, no homes were evacuated.[3] The flood water carried lots of mud during the 2005 flood (See **Figure A-10** at Appendix A).[1] A peak instantaneous discharge of [3,790 m^3/s] was recorded at South Saskatchewan River gauge at Medicine Hat (Station 05AJ001) by WSC.

Table 2 Recent and recorded open water floods observations in the study area (continued)

Watercourse	Date	Details
South Saskatchewan River	June 23-24, 2013	Overland flow occurred along the South Saskatchewan River at Lions Park, Harlow, Riverside, Water Plant and Power Plant, River Road, and along the Seven Persons Creek (from backflow) (See Figure A-11 at Appendix A). During the flood, approximately 3000 homes were evacuated and a total number of 561 properties were affected by overland flooding or sewer back up. Trans-Canada Highway East and West Bound Bridges were under threat of being closed to the public due to the floodwater rising to within 1 m of the freeboard. Approximate Estimated damage in City of Medicine Hat is $42 million.[4]
Ross Creek	March 4, 1994	A chinook on March 4 caused high runoff and localized flooding (See **Figure A-12** at Appendix A).[5]
	June 19-20, 2010	The Trans-Canada highway flooded between Dunmore and Maple Creek, the village of Irvine was inundated. Farms and ranches, CPR tracks adjacent to Creek had seriously impacted (See **Figure A-13** at Appendix A).[3]
Seven Persons Creek	March 31, 1952	The late March 1952 flood was occurred because of unusual high spring runoff. Largest flow on Seven Persons Creek was recorded during the flood (See **Figure A-14** at Appendix A). The areas affected most were those in South Flats industrial district, Purmal subdivision, residential properties near Kingsway Avenue and Allowance Avenue and properties adjoining Kipling Street, Spencer Street and Marshall Avenue.[1]
	1994	A low volume but high peak flood occurred (see **Figure A-12**, Appendix A).[6]
	June 19-20, 2010	The Golf Course area has been affected badly.[3] Also there was standing water in South Flats (see **Figure A-13**, Appendix A).[7]

Notes:

1. AENV (1986). Medicine Hat Floodplain Study, Main Report. Alberta Department of Environment, Water Resources Management Services, Technical Division, May 1986.
2. Historical Imagery at Esplanade Arts and Heritage Centre Archive (http://archives.esplanade.ca/images).
3. Flood Over the Years by Grace Christie (Medicine Hat Museum Flood Documentation).
4. AECOM (2014). Southern Alberta Flood Mitigation Feasibility Study for Sheep, Highwood River Basins and South Saskatchewan River Sub-basin – and South Saskatchewan River Sub-basin Water Management Plan. Prepared by AECOM, June 2014.Prepared for Alberta Flood Recovery Task Force, June 2014.
5. Alberta Transportation, Bridge File 00658.
6. Alberta Transportation, Bridge File 00659.
7. The Calgary Herald (June 20, 2010).

Table 3 Associated peak discharges published by Water Survey of Canada for recent and recorded open water floods on South Saskatchewan River and local tributaries

Year	Peak Discharge (m^3/s)			
	South Saskatchewan River at Medicine Hat	Seven Persons Creek at Medicine Hat	Ross Creek at Highway 41	Bullshead Creek at Black and White Trail
1953	4,300 11 June 08:30	n/a	n/a	n/a
1975	3,170 23 Jun 01:00	n/a	n/a	n/a
1995	5,110 09 Jun 19:30	n/a	n/a	n/a
2010	n/a	76.7 19 Jun 16:05	209 19 Jun 00:00	81.6 18 Jun 12:01
2013	5,040 24 Jun 01:15	n/a	n/a	n/a

1953 Flood

The 1953 flood is the largest flood since the continual systematic collection of gauge data was initiated at Medicine Hat. This flood resulted from a massive storm which brought heavy precipitation over a large portion of the South Saskatchewan River basin during late May and first two weeks of June. WSC published a peak instantaneous flow of 4,300 m^3/s at Medicine Hat, reaching a stage of 8.9 m at the WSC gauging station near Finlay bridge (AENV, 1986). The backup of water from the South Saskatchewan River into Ross Creek and Seven Persons Creek made the flooding worse. A single highwater mark is available at the WSC 05AJ001 gauge site (downstream side of Finlay Bridge).

1975 Flood

The 1975 flood was well documented by Alberta Environment. The flood had a peak discharge of 3,170 m^3/s recorded at WSC gauge 05AJ001 on June 23 at 01:00. A highwater mark survey is available at Medicine Hat along the right bank of the South Saskatchewan River as well as two points along Seven Persons Creek.

1995 Flood

The 1995 flood was one of the biggest floods along the South Saskatchewan River at Medicine Hat. Most of the flood water originated from the Oldman River Basin. WSC published a peak instantaneous flow at Medicine Hat of 5,110 m^3/s on 09 June at 19:30. A highwater mark survey is available for this event.

2010 Flood

In 2010, flooding occurred along the local tributaries of the South Saskatchewan River including Ross Creek, Seven Persons Creek, and Bullshead Creek. The flood of 2010 came with very little warning and few people can remember the last time flooding from these tributaries caused so much damage. The recorded peak discharges were 209 m^3/s at Ross Creek at Highway 41, 76.7 m^3/s Seven Persons Creek at Medicine Hat and 81.6 m^3/s at Bullshead Creek at Black and White Trail. A highwater mark report is available for this event along Ross Creek and Seven Persons Creek.

2013 Flood

In June 2013, most of the flood water in the South Saskatchewan River at Medicine Hat originated from the Bow River Basin. WSC published a peak instantaneous flow at Medicine Hat of 5,040 m^3/s on 24 June at 01:15. During the flood, Alberta Environment collected the location and elevation of highwater marks along the flooded area. Alberta Environment also acquired aerial photography during the flood, to record the extent of the flooded areas (AECOM, 2014). The highwater marks were used to inform the model calibration.

2.2 Ice Affected Floods

Severe flooding under ice affected conditions is generally attributed to the accumulation of river ice in the form of an ice jam. Flooding due to ice jamming in the reach of the South Saskatchewan River at Medicine Hat was documented in 1951. The 1951 ice jam developed when ice accumulated and lodged at a sharp bend in the river several kilometers downstream of the City Centre (AENV, 1986). Over a few hours, the ice continued to accumulate and progressed upstream past Medicine Hat on March 31, 1951. The jam caused an abrupt increase in river stage and the backing up of water on both Seven Persons and Ross Creeks. The spring runoff water arriving from Seven Persons Creek and Ross Creek contributed to the flooding. The ice jam remained in place for about 5 days and caused more than 60 homes to flood, 12 families to evacuate, and several industries to be closed (AENV, 1986) (see **Figure A-15** and **Figure A-16**, Appendix A).

On March 17, 1918, Seven Persons Creek experienced a flood which was attributed to ice jamming at the Hedley Shaw Railway bridge. The southwest corner of the Flats and the South Railway Street area were heavily affected. Almost 300 homes were inundated (Christie, 2018).

3 AVAILABLE DATA

Key data used to develop and calibrate the hydraulic model includes high-resolution terrain data representing the geometry of the floodplain, highwater marks, gauge data, and associated rating curves. Additional information such as past studies, historical flood photographs, and existing hydraulic models, also informed model development and calibration. The data available for this study is summarized below.

3.1 Hydrology Summary

An open water hydrology assessment, documented in the ***Open Water Hydrology Assessment*** study report (NHC, 2019a), determined estimates of flood frequencies for both regulated and natural conditions for a range of return periods up to 1000 years at the following eight flow change locations:

- South Saskatchewan River at Medicine Hat (WSC Station 05AJ001)
- South Saskatchewan River below Ross Creek
- Ross Creek at Highway 41 (WSC Station 05AH052)
- Ross Creek below Bullshead Creek
- Ross Creek below Seven Persons Creek
- Seven Persons Creek at Medicine Hat (WSC Station 05AH005)
- Seven Persons Creek at the mouth
- Bullshead Creek at Black and White Trail (WSC Station 05AH052)

In accordance with the terms of reference and FHIP guidelines, flood frequency water level profiles were calculated using the naturalized flood frequency discharges. **Table 4** summarizes the naturalized flood frequency discharges from the 2- to 1000-year floods, with associated probabilities of exceedance in any given year.

Table 4 **Naturalized flood frequency discharge estimates for the South Saskatchewan River and local tributaries**

Return Period (Years)	Probability of Exceedance in Any Given Year (%)	Naturalized Flood Frequency Discharge (m^3/s)					
		South Saskatchewan River at Medicine Hat below Ross Creek	Ross Creek at Highway 41	Ross Creek below Bullshead Creek	Ross Creek below Seven Persons Creek	Seven Persons Creek at Medicine Hat at the mouth	Bullshead Creek at Black and White Trail
1,000	0.10	12,700	225	263	425	162	145
750	0.13	11,700	215	256	411	155	139
500	0.20	10,500	201	249	393	144	132
350	0.29	9,470	189	224	360	136	118
200	0.50	8,030	169	207	328	121	107
100	1.0	6,500	145	188	292	104	92.3
75	1.3	5,950	136	177	274	97	85.9
50	2.0	5,210	121	152	239	87	72.8
35	2.9	4,630	110	144	222	78	66.9
20	5.0	3,810	91	118	182	64	52.6
10	10	2,930	68	92.3	140	48	38.1
5	20	2,180	45	64.7	95.7	31	24.2
2	50	1,320	17	28.7	40.7	12	7.79

3.2 Digital Terrain Model Data

A digital terrain model (DTM) based on airborne LiDAR data was supplied by AEP for this study. The DTM was developed from data collected by Airborne Imaging (Airborne Imaging, 2018). A complete description of the digital terrain model data, including a comparison to ground survey data, is provided in the ***Survey and Base Data Collection*** study report (NHC, 2019b).

3.3 Survey Data

The development of the hydraulic model relied on survey data of the river cross sections, bridges, and flood control structures. Control points were also established to validate the DTM and facilitate the extension of the river cross sections through the overbank beyond the expected flood inundation limits. The majority of the survey program was conducted during the fall of 2017 with some additional surveying completed during the summer of 2018; the survey data is documented in the ***Survey and Base Data Collection*** study report (NHC, 2019b).

A total of 667 cross sections were modelled: 120 on the South Saskatchewan River, 157 on Ross Creek, 282 on Seven Persons Creek, and 108 on Bullshead Creek. The cross section locations were selected to capture changes in key hydraulic parameters such as the width and depth and at the location of islands.

Cross sections were surveyed immediately upstream and downstream of bridges and culverts to facilitate the calculation of the energy losses and resulting water surface elevations through the structures and over embankments under high flow conditions. Additional cross sections were surveyed approximately one channel width upstream and downstream of the bridge faces. Model bridge geometry was derived from survey data and available bridge design drawings. The profile of the approaches and embankments was derived from the DTM.

3.4 Existing Hydraulic Models

A hydraulic model was developed previous as part of the 1986 Medicine Hat Floodplain Study. This model included the South Saskatchewan River, Seven Persons Creek, and a small portion of Ross Creek which was limited to the City of Medicine Hat. Model parameters from the 1986 Study were referenced during the development and calibration of the hydraulic model for this study. The calibrated channel roughness and prescribed overbank roughness values for this study were comparable to the values found in the 1986 Study.

3.5 Highwater Marks

Highwater mark observations provide documentation of the peak water levels that occurred at a given location for a particular flood of interest. These data are used for hydraulic model calibration and validation by comparing simulated water levels to the observed highwater mark elevations along the study reach. For this study, open water highwater marks were found in records from WSC and the Government of Alberta. Highwater marks were available on the South Saskatchewan River during floods in 1953, 1975, 1986, 1995, 2002, and 2013. On Ross Creek, highwater marks were available in 2002, 2010 and 2013. Finally, highwater marks were available on Seven Persons Creek in 1975, 2002, 2010, and 2013. All of the highwater marks occurred during open water flood events except for the 1986 flood on the South Saskatchewan River which occurred due to an ice jam. **Table 5** provides a summary of the open water highwater mark data available for each flood event.

The location of the highwater mark data found for this investigation are depicted on **Figure 2**.

Table 5 Summary of open water highwater marks

Location Name	Highwater Mark ID	River Station (m)	Event Date	Highwater Mark Elevation (m)
South Saskatchewan River				
WSC Gauge Site		29893.9	11-Jun-53	660.95
Below Powerline North of Power House		33142.7	23-Jun-75	660.88
15 m U/S from TransCanada Highway Bridge		32931.2	23-Jun-75	660.96
15 m D/S from TransCanada Highway Bridge		32829.2	23-Jun-75	660.9
106 m U/S from Junction of Harris St and Red Deer Dr		32476.8	23-Jun-75	660.76
92 m D/S from Junction of Harris St and Red Deer Dr		32262.8	23-Jun-75	660.72
30 m U/S from Finlay Bridge		29938.2	23-Jun-75	659.95
46 m D/S from Finlay Bridge		29850.0	23-Jun-75	659.91
30 m U/S from Railway Bridge		29735.2	23-Jun-75	659.91
15 m D/S from New Bridge		29449.7	23-Jun-75	659.79
30 m East and 15 m North of NE corner of YM-YWCZ BLDG		29297.2	23-Jun-75	659.73
46 m North and 15 m East of Junction of Woodman and 2nd St SE		28543.4	23-Jun-75	658.76
91 m North and 30 m West of Junction of Minto Ave and 5th St SE		27881.9	23-Jun-75	658.79
East End of Bram St and approximate 106 m east of Minto Ave		27661.7	23-Jun-75	658.77
SW 5-13-6-W4 - Redcliff River Valley Park	95-SSASK-1	39675.5	10-Jun-95	665.32
TransCanada Highway Bridge	95-SSASK-2	32915.3	10-Jun-95	663.64
TransCanada Highway Bridge	95-SSASK-2	32901.4	10-Jun-95	663.50
U/S 877 3rd St NW	95-SSASK-3	32233.5	10-Jun-95	662.97
550 - 1st St NW	95-SSASK-4	31556.2	10-Jun-95	662.84
1st St and 4th Ave NW	95-SSASK-5	31274.8	10-Jun-95	662.60
1st St and 2nd Ave NW	95-SSASK-6	30915.9	10-Jun-95	662.44
1st St and Division Ave	95-SSASK-7	30538.6	10-Jun-95	662.29
Parkview Dr and 1st Ave	95-SSASK-8	30072.7	10-Jun-95	662.04
Findlay St Bridge	95-SSASK-9	29882.2	10-Jun-95	661.85

Table 5 Summary of open water highwater marks (continued)

Location Name	Highwater Mark ID	River Station (m)	Event Date	Highwater Mark Elevation (m)
South Saskatchewan River				
D/S of RR bridge	95-SSASK-10	29665.9	10-Jun-95	661.87
Entrance to Police Point Park	95-SSASK-12	25260.1	10-Jun-95	659.06
SE 8-13-5-W4M	95-SSASK-15	23318.4	10-Jun-95	658.25
NE 17-13-5-W4M	95-SSASK-16	16652.3	10-Jun-95	654.46
SW 20-13-5-W4M	95-SSASK-17	14242.2	10-Jun-95	652.72
Findlay St Bridge		29882.2	13-Jun-02	658.46
	2013-SSASK-1-a	39714.8	24-Jun-13	665.63
	2013-SSASK-1-b	39704.6	24-Jun-13	665.74
	2013-SSASK-2-a	33007.2	24-Jun-13	663.63
	2013-SSASK-2-b	32915.6	24-Jun-13	663.70
	2013-SSASK-3-a	32231.8	24-Jun-13	663.16
	2013-SSASK-5-a	31276.9	24-Jun-13	662.76
	2013-SSASK-6-a	30932.7	24-Jun-13	662.52
	2013-SSASK-7-b	30535.1	24-Jun-13	662.25
	2013-SSASK-7-a	30527.4	24-Jun-13	662.29
	2013-SSASK-8-a	30089.5	24-Jun-13	662.08
	2013-SSASK-9.1-a	29891.6	24-Jun-13	661.81
	2013-SSASK-9-a	29887.5	24-Jun-13	661.84
	2013-SSASK-9-b	29885.8	24-Jun-13	661.95
	2013-SSASK-9-c	29883.8	24-Jun-13	662.02
	2013-SSASK-10-a	29632.3	24-Jun-13	661.82
	2013-SSASK-11-a	29447.0	24-Jun-13	661.83
	2013-SSASK-12-a	24856.1	24-Jun-13	658.95
	2013-SSASK-14-a	24282.3	24-Jun-13	658.87
	2013-SSASK-16-a	16662.6	24-Jun-13	654.58
	2013-SSASK-17-a	13473.1	24-Jun-13	652.68
Ross Creek				
Industrial Avenue		2144.8	13-Jun-02	659.17
Highway 41 Bridge at WSC gauge	2010-MHRC-6-c	24529.5	19-Jun-10	704.04
Highway 41 Bridge at WSC gauge	2010-MHRC-6-a	24512.3	19-Jun-10	704.02
Highway 41 Bridge at WSC gauge	2010-MHRC-6-b	24475.5	19-Jun-10	703.77
Range Road 51A Bridge	2010-MHRC-5-a	14788.9	19-Jun-10	693.61
Range Road 51A Bridge	2010-MHRC-5-b	14768.6	19-Jun-10	693.54

Table 5 Summary of open water highwater marks (continued)

Location Name	Highwater Mark ID	River Station (m)	Event Date	Highwater Mark Elevation (m)
Ross Creek				
Day St Bridge	2010-MHRC-4-a	2926.6	19-Jun-10	663.68
Day St Bridge	2010-MHRC-4-b	2910.9	19-Jun-10	663.73
Industrial Ave Bridge	2010-MHRC-3-b	2189.2	19-Jun-10	662.14
Industrial Ave Bridge	2010-MHRC-3-a	2168.0	19-Jun-10	661.79
Industrial Ave and Porcelain Ave	2010-MHRC-2-b	1611.1	19-Jun-10	660.15
Industrial Ave and Porcelain Ave	2010-MHRC-2-a	1603.6	19-Jun-10	660.12
	2013-MHRC-2-a	1592.2	28-Jun-13	659.352
	2013-MHRC-2-b	1589.1	28-Jun-13	659.386
	2013-MHRC-2-c	1611.1	28-Jun-13	660.386
	2013-MHRC-2-d	1589.8	28-Jun-13	660.164
	2013-MHRC-2-e	1624.0	28-Jun-13	660.414
	2013-MHRC-3-a	2160.5	28-Jun-13	660.358
	2013-MHRC-3-b	2160.9	28-Jun-13	660.361
	2013-MHRC-3-c	2184.3	28-Jun-13	659.259
Seven Persons Creek				
Bray Home Site		241.69	1953	659.29
	HWM-14	53.9	Jun-75	658.26
	HWM-15	343.6	Jun-75	658.32
At Dunmore Road		2432.0	13-Jun-02	659.61
At South Railway Avenue		1133.6	13-Jun-02	657.38
At Industrial Avenue		530.6	13-Jun-02	657.36
Upstream of Hwy 1	2010-MH7P-2B-b	4648.2	19-Jun-10	670.10
Downstream of Hwy 1	2010-MH7P-2A-c	4517.0	19-Jun-10	668.95
College Avenue Bridge	2010-MH7P-3-a	3445.7	19-Jun-10	665.07
Access bridge near intersection of Kipling St and 3 Ave	2010-MH7P-4-a	3210.6	19-Jun-10	663.63
Railroad Bridge south of Spencer St	2010-MH7P-5-a	3004.0	19-Jun-10	662.86
Dunmore Road Bridge	2010-MH7P-6-b	2439.3	19-Jun-10	661.96
South railway St Bridge	2010-MH7P-7-a	1149.8	19-Jun-10	659.81
Industrial Ave Bridge	2010-MH7P-9-a	530.5	19-Jun-10	659.75
	2013-MH7P-7-a	1154.07	28-Jun-13	659.679
	2013-MH7P-7-b	1126.6	28-Jun-13	659.463
	2013-MH7P-9-a	531.6	28-Jun-13	659.624
	2013-MH7P-9-b	548.0	28-Jun-13	659.455

3.6 Gauge Data and Rating Curves

Water level (stage) records and rating curves from WSC hydrometric gauging stations located along the study reaches were used to support creation and calibration of the hydraulic model – their station name and period of record are listed in **Table 6**.

Table 6 List of hydrometric gauges supporting model creation and calibration

Station Name	Period of Record
South Saskatchewan River at Medicine Hat (05AJ001)	1911-Present
Ross Creek at Highway 41 (05AH052)	2000-Present (seasonal)

3.7 Flood Photography

A series of historical flood photographs documenting local floods were compiled and annotated. The set of photographs are provided in Appendix A.

4 RIVER AND VALLEY FEATURES

4.1 Channel Characteristics

The South Saskatchewan River channel follows an irregular meander pattern with the occurrence of occasional islands, mid-channel bars, and point bars. The channel shape is partly entrenched and confined by the valley (Kellerhals et al, 1972). The reach-average channel slope is 0.00053 m/m. The channel bed material consists of gravel over soft cohesive (shale) bedrock; bank materials consist of gravel overlain by silt, silt and sand, and till (Kellerhals et al, 1972). Based on 2-year flow conditions, the average top width through the South Saskatchewan River is about 200 m and the mean depth is about 5.5 m.

The reach average channel slope for Ross Creek, Seven Persons Creek and Bullshead Creek are 0.0019 m/m, 0.0022 m/m and 0.0022 m/m respectively. Based on 2-year flow conditions, the average top width through the Ross Creek was 29 m and the mean depth was about 2.2 m. The average top width and mean depth for Seven Persons Creek was 16 m and 2.3 m, respectively; the average top width and mean depth for Bullshead Creek was 1.6 m and 1.3 m, respectively.

4.2 Floodplain Characteristics

The floodplain of the South Saskatchewan River is generally fragmented, narrow, and covered mostly in shrub vegetation with some cultivation. The valley slopes are sparsely forested and are prone to occasional slumps (Kellerhals et al, 1972).

4.3 Hydraulic Structures

The study area of the Medicine Hat River Hazard Study contains a total of 61 bridges, 8 culverts, and 1 weir. The descriptions and locations with respect to the established model river stationing are provided in **Table 7**. Detailed information concerning the bridge configurations can be found in Appendix B of the ***Survey and Base Data Collection*** study report (NHC, 2019b).

Table 7 Hydraulic structures located within the study area

Reach	Description	River Station (m)	Structure Type
South Saskatchewan River	BF78572 - Trans-Canada Highway EB	32,888	Bridge
	BF73802 - Trans-Canada Highway WB	32,857	Bridge
	Finlay Bridge	29,902	Bridge
	CPR Bridge	29,692	Bridge
	Maple Avenue Bridge	29,476	Bridge

Table 7 Hydraulic structures located within the study area (continued)

Reach	Description	River Station (m)	Structure Type
Ross Creek	BF75672 - Highway 41	24,494	Bridge
	Private Road 1	19,772	Bridge
	Private Road 2	19,702	Bridge
	Range Road 51A	14,777	Bridge
	Private Road 3	9,914	Bridge
	Day Street Bridge	2,921	Bridge
	Industrial Avenue Bridge	2,153	Bridge
	Porcelain Avenue Bridge	1,603	Bridge
Seven Persons Creek	Private Road 1	23,810	Bridge
	BF2164 - Township Road 120	23,384	Culvert
	Desert Blume Golf Course Bridge 1	18,491	Bridge
	Desert Blume Golf Course Bridge 2	18,278	Bridge
	Desert Blume Golf Course Bridge 3	18,128	Bridge
	Desert Blume Golf Course Bridge 4	17,800	Bridge
	Desert Blume Golf Course Bridge 5	17,601	Bridge
	Desert Blume Golf Course Bridge 6	16,934	Bridge
	Desert Blume Golf Course Bridge 7	16,139	Bridge
	Desert Blume Golf Course Bridge 8	15,465	Bridge
	BF1155 - South Boundary Road	14,241	Bridge
	Private Road 2	10,869	Bridge
	Cottonwood Coulee Golf Course Bridge 1	9,095	Bridge
	Cottonwood Coulee Golf Course Bridge 2	9,004	Bridge
	Cottonwood Coulee Golf Course Bridge 3	8,844	Bridge
	Cottonwood Coulee Golf Course Bridge 4	8,776	Bridge
	Cottonwood Coulee Golf Course Bridge 5	8,338	Bridge
	Cottonwood Coulee Golf Course Bridge 6	8,326	Bridge
	Cottonwood Coulee Golf Course Bridge 7	8,116	Bridge
	Cottonwood Coulee Golf Course Bridge 8	8,018	Bridge
	Cottonwood Coulee Golf Course Bridge 9	7,851	Bridge
	Paradise Valley Golf Course Bridge 1	7,245	Bridge
	Paradise Valley Golf Course Bridge 2	7,185	Bridge
	Paradise Valley Golf Course Bridge 3	6,748	Bridge
	Paradise Valley Golf Course Bridge 4	6,633	Bridge
	Paradise Valley Golf Course Bridge 5	6,299	Bridge

Table 7 Hydraulic structures located within the study area (continued)

Reach	Description	River Station (m)	Structure Type
Seven Persons Creek	Paradise Valley Golf Course Bridge 6	6,149	Bridge
	Pedestrian Bridge	5,273	Bridge
	Pedestrian Bridge	5,035	Bridge
	BF73807 - Trans-Canada Highway	4,611	Culvert
	Kin Coulee Road	4,517	Bridge
	Kin Coulee Park Weir	4,206	Weir
	Kin Coulee Park Pedestrian Bridge 1	4,108	Bridge
	Kin Coulee Park Pedestrian Bridge 2	3,724	Bridge
	College Avenue Culvert	3,433	Culvert
	Private Road 4	3,217	Bridge
	Private Rail Bridge	3,000	Bridge
	Pedestrian Bridge	2,978	Bridge
	Pedestrian Bridge	2,724	Bridge
	Dunmore Road	2,453	Bridge
	Pedestrian Bridge	1,785	Bridge
	BR-11 Carry Drive Bridge	1,144	Bridge
	CPR Bridge	1,065	Bridge
	Industrial Avenue Bridge	539	Bridge
	Abandoned Piers	343	Bridge
	Pedestrian Bridge	121	Bridge
Bullshead Creek	BF81332 - Township Road 120 2KM SW of Dunmore	9,962	Culvert
	CPR branch line	4,264	Culvert
	BF493 - Trans-Canada Highway EB	3,488	Culvert
	BF493 - Trans-Canada Highway WB	3,457	Bridge
	Ross Creek Golf Course Bridge 1	3,333	Bridge
	Ross Creek Golf Course Bridge 2	3,248	Bridge
	Ross Creek Golf Course Bridge 3	3,141	Bridge
	Ross Creek Golf Course Bridge 4	2,928	Bridge
	54 Street SE (Location 1)	2,894	Culvert
	CPR Bridge	2,480	Bridge
	54 Street SE (Location 2)	2,364	Culvert

4.4 Flood Control Structures

There are six dedicated flood control structures within the study reach **(Table 8)**. The locations and extents of flood control structures are illustrated in **Figure 3**.

The extents of three of the flood control structures (Harlow Area -Phase 1, Riverside – Phase 1, and Lions Park Overland Flow Protection Strategy – Phase 1 and 2) were measured during the field survey. They were installed in response to the 2013 flood. The Harlow Area – Phase 1 flood control structure protects residential development on the south (right) river bank from the Highway 1 embankment at the upstream end, along Red Deer Street SW and Harris Street SW, downstream to Finlay Court SW. Construction began in the fall of 2014 and was completed in the spring of 2015. The Riverside – Phase 1 flood control structure protects residential development on the north (left) river bank from 1st Avenue NE to Finlay Bridge, with a demountable floodwall that crosses Altawana Avenue NE. Construction was completed during the summer of 2016. The Lions Park flood control structure protects an area of Medicine Hat along the south bank known as the North Flats and extends from Altawana Drive NE downstream to Queen Street SE, with floodwalls at Ash Avenue SE and 5th Street SE. Construction was started in the spring of 2015 and completed in 2016. Detailed information concerning these flood control structures is available in Appendix C of the ***Survey and Base Data Collection*** study report (NHC, 2019b).

AEP provided information on the other three flood control structures (Water Treatment Plant, Harlow Area – Phase 2, and Industrial Avenue) to include in the study in 2021. These flood control structures were not surveyed as part of this river hazard study. The Water Treatment Plant flood control structure protects the Power Plant and Water Treatment Plant. The Harlow-Phase 2 flood control structure extends the protection on the south (right) river bank residential development in the Harlow neighborhood downstream to Valleyview Drive SW. The Industrial Avenue flood control structure is an extension of the Lions Park Overland Flow Protection Strategy and protects the North Flats area, north of the CP Rail lines along Seven Persons Creek.

Table 8 Flood control structure summary

River	Description	Upstream River Station (m)	Downstream River Station (m)	Crest Length (m)	Source
South Saskatchewan River	Harlow Area – Phase 1	32,700	31,954	775	NHC Field Survey (2017)
	Riverside – Phase 1	30,178	29,912	350	
	Lions Park Overland Flow Protection Strategy- Phases 1 and 2	29,304	27,102	2,295	
	Water Treatment Plant	33,143	32,873	335	AEP (2021)
	Harlow Area – Phase 2	31,954	31,830	370	
Seven Persons Creek	Industrial Avenue	1,063	0	1,112	

4.5 Other Features

The majority of major infrastructure and populated areas within the study area are found in the City of Medicine Hat. Other features of note within the study area highlighted below.

- Medicine Hat Power Plant and Water Treatment Plant is located on the right bank of the South Saskatchewan River at river station 32,996 m.
- Medicine Hat Provincial Law Courts, the Court of Queen's Bench, City Hall, Public Library all are located on the right bank on the South Saskatchewan River between river station 30,278 m to 29,912 m.
- Athletic Park is located along the right bank of the South Saskatchewan River at river stations 28,981 m.
- Police Point Park is located on the meander bend (left bank) on the South Saskatchewan River starting at river station 27,944 m.
- Lions Park is located along the right bank of the South Saskatchewan River at river station 27,944 m.
- Strathcona Island Park is located on the right bank of the South Saskatchewan River at river station 27,259 m.
- Medicine Hat Wastewater Treatment Plant is located on the South Saskatchewan River starting at river station 25,470 m.

5 MODEL CONSTRUCTION

5.1 HEC-RAS Program

The U.S. Army Corps of Engineers *Hydrologic Engineering Center-River Analysis System* (HEC-RAS) computer program (Version 6.1) was used to calculate the flood levels along the study reach. The basic inputs required by HEC-RAS are a series of cross sections with known distances between sections, roughness coefficients for the channel and overbank areas for each cross section, inflow discharge at the upstream limits of each reach, and a prescribed water level at the downstream outflow boundary.

5.1.1 Theoretical Aspects

HEC-RAS can perform one-dimensional (1D), two-dimensional (2D), or combined 1D and 2D hydraulic calculations for a network of channels and hydraulic structures. For this study, a 1D model was constructed to calculate water surface profiles for steady state gradually varied flow. The computational procedure for steady flow calculations are based on the solution of the 1D energy equation. Energy losses between river sections are calculated as friction losses (using Manning's equation) and expansion/contraction losses. The momentum equation is used by the model where rapidly varied flow conditions arise, for the hydraulics through bridges, and for evaluating water surface profiles at stream junctions. The analytical approach employed by HEC-RAS has the following assumptions and potential limitations:

- Flow is gradually varied and boundary friction losses between cross sections are estimated by Manning's equation using section-average parameters.
- The geometry is assumed to be fixed and changes in the channel and floodplain geometry that may occur during a flood are not accounted for.
- Each model cross section is apportioned into three separate conveyance components representing the main channel, left overbank, and right overbank; the water level is assumed to be constant across all three conveyance components.
- The flow is one-dimensional.

5.1.2 General Model Setup

Geometric Layout

The following describes the approach for developing the key components comprising the geometric layout of the model.

- Channel centrelines followed along the middle of the main channel of the South Saskatchewan River and the three local tributaries – Ross Creek, Seven Persons Creek, and Bullshead Creek. The

centreline was digitized using ArcGIS tools and visual referencing of the DTM and aerial imagery. A single continuous centreline was created to represent each individual model reach.

  - The *South Saskatchewan River Upper* reach represented the model reach upstream of the confluence with Ross Creek and the *South Saskatchewan River Lower* reach represented the model reach downstream of the confluence with Ross Creek.
  - The *Ross Creek Upper* reach extended from the upstream study limit of Ross Creek down to the confluence with Bullshead Creek. The *Ross Creek Middle* reach extended from the Bullshead Creek confluence down to the confluence with Seven Persons Creek and the *Ross Creek Lower* reach represented the remaining section downstream of Seven Persons Creek to the South Saskatchewan River.
  - Seven Persons and Bullshead creeks were represented by single channel centerlines denoted as *Seven Persons Creek Lower* and *Bullshead Creek Lower*, respectively.

- Flow path lines were digitized along the mainstem of each river (coincident with the channel centerlines) and along the left and right floodplains so as to represent the length of the flow path in the main channel, left overbank, and right overbank. The distance between cross sections were measured along flow path lines between cross sections. These lengths are used by the model to estimate the energy loss between cross sections within the main channel and floodplain (left and right overbank areas).
- Model cross sections were digitized at each surveyed cross section. Each model cross section was comprised of three portions. A portion crossing the main channel directly over top of the hydrographic and bank survey data. The main channel portion was then extended left and right across the floodplain (overbank areas) and up the valley walls. The overbank portions were aligned perpendicular to the anticipated path of the floodplain flows. A coarse 2D model was used to help visualize the floodplain flow paths and orient the overbank portions of the cross sections. The overbank portions were projected far enough to extend beyond the 1000-year flood inundation extents. Cross section elevation values from the survey point survey data were projected onto the cross section lines using the HEC-GeoRAS GIS toolset through a process denoted herein as conflation. Elevation data in the overbank areas was determined by sampling elevation values from the underlying DTM along the cross section polylines.
- The location of the left and right banks (denoted as bank stations) were determined by inspection of the cross section geometry and examining the channel geometry as represented by the DTM. The model bank stations demarcate the extent of the left overbank, main channel, and right overbank portions of the model cross section.

Channel and Overbank Roughness

Manning's roughness values were used to simulate roughness in the modelled reaches. At each cross section, roughness was varied horizontally across the channel, as required, to represent changes in river and floodplain characteristics. A minimum of three (one channel and two overbank) roughness values

were used within each cross section. The number of roughness values used was dependent on the complexity of the channel and the presence of distinct features, such as bars and islands.

Manning's roughness is used to account for an array of energy losses that may vary with respect to discharge. Due to the complexity and length of the model and the limited spatial distribution of calibration data, roughness values were assumed to be constant with discharge. At the locations where rating curve data were available, using a single roughness value for all discharges provided reasonable results. Roughness values were set for the overbank areas based on inspection of the land cover information deduced from survey photographs, aerial imagery, and the DTM. The adopted channel roughness values were comparable to those determined in the previous flood hazard study (AENV, 1986).

Expansion and Contraction Coefficients

To account for the effect of flow contraction or expansion on the energy balance between successive cross sections, HEC-RAS multiplies the absolute difference in velocity head by a coefficient. The coefficients range from 0.10 for gradual transitions to 0.80 for abrupt transitions (Brunner, 2016). The default values of 0.1 and 0.3 (for expansion and contraction coefficients) were utilized throughout the majority of the hydraulic model. Expansion and contraction coefficients were increased to 0.3 and 0.5, respectively for cross sections located near bridges where flow through the bridge opening resulted in rapid contraction of the flow. The coefficients were also increased where the cross-sectional area quickly expands such as at the confluence of Ross Creek with the South Saskatchewan River.

Boundary Conditions

Boundary conditions are required at the inflow and outflow boundaries of the model as well as at the internal boundaries located at the junctions within the model domain. HEC-RAS defines junctions as locations where two or more streams converge together or split apart. Within the Medicine Hat study reach, all of the junctions occur where two streams converge together. Junctions divide the streams in the model domain into sub-reaches. The sub-reaches of the HEC-RAS model are summarized in **Table 9**. Discharge is required as the boundary condition at the upstream end of each sub-reach.

Each junction within the model domain represent internal boundaries through which the discharge of the upstream sub-reaches pass into the downstream sub-reach. The hydraulics of the junctions were calculated using the momentum equation which calculates the energy losses through the junction using the internal angle between the upstream sub-reaches.

A normal depth water level approximation was assigned as the boundary condition at the downstream boundary of the South Saskatchewan River. The normal depth slope was 0.0008 m/m which was calculated based on the reach-averaged energy grade line slope near the downstream limit of the study reach.

Table 9 Summary of Model Sub-Reaches

Stream Name	HEC-RAS Model Sub-Reach	Upstream River Station (m)	Flow Zone Name
South Saskatchewan River	Upper	45,325	South Saskatchewan River above Ross Creek
	Lower	26,592	South Saskatchewan River below Ross Creek
Ross Creek	Upper	25,004	Ross Creek above Bullshead Creek
	Middle	8,553	Ross Creek above Seven Persons Creek
	Lower	880	Ross Creek below Seven Persons Creek
Seven Persons Creek	Lower	24,132	Seven Persons Creek above Ross Creek
Bullshead Creek	Lower	10,054	Bullshead Creek above Ross Creek

5.2 Geometric Database

The geometric database provides all of the components of the HEC-RAS model geometry developed using the geospatial analysis tool within ArcGIS. The HEC-GeoRAS toolbox facilitated the development of the model geometry. Further processing of the data was performed using the HEC-RAS geometry editor. The following describes the content of the geometric database and methods for model geometry development. The resulting geometric database is provided as part of the electronic deliverables of the study.

5.2.1 Cross Section Data

Cross section alignments were established in ArcGIS following the general path of the topographic and hydrographic survey points for each of the surveyed cross section (refer to Section 3.3).

Each cross section extends through the left and right overbanks up the valley wall to an elevation beyond the anticipated 1,000-year flood level. Cross section elevations were derived from a combination of the DTM data, the topographic survey data, and the hydrographic survey data as follows:

1. The cross section alignments were defined to pass through the surveyed point data and extended into the overbank above the anticipated 1000-year flood level.

2. Two separate station-elevation data sets were created for each cross section.

    a. The first was developed from elevation data extracted from the DTM using the GeoRAS ArcGIS extension tool.

    b. The second was based on the survey data and was developed by projecting the topographic and hydrographic survey points onto the cross section line in a direction perpendicular to alignment of the cross section line using the GeoRAS ArcGIS extension tool.

3. Both station-elevation data sets were exported from ArcGIS to a HEC-RAS geometry format.

4. The DTM-based and survey-based cross sections were combined in HEC-RAS using the Graphical Cross Section Editor. The number of elevation points in the combined cross sections were reduced to less than 500 using the minimize area change point filter option.

Distances between each cross section along the channel centerline and along the central flow path of the left and right overbank areas were measured in ArcGIS and exported with other cross section data to the HEC-RAS model. Cross section details based on NHC's surveys are provided in Appendix B.

5.2.2 Bridges, Culverts and Weirs

The modelled reach includes 61 bridge crossings, 8 culverts and one weir. **Table 7** provides a summary of bridges, culverts and weir included in the analysis, and key design information incorporated into the model is tabulated in **Table B-2** and **Table B-3**, found in Appendix B. Any culverts in the study area that service local drainage only or were not relevant to the hydraulic model computations were not modelled.

The alignment and location of each bridge structure was established in ArcGIS between the upstream and downstream surveyed cross sections adjacent to the bridge. The bridge cross section included the approach roadway in the overbanks, the abutments, high and low chord profiles defining the bridge deck, and the bridge piers. The approach roadway profile was based on elevation data sampled from the DTM. Geometry of the bridge abutments, high and low chords, and piers were determined from the surveyed data and/or drawings. The model bridge geometry was checked against design drawings, the full feature LiDAR points, details from available AT bridge file records, and other available information.

Bridge hydraulics for all South Saskatchewan River crossings were modelled using the momentum equation for low flow and pressure and/or weir method for high flow. Bridge hydraulics for the tributaries varied somewhat from structure to structure. The low and high flow modelling approaches adopted for each structure are listed in Appendix B.

A single weir located on Seven Persons Creek was modelled. The weir is located in Kin Coulee Park at river station 4,206 m. The weir has a crest elevation of 666.55 m and a width of 0.35 m. The weir was modelled using the broad crested weir equation.

5.2.3 Flood Control Structures

The top of flood control structure profiles were surveyed along the South Saskatchewan River during the field program for the Harlow Area-Phase1, Riverside - Phase 1, and Lions Park Overland Flow Protection Strategy – Phase 1 and 2 flood control structures . For the other three flood control structures (Water Treatment Plant, Harlow Area – Phase 2, Industrial Avenue), the top elevation profiles were provided by AEP. These data, in conjunction with the DTM, were used to inform the specification of levees in the HEC-RAS model. Levees in HEC-RAS restrict the wetted portion of the channel to the area inside the

levees until the simulated water level exceeds a specified elevation. Generally, the levee elevation at a model cross section corresponds to the crest elevation of the flood control structure where the cross section interests the flood control structure. However, consideration was given to overtopping points upstream and downstream of the model cross section to best represent streamwise conditions along the crest (including between model sections) where water overtops and inundates areas behind the structure. The adopted levee elevation values were assigned at each model cross section to define the ineffective flow areas behind the flood control structure. The surveyed crest elevations and the corresponding elevations used for modelling are provided in **Table 10**.

Table 10 Modelled flood control structure details

Description	Cross section	Surveyed crest elevation (m)	Modelled elevation (m)
Water Treatment Plant	XS-93	N/A	665.08
Harlow Area – Phase 1	XS-88	664.66	664.62
	XS-87	664.63	664.64
	XS-86	664.51	664.55
Harlow Area -Phase 2	XS-85	N/A	664.45
Riverside – Phase 1	XS-80	663.69	663.69
	XS-79	664.38	664.38
Lions Park Overland Flow Protection Strategy – Phase 1 and 2	XS-71	663.27	663.27
	XS-70	663.32	662.80
	XS-69	663.17	662.60
	XS-68	663.01	662.50
	XS-67	662.81	662.40
	XS-66	662.56	662.20
	XS-65	662.42	662.10
	XS-64	662.29	661.90
	XS-63	662.21	661.80
	XS-62	662.01	661.80
Industrial Avenue	XS-278	N/A	661.87
	XS-279		661.76
	XS-280		661.84
	XS-281		661.86
	XS-282		661.84
	XS-283		661.78
	XS-284		661.48
	XS-285		661.35
	XS-286		661.65
	XS-287		661.64
	XS-288		661.65
	XS-289		661.04

5.3 Model Calibration

5.3.1 Methodology

Model calibration involved the selection of modelling parameters to simulate observed water levels along the study reach under flood conditions. The modelling parameters that were calibrated included:

- Manning's roughness coefficient for the channel, islands, and floodplain.
- Friction slope associated with the downstream normal depth boundary condition.
- Ineffective flow areas.
- Expansion and contraction coefficients.

Of the above, the primary calibration parameters were the Manning's roughness coefficients for the river channel, which were selected for each cross section by comparing the simulated water surface profile elevations to observed water levels and highwater marks. The challenges or limitations that are typical to the calibration process include:

- The accuracy of the highwater mark elevations.
- Improper identification of highwater marks.
- Uncertainties in estimates of the flood peak discharge.
- Presence of a hydraulic control between model cross sections.

The type of land cover can be used to help characterize roughness in the floodplain areas. Three different land cover types were identified for this study and they are described in **Table 11**. The land cover type was not used explicitly to determine floodplain roughness, it did however influence the values of roughness ascribed to the overbank areas.

Table 11 Description of floodplain land cover types within the study reach

Land cover type	Description
Light vegetation	Agricultural crops or pastureland within the overbank with grasses with a general height of one meter or less.
Dense vegetation	Forest cover either in the overbank or on islands with medium/ large size trees with height greater than the depth during the design event.
Urban	Development within the wetted width of the design flood, possibly behind a flood control structure, with buildings taller than the maximum expected flow depth with transportation corridors comprised of either asphalt or gravel between the buildings.

5.3.2 Model Calibration

South Saskatchewan River

The June 1995 and 2013 floods were the largest floods on record and were of comparable magnitude; the estimated peak discharge for the 1995 and 2013 floods were 5,110 m^3/s and 5,040 m^3/s, respectively. Emphasis was placed on calibrating computed water levels to the observed highwater marks for these two events. Highwater mark observations for these two floods extended over a

significant portion of the study reach and the flood magnitudes are representative of a high flow condition. Computed water levels for the smaller 1975 flood were examined for comparison. The high flow calibration was completed using highwater marks provided by AEP, as well as WSC hydrometric gauge data and measurements. The number and location of highwater marks are described in Section 3.5. The majority of the highwater marks are located along developed areas within Medicine Hat.

Ross Creek and Seven Persons Creek

The 2010 flood was selected for calibration of the Ross Creek and Seven Persons Creek reaches. Other available highwater mark survey data is associated primarily with the backwater from South Saskatchewan River and therefore not suited for calibration of these tributaries. The model calibration relied on highwater mark data provided by AEP, as well as WSC hydrometric gauge data and measurements. The number and location of highwater marks are described in Section 3.5.

Bullshead Creek

There are no known published highwater mark data suitable for calibration of the Bullshead Creek study reach. The roughness values calibrated for Seven Persons Creek were adopted for Bullshead Creek.

The flows used for the calibration and validation were those listed in **Table 3**. Results of the model calibration are provided in Section 5.3.4.

5.3.3 Gauge Data and Rating Curves

The WSC gauge for South Saskatchewan River at Medicine Hat (05AJ001) is located at Finlay Bridge. The published rating curves developed for the gauge were used to verify the Manning's roughness factors over a range of discharges. The HEC-RAS model was used to generate a simulated rating curve for discharges from 1,320 m^3/s to 6,500 m^3/s. The simulated rating curve from the calibrated model compared well to the WSC gauge rating curves as depicted in **Figure 4.** Rating curves are updated periodically by WSC as new data records become available; the periodic updates are illustrated by the various curves plotted in the figure. Good agreement was obtained between the simulated and most recent WSC gauge rating curve (derived in 2005-07-07).

WSC also operates a water level gauging station (05AH052) on Ross Creek at Highway 41. **Figure 5** illustrates the simulated rating curve from the calibrated model compared to the WSC gauge rating curves. The simulated rating curve compares well with the WSC gauge rating curves at lower discharges and fits well with the observed 2010 highwater elevation. The WSC rating curve has an uncharacteristic shape between these data points where the computed rating curve differs from the WSC curve.

WSC also operates water level gauging stations on Ross Creek at Medicine Hat (05AH049) and Seven Persons Creek at Medicine Hat (05AH005). At both of these gauges, water levels are influenced by backwater from the South Saskatchewan River and establishing a unique stage discharge relationship

(rating curve) at these gauges was not practical. There were no useful comparisons between computed and observed rating curves for these sites.

5.3.4 Calibration Results

South Saskatchewan River

The results of the model calibration are illustrated through comparison between the observed highwater mark elevations and simulated water surface elevations along the highwater mark observations. **Figure 6** plots a comparison between the simulated water surface profile and observed highwater mark elevations for the selected model calibration events (1975, 1995 and 2013 floods). A tabular summary of the calibration results are provided in **Table 12** through **Table 14.** Simulated water levels were on average 0.03 m below observed highwater marks for the 2013 flood event. For the 1975 and 1995 flood events the simulated water level was on average 0.23 m and 0.12 m above the observed highwater marks, respectively.

Table 12 Calibration results for South Saskatchewan River reach (June 1975 flood event)

Location	River Station (m)	Date	Discharge (m^3/s)	Observed Highwater Mark (m)	Simulated Water Level (m)	Simulated Minus Observed
Below Powerline North of Power House	33142.7	23-Jun-75	3,170	660.88	661.47	0.59
15 m U/S from TransCanada Highway Bridge	32931.2	23-Jun-75	3,170	660.96	661.41	0.45
15 m D/S from TransCanada Highway Bridge	32829.2	23-Jun-75	3,170	660.9	661.26	0.36
106 m U/S from Junction of Harris St and Red Deer Dr	32476.8	23-Jun-75	3,170	660.76	661.06	0.30
92 m D/S from Junction of Harris St and Red Deer Dr	32262.8	23-Jun-75	3,170	660.72	661.00	0.28
30 m U/S from Finlay Bridge	29938.2	23-Jun-75	3,170	659.95	660.09	0.14
46 m D/S from Finlay Bridge	29850.0	23-Jun-75	3,170	659.91	660.03	0.12
30 m U/S from Railway Bridge	29735.2	23-Jun-75	3,170	659.91	660.02	0.11
15 m D/S from New Bridge	29449.7	23-Jun-75	3,170	659.79	659.78	-0.01
30 m East and 15 m North of NE corner of YM-YWCZ BLDG	29297.2	23-Jun-75	3,170	659.73	659.75	0.02
46 m North and 15 m East of Junction of Woodman and 2nd St SE	28543.4	23-Jun-75	3,170	658.76	659.27	0.51
91 m North and 30 m West of Junction of Minto Ave and 5th St SE	27881.9	23-Jun-75	3,170	658.79	658.86	0.07
East End of Bram St and approximate 106 m east of Minto Ave	27661.7	23-Jun-75	3,170	658.77	658.76	-0.01

Table 13 Calibration results for South Saskatchewan River reach (June 1995 flood event)

Location	Highwater Mark ID	River Station (m)	Date	Discharge (m^3/s)	Observed Highwater Mark (m)	Simulated Water Level (m)	Simulated Minus Observed
SW 5-13-6-W4 - Redcliff River Valley Park	95-SSASK-1	39675.5	10-Jun-95	5,110	665.32	665.74	0.42
TransCanada Highway Bridge	95-SSASK-2	32915.3	10-Jun-95	5,110	663.64	663.55	-0.09
TransCanada Highway Bridge	95-SSASK-2	32901.4	10-Jun-95	5,110	663.50	663.55	0.05
U/S 877 3rd St NW	95-SSASK-3	32233.5	10-Jun-95	5,110	662.97	663.04	0.07
550 - 1st St NW	95-SSASK-4	31556.2	10-Jun-95	5,110	662.84	662.85	0.01
1st St and 4th Ave NW	95-SSASK-5	31274.8	10-Jun-95	5,110	662.60	662.80	0.20
1st St and 2nd Ave NW	95-SSASK-6	30915.9	10-Jun-95	5,110	662.44	662.68	0.24
1st St and Division Ave	95-SSASK-7	30538.6	10-Jun-95	5,110	662.29	662.48	0.19
Parkview Dr and 1st Ave	95-SSASK-8	30072.7	10-Jun-95	5,110	662.04	662.18	0.14
Findlay St Bridge	95-SSASK-9	29882.2	10-Jun-95	5,110	661.85	662.05	0.20
D/S of RR bridge	95-SSASK-10	29665.9	10-Jun-95	5,110	661.87	661.91	0.04
Entrance to Police Point Park	95-SSASK-12	25260.1	10-Jun-95	5,110	659.06	659.18	0.12
SE 8-13-5-W4M	95-SSASK-15	23318.4	10-Jun-95	5,110	658.25	658.16	-0.09
NE 17-13-5-W4M	95-SSASK-16	16652.3	10-Jun-95	5,110	654.46	654.48	0.02
SW 20-13-5-W4M	95-SSASK-17	14242.2	10-Jun-95	5,110	652.72	652.96	0.24

Table 14 Calibration results for South Saskatchewan River reach (June 2013 flood event)

Highwater Mark ID	River Station (m)	Date	Discharge (m^3/s)	Observed Highwater Mark (m)	Simulated Water Level (m)	Simulated Minus Observed
2013-SSASK-1-a	39714.8	24-Jun-13	5,040	665.63	665.69	0.06
2013-SSASK-1-b	39704.6	24-Jun-13	5,040	665.74	665.68	-0.06
2013-SSASK-2-a	33007.2	24-Jun-13	5,040	663.63	663.51	-0.12
2013-SSASK-2-b	32915.6	24-Jun-13	5,040	663.70	663.48	-0.21
2013-SSASK-3-a	32231.8	24-Jun-13	5,040	663.16	662.98	-0.18
2013-SSASK-5-a	31276.9	24-Jun-13	5,040	662.76	662.74	-0.02
2013-SSASK-6-a	30932.7	24-Jun-13	5,040	662.52	662.62	0.10
2013-SSASK-7-b	30535.1	24-Jun-13	5,040	662.25	662.41	0.16
2013-SSASK-7-a	30527.4	24-Jun-13	5,040	662.29	662.41	0.12
2013-SSASK-8-a	30089.5	24-Jun-13	5,040	662.08	662.14	0.06
2013-SSASK-9.1-a	29891.6	24-Jun-13	5,040	661.81	661.99	0.18
2013-SSASK-9-a	29887.5	24-Jun-13	5,040	661.84	661.99	0.15
2013-SSASK-9-b	29885.8	24-Jun-13	5,040	661.95	661.99	0.04
2013-SSASK-9-c	29883.8	24-Jun-13	5,040	662.02	661.99	-0.02
2013-SSASK-10-a	29632.3	24-Jun-13	5,040	661.82	661.84	0.02
2013-SSASK-11-a	29447.0	24-Jun-13	5,040	661.83	661.67	-0.16
2013-SSASK-12-a	24856.1	24-Jun-13	5,040	658.95	658.95	0.00
2013-SSASK-14-a	24282.3	24-Jun-13	5,040	658.87	658.44	-0.43
2013-SSASK-16-a	16662.6	24-Jun-13	5,040	654.58	654.41	-0.17
2013-SSASK-17-a	13473.1	24-Jun-13	5,040	652.68	652.54	-0.14

Ross Creek

The model calibration for Ross Creek was based on a comparison between the HWM elevations and simulated water surface profiles for the 2010 flood event. During the 2010 flood the South Saskatchewan River had negligible backwater influence on Ross Creek. **Figure 7** plots a comparison between the simulated water surface profile and observed HWMs. A tabular summary of the model calibration is provided in **Table 15**. Simulated water levels were on average 0.04 m above observed highwater marks for the 2010 flood.

Table 15 Calibration results for Ross Creek reach (June 2010 flood event)

Location	Highwater Mark ID	River Station (m)	Date	Discharge (m^3/s)	Observed Highwater Mark (m)	Simulated Water Level (m)	Simulated Minus Observed
Highway 41 Bridge at WSC gauge	2010-MHRC-6-c	24529.5	19-Jun-10	209	704.04	703.95	-0.09
Highway 41 Bridge at WSC gauge	2010-MHRC-6-a	24512.3	19-Jun-10	209	704.02	703.90	-0.12
Highway 41 Bridge at WSC gauge	2010-MHRC-6-b	24475.5	19-Jun-10	209	703.77	703.64	-0.12
Range Road 51A Bridge	2010-MHRC-5-a	14788.9	19-Jun-10	209	693.61	693.48	-0.13
Range Road 51A Bridge	2010-MHRC-5-b	14768.6	19-Jun-10	209	693.54	693.47	-0.07
Day St Bridge	2010-MHRC-4-a	2926.6	19-Jun-10	268	663.68	663.72	0.04
Day St Bridge	2010-MHRC-4-b	2910.9	19-Jun-10	268	663.73	663.64	-0.10
Industrial Ave Bridge	2010-MHRC-3-b	2189.2	19-Jun-10	268	662.14	662.44	0.31
Industrial Ave Bridge	2010-MHRC-3-a	2168.0	19-Jun-10	268	661.79	662.37	0.58
Industrial Ave and Porcelain Ave	2010-MHRC-2-b	1611.1	19-Jun-10	268	660.15	660.25	0.10
Industrial Ave and Porcelain Ave	2010-MHRC-2-a	1603.6	19-Jun-10	268	660.12	660.20	0.08

Seven Persons Creek

The model calibration at Seven Persons Creek was based on a comparison between the observed HWMs and simulated water surface profiles for 2010 flood event. Similarly, as for Ross Creek, the South Saskatchewan River had negligible backwater influence on Seven Persons Creek during the flood. **Figure 8** plots a comparison between the simulated water surface profile and observed HWMs. A tabular summary of the high flow calibration is provided in **Table 16**. Simulated water levels were on average 0.02 m above observed highwater marks for the 2010 flood.

Table 16 Calibration results for Seven Persons Creek reach (June 2010 flood event)

Location	Highwater Mark ID	River Station (m)	Date	Discharge (m^3/s)	Observed Highwater Mark (m)	Simulated Water Level (m)	Simulated Minus Observed
Upstream of Hwy 1	2010-MH7P-2B-b	4648.2	19-Jun-10	76.7	670.10	670.26	0.16
Downstream of Hwy 1	2010-MH7P-2A-c	4517.0	19-Jun-10	76.7	668.95	668.88	-0.07
College Avenue Bridge	2010-MH7P-3-a	3445.7	19-Jun-10	76.7	665.07	665.05	-0.02
Access bridge near intersection of Kipling St and 3 Ave	2010-MH7P-4-a	3210.6	19-Jun-10	76.7	663.63	663.68	0.04
Railroad Bridge south of Spencer St	2010-MH7P-5-a	3004.0	19-Jun-10	76.7	662.86	663.14	0.28
Dunmore Road Bridge	2010-MH7P-6-b	2439.3	19-Jun-10	76.7	661.96	661.61	-0.34
South railway St Bridge	2010-MH7P-7-a	1149.8	19-Jun-10	76.7	659.81	659.97	0.16
Industrial Ave Bridge	2010-MH7P-9-a	530.5	19-Jun-10	76.7	659.75	659.74	-0.01

Bullshead Creek

There were no calibration data available for Bullshead Creek.

5.4 Model Parameters and Options

The following sections describe the key model parameters and options adopted in the calibrated HEC-RAS model. These include Manning's roughness coefficients for the channel and overbank areas, contraction and expansion loss coefficients, ineffective areas, and geometric configuration around flow splits, islands, and diversions.

5.4.1 Manning's Roughness Values

Computations in HEC-RAS are based on quantifying the friction loss between cross sections using Manning's roughness equation. The Manning's roughness coefficient is a parameter that accounts for losses attributed to river bottom material size and shape, floodplain conditions, and variations in the general river planform. A description of the channel and floodplain roughness values adopted in the model follows.

Channel Roughness

Table 17 summarizes the calibrated channel roughness at each model cross section based on the model calibration. During development of the model and initial calibration effort, it was determined that a

single channel roughness value for each modelled reach resulted in acceptable agreement between simulated water levels and observed highwater marks. There was no compelling evidence to suggest that there was any notable variation in roughness along the study reach (neither within the observed highwater mark data nor the channel geometry characteristics). Calibration was not performed for Bullshead Creek – the calibrated channel roughness parameter for Seven Persons Creek was adopted for Bullshead Creek.

Table 17 Adopted Manning's roughness values for the channel based on model calibration

Reach Description	Channel Roughness
South Saskatchewan River above Ross Creek	0.029
South Saskatchewan River below Ross Creek	0.029
Ross Creek above Bullshead Creek	0.050
Ross Creek above Seven Persons Creek	0.050
Ross Creek below Seven Persons Creek	0.050
Seven Persons Creek above Ross Creek	0.045
Bullshead Creek above Ross Creek	0.045

The above calibrated roughness values were tested over a range of flows by comparing the computed rating curves with those published by WSC on the South Saskatchewan River and Ross Creek, as was previously presented in **Section 5.3.3**.

Overbank Roughness

Table 18 shows the adopted overbank roughness values for the modelled reaches. Initially, the overbank roughness values were prescribed on section by section basis according to a landcover condition based on inspection of the aerial imagery. Subsequently, they were adjusted to a uniform reach-averaged value. The reach average values were influenced by comparison between computed and observed water levels during model calibration. The adopted values are consistent with previous studies.

Table 18 Adopted Manning's roughness values for the overbank areas

Reach Description	Overbank Roughness
South Saskatchewan River above Ross Creek	0.045
South Saskatchewan River below Ross Creek	0.045
Ross Creek above Bullshead Creek	0.065
Ross Creek above Seven Persons Creek	0.065
Ross Creek below Seven Persons Creek	0.065
Seven Persons Creek above Ross Creek	0.060
Bullshead Creek above Ross Creek	0.060

5.4.2 Expansion and Contraction Coefficients

To account for the effect of flow contraction or expansion on the energy balance between successive cross sections, HEC-RAS multiplies the absolute difference in velocity head by a coefficient. Coefficients range from 0.10 for gradual transitions to 0.80 for abrupt transitions (Brunner, 2016).

Expansion and contraction coefficients were set to 0.3 and 0.5, respectively for cross sections located near bridges where the abutment resulted in rapid contraction of the flow. These coefficients were also used where the cross-sectional area quickly expands. The default values of 0.1 and 0.3 for contraction and expansion loss coefficients were used at all other cross sections.

5.4.3 Obstructions and Ineffective Flow Areas

Blocked Obstructions

Blocked obstructions in the floodplain, such as buildings, walls, storage tanks, or elevated foundations were not specified in the HEC-RAS model. Obstructions associated with bridge piers and structural members were modelled using the standard bridge editor specifications in HEC-RAS.

Ineffective Flow Areas

Ineffective flow areas were specified at cross sections in the HEC-RAS model based on a review of the local terrain and floodplain features both at and between cross sections. Ineffective flow areas can be specified within portions of cross sections where water is expected to pond, but where the velocity of that water, in the downstream direction, is also expected to be close to or equal to zero (Brunner, 2016). The downstream direction is taken relative to the cross section lines defined in the model, so the orientation of cross sections was considered when specifying ineffective flow areas.

Ineffective flow areas in the model may be specified as either permanent or non-permanent. Permanent ineffective flow areas apply regardless of the water surface elevation, whereas temporary ineffective flow areas become effective above a defined elevation. For this study, the selection of a permanent or non-permanent condition was weighted towards evaluations made on flow conditions under the 100-year flood scenario. Non-permanent conditions often produce the undesirable result of water level profiles of high magnitudes crossing below water level profiles computed for lower flood magnitudes. Wherever possible, selection of a non-permanent condition was avoided.

Permanent ineffective flow areas were also used to account for flow patterns influenced by nearby bridge abutments and roadway embankments crossing the floodplain. These types of obstructions tend to direct flows towards the bridge opening. Several site-specific factors were taken into account when configuring ineffective flow areas at bridges in the study area, including: distance from the cross section to the bridge, terrain features, bridge geometry, and skew of the bridge opening relative to the river.

Ineffective Areas Behind Flood Control Structures

Permanent ineffective flow areas were also defined behind flood control structures such that they worked in combination with specified levees to simulate a plausible degree of floodplain conveyance in the overbank areas across the full range of flood discharges of interest. The top elevation of these ineffective areas was set while taking into consideration upstream and downstream flow-limiting elevations through connected floodplain areas. For scenarios that overtop the flood control structures in this study, the above configuration was chosen to ensure that flood levels were reasonable but not under-represented.

Although areas behind and below the crest of the structures may be specified as permanently ineffective for hydraulic modelling purposes, flow velocities in these areas may be appreciable, if the structures are breached or overtopped.

5.4.4 Flow Splits, Islands and Diversions

The study reaches were adequately represented without flow splits around islands. Where a cross section intersected an island, the HEC-RAS model assumed equal water level on both sides of an island based on the composite channel conveyance properties and computed energy losses. This assumption is most valid once flood magnitudes increases and the island becomes inundated.

Diversions may include avulsion channels or flow paths that reduce the total discharge carried by the main channel along a portion of the study reach. There were no such diversions encountered within the study area, and all flood flows were confined to the cross sections modelled along the study reaches.

5.5 Flood Frequency Profiles

The calibrated hydraulic model was used to generate flood frequency profiles for the thirteen naturalized open water floods of varying magnitude listed in **Table 4**. The computed flood frequency water levels at each surveyed cross section on the South Saskatchewan River, Ross Creek, Seven Persons Creek and Bullshead Creek are provided in Appendix B. These results are plotted in **Figure 9** for the South Saskatchewan River and **Figure 10** through **Figure 12** for the tributaries.

5.6 Model Sensitivity

The sensitivity of water levels computed by the calibrated open water hydraulic model to adjustments in boundary conditions and Manning's roughness values was evaluated. Variation in these parameters affects the computed water surface profiles, and consequently, flood depths and inundation limits. The sensitivity analysis provides an indication of the plausible range of error in the model results and identifies the relative sensitivity of the model to variations in each parameter. The 100-year flood was used as the baseline for the sensitivity analyses.

A summary of the sensitivity analysis results is provided below. Detailed tabulated results are provided in Appendix C.

5.6.1 Boundary Conditions

The hydraulic model requires a downstream water level and an upstream discharge as boundary conditions for each river reach. The adopted downstream boundary condition in the calibrated model was a normal depth, which was given by specifying an estimate of the energy grade slope equal to 0.0008 m/m at the most downstream cross section. At the 100-year flood frequency discharge, this corresponds to a water surface elevation of 645.50 m at the downstream boundary. A plausible range of uncertainty in this elevation is ±0.5 m, which corresponds to energy grade slopes for normal depth conditions of 0.000652 m/m (downstream water level of 646.00 m) and 0.000996 m/m (downstream water level of 645.00 m). The results are presented in **Table C-1** at Appendix C.

The water surface elevation profiles (calibrated, low downstream water level case and high downstream water level case) for South Saskatchewan River are illustrated in **Figure 13**. The variation from the calibrated profile falls below 0.1 m beyond RS 4619.6 m for the low water level case and RS 5902.0 m for the highwater level case. The average variation from the calibrated profile is 0.03 m for both the low and highwater level cases on the South Saskatchewan River. None of the tributaries (Ross Creek, Seven Persons Creek and Bullshead Creek) are impacted by changes to the downstream boundary condition.

5.6.2 Manning's Roughness

Channel roughness was examined independently of overbank roughness. The sensitivity of a lower and higher Manning's roughness was examined for all the modelled reaches.

Channel Roughness

The calibrated channel roughness on the South Saskatchewan River was 0.029 for both above and below Ross Creek confluence. A plausible range of channel roughness for the modelled length of the South Saskatchewan River was considered to be approximately 0.025 to 0.033. For the low and high roughness sensitivity runs, the channel roughness value was adjusted by ±15% to reflect this range. The same ±15% range was applied to the roughness values in Ross Creek, Seven Persons Creek, and Bullshead Creek. The sensitivity analysis was run concurrently for the South Saskatchewan River and the tributaries using the values listed in **Table 19**.

Table 20 summarizes the average difference between the calibrated 100-year flood levels and the flood levels computed using the low and high roughness values. Water surface elevations for each river/creek are presented in **Table C-2** in Appendix C and profiles are illustrated in **Figure 14** through **Figure 17.** On average, the South Saskatchewan River reaches are more sensitive to changes in channel roughness than the tributaries.

Table 19 Channel roughness values used in sensitivity analysis

River	Reach	Channel Roughness		
		Calibrated	Low (-15%)	High (+15%)
South Saskatchewan River	All	0.029	0.025	0.033
Ross Creek	All	0.050	0.043	0.058
Seven Persons Creek	All	0.045	0.038	0.052
Bullshead Creek	All	0.045	0.038	0.052

Table 20 Sensitivity analysis results for variation in main channel roughness

River	Difference from Baseline Profile (m)			
	Low Roughness (-15%)		High Roughness (+15%)	
	Maximum	Average	Maximum	Average
South Saskatchewan River	-0.69	-0.53	0.59	0.45
Ross Creek	-0.69	-0.14	0.32	0.08
Seven Persons Creek	-0.53	-0.13	0.25	0.09
Bullshead Creek	-0.12	-0.01	0.11	0.01

Overbank Roughness

The sensitivity of computed 100-year flood levels to variations in overbank roughness were evaluated by varying the overbank roughness values by 20%. The values adopted for the tests are listed in **Table 21**. **Table 22** presents a summary of the results of the 100-year computed flood level sensitivity analysis for variation in overbank roughness. Water surface elevations for each case are presented in **Table C-3** in Appendix C and profiles are plotted on **Figure 18** through **Figure 21**.

Table 21 Overbank roughness values used in sensitivity analysis

River	Reach	Overbank Roughness		
		Calibrated	Low (-20%)	High (+20%)
South Saskatchewan River	All	0.045	0.036	0.054
Ross Creek	All	0.065	0.052	0.078
Seven Persons Creek	All	0.060	0.048	0.072
Bullshead Creek	All	0.060	0.048	0.072

Table 22 Sensitivity analysis results for variation in overbank roughness

River	Difference from Baseline Profile (m)			
	Low Roughness (-20%)		High Roughness (+20%)	
	Maximum	Average	Maximum	Average
South Saskatchewan River	-0.24	-0.13	0.11	0.07
Ross Creek	-0.57	-0.15	0.16	0.08
Seven Persons Creek	-0.31	-0.10	0.18	0.06
Bullshead Creek	-0.12	-0.05	0.12	0.04

The largest differences from calibrated flood levels due to change in overbank roughness (0.16 m to 0.57 m) were found in the highly braided reaches of Ross Creek.

6 FLOOD INUNDATION MAPS

Flood inundation mapping shows areas of ground that could be covered by water under one or more flood scenarios. For this study, one flood inundation map series was created for each of the 13 flood frequency return periods from the 2-year through 1000-year scenarios. Additional information concerning the flood inundation map production is provided below. The open water flood inundation maps are provided in Appendix D.

6.1 Methodology

The methodology used to create the flood inundation maps followed four basic steps.

- Create a water surface elevation (WSE) triangular irregular network (TIN) representing a contiguous flood level profile along the modelled river reaches.
- Generate a WSE grid with the same grid geometry as the underlying DTM. Assign elevation values to each grid cell based on the corresponding value taken from the WSE TIN.
- Generate a depth grid (with the same grid geometry as the WSE grid) by subtracting elevation values from the underlying DTM from the corresponding WSE grid value. Negative depth values represent dry cells and were assigned a value of *NoData*.
- Generate inundation polygons based on the depth grids by converting depths greater than 0 m into inundation polygons.

The inundation polygons were further processed by smoothing, filtering out wetted areas that were not directly inundated (or "isolated"), and removing very small dry areas (or "holes"). These inundation polygons were then used to clip the WSE grids and depth grids to the full inundation extent. All of the WSE TINs, WSE grids, depth grids, and inundation polygons were produced in a conventional Esri file format and were created using standard ArcGIS tool sets.

6.1.1 Direct Flood Inundation Areas

Direct flood inundation areas were identified as either being part of the actively-flowing river channel or flooded overbank areas connected to the actively-flowing river channel. Areas showing extensive overbank flooding directly connected to the channel at one distinct location (overtopping point) were adjusted such that the water surface elevation across that area was set equal to the water surface elevation at the overtopping point. This generally reduced the size of the inundated area extending upstream of an overtopping point and increased the size of the inundated area extending downstream of the overtopping point. Areas behind railroad embankments were assumed to be permeable and were denoted as direct inundation areas.

All adjustments were made to the water surface TINs so that inundation polygons could be re-generated from the data using the procedure described in Section 6.1 above.

6.1.2 Potential Flood Control Structure Failure

For a given flood scenario, areas behind the flood control structure were shown as inundated due to potential failure of the structure when the water surface elevation was higher than the ground elevation behind the flood control structure and the area would otherwise be considered a direct inundation area in the absence of the flood control structure. Identifying inundated areas due to potential flood control structure does not imply failure of a flood protection structure is expected to occur.

For conditions where water surface elevations overtopped or outflanked portions of a flood control structure, the areas behind the flood control structures were mapped as direct flood inundation areas.

In either case, the inundation extent of the protected area was determined by extending the water surface elevation from the main channel into the area behind the flood control structure.

6.2 Flood Impacts

6.2.1 Residential Areas

Residential areas in several communities have the potential to be impacted by flooding.

Medicine Hat

- Residences west of Echodale Road are inundated during the 200-year flood.
- The Harlow flood control structure protects the Harlow neighbourhood from flooding. Direct flooding of the residences begins at the 100-year flood. Flooding of residences due to potential failure of the flood control structure beings as early as during the 2-year flood. The severity of the flooding increases with the flood magnitude and flooding extents cross 1 Street SW at the 350-year flood.
- Direct inundation begins during the 20-year flood along 1 Street NE upstream of the Riverside flood control structure. The inundation during the 100-year flood extended to 2 Street NW between 1 Avenue NW and the railway bridge. The maximum inundation for the 1000-year flood includes most of the Riverside neighbourhood extending to 4 Street NW on both sides of Division Avenue.
- Residences downstream of Maple Avenue Bridge along the north bank of the South Saskatchewan River are inundated by the 75-year flood.
- In Downtown Medicine Hat, government buildings along River Road SE become inundated during the 200-year flood. Flooding west of South Railway Street SE begins during the 350-year flood. At the 1000-year flood, the inundation west of South Railway Street SE extends to the intersection of 6 Avenue SE and 2 Street SE. East of North Railway Street SE, direct inundation flooding occurs during the 200-year flood during which most of the residences are inundated.

- Direct inundation in the North Flats begins during the 100-year flood. Flooding of residences at North Flat due to potential failure of the flood control structure beings as early as during the 5-year flood. At the 100-year flood, the inundation extents are significant and by the 200-year flood when the Lions Park and Industrial Avenue flood control structures are overtopped, the majority of the North Flats are inundated.
- Inundation of the South Flats occurs during the 35-year flood from Seven Persons Creek across Allowance Avenue SE. The majority of residences in the South Flats are inundated by the 100-year flood.

Redcliff

- Residences along Josephine Avenue SW start becoming inundated during the 20-year flood. By the 200-year flood, all residences along Josephine Avenue SW are inundated.

Desert Blume

- No residences are flooded in Desert Blume for the various flood scenarios.

Cypress County

- Two residences at the end of Range Road 71 are inundated, the first during the 200-year flood, and the second during the 750-year flood.
- A residence at the end of Galt Street is inundated during the 50-year flood.
- Residences begin being inundated along Paramatta Avenue during the 100-year flood.
- Residences begin being inundated along 5431 Township Road 132A during the 100-year flood. All residences are inundated in this area during the 500-year flood.
- Residences are flooded along Ross Creek at several locations. The residence along the west side of Range Road 51A is flooded during the 200-year event and the house east of Range Road 51A is flooded during the 100-year event. Residences at the end of Day St SE become inundated during the 20-year flood. Along Seven Persons Creek, residences become inundated north and south of Township Road 120 during the 35-year flood.
- Along Bullshead Creek west of the Trans Canada Highway, residences are inundated during the 350-year flood.

Further details regarding flood impacted areas are available in the ***Flood Risk Inventory and Assessment*** study report (NHC, 2022).

6.2.2 Commercial and Industrial Areas

Commercial and industrial areas in several communities have the potential to be impacted by flooding.

Medicine Hat

- Echo Dale Regional Park begins flooding during the 100-year flood and is completely inundated during the 200-year flood.
- The water treatment plant upstream of the Trans Canada Highway crossing of the South Saskatchewan River experiences flooding from direct inundation during the 200-year flood and above.
- Flooding occurs at the Paradise Valley Golf Course and Cottonwood Coulee Golf Course located on Seven Persons Creek starting at the 5-year flood. As the magnitude of the flood increases, several buildings become impacted.
- Buildings are flooded along Seven Persons Creek via Kipling Street SE and Spencer Street SE during the 50-year flood.
- Flooding occurs along Industrial Avenue SE near the confluence of Ross Creek and Seven Persons Creek. Buildings begin to flood during the 20-year flood with complete inundation occurring by the 50-year flood.

Redcliff

- A building in River Valley Park near the parking lot is inundated during the 35-year flood.

Desert Blume

- The Desert Blume Golf Course begins flooding during the 5-year flood. No buildings are inundated for any of the return period floods that were analyzed.

Cypress County

- A public utility building south of Township Road 120 on Bullshead Creek is inundated during the 200-year flood.
- The wastewater treatment plant facility begins flooding during the 200-year flood.

Further details regarding flood impacted areas are available in the ***Flood Risk Inventory and Assessment*** study report (NHC, 2022).

6.2.3 Hydraulic and Flood Control Structures

The road and rail deck elevations for bridges crossing the South Saskatchewan River are well above the 100-year flood level. On Seven Persons Creek and Ross Creek, some smaller bridges begin overtopping during 5-year flood. The number of bridges and culverts affected by different flood inundation scenario are listed in **Table 23** and **Table 24**.

Table 23 Number of bridges affected by direct inundation

Flood Scenario	Number of bridges by local authority - direct inundation				
	Medicine Hat	Redcliff	Desert Blume	MD Cypress County	Total
2-YR	0	0	0	2	2
5-YR	5	0	6	3	14
10-YR	16	0	8	3	27
20-YR	23	0	8	4	35
35-YR	27	0	8	5	40
50-YR	31	0	8	5	44
75-YR	35	0	8	5	48
100-YR	36	0	8	5	49
200-YR	41	0	8	5	54
350-YR	42	0	8	5	55
500-YR	42	0	8	5	55
750-YR	42	0	8	5	55
1000-YR	43	0	8	5	56

Table 24 Number of culverts affected by direct inundation

Flood Scenario	Number of culverts by local authority - direct inundation				
	Medicine Hat	Redcliff	Desert Blume	MD Cypress County	Total
2-YR	1	0	0	0	1
5-YR	1	0	0	1	2
10-YR	1	0	0	1	2
20-YR	2	0	0	2	4
35-YR	2	0	0	2	4
50-YR	2	0	0	2	4
75-YR	2	0	0	2	4
100-YR	2	0	0	2	4
200-YR	2	0	0	2	4
350-YR	2	0	0	3	5
500-YR	2	0	0	3	5
750-YR	2	0	0	4	6
1000-YR	2	0	0	4	6

Flood impacts from different flood scenarios on areas behind each flood control structure are summarized in **Table 25** below.

Table 25 Flood impacts on areas behind the Flood Control Structures

Flood Scenario	Flood impacts
Water Treatment Plant Dike	
2-YR	No direct inundation
5-YR	No direct inundation
10-YR	No direct inundation
20-YR	No direct inundation
35-YR	No direct inundation
50-YR	No direct inundation
75-YR	No direct inundation
100-YR	No direct inundation
200-YR	Overtopping causing direct inundation
350-YR	Overtopping causing direct inundation
500-YR	Overtopping causing direct inundation
750-YR	Overtopping causing direct inundation
1000-YR	Overtopping causing direct inundation
Harlow Area Dikes	
2-YR	No direct inundation
5-YR	No direct inundation
10-YR	No direct inundation
20-YR	No direct inundation
35-YR	No direct inundation
50-YR	No direct inundation
75-YR	No direct inundation
100-YR	Overtopping causing direct inundation
200-YR	Overtopping causing direct inundation
350-YR	Overtopping causing direct inundation
500-YR	Overtopping causing direct inundation
750-YR	Overtopping causing direct inundation
1000-YR	Overtopping causing direct inundation
Riverside Dike	
2-YR	No direct inundation
5-YR	No direct inundation
10-YR	No direct inundation
20-YR	No direct inundation
35-YR	No overtopping but direct inundation from South Saskatchewan River upstream flow (at RS 30278)
50-YR	No overtopping but direct inundation from South Saskatchewan River upstream flow (at RS 30278)
75-YR	No overtopping but direct inundation from South Saskatchewan River upstream flow (at RS 30278)
100-YR	No overtopping but direct inundation from South Saskatchewan River flows
200-YR	Overtopping causing direct inundation
350-YR	Overtopping causing direct inundation
500-YR	Overtopping causing direct inundation
750-YR	Overtopping causing direct inundation
1000-YR	Overtopping causing direct inundation
Lions Park Dike and Industrial Avenue Dike	
2-YR	No direct inundation
5-YR	No direct inundation
10-YR	No direct inundation
20-YR	No direct inundation
35-YR	No direct inundation
50-YR	No direct inundation
75-YR	No direct inundation
100-YR	Overtopping and direct inundation from Seven Persons Creek (at RS 1056)
200-YR	Overtopping causing direct inundation
350-YR	Overtopping causing direct inundation
500-YR	Overtopping causing direct inundation
750-YR	Overtopping causing direct inundation
1000-YR	Overtopping causing direct inundation

7 CONCLUSIONS

The objectives of this study were to assess river flood-related hazards along the South Saskatchewan River and local tributaries in the Medicine Hat area (Ross Creek, Seven Persons Creek, and Bullshead Creek). Communities affected by flooding in the study area include the City of Medicine Hat, the Town of Redcliff, the Hamlet of Desert Blume, and Cypress County. The Medicine Hat River Hazard Study was divided into eight major project components. This report summarizes the work of the ***Hydraulic Model Creation and Calibration and Open Water Flood Map Production*** components. For the ***Hydraulic Model Creation and Calibration*** component a numerical model has been developed using the HEC-RAS computer program from the U.S. Army Corps of Engineers. River bathymetry and digital terrain data from the ***Survey and Base Data Collection*** component as well as flood frequency estimates from the ***Open Water Hydrology Assessment*** component have been used to develop, calibrate, and apply the open water hydraulic model as described throughout this report. The reports for the two previous work components mentioned above should also be read in conjunction with this report, as they provide additional pertinent background information.

Historically, a number of open water floods have occurred on the South Saskatchewan River, Ross Creek, Seven Persons Creek, and Bullshead Creek. The largest recorded flood event on South Saskatchewan River was the June 1995 flood (peak discharge 5,110 m^3/s) followed by June 2013 flood (peak discharge 5,040 m^3/s). Both of these two events were adopted for model calibration of South Saskatchewan River. The simulated water surface profiles agreed well with the measured highwater marks with an average absolute difference of 0.23 m for 1975 flood event, 0.14 m for the 1995 flood event, and 0.12 m for the 2013 flood event. Seven Persons Creek and Ross Creek were calibrated to the June 2010 flood event. This event was the only event with sufficient highwater mark data to facilitate calibration along the Seven Persons Creek and Ross Creek study reaches. The simulated water surface profiles agreed well with the measured 2010 highwater marks with an average absolute difference of 0.16 m for Ross Creek and 0.14 m for Seven Persons Creek. No model calibration data was available for Bullshead Creek.

Water surface profiles were calculated for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1000-year open water flood frequency return period discharges. These profiles showed that the road and rail deck elevations for bridges crossing the South Saskatchewan River are well above the 100-year flood level. On Seven Persons Creek, Ross Creek and Bullshead Creek small private bridges begin overtopping during 5-year flood.

Sensitivity of simulated water levels to various model parameters was also investigated. Channel roughness in South Saskatchewan River were shown to have greater effect on predicted 100-year flood levels than variation in the downstream boundary condition or overbank roughness (within the range of plausible values).

8 REFERENCES

AECOM. 2014. Southern Alberta Flood Mitigation Feasibility Study for Sheep, Highwood River Basins and South Saskatchewan River Sub-basin – and South Saskatchewan River Sub-basin Water Management Plan. Prepared by AECOM, June 2014.

AENV. 1986. Medicine Hat Floodplain Study, Main Report. Alberta Department of Environment, Water Resources Management Services, Technical Division, May 1986.

Airborne Imaging. 2018. Bow, Red Deer, South Saskatchewan & Priddis, Report on: LiDAR Acquisition and Processing, by Airborne Imaging, July 10, 2018.

Brunner, G. 2016. HEC-RAS River Analysis System Hydraulic Reference Manual. Version 5.0. Hydrologic Engineering Center, U.S. Army Corps of Engineers. Davis, California. February 2016.

Christie, Grace. "Flood Over the Years by Grace Christie". Acquired in 2018 from Esplanade Arts & Heritage Centre in 2018, Medicine Hat, Alberta. Publication date unknown.

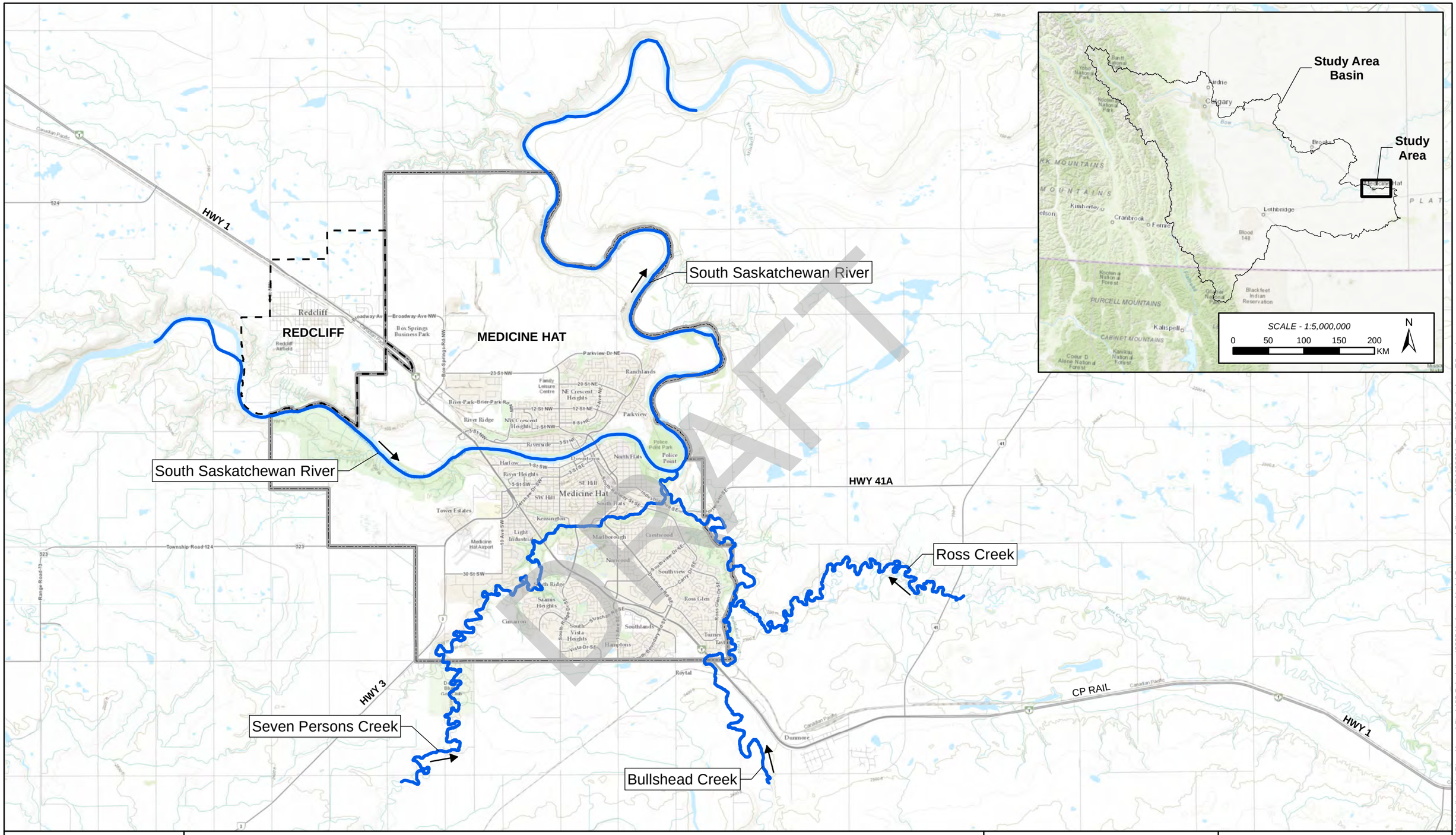
Kellerhals, R., Neill, C.R., and Bray, D.I. 1972. Hydraulic and Geomorphic Characteristics of Rivers in Alberta. River Engineering and Surface Hydrology Report 72-1, Research Council of Alberta, Edmonton, Alberta.

Northwest Hydraulic Consultants Ltd. 2019a. Medicine Hat River Hazard Study – Open Water Hydrology Assessment Report. Report for Alberta Environment and Parks.

Northwest Hydraulic Consultants Ltd. 2019b. Medicine Hat River Hazard Study – Survey and Base Data Collection Report. Report for Alberta Environment and Parks.

Northwest Hydraulic Consultants Ltd. 2022. Medicine Hat River Hazard Study – Flood Risk Inventory and Assessment Report. Report for Alberta Environment and Parks.

Figures



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- Model Stream Network
- Redcliff Town Boundary
- Medicine Hat City Boundary

DATA SOURCES: Basemap from Esri & NRCAN.

SCALE - 1:100,000
0 1 2 3 4 KM
N

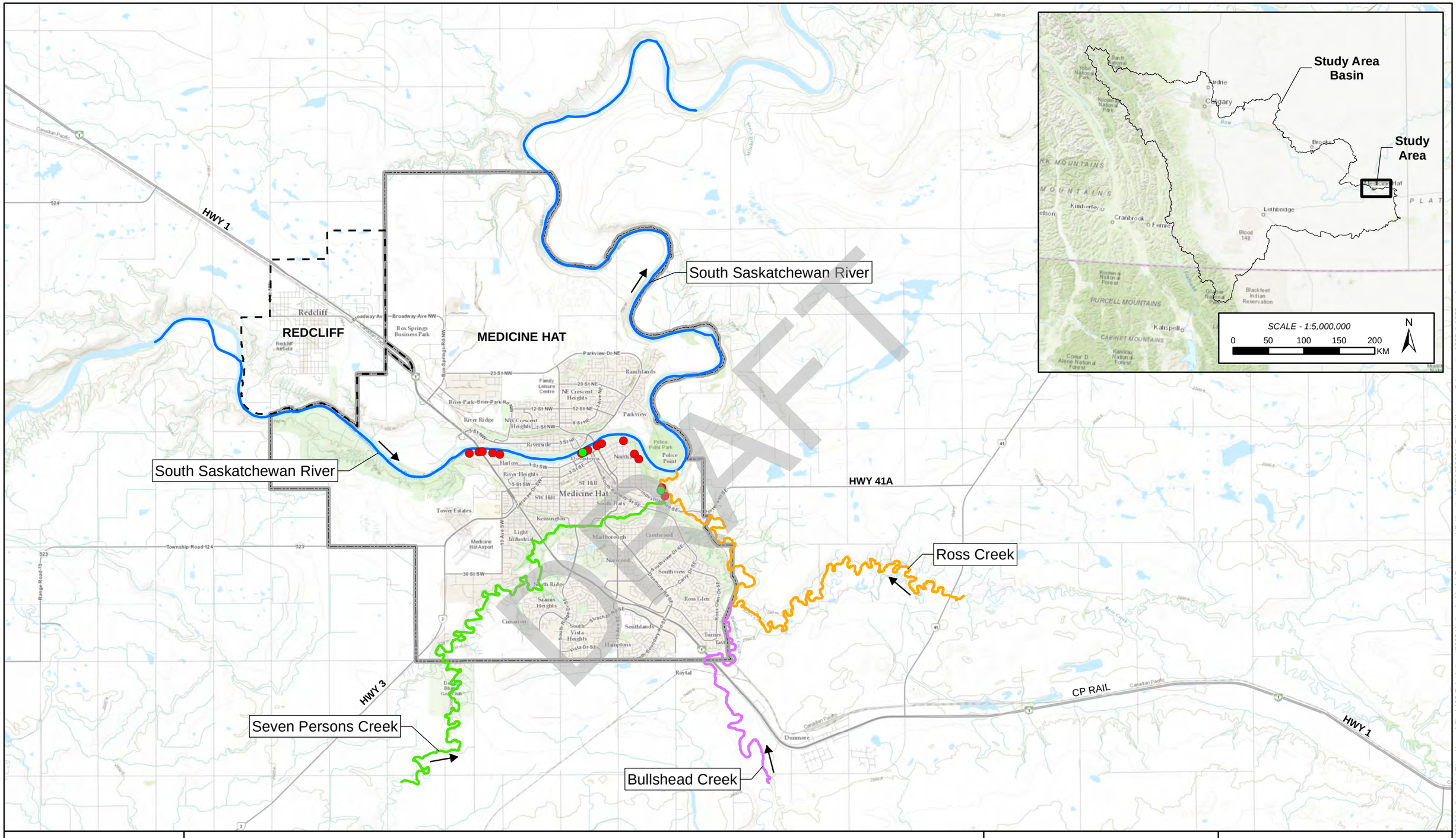
Coordinate System: NAD 1983 CSRS 3TM 111
Units: METRES

Job: 1003094 | Date: 10-SEP-2019

MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

STUDY AREA

FIGURE 1



HWM Locations (1953)
HWM Locations (1975)
Redcliff Town Boundary
Medicine Hat City Boundary
Bullshead Creek
Ross Creek
Seven Persons Creek
South Saskatchewan River

DATA SOURCES: Basemap from Esri & NRCAN.

Coordinate System: NAD 1983 CSRS 3TM 111
Units: METRES

Job: 1003094 | Date: 10-SEP-2019

MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING
AND FLOOD INUNDATION MAPPING

HIGH WATER MARK LOCATIONS
1953 and 1975 FLOOD

FIGURE 2A

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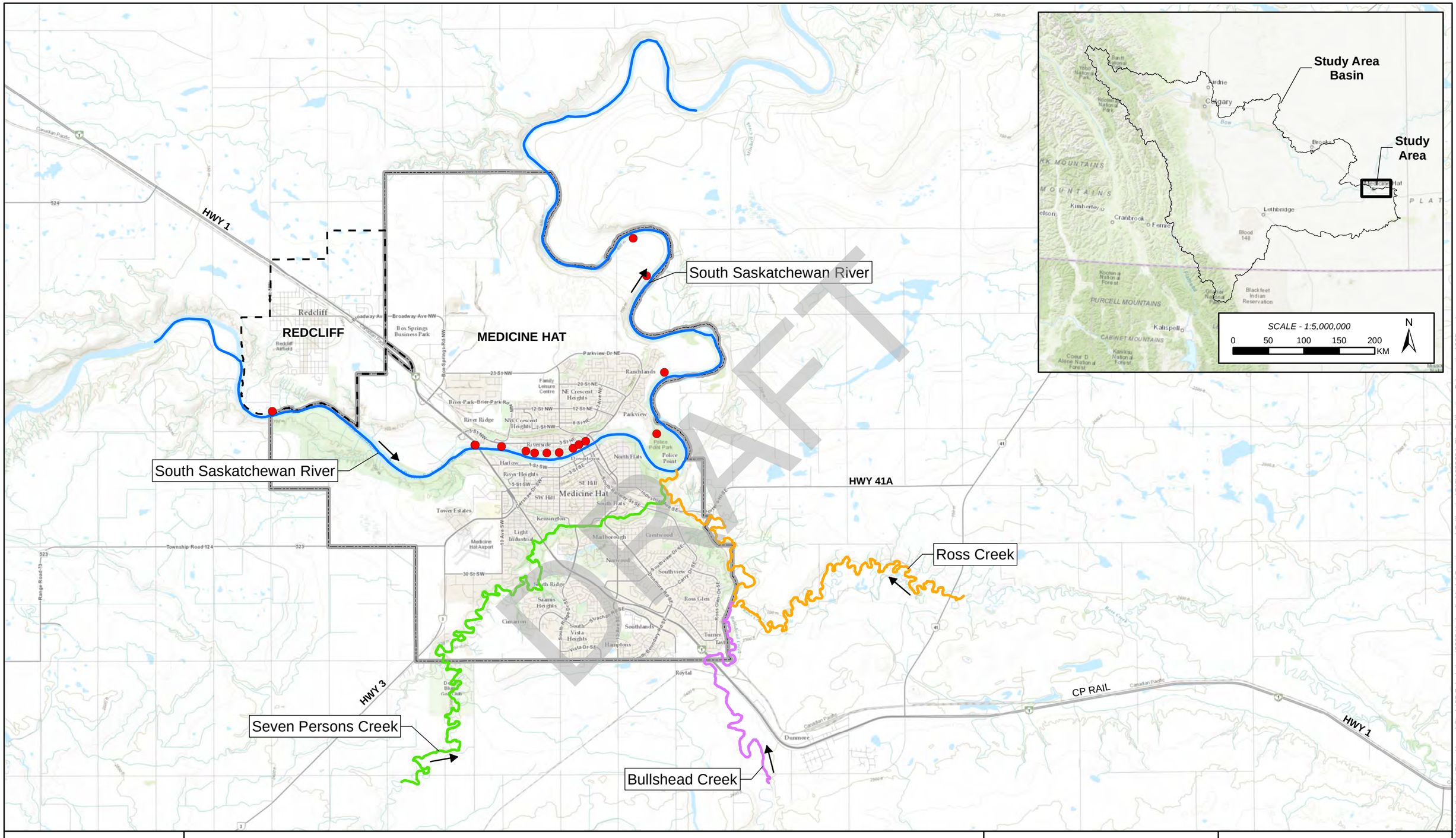

HWM Locations (1995)
Redcliff Town Boundary
Medicine Hat City Boundary

Bullshead Creek
Ross Creek
Seven Persons Creek
South Saskatchewan River

DATA SOURCES: Basemap from Esri & NRCAN.

Coordinate System: NAD 1983 CSRS 3TM 111
Units: METRES

Job: 1003094 | Date: 10-SEP-2019

MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
HIGHWATER MARK LOCATIONS 1995 FLOOD

FIGURE 2B

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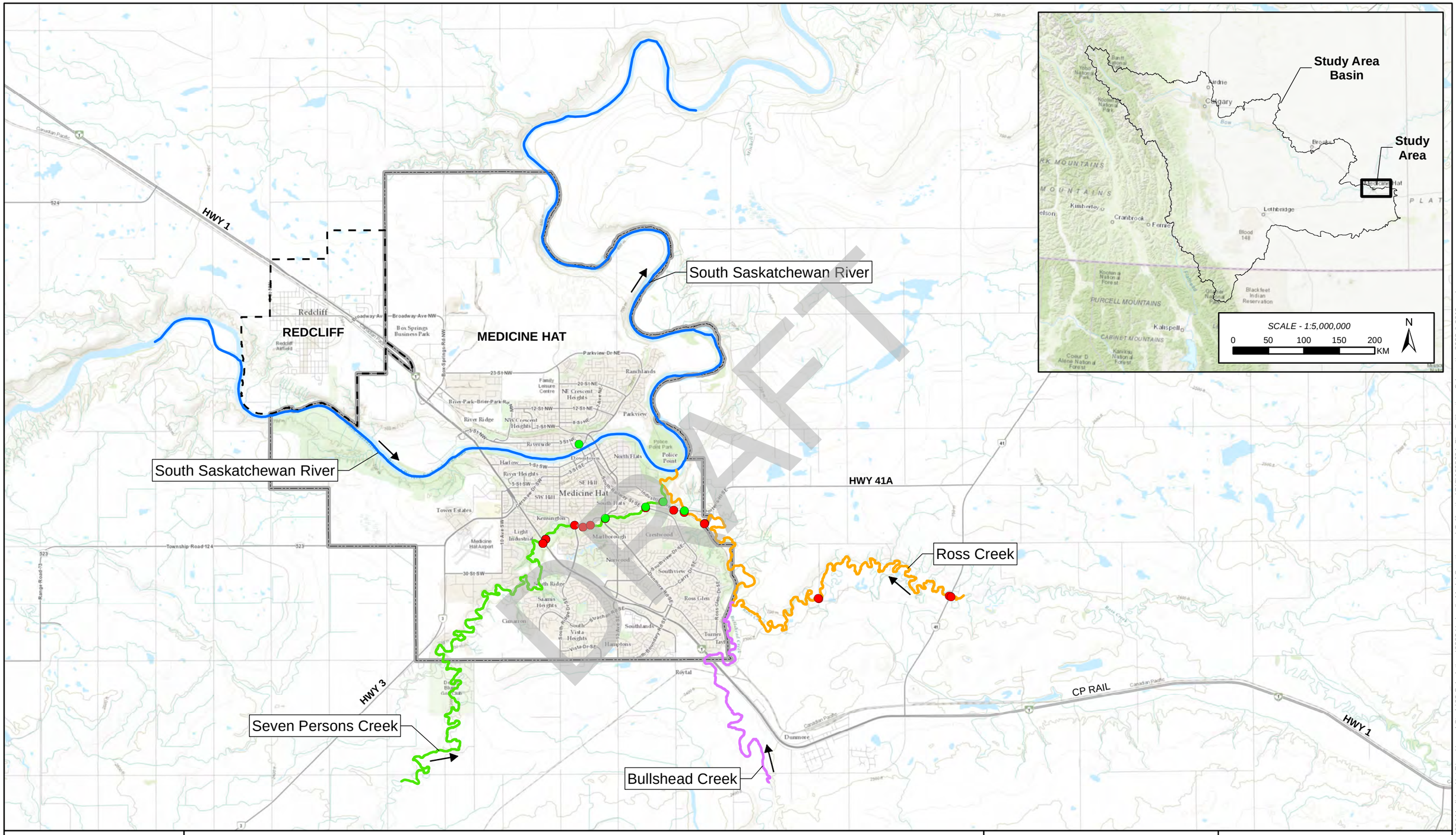

HWM Locations (2002)
HWM Locations (2010)
Redcliff Town Boundary
Medicine Hat City Boundary
Bullshead Creek
Ross Creek
Seven Persons Creek
South Saskatchewan River

DATA SOURCES: Basemap from Esri & NRCAN.

SCALE - 1:100,000
0 1 2 3 4 KM
N

Coordinate System: NAD 1983 CSRS 3TM 111
Units: METRES

Job: 1003094
Date: 10-SEP-2019

MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING
AND FLOOD INUNDATION MAPPING

HIGHWATER MARK LOCATIONS
2002 and 2010 FLOOD

FIGURE 2C

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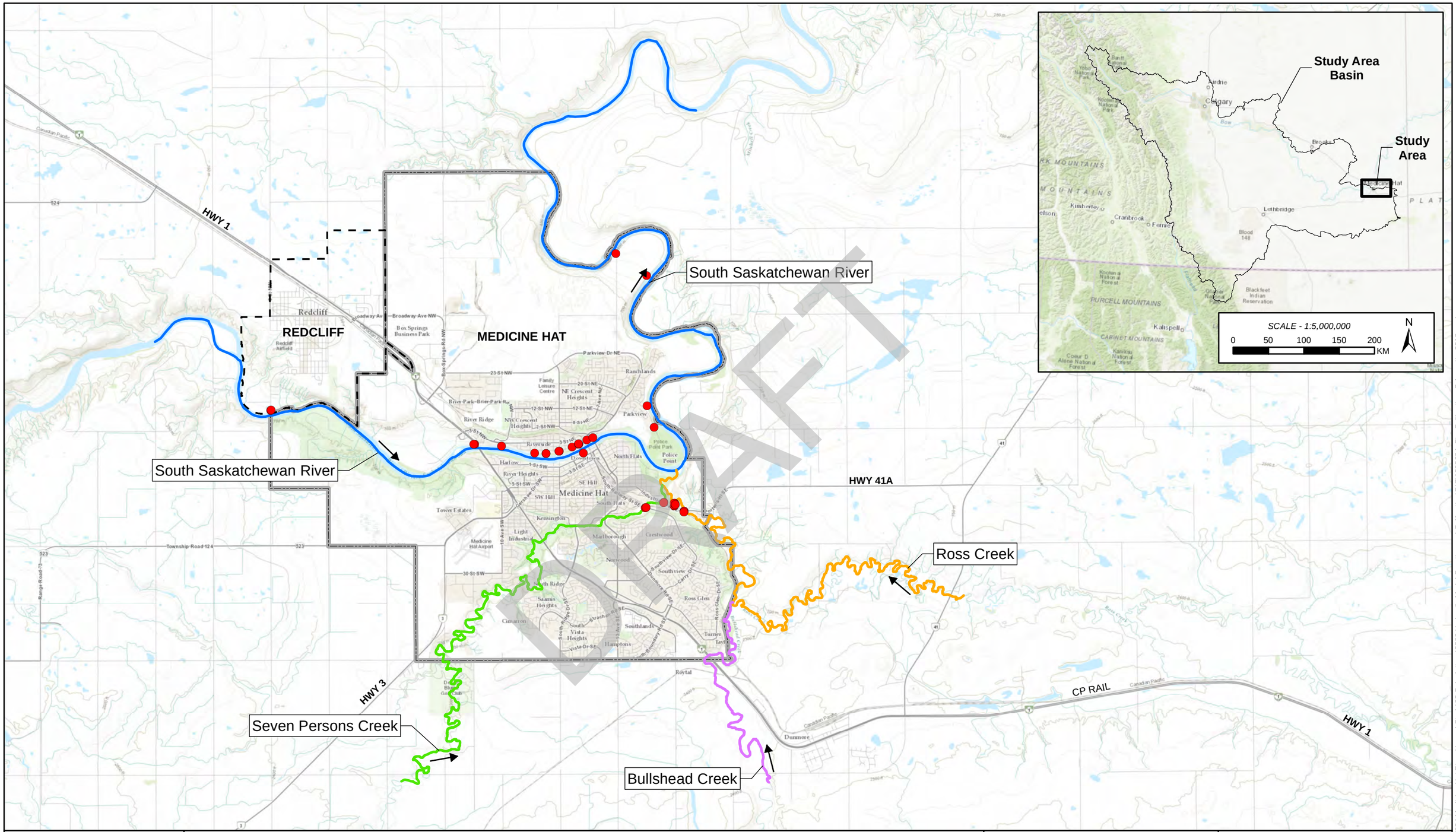

HWM Locations (2013)
Redcliff Town Boundary
Medicine Hat City Boundary
Bullshead Creek
Ross Creek
Seven Persons Creek
South Saskatchewan River

DATA SOURCES: Basemap from Esri & NRCAN.

SCALE - 1:100,000
0 1 2 3 4 KM
N

Coordinate System: NAD 1983 CSRS 3TM 111
Units: METRES

Job: 1003094 | Date: 10-SEP-2019

MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING
AND FLOOD INUNDATION MAPPING
HIGHWATER MARK LOCATIONS
2013 FLOOD

FIGURE 2D

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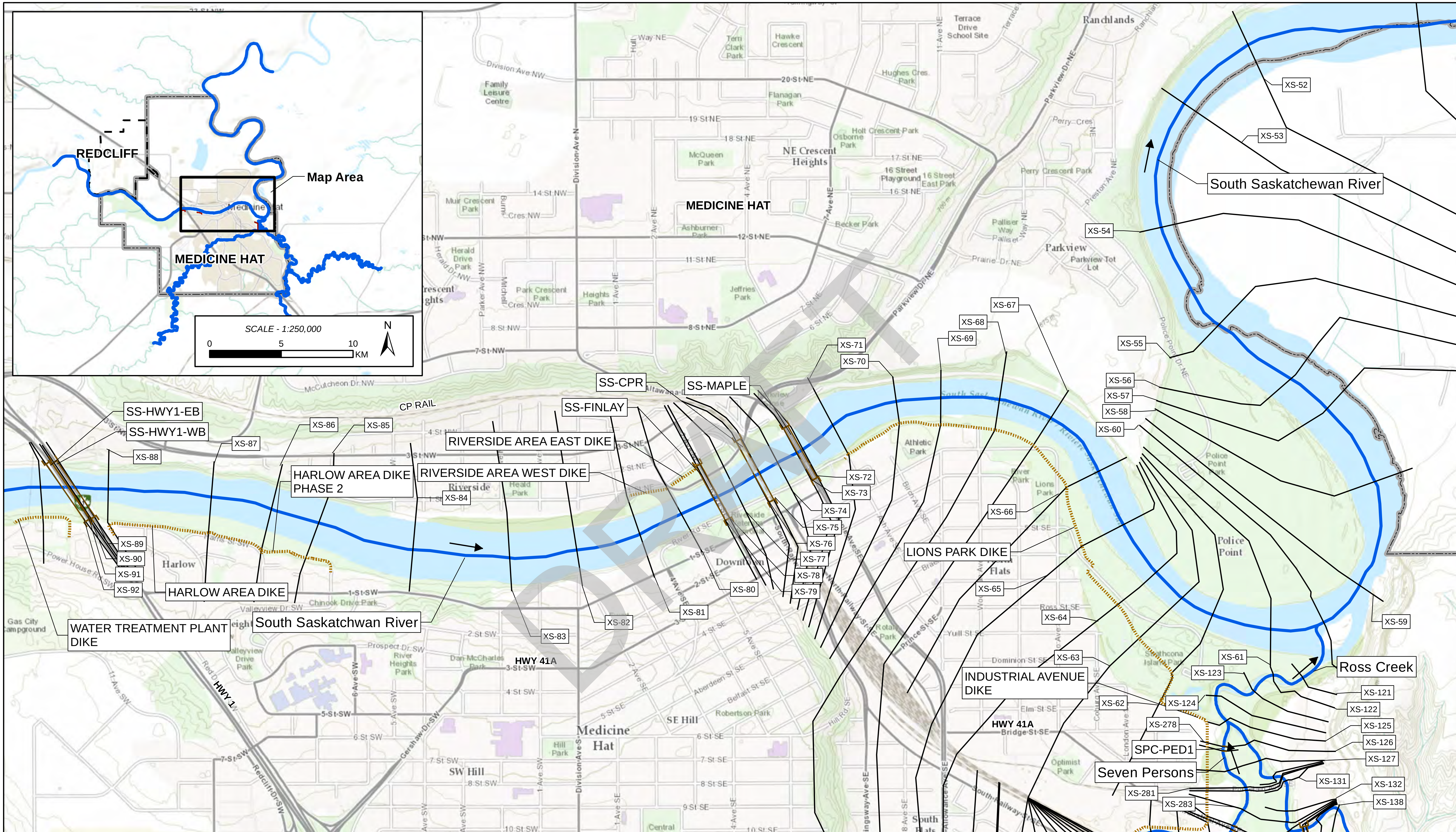

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Flood Control Structure
Bridge
Model Stream Network
Model Cross Section
Medicine Hat City Boundary

DATA SOURCES: Basemap from Esri & NRCAN.

SCALE - 1:16,000
0 200 400 600 M
N

Coordinate System: NAD 1983 CSRS 3TM 111
Units: METRES

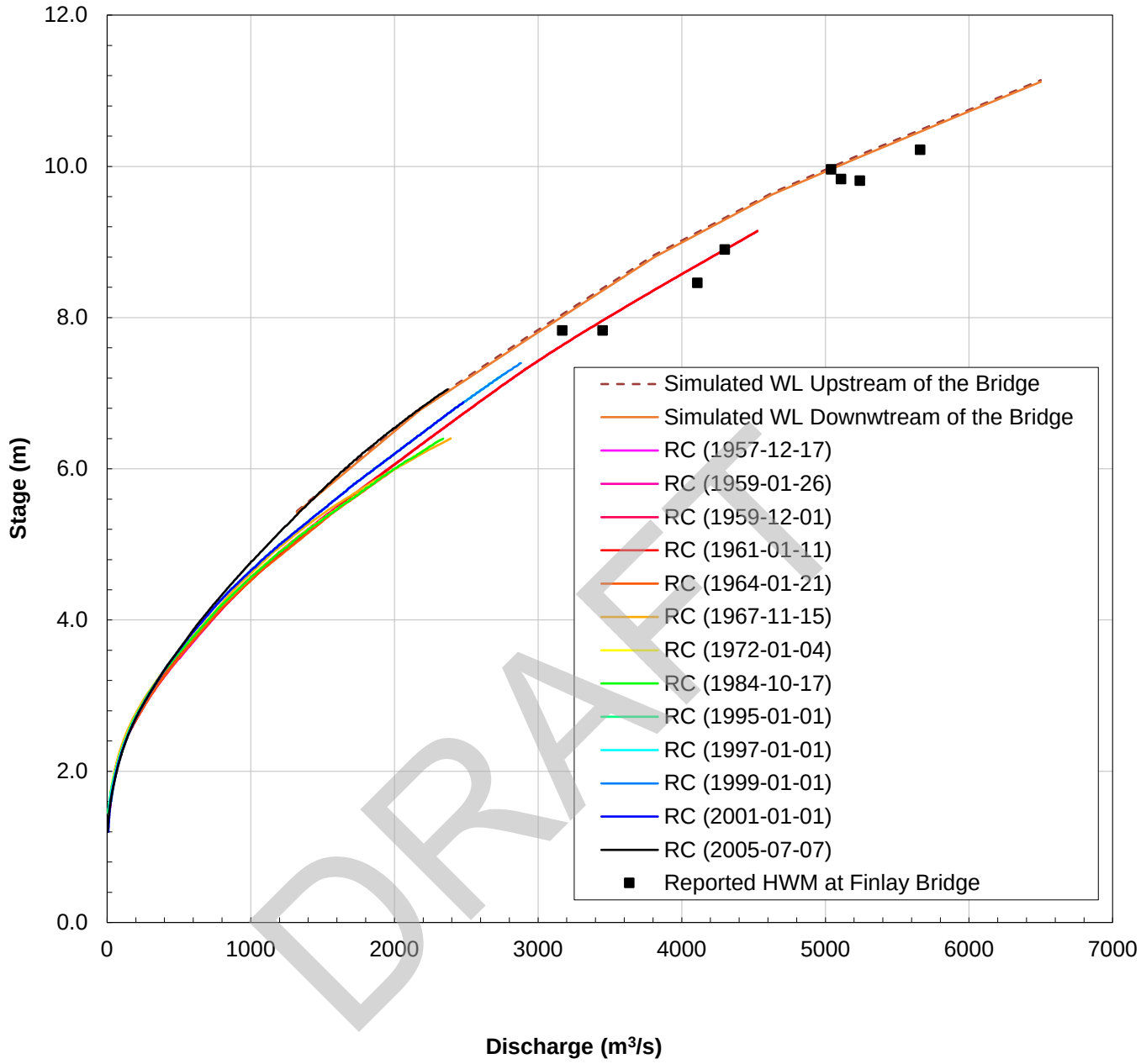
Job: 1003094 Date: 21-MAR-2022

MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND
FLOOD INUNDATION MAPPING

FLOOD CONTROL STRUCTURE LOCATIONS AND EXTENTS

FIGURE 3

MSN, P:_Projects (Active)\1003094 Medicine Hat River Hazard Study\04 Models\GIS\GIS_1006302_Fig_T300_FCS_R0.mxd



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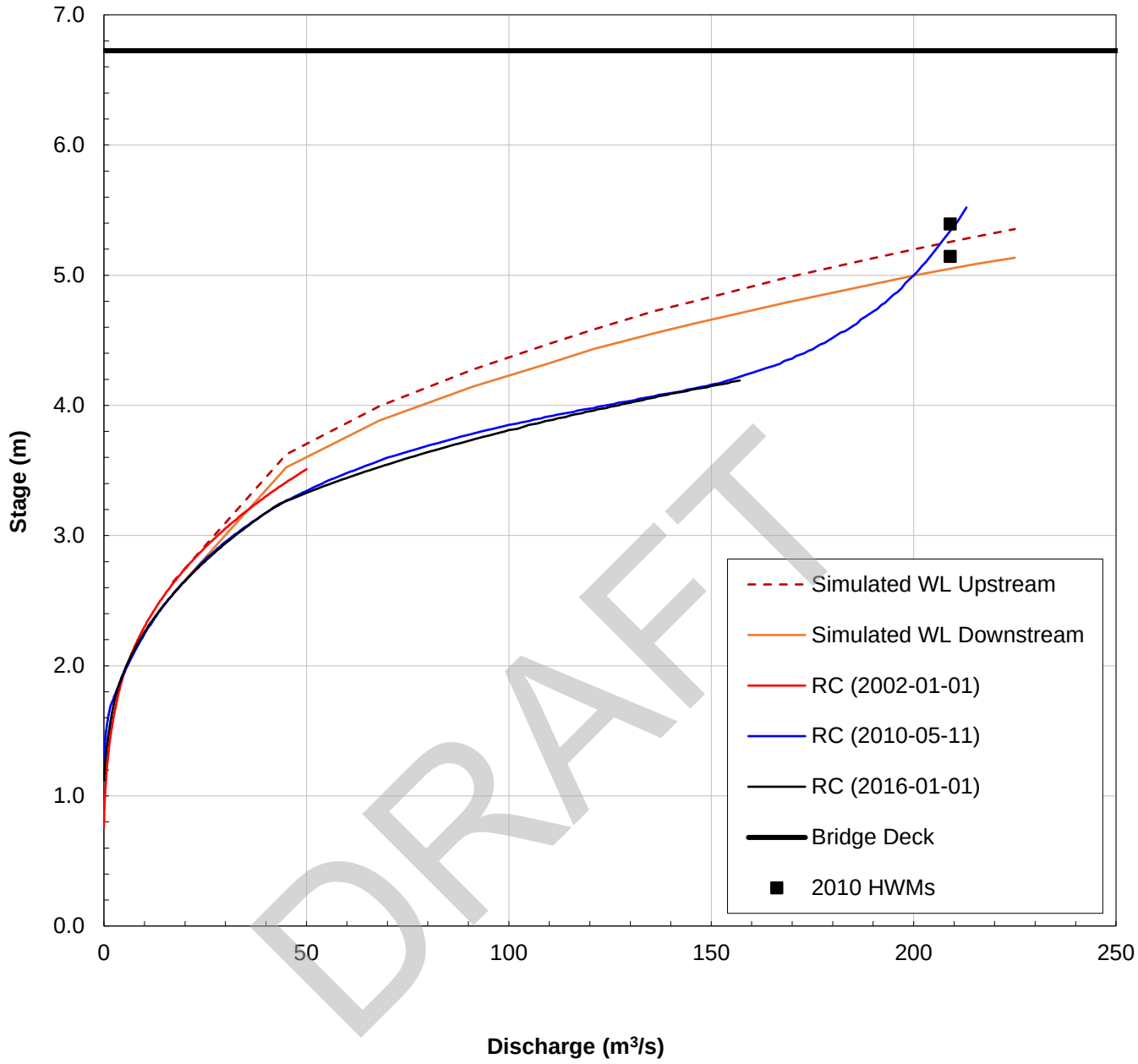
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPARISON OF SIMULATED RATING CURVE TO GAUGE RATING CURVE (WSC STATION 05AJ001)

Job: 1003094

Date: 21-MAR-2022

FIGURE 4



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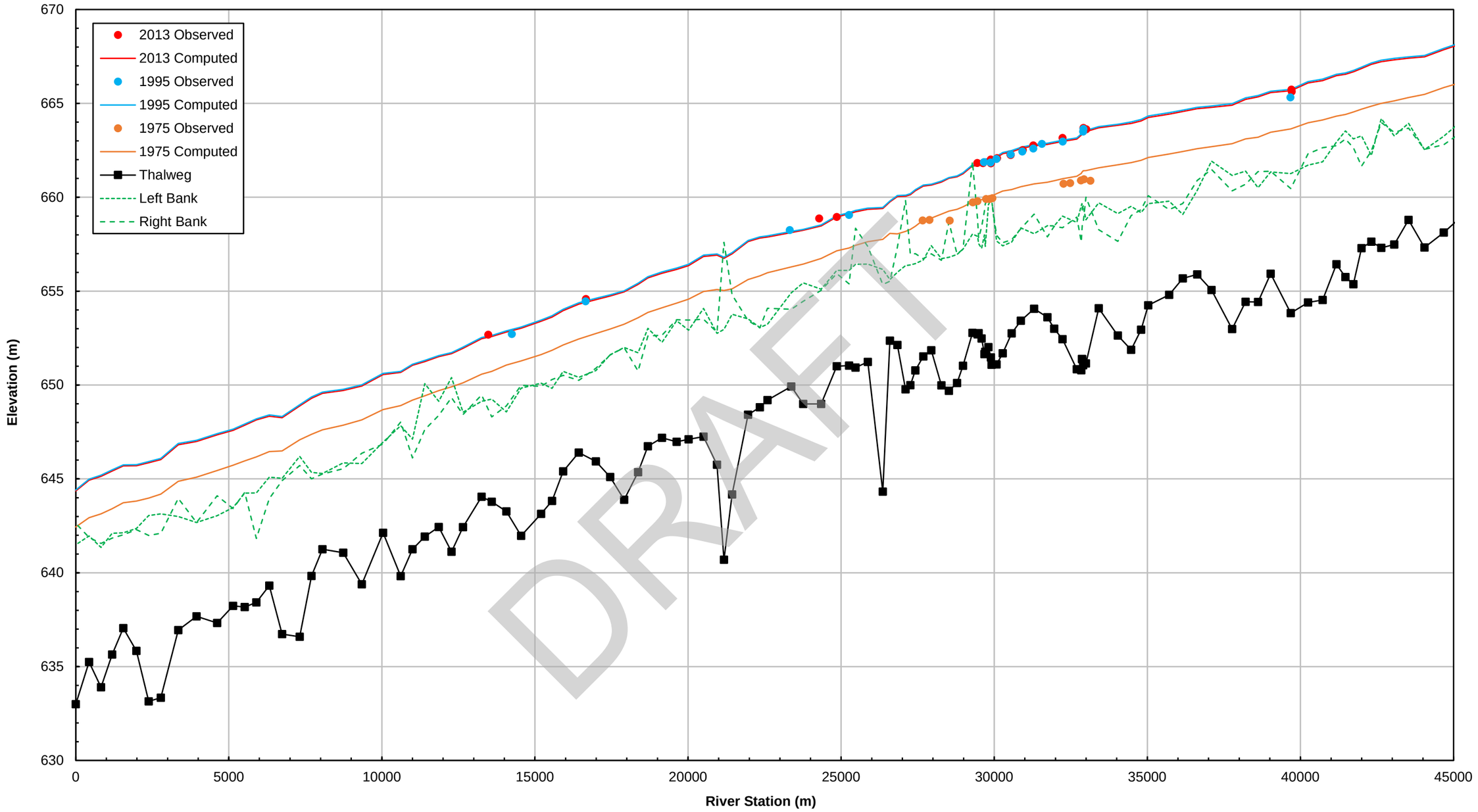
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPARISON OF SIMULATED RATING CURVE TO GAUGE RATING CURVE (WSC STATION 05AH052)

Job: 1003094

Date: 21-MAR-2022

FIGURE 5



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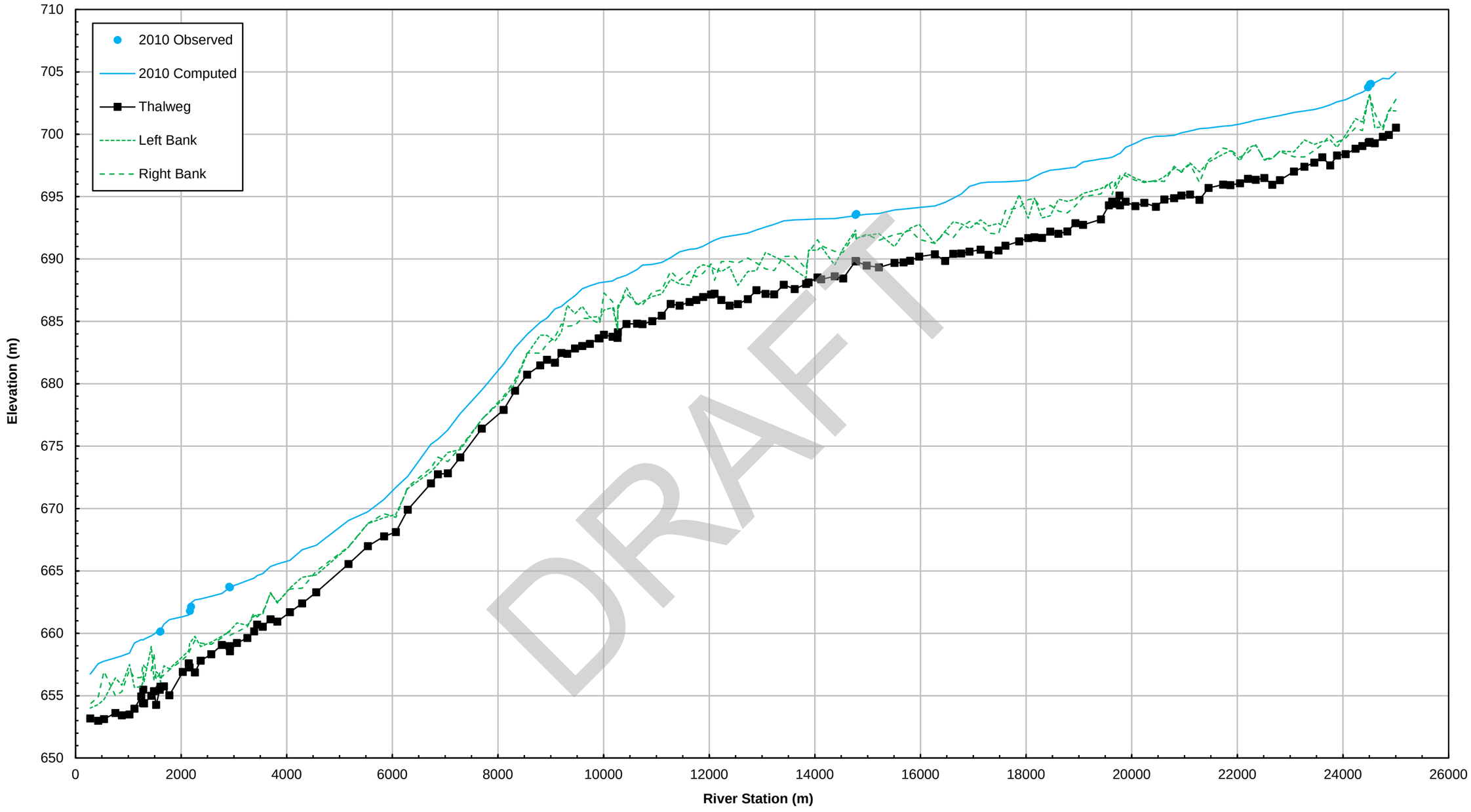
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

WATER SURFACE PROFILE CALIBRATION (SOUTH SASKATCHEWAN RIVER)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 6



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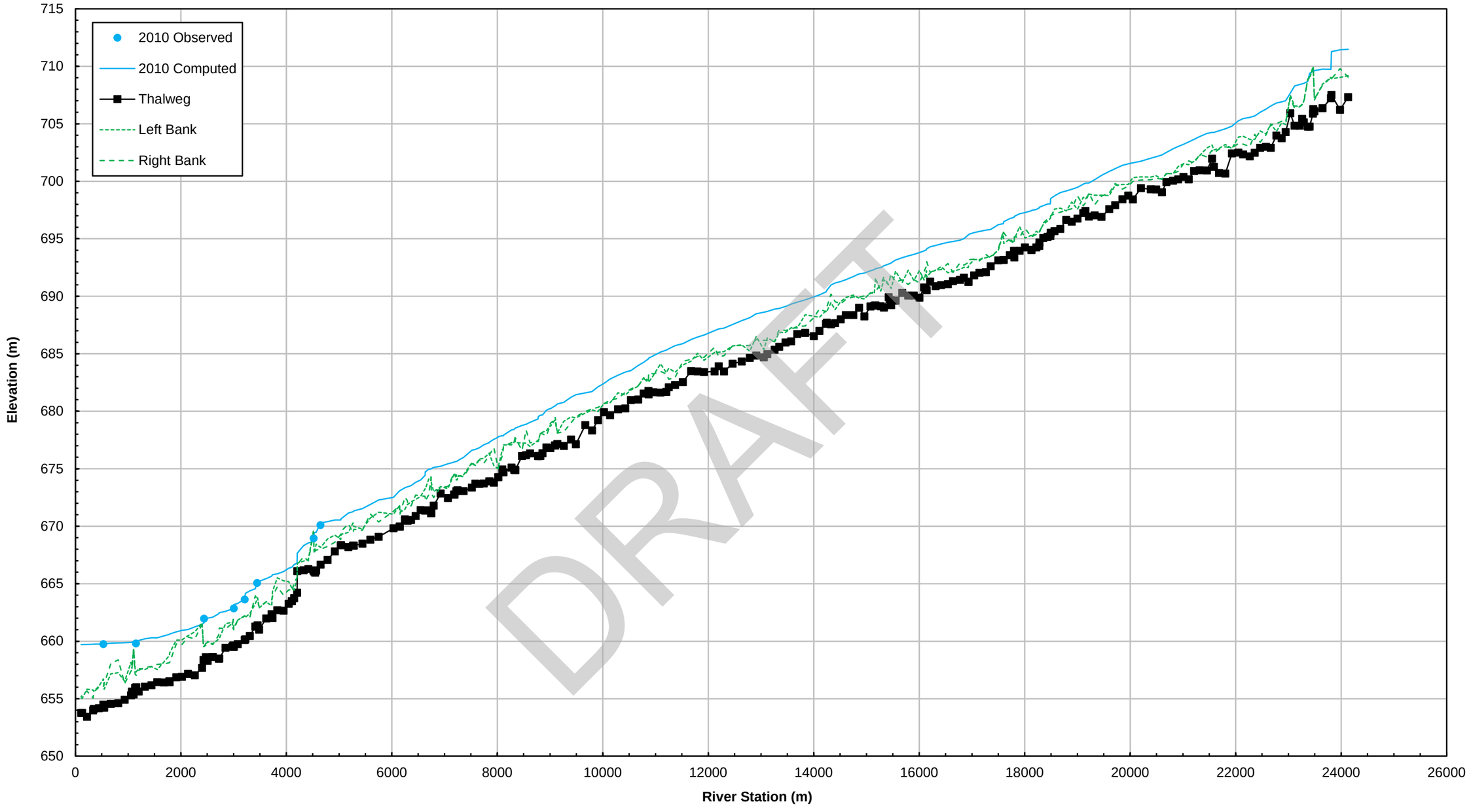
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

WATER SURFACE PROFILE CALIBRATION (ROSS CREEK)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 7



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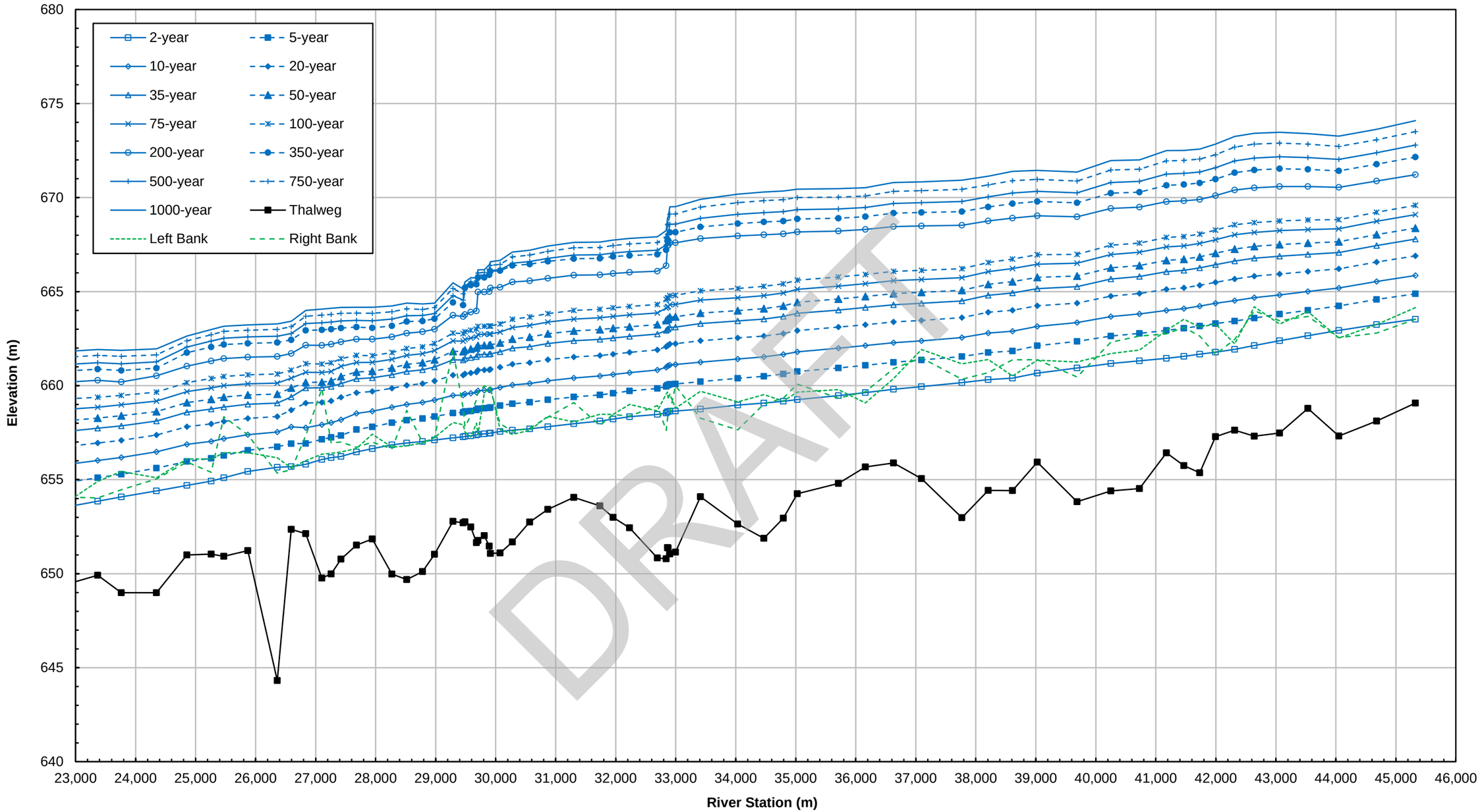
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

WATER SURFACE PROFILE CALIBRATION
(SEVEN PERSONS CREEK)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 8



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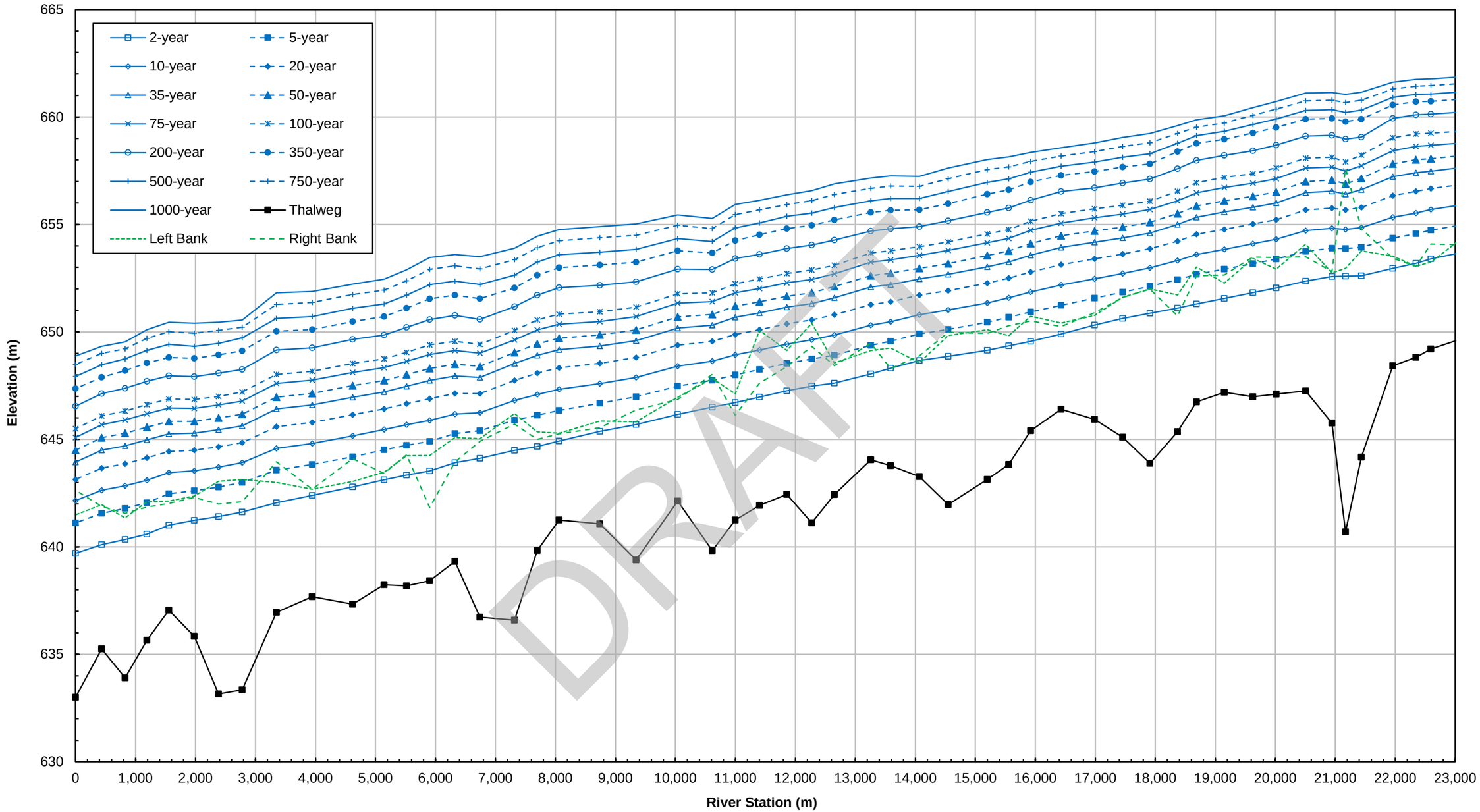
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

SOUTH SASKATCHEWAN RIVER FLOOD FREQUENCY PROFILES (1/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 9A



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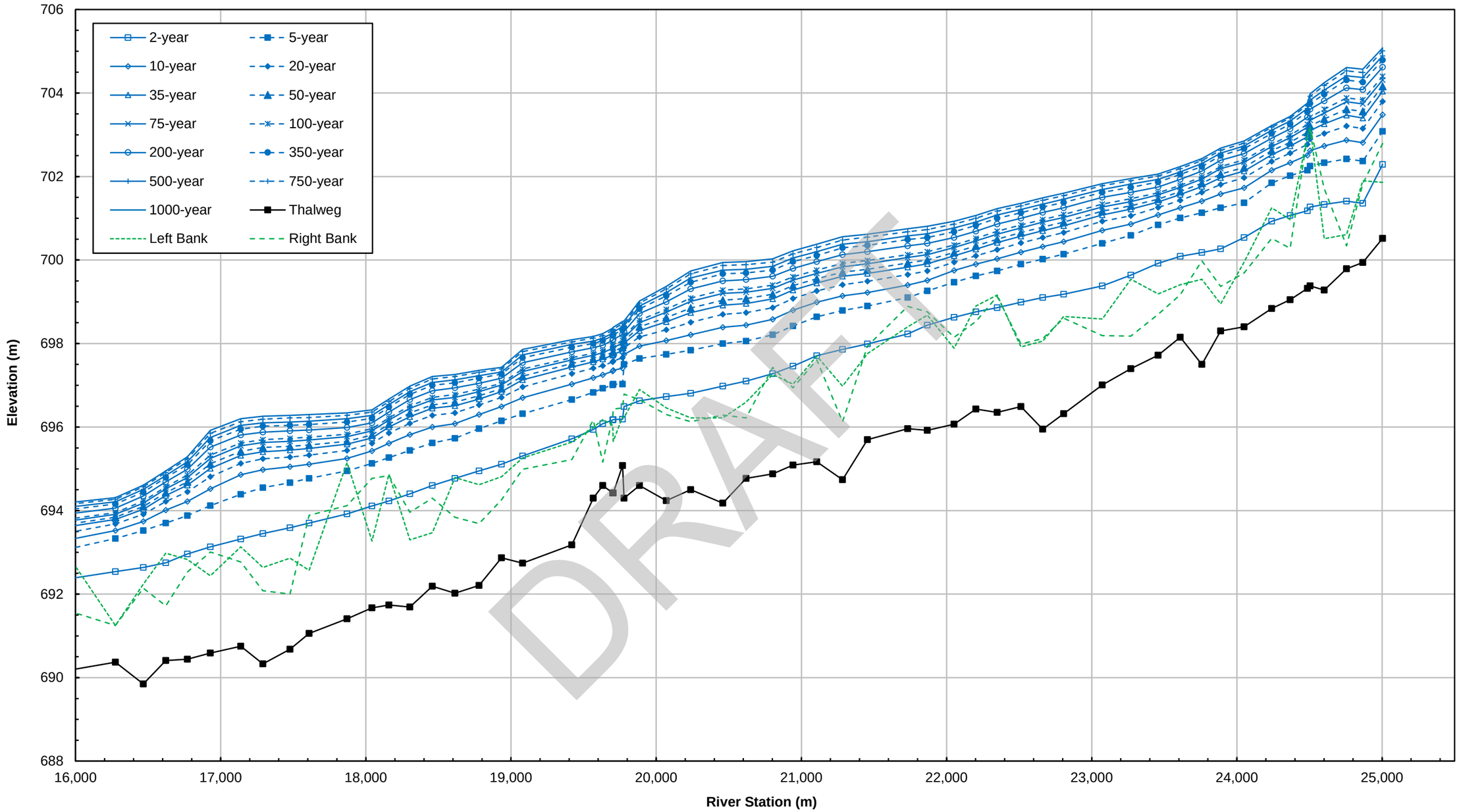
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

SOUTH SASKATCHEWAN RIVER FLOOD FREQUENCY PROFILES (2/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 9B



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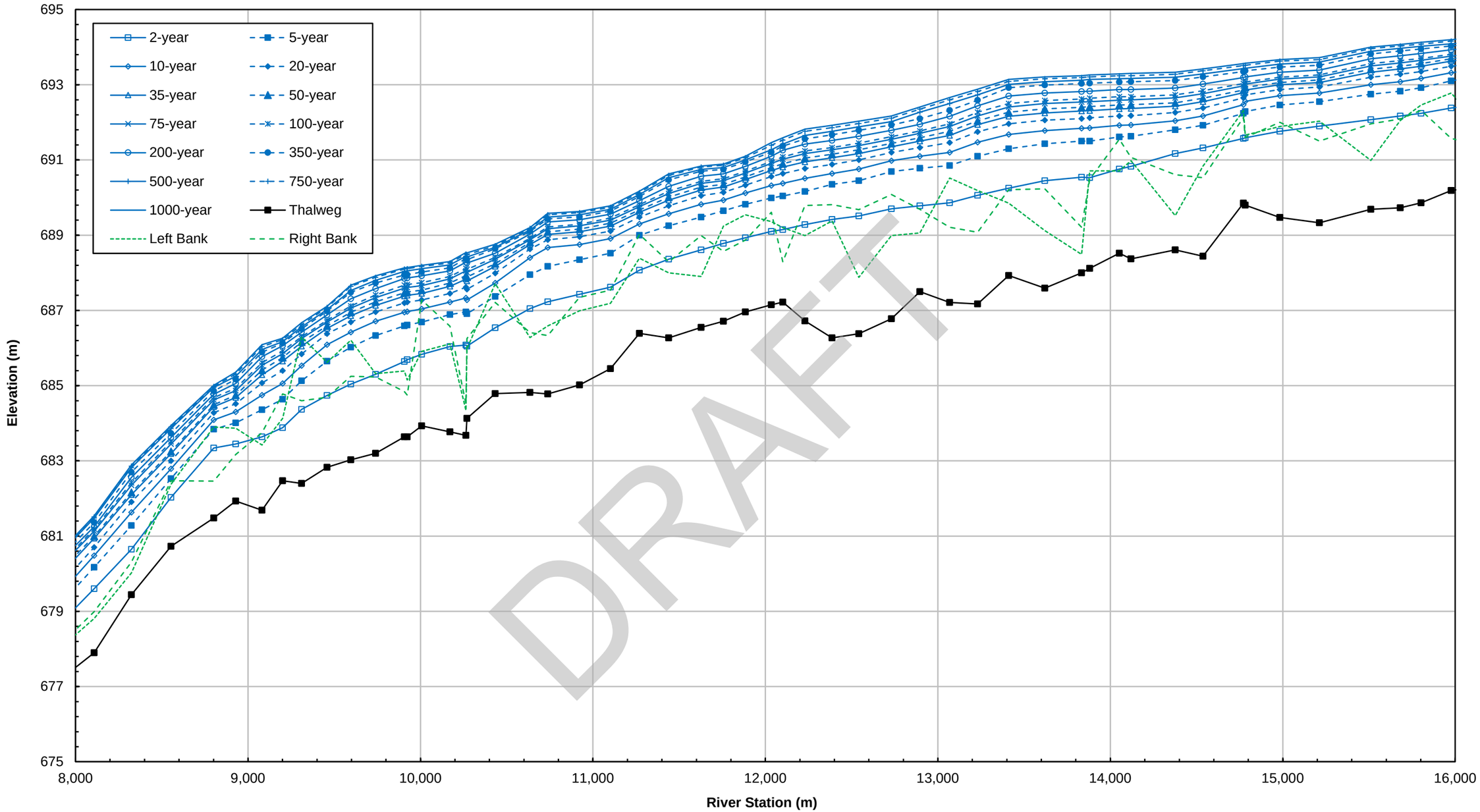
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

ROSS CREEK FLOOD FREQUENCY PROFILES (1/3)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 10A



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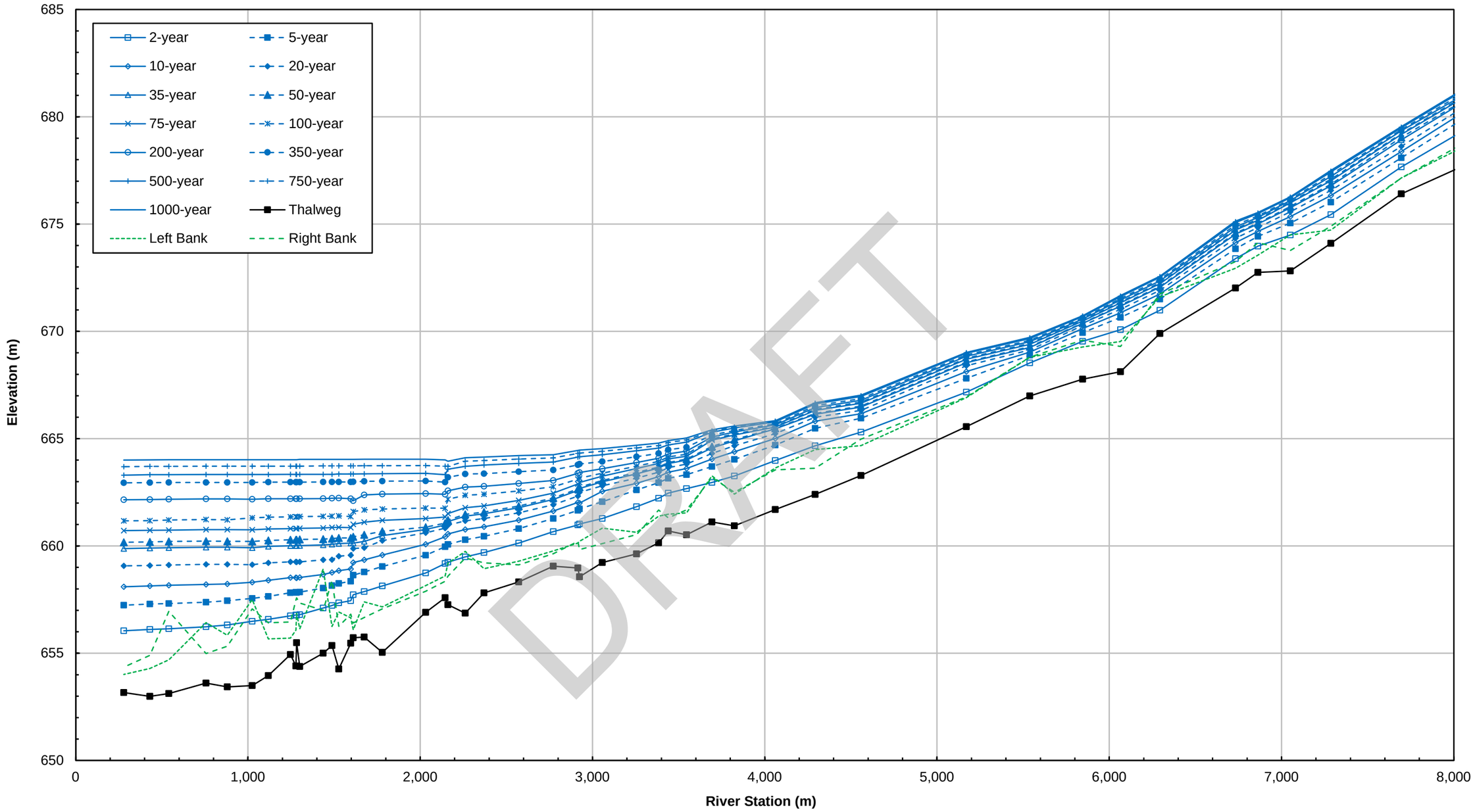
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

ROSS CREEK FLOOD FREQUENCY PROFILES (2/3)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 10B



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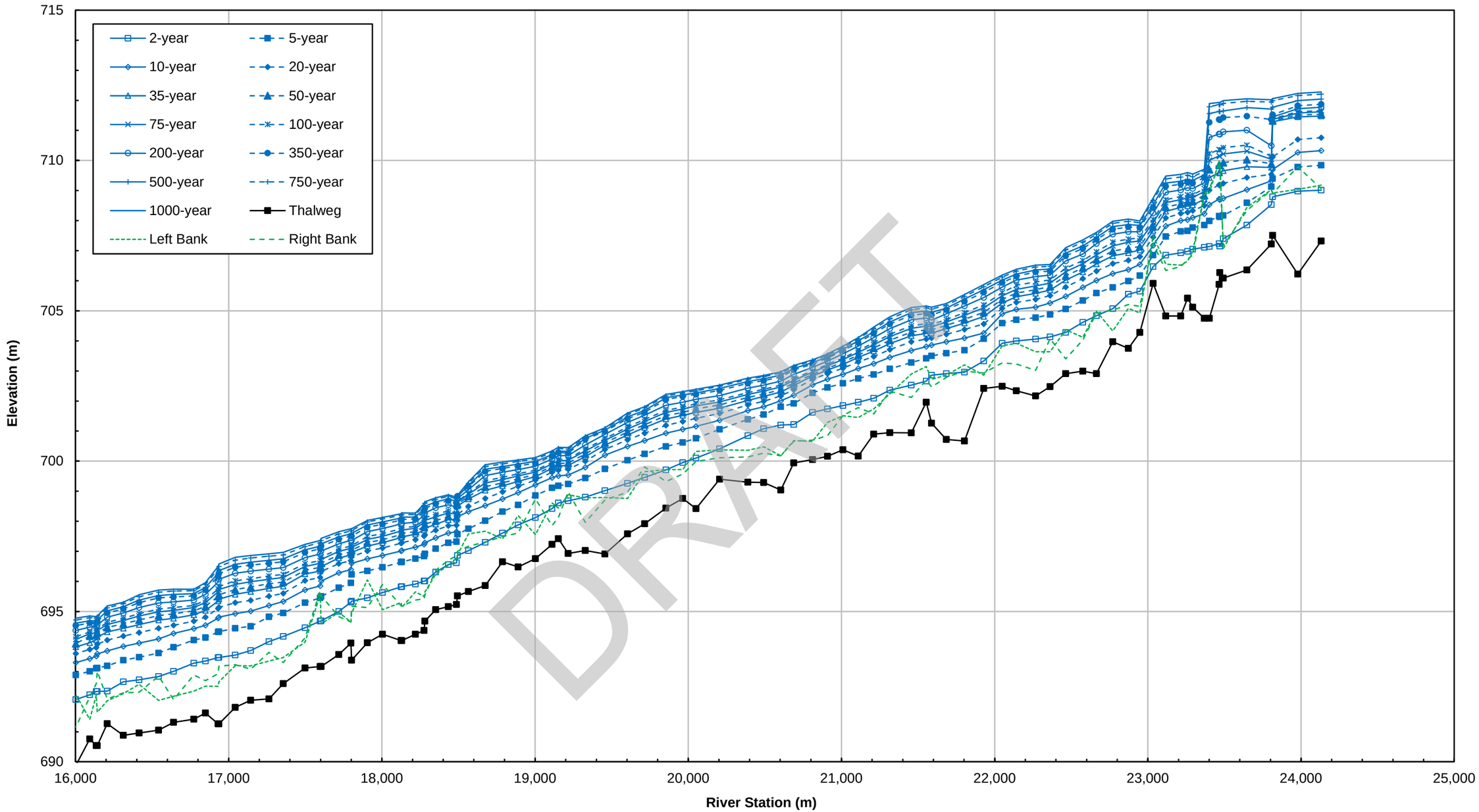
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

ROSS CREEK FLOOD FREQUENCY PROFILES (3/3)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 10C



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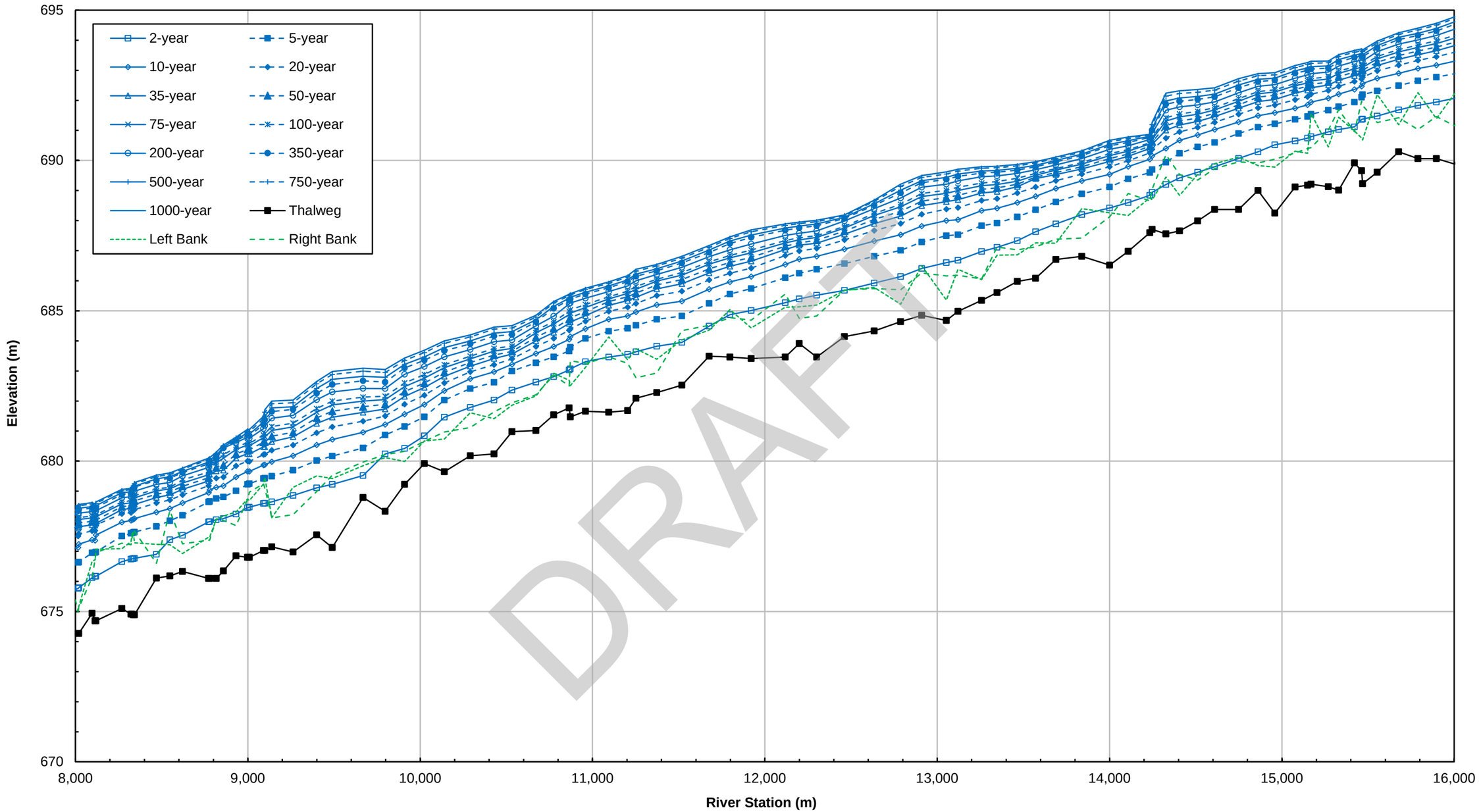
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

SEVEN PERSONS CREEK FLOOD FREQUENCY PROFILES (1/3)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 11A



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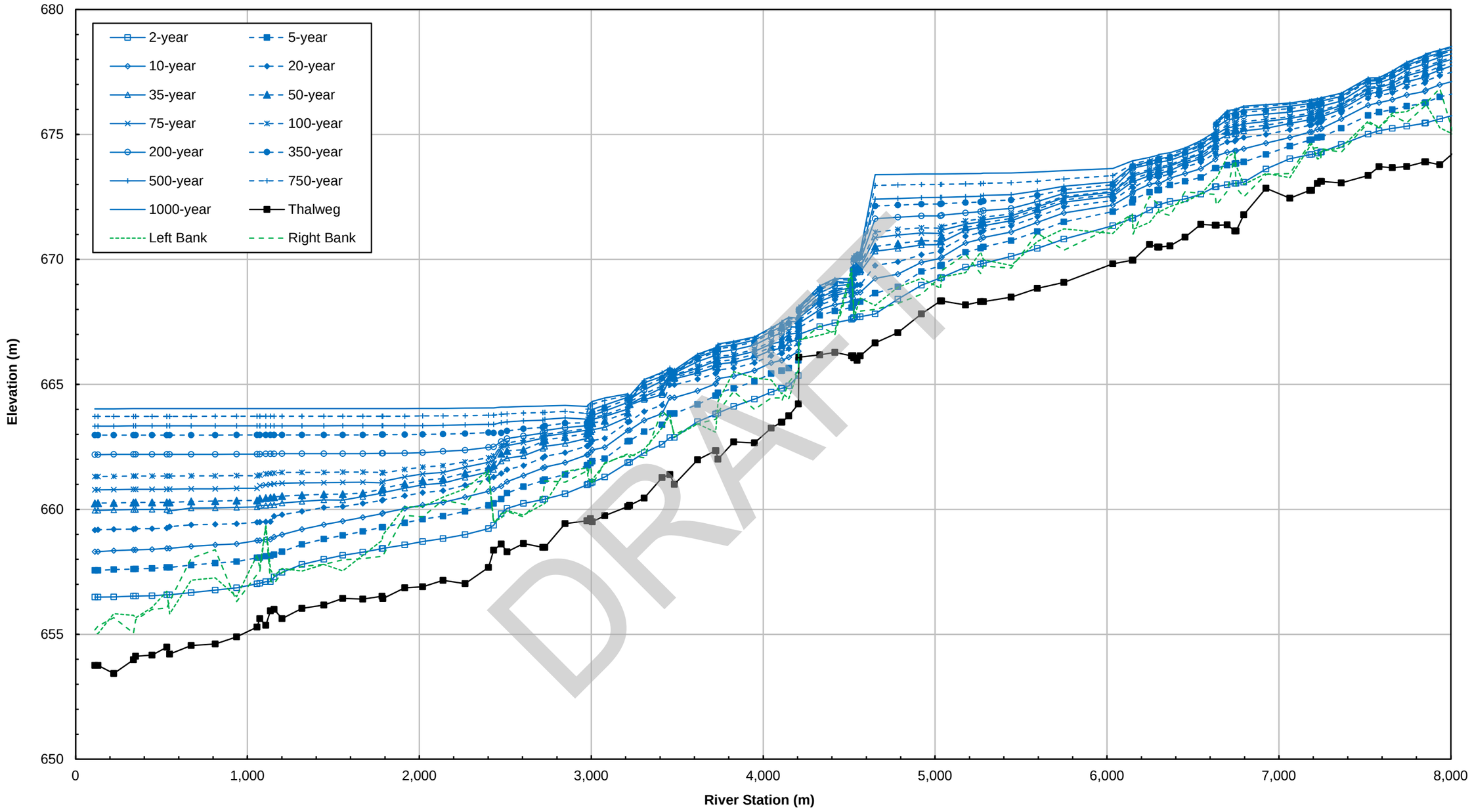
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

SEVEN PERSONS CREEK FLOOD FREQUENCY PROFILES (2/3)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 11B



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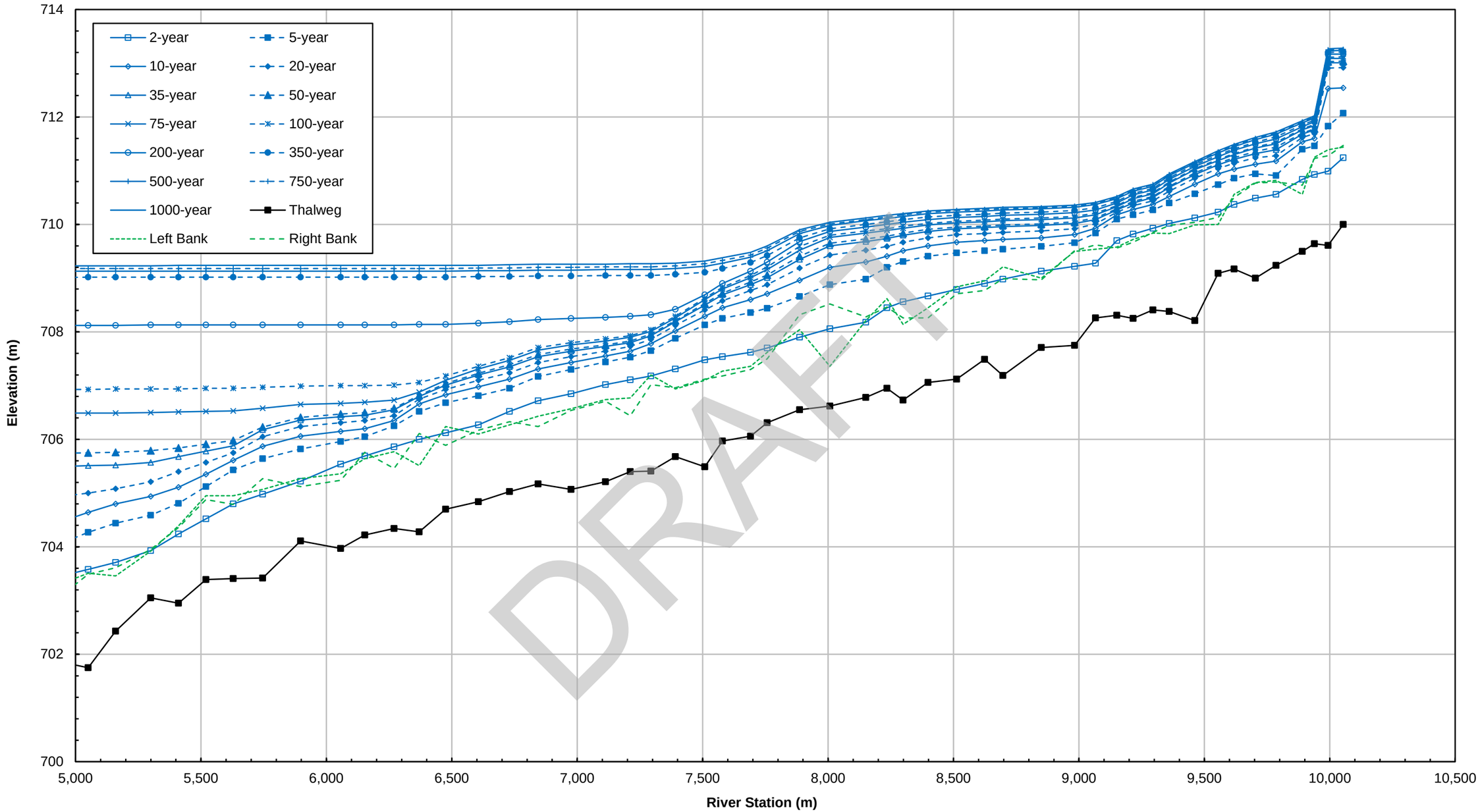
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

SEVEN PERSONS CREEK FLOOD FREQUENCY PROFILES (3/3)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 11C



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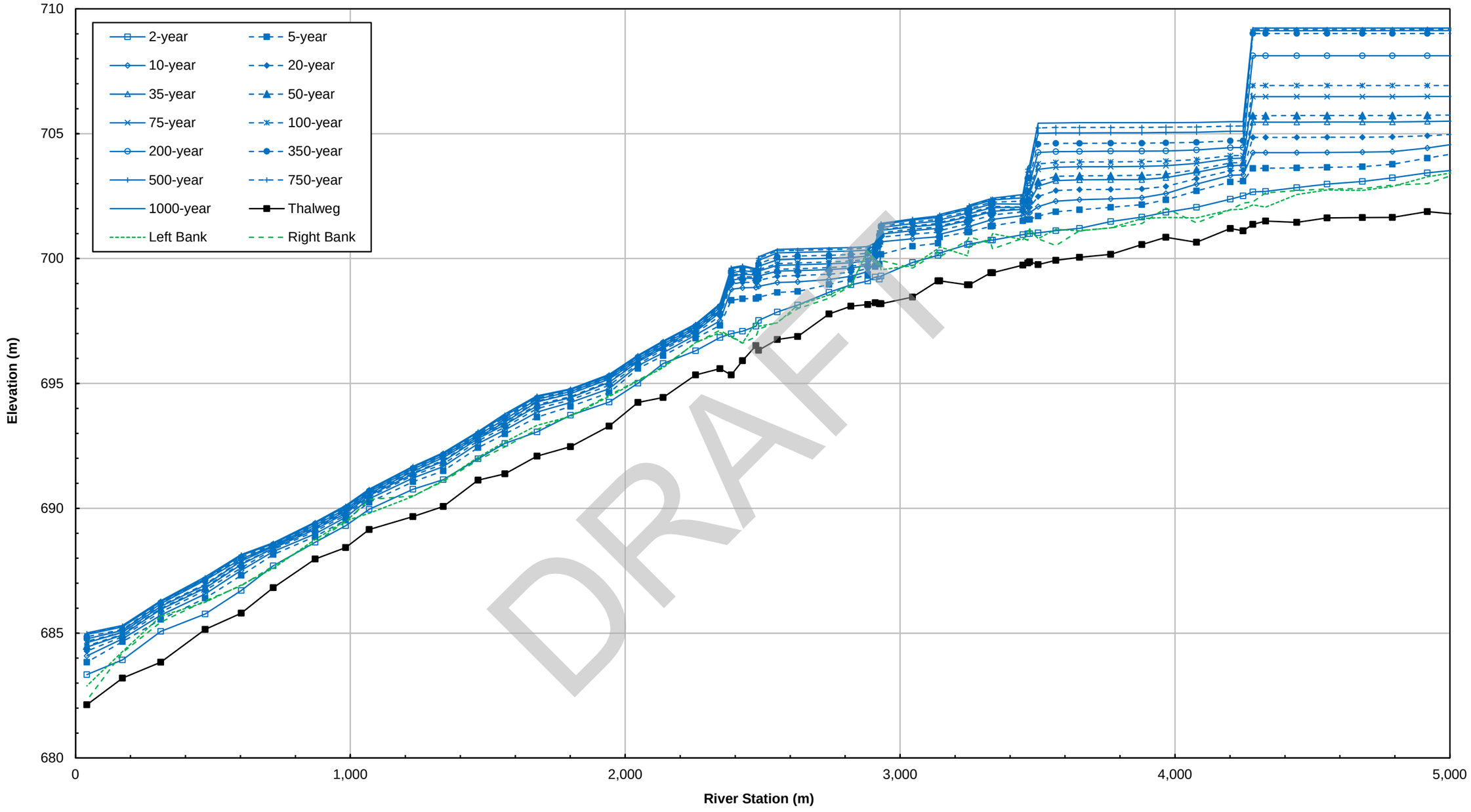
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

BULLSHEAD CREEK FLOOD FREQUENCY PROFILES (1/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 12A



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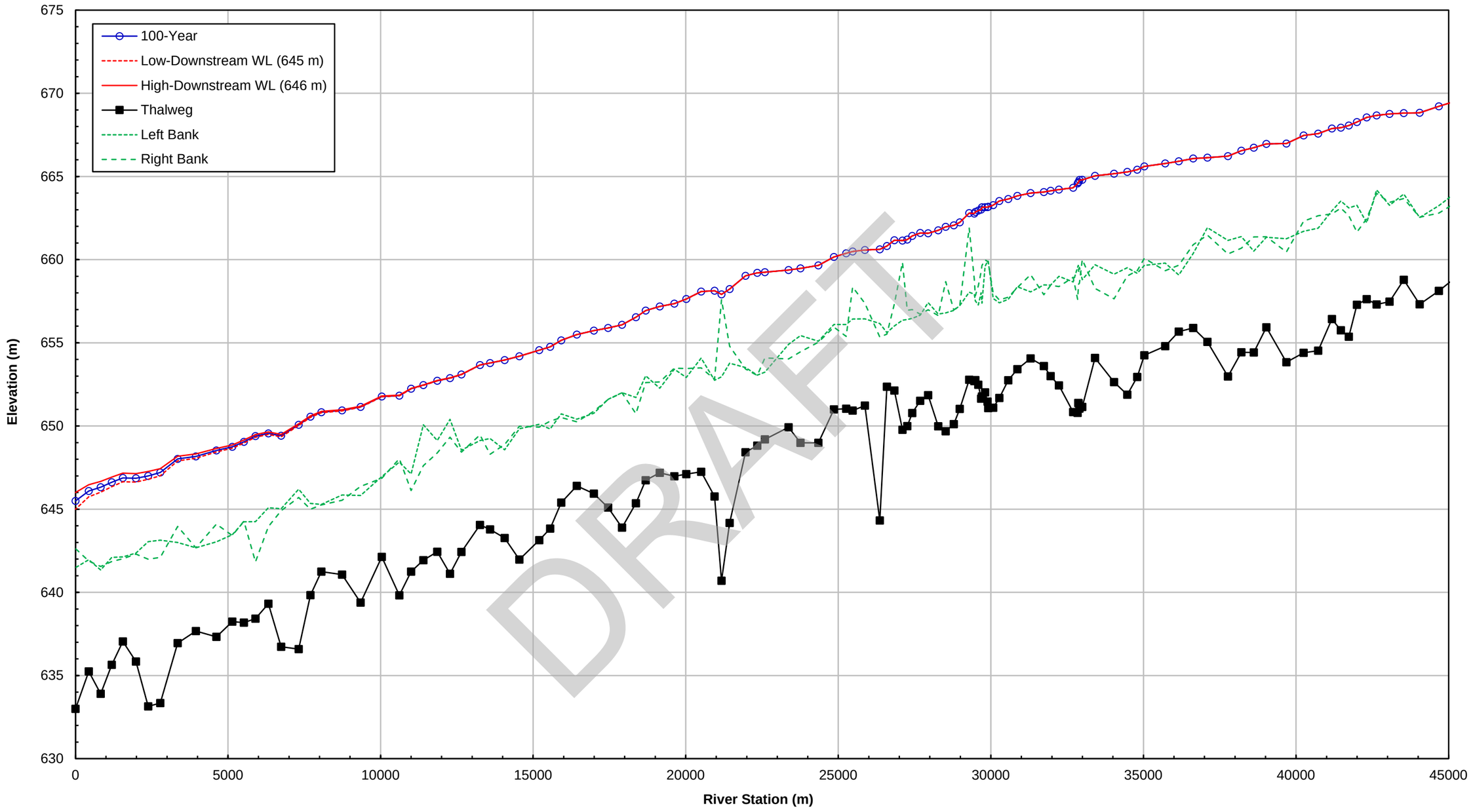
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

BULLSHEAD CREEK FLOOD FREQUENCY PROFILES (2/2)

Job: 01003094 | *Date: 21-MAR-2022*

FIGURE 12B



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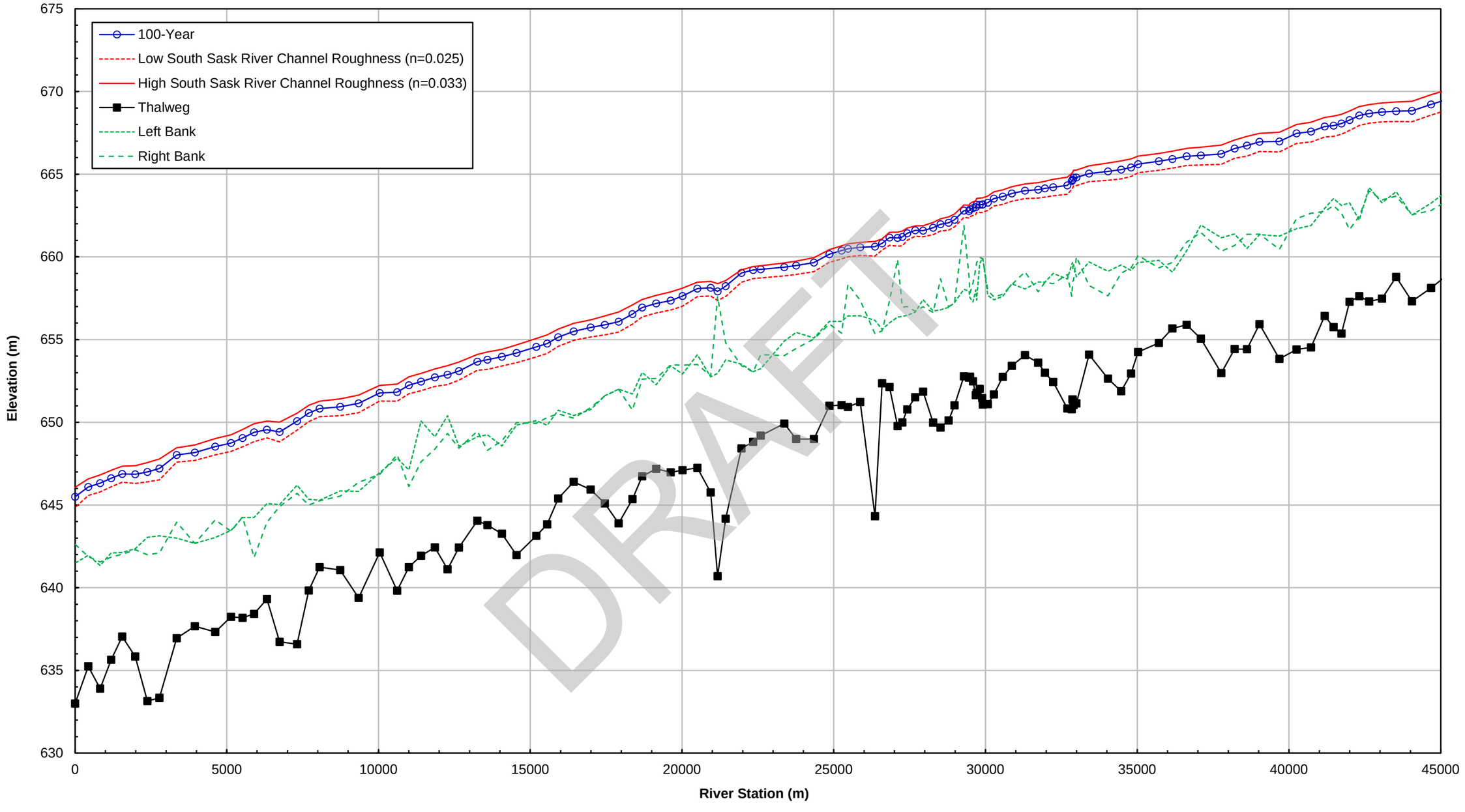
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO DOWNSTREAM BOUNDARY CONDITION (SOUTH SASKATCHEWAN RIVER)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 13



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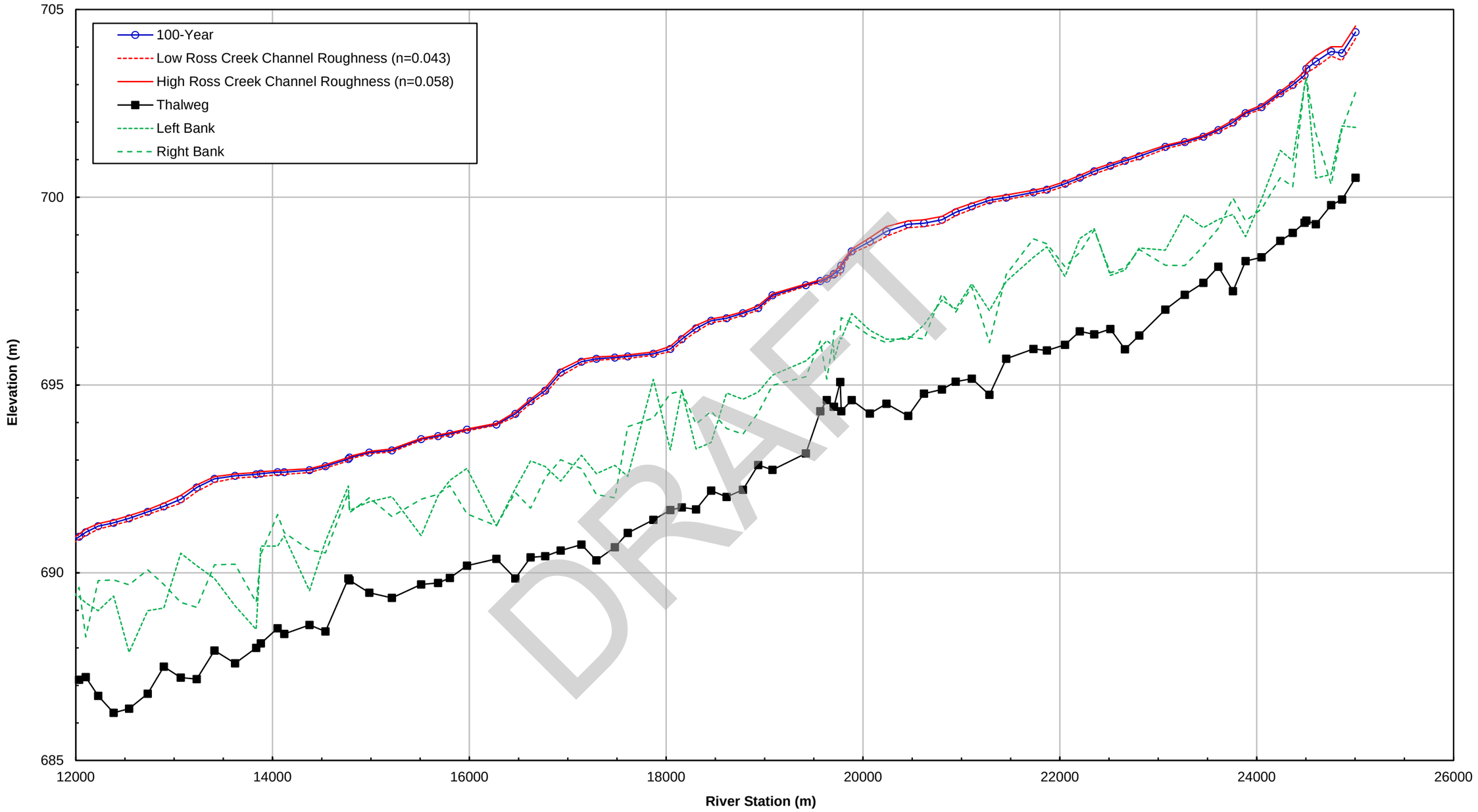
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO CHANNEL ROUGHNESS (SOUTH SASKATCHEWAN RIVER)

Job: 01003094 | *Date: 21-MAR-2022*

FIGURE 14



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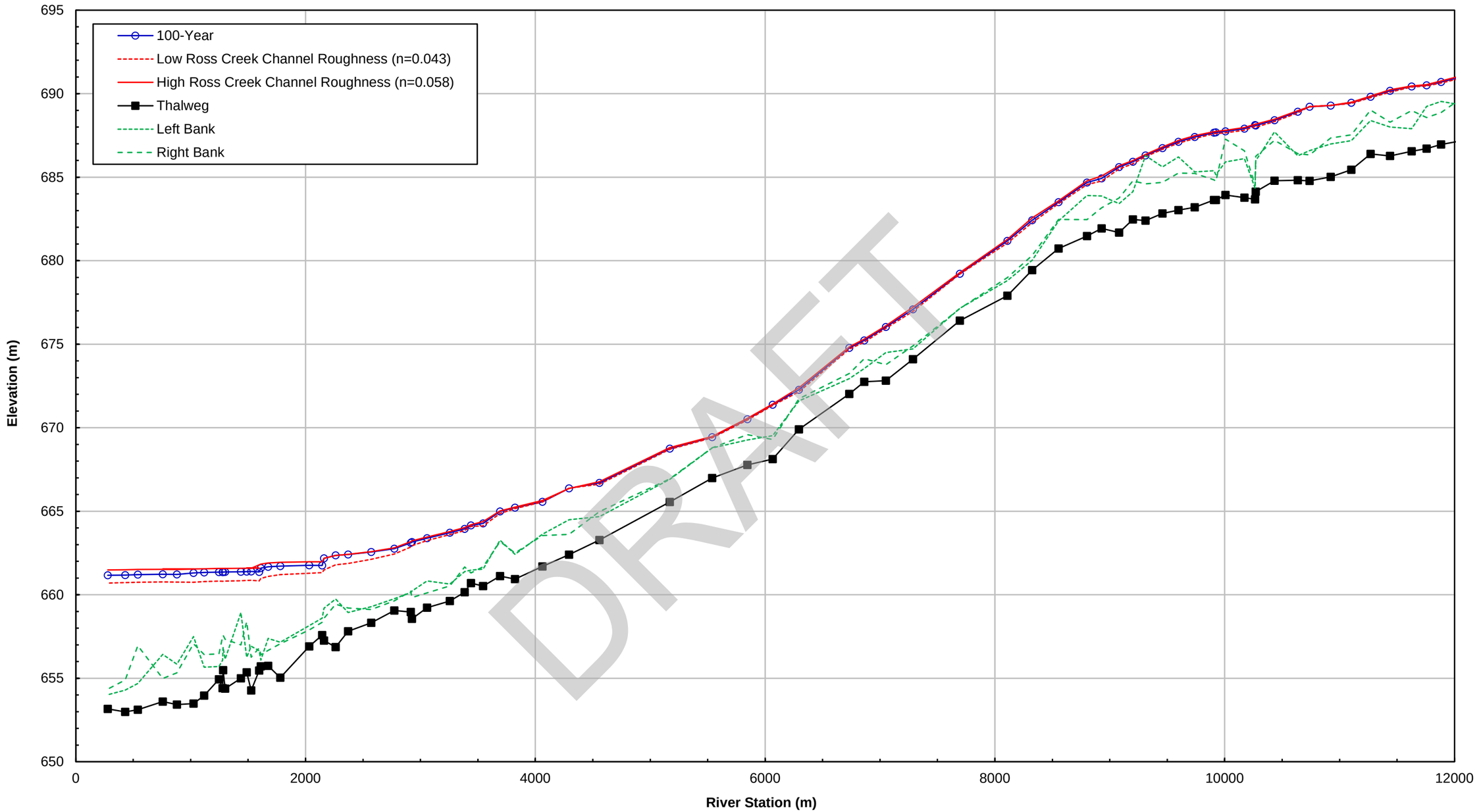
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO CHANNEL ROUGHNESS (ROSS CREEK) (1/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 15A



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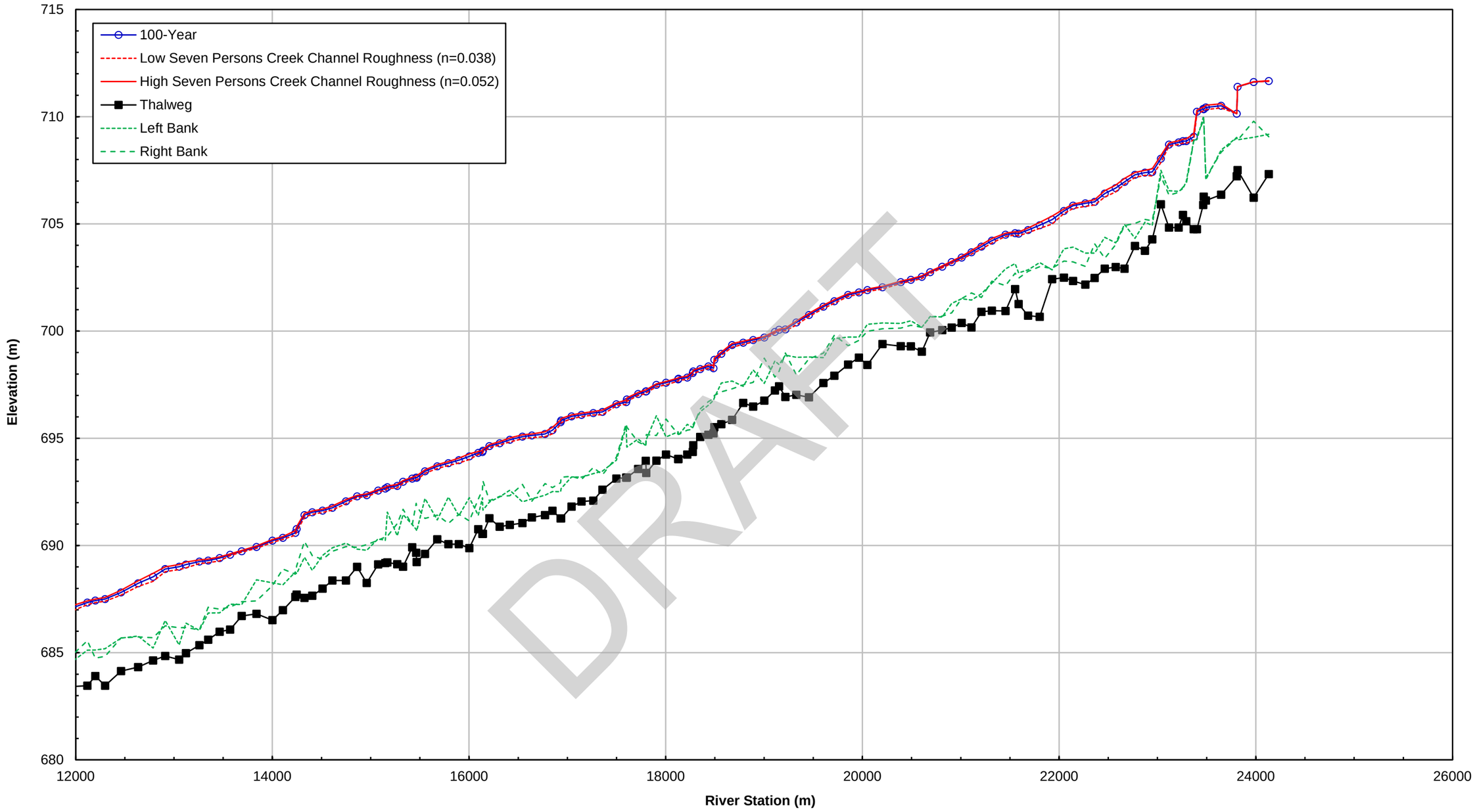
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO CHANNEL ROUGHNESS (ROSS CREEK) (2/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 15B



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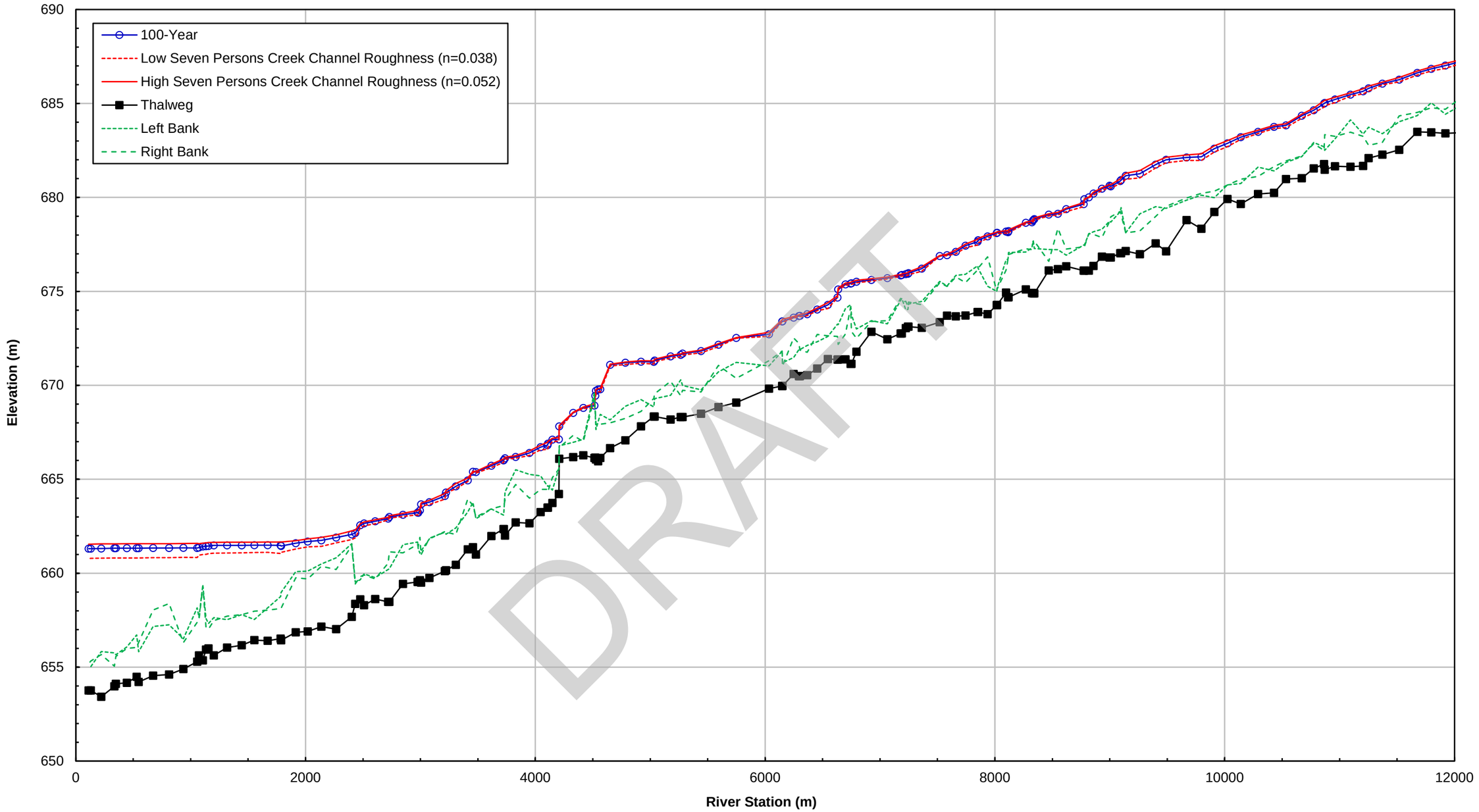
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO CHANNEL ROUGHNESS (SEVEN PERSONS CREEK) (1/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 16A



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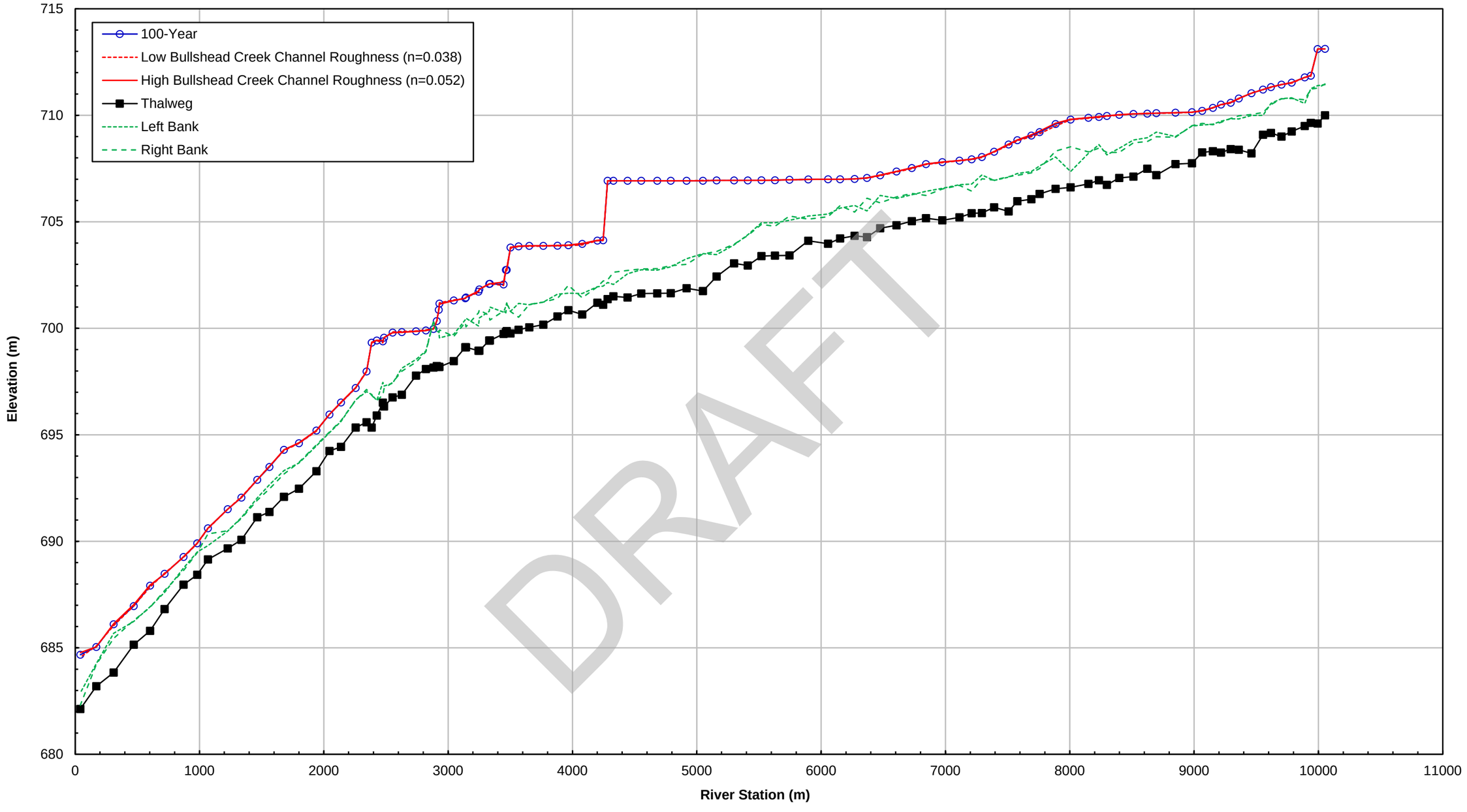
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO CHANNEL ROUGHNESS (SEVEN PERSONS CREEK) (2/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 16B



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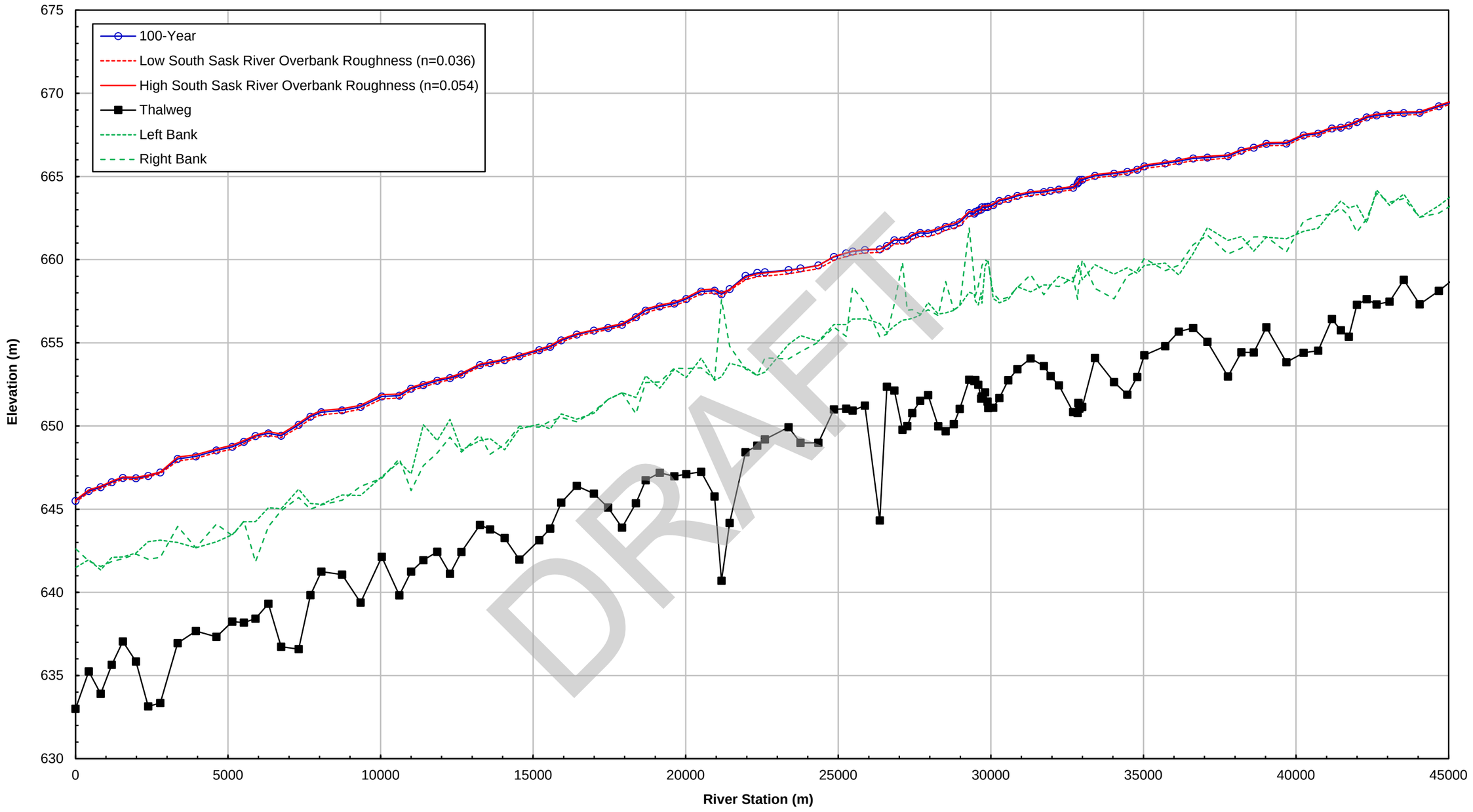
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO CHANNEL ROUGHNESS (BULLSHEAD CREEK)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 17



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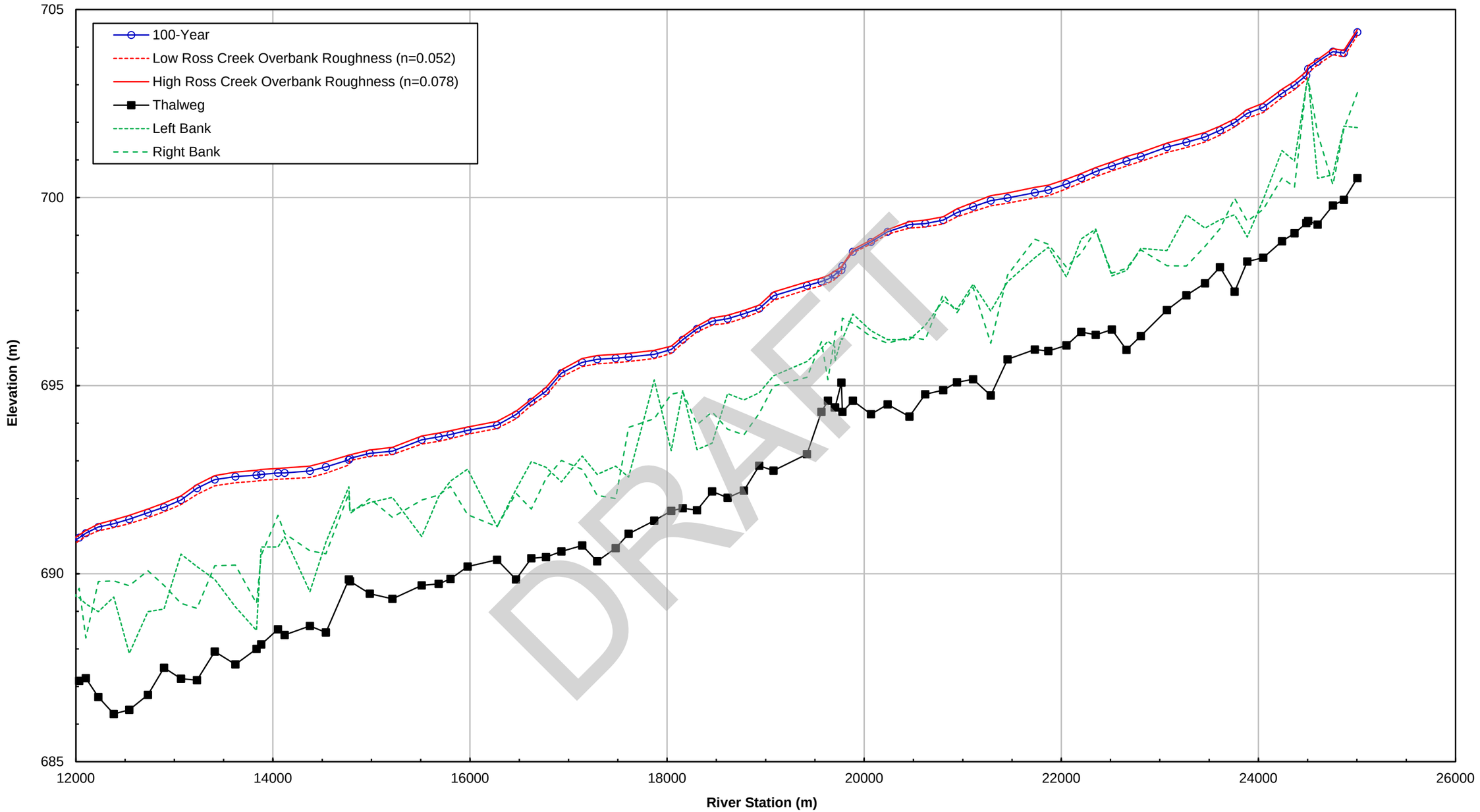
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO OVERBANK ROUGHNESS (SOUTH SASKATCHEWAN RIVER)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 18



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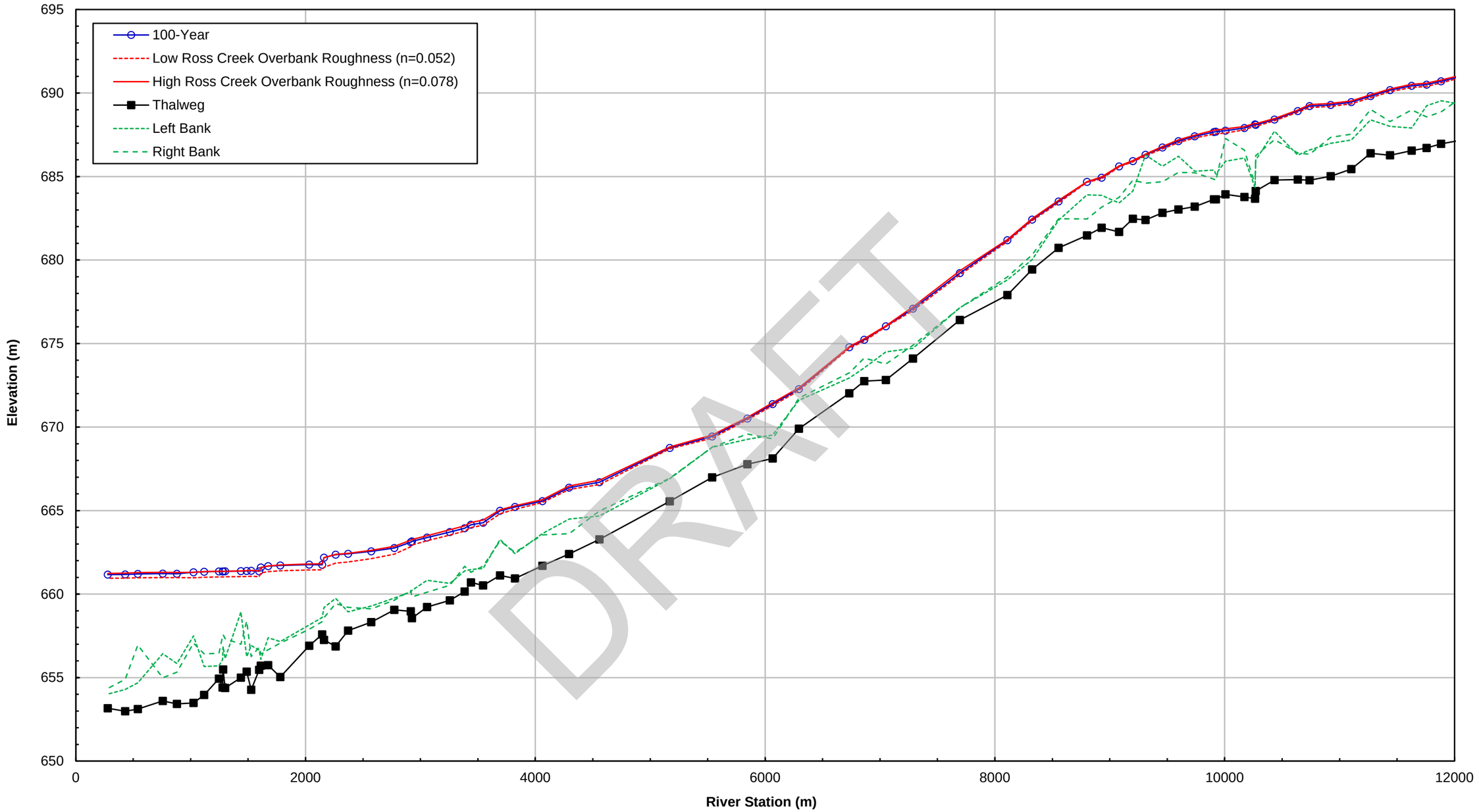
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO OVERBANK ROUGHNESS (ROSS CREEK) (1/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 19A



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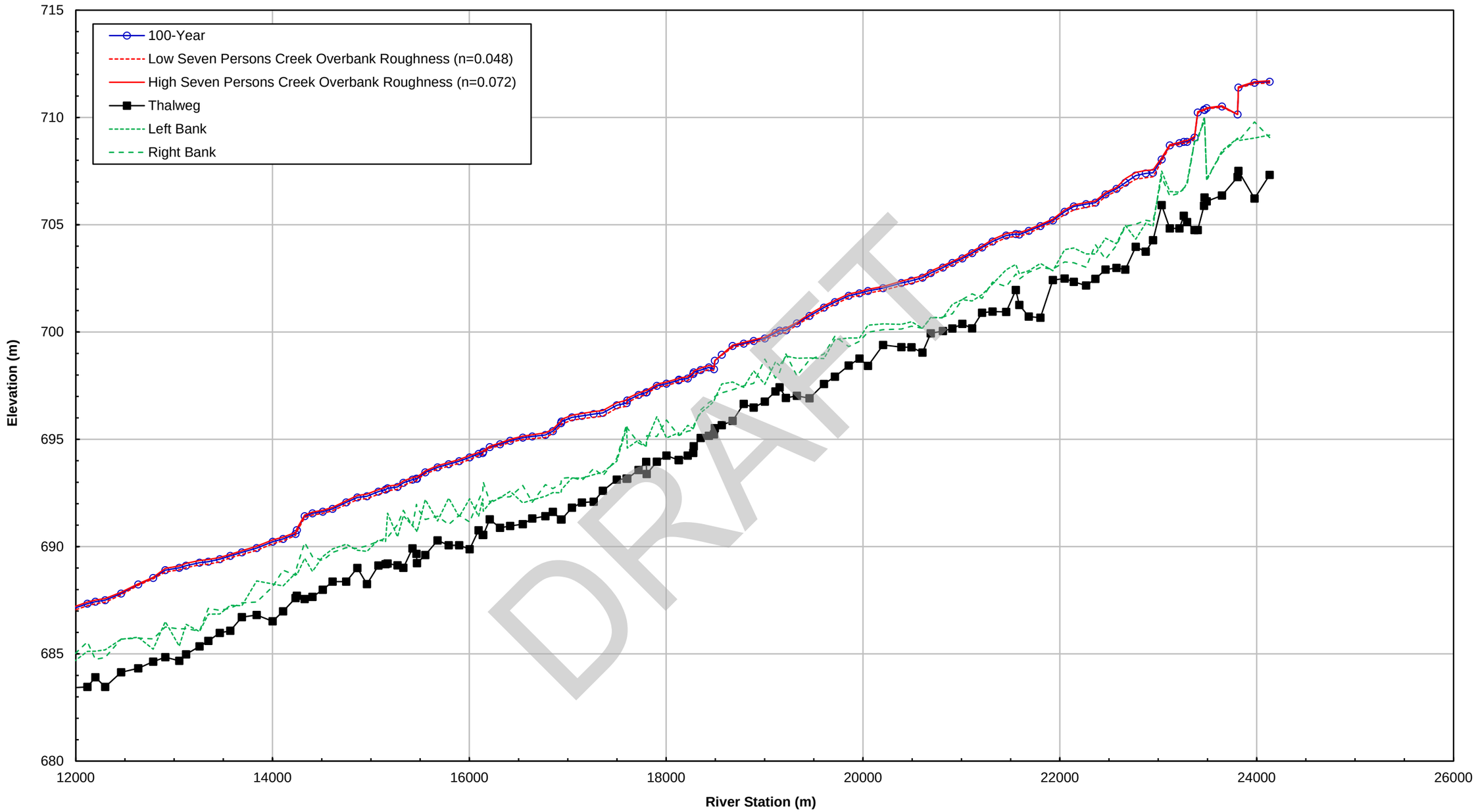
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO OVERBANK ROUGHNESS (ROSS CREEK) (2/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 19B



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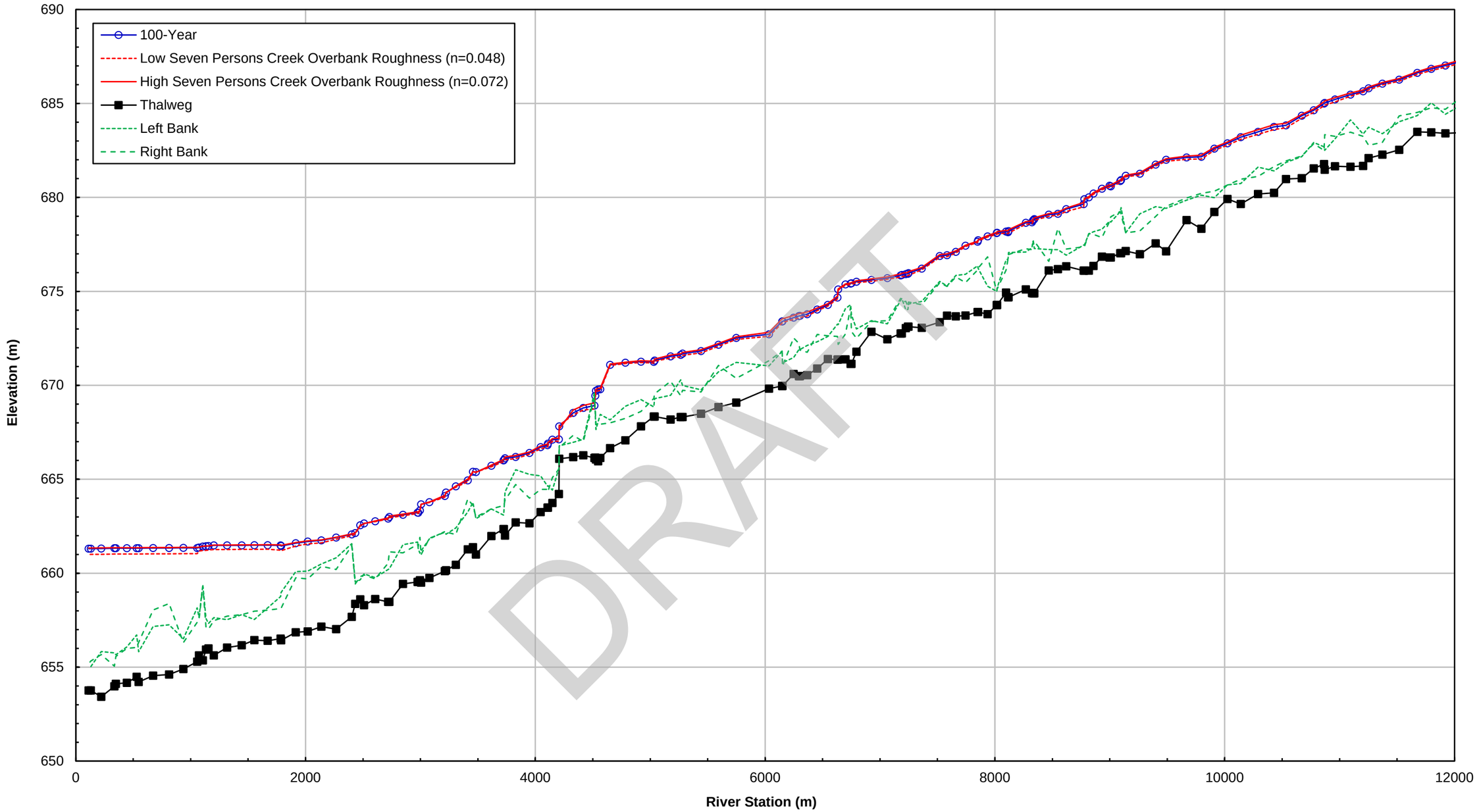
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO OVERBANK ROUGHNESS (SEVEN PERSONS CREEK) (1/2)

Job: 01003094 | *Date: 21-MAR-2022*

FIGURE 20A



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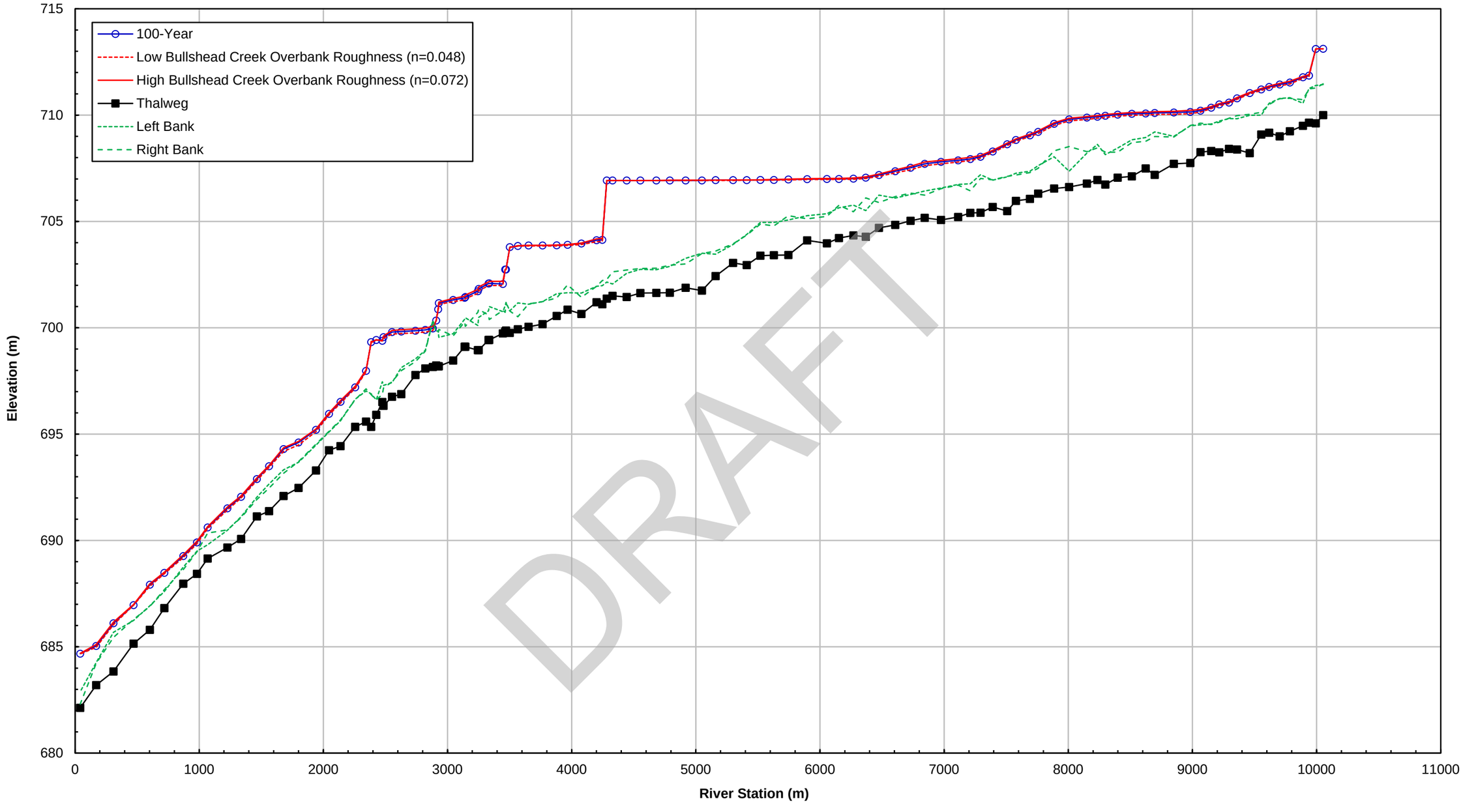
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO OVERBANK ROUGHNESS (SEVEN PERSONS CREEK) (2/2)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 20B



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MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING

COMPUTED 100-YEAR WATER SURFACE PROFILE SENSITIVITY TO OVERBANK ROUGHNESS (BULLSHEAD CREEK)

Job: 01003094 | Date: 21-MAR-2022

FIGURE 21

Appendix A
Flood History Photo Documentation

Notes:

1. (Top Left) 1908 Flood. View of the east Flats area of Medicine Hat flooded by the South Saskatchewan River showing the Woolen Mills and the Cannery in the foreground.
2. (Bottom Left) Flood waters surrounding the area near the Malcom's Western Canneries Ltd. building and adjacent Woolen Buildings (1908).
3. (Right) Flood in Medicine Hat viewed from the south east (1908).

[Image from Esplanade Arts and Heritage Centre]

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ALBERTA ENVIRONMENT AND PARKS		
MEDICINE HAT RIVER HAZARD STUDY HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING **HISTORICAL OPEN WATER FLOOD 1908 – MEDICINE HAT (SOUTH SASKATCHEWAN RIVER)**		
1003094	27 SEP 2019	**FIGURE A-1**

Notes:

1. (Left) Flood at east end of Medicine Hat, possibly showing Ross Creek with train on tracks, in middle of flood waters, heading to Medicine Hat (1903)
2. (Right) Looking south east from north side of river, shows Woolen Mills and residences surrounded by flood waters.

[Image from Esplanade Arts and Heritage Centre]

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MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
HISTORICAL OPEN WATER FLOOD
1903 – MEDICINE HAT
(ROSS CREEK)

1003094	27 SEP 2019	**FIGURE A-2**

Notes:
1. (Top Left) People crossing by railway bridge because of flood waters. IXL plant in background (1947).
2. (Top Right) Truck making its way along flooded road (1947).
3. (Bottom Left) Flood water surrounding farm house (1947).
4. (Bottom Right) Looking up a flooded Ross Creek (1947).

[Image from Esplanade Arts and Heritage Centre]

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HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
HISTORICAL SPRING FLOOD
1947 – MEDICINE HAT
(ROSS CREEK)

1003094	27 SEP 2019	**FIGURE A-3**

Notes: 1. (Top left) From the top of the hill on 6th Ave looking east over 7th Ave SE during the Seven Persons Creek flood.
2. (Top right) View from the golf course, looking toward the Ball Park.
3. (Bottom right) Corner of 1st St NW one block west of the bridge. The road was completely flooded.

[Image from Esplanade Arts and Heritage Centre]

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HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
HISTORICAL OPEN WATER FLOOD
1960 – MEDICINE HAT
(SEVEN PERSONS CREEK)

1003094	27 SEP 2019	**FIGURE A-4**

Notes:

1. (Top left) Flood in Medicine Hat. Flood waters surrounding a home on the north side of the river, Finlay Bridge in background (1922 -1924).
2. (Top right) Appears to be 1069 Mill St SE (1922 - 1924).
3. (Bottom left) Tabor Candy Company building with Alberta Foundry behind (1922 - 1924).
4. (Bottom right) Aerial view of the flood.

[Image from Esplanade Arts and Heritage Centre]

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MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD
1922-1924 (DATE UNKNOWN) – MEDICINE HAT (SOUTH SASKATCHEWAN RIVER)

1003094	27 SEP 2019	**FIGURE A-5**

Notes: 1. (Left) Flooded land in the industrial area (June, 1932)
2. (Right) Flooded railway tracks (1932).

[Image from Esplanade Arts and Heritage Centre]

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HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD
1932 – MEDICINE HAT
(SOUTH SASKATCHEWAN RIVER)

1003094	27 SEP 2019	**FIGURE A-6**

Notes: Images of the Seven Persons Creek backed up from South Saskatchewan River. Photos are taken in the location of Shannon Court.

[Image from Esplanade Arts and Heritage Centre]

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HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD
1953 – MEDICINE HAT
(SOUTH SASKATCHEWAN RIVER)

1003094	27 SEP 2019	**FIGURE A-7**

Notes: 1. Flooding in Lion's Park along the South Saskatchewan River east of the greenhouses dated June 23, 1975.

[Image from Alberta Environment]

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MEDICINE HAT RIVER HAZARD STUDY HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING **OPEN WATER FLOOD** **1975 – MEDICINE HAT** **(SOUTH SASKATCHEWAN RIVER)**		
1003094	27 SEP 2019	**FIGURE A-8**

Notes: 1. (Left), Buildings near Iron Avenue are pictured partially submerged in debris laden flood waters. All but the roof of a truck is also submerged (1995).
2. (Right)) A black and white photograph documenting the Medicine Hat June 1995 flood. Photo taken north of the Industrial Avenue near the IXL Brick Plant.

[Image from Esplanade Arts and Heritage Centre]

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MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD
1995 – MEDICINE HAT
(SOUTH SASKATCHEWAN RIVER)

1003094	27 SEP 2019	**FIGURE A-9**

Notes:
1. (Left), Image shows the Allowance Ave Bridge. The inundated area behind the first line of trees is the River Road which passes underneath the bridge. The photo shows how muddy this flood water is.(June, 2005)
2. (Right) Image shows both the Railway Bridge and the Finlay Bridge The image shows some of the flooding on the north side on the lower part of the photo.

[Image from RC Groups Forum (www.rcgroups.com/forums/showthread.php?381471-Flood-Photos-Medicine-Hat-Alberta)]

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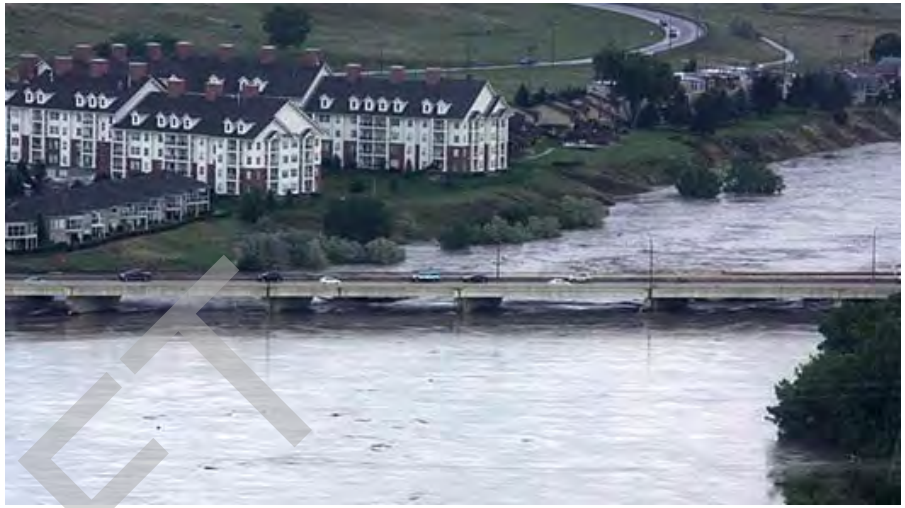
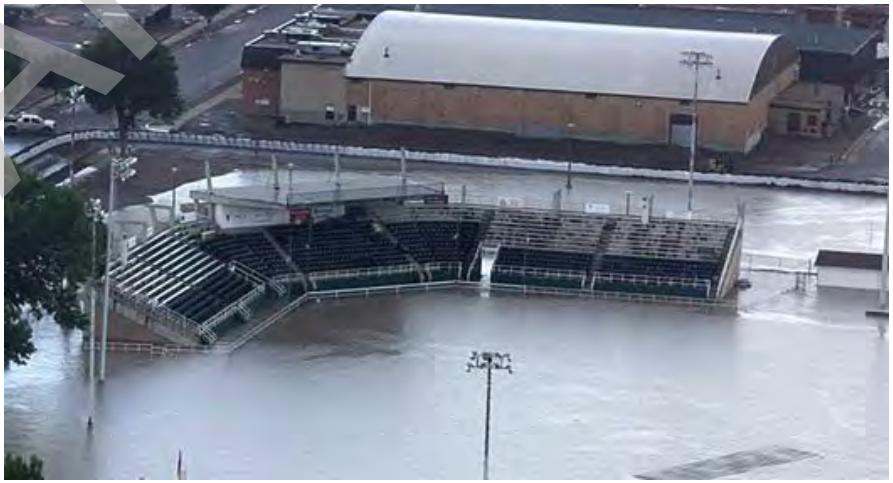
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD
2005 – MEDICINE HAT
(SOUTH SASKATCHEWAN RIVER)

1003094	27 SEP 2019	**FIGURE A-10**





Notes:
1. (Top Left) Flood water almost touches the lower cord of the bridges located at 2 Ave NE, Railway Bridge and bridge at Altawana Dr NE (June, 2013).
2. (Top Right) Flood level at Trans Canada Highway Bridge on South Saskatchewan River (June, 2013).
3. (Bottom Left) River Road SE was flooded and the water is very close to City of Medicine Hat Building (June, 2013).
4. (Bottom Right) Athletic Park Baseball Complex was flooded (June, 2013).

[Image from Medicine Hat Directory (www.medicinehatdirectory.com)]

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MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD 2013 – MEDICINE HAT (SOUTH SASKATCHEWAN RIVER)

1003094	27 SEP 2019	**FIGURE A-11**

Notes: 1. (Top Left), High water over weir in Kin Coulee Park.
2. (Top Right), Looking upstream to culverts in College Avenue.
3. (Bottom Left), Downstream side of bridge on road south to trailer homes just east of Hwy#41 bridge.
4. (Bottom Right), Downstream side of Porcelain Ave bridge at Ross Creek.

[Image from Alberta Environment High Water Mark Report]

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HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD
1994 – MEDICINE HAT
(SEVEN PERSONS CREEK AND ROSS CREEK)

1003094	27 SEP 2019	**FIGURE A-12**

Notes:
1. (Top Left) Standing water sits in the South Flats (June 20, 2010).
2. (Right) A house stands precariously in a widened Ross Creek during flooding east of Medicine Hat, Alberta (June 19, 2010).
3. (Bottom Left) The flood damage in South Flats looking from Scholten Hill in Medicine Hat (June 20, 2010).

[Image from Calgary Herald (Top Left), The Globe and Mail (Right), CTV (Bottom Left)]

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MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD
2010 – MEDICINE HAT
(ROSS CREEK AND SEVEN PERSONS CREEK)

1003094	27 SEP 2019	**FIGURE A-13**

Notes:
1. (Left), View of Medicine Hat during the 1952 flood, possibly looking down from Scholten Hill area into the South Flat area, with flooded houses and yards.
2. (Right) Flooded houses during 1952 flood, possibly in the River Flats area near what is now Kingsway Avenue.

[Image from Esplanade Arts and Heritage Centre]

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HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
OPEN WATER FLOOD
1952 – MEDICINE HAT
(SEVEN PERSONS CREEK)

1003094	27 SEP 2019	**FIGURE A-14**

Notes:
1. (Top Left) Devastating effects of 1951 flood.
2. (Top Right) Lauder house on Riverside surrounded by flood waters (March 29, 1951)
3. (Bottom Left) Inundated area near the IXL plant and Medalta during the flood of 1951. Hill approaching Highway 41 seen in the top left.
4. (Bottom Right) Looking at flooded land around the Medicine Hat Brick and Tile from a top of a cliff (March, 1951). Police Point Park is visible in the distance.

[Image from Esplanade Arts and Heritage Centre]

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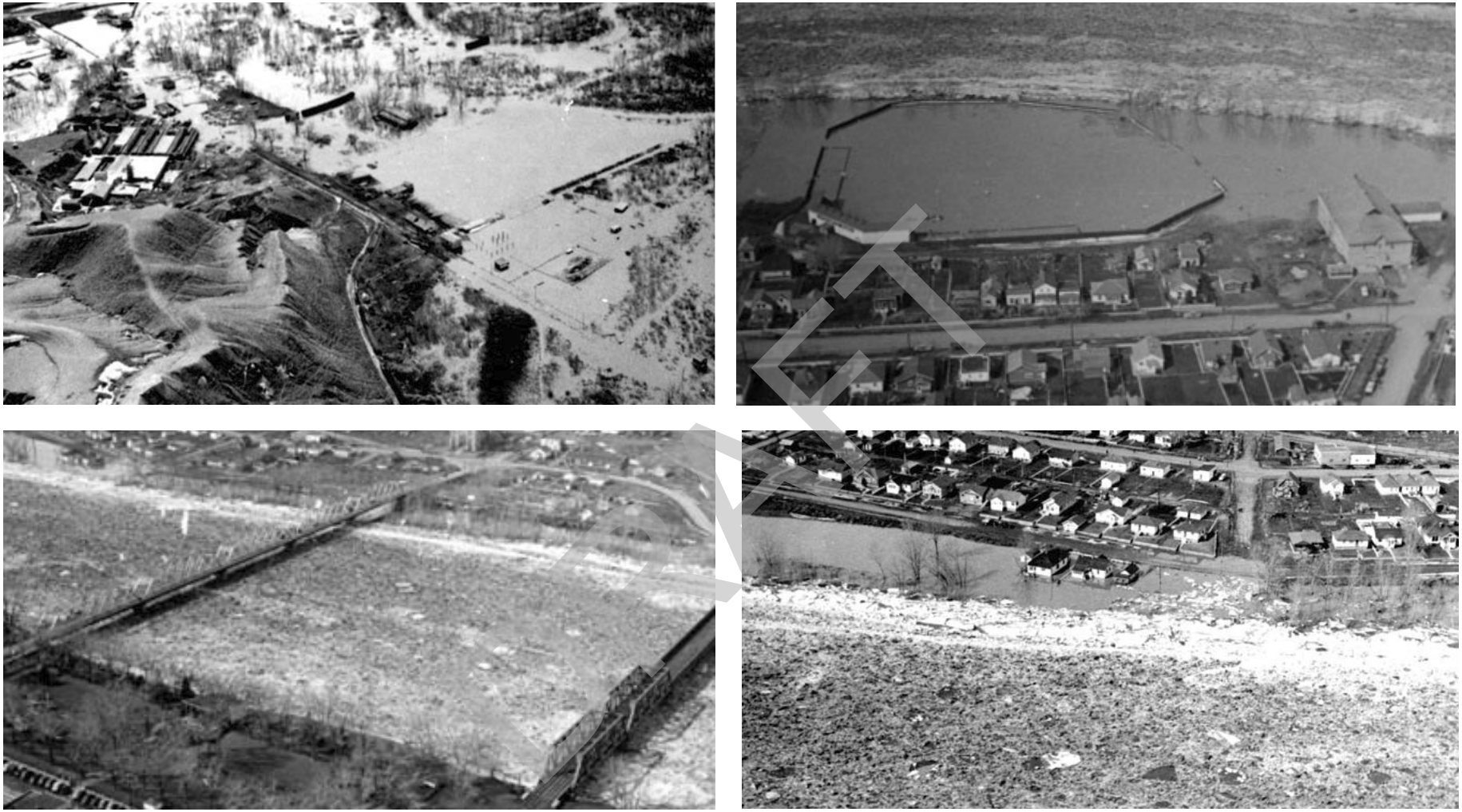
MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
ICE JAM FLOOD
1951 – MEDICINE HAT
(SOUTH SASKATCHEWAN RIVER)

1003094	27 SEP 2019	**FIGURE A-15**



Notes: 1. Aerial views of Medicine Hat flood in 1951 (From top left, Medicine Hat Brick and Tile Co Ltd, at top right aerial photo of flooded Athletic Park, at bottom left aerial view of raging river showing both the Finlay and Railway bridges and at bottom right aerial view of raging river and flooded banks)

[Image from Esplanade Arts and Heritage Centre]

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MEDICINE HAT RIVER HAZARD STUDY
HYDRAULIC MODELLING AND FLOOD INUNDATION MAPPING
ICE JAM FLOOD
1951 – MEDICINE HAT
(SOUTH SAKATCHEWAN RIVER)

1003094	27 SEP 2019	**FIGURE A-16**

Appendix B
Detailed Model Data

Table B-1 Model cross section details

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
South Saskatchewan River					
XS-120	45325	survey/DTM	659.07	221.9	Upstream Model Limit
XS-119	44679	survey/DTM	658.12	182.8	
XS-118	44049	survey/DTM	657.32	182.0	
XS-117	43533	survey/DTM	658.79	246.5	
XS-116	43063	survey/DTM	657.48	449.9	
XS-115	42640	survey/DTM	657.31	469.4	
XS-114	42313	survey/DTM	657.63	461.5	
XS-113	41994	survey/DTM	657.29	221.2	
XS-112	41730	survey/DTM	655.37	178.7	
XS-111	41467	survey/DTM	655.75	178.3	
XS-110	41176	survey/DTM	656.43	200.0	
XS-109	40727	survey/DTM	654.53	163.3	
XS-108	40250	survey/DTM	654.4	184.3	
XS-107	39686	survey/DTM	653.83	156.7	
XS-106	39026	survey/DTM	655.93	219.0	
XS-105	38612	survey/DTM	654.42	147.0	
XS-104	38206	survey/DTM	654.43	194.8	
XS-103	37769	survey/DTM	652.98	163.8	
XS-102	37096	survey/DTM	655.06	238.4	
XS-101	36628	survey/DTM	655.89	279.9	
XS-100	36160	survey/DTM	655.68	247.3	
XS-99	35711	survey/DTM	654.8	228.9	
XS-98	35027	survey/DTM	654.25	220.4	
XS-97	34794	survey/DTM	652.95	173.4	
XS-96	34469	survey/DTM	651.88	156.5	
XS-95	34035	survey/DTM	652.64	186.5	
XS-94	33412	survey/DTM	654.09	252.2	
XS-93	32996	survey/DTM	651.15	198.8	
XS-92	32901	survey/DTM	651.05	190.8	
XS-91	32874	survey/DTM	651.37	193.4	
XS-90	32864	survey/DTM	651.39	189.4	
XS-89	32841	survey/DTM	650.79	180.3	
XS-88	32695	survey/DTM	650.84	145.7	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
South Saskatchewan River					
XS-87	32232	survey/DTM	652.44	202.7	
XS-86	31958	survey/DTM	653	199.6	
XS-85	31737	survey/DTM	653.61	213.4	
XS-84	31302	survey/DTM	654.06	269.4	
XS-83	30870	survey/DTM	653.42	232.3	
XS-82	30568	survey/DTM	652.75	202.7	
XS-81	30278	survey/DTM	651.69	192.7	
XS-80	30073	survey/DTM	651.1	166.6	
XS-79	29912	survey/DTM	651.08	176.0	
XS-78	29893	survey/DTM	651.47	182.9	
XS-77	29810	survey/DTM	652.02	188.6	
XS-76	29705	survey/DTM	651.77	192.6	
XS-75	29679	survey/DTM	651.65	208.7	
XS-74	29586	survey/DTM	652.48	198.4	
XS-73	29490	survey/DTM	652.76	206.9	
XS-72	29458	survey/DTM	652.7	212.7	
XS-71	29288	survey/DTM	652.78	275.4	
XS-70	28982	survey/DTM	651.03	164.4	
XS-69	28782	survey/DTM	650.11	154.0	
XS-68	28518	survey/DTM	649.69	184.9	
XS-67	28272	survey/DTM	649.98	167.9	
XS-66	27944	survey/DTM	651.85	197.2	
XS-65	27680	survey/DTM	651.52	236.8	
XS-64	27421	survey/DTM	650.78	170.6	
XS-63	27259	survey/DTM	649.99	146.8	
XS-62	27103	survey/DTM	649.77	171.2	
XS-61	26834	survey/DTM	652.13	218.7	U/S of Ross Creek
XS-60	26592	survey/DTM	652.36	188.7	D/S of Ross Creek
XS-59	26362	survey/DTM	644.32	122.1	
XS-58	25869	survey/DTM	651.23	266.4	
XS-57	25470	survey/DTM	650.93	304.8	
XS-56	25260	survey/DTM	651.04	275.7	
XS-55	24856	survey/DTM	651	282.9	
XS-54	24346	survey/DTM	648.99	174.1	
XS-53	23762	survey/DTM	648.99	202.5	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
South Saskatchewan River					
XS-52	23368	survey/DTM	649.92	233.4	
XS-51	22594	survey/DTM	649.2	273.1	
XS-50	22345	survey/DTM	648.82	231.9	
XS-49	21960	survey/DTM	648.42	191.9	
XS-48	21436	survey/DTM	644.17	137.8	
XS-47	21170	survey/DTM	640.7	122.9	
XS-46	20944	survey/DTM	645.76	288.3	
XS-45	20505	survey/DTM	647.25	427.0	
XS-44	20015	survey/DTM	647.11	213.4	
XS-43	19627	survey/DTM	646.98	186.3	
XS-42	19151	survey/DTM	647.19	196.7	
XS-41	18687	survey/DTM	646.74	215.3	
XS-40	18369	survey/DTM	645.36	157.9	
XS-39	17911	survey/DTM	643.89	143.0	
XS-38	17457	survey/DTM	645.1	182.1	
XS-37	16987	survey/DTM	645.93	199.8	
XS-36	16430	survey/DTM	646.4	228.3	
XS-35	15922	survey/DTM	645.4	203.5	
XS-34	15557	survey/DTM	643.83	168.9	
XS-33	15200	survey/DTM	643.14	169.9	
XS-32	14548	survey/DTM	641.97	172.2	
XS-31	14068	survey/DTM	643.27	184.4	
XS-30	13587	survey/DTM	643.78	203.8	
XS-29	13257	survey/DTM	644.05	248.9	
XS-28	12651	survey/DTM	642.43	181.5	
XS-27	12272	survey/DTM	641.12	176.9	
XS-26	11856	survey/DTM	642.44	218.0	
XS-25	11401	survey/DTM	641.93	209.1	
XS-24	10997	survey/DTM	641.25	186.9	
XS-23	10616	survey/DTM	639.82	177.3	
XS-22	10038	survey/DTM	642.13	265.0	
XS-21	9344	survey/DTM	639.39	166.6	
XS-20	8739	survey/DTM	641.07	201.5	
XS-19	8061	survey/DTM	641.25	260.4	
XS-18	7699	survey/DTM	639.83	195.8	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
South Saskatchewan River					
XS-17	7319	survey/DTM	636.59	162.8	
XS-16	6742	survey/DTM	636.73	143.9	
XS-15	6324	survey/DTM	639.32	220.4	
XS-14	5902	survey/DTM	638.42	132.6	
XS-13	5517	survey/DTM	638.18	181.3	
XS-12	5143	survey/DTM	638.24	188.5	
XS-11	4620	survey/DTM	637.33	171.9	
XS-10	3946	survey/DTM	637.68	175.7	
XS-9	3351	survey/DTM	636.95	230.9	
XS-8	2779	survey/DTM	633.35	114.4	
XS-7	2385	survey/DTM	633.15	145.9	
XS-6	1981	survey/DTM	635.84	177.8	
XS-5	1554	survey/DTM	637.05	258.5	
XS-4	1188	survey/DTM	635.65	274.6	
XS-3	826	survey/DTM	633.9	199.3	
XS-2	434	survey/DTM	635.25	193.9	
XS-1	0	survey/DTM	633	152.1	
Ross Creek					
XS-277	25004	survey/DTM	700.52	12.0	Upstream Model Limit
XS-276	24867	survey/DTM	699.94	12.8	
XS-275	24755	survey/DTM	699.79	19.2	
XS-274	24601	survey/DTM	699.28	16.6	
XS-273	24504	survey/DTM	699.38	28.0	
XS-272	24485	survey/DTM	699.32	27.9	
XS-271	24367	survey/DTM	699.05	10.7	
XS-270	24239	survey/DTM	698.84	13.0	
XS-269	24049	survey/DTM	698.4	6.6	
XS-268	23888	survey/DTM	698.3	7.1	
XS-267	23758	survey/DTM	697.5	12.2	
XS-266	23609	survey/DTM	698.15	13.8	
XS-265	23458	survey/DTM	697.72	8.1	
XS-264	23269	survey/DTM	697.4	6.3	
XS-263	23072	survey/DTM	697.01	9.0	
XS-262	22807	survey/DTM	696.32	10.8	
XS-261	22662	survey/DTM	695.95	8.6	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Ross Creek					
XS-260	22513	survey/DTM	696.49	8.2	
XS-259	22349	survey/DTM	696.35	14.9	
XS-258	22202	survey/DTM	696.43	17.1	
XS-257	22052	survey/DTM	696.07	10.4	
XS-256	21868	survey/DTM	695.92	13.8	
XS-255	21732	survey/DTM	695.96	13.1	
XS-254	21455	survey/DTM	695.7	17.2	
XS-253	21284	survey/DTM	694.74	6.0	
XS-252	21105	survey/DTM	695.17	11.8	
XS-251	20942	survey/DTM	695.09	9.1	
XS-250	20802	survey/DTM	694.88	12.5	
XS-249	20619	survey/DTM	694.77	12.1	
XS-248	20459	survey/DTM	694.18	10.7	
XS-247	20238	survey/DTM	694.5	12.3	
XS-246	20069	survey/DTM	694.24	15.9	
XS-245	19885	survey/DTM	694.6	23.5	
XS-244	19778	survey/DTM	694.3	13.4	
XS-243	19768	survey/DTM	695.08	11.4	
XS-242	19704	survey/DTM	694.42	15.6	
XS-241	19701	survey/DTM	694.42	18.0	
XS-240	19632	survey/DTM	694.6	7.9	
XS-239	19567	survey/DTM	694.3	17.7	
XS-238	19419	survey/DTM	693.18	9.1	
XS-237	19079	survey/DTM	692.74	11.2	
XS-236	18934	survey/DTM	692.87	9.1	
XS-235	18780	survey/DTM	692.21	12.5	
XS-234	18614	survey/DTM	692.02	8.6	
XS-233	18458	survey/DTM	692.19	9.8	
XS-232	18303	survey/DTM	691.69	9.6	
XS-231	18159	survey/DTM	691.74	20.5	
XS-230	18042	survey/DTM	691.67	12.6	
XS-229	17870	survey/DTM	691.41	26.2	
XS-228	17609	survey/DTM	691.06	14.3	
XS-227	17478	survey/DTM	690.68	7.8	
XS-226	17291	survey/DTM	690.33	7.1	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Ross Creek					
XS-225	17138	survey/DTM	690.75	11.6	
XS-224	16928	survey/DTM	690.59	10.3	
XS-223	16771	survey/DTM	690.44	12.7	
XS-222	16622	survey/DTM	690.41	8.6	
XS-221	16467	survey/DTM	689.85	11.8	
XS-220	16275	survey/DTM	690.37	7.0	
XS-219	15977	survey/DTM	690.19	15.2	
XS-218	15802	survey/DTM	689.86	16.6	
XS-217	15681	survey/DTM	689.73	21.3	
XS-216	15510	survey/DTM	689.69	12.7	
XS-215	15213	survey/DTM	689.33	14.6	
XS-214	14983	survey/DTM	689.47	17.5	
XS-213	14783	survey/DTM	689.8	20.8	
XS-212	14771	survey/DTM	689.85	23.9	
XS-211	14537	survey/DTM	688.44	10.0	
XS-210	14376	survey/DTM	688.61	7.7	
XS-209	14120	survey/DTM	688.37	13.4	
XS-208	14052	survey/DTM	688.52	19.1	
XS-207	13881	survey/DTM	688.12	14.5	
XS-206	13834	survey/DTM	688	9.1	
XS-205	13620	survey/DTM	687.59	9.1	
XS-204	13411	survey/DTM	687.93	11.9	
XS-203	13230	survey/DTM	687.17	9.6	
XS-202	13068	survey/DTM	687.21	10.5	
XS-201	12896	survey/DTM	687.5	17.7	
XS-200	12731	survey/DTM	686.78	13.3	
XS-199	12542	survey/DTM	686.38	6.8	
XS-198	12386	survey/DTM	686.27	14.0	
XS-197	12229	survey/DTM	686.72	10.9	
XS-196	12101	survey/DTM	687.22	13.4	
XS-195	12034	survey/DTM	687.15	24.7	
XS-194	11884	survey/DTM	686.96	18.2	
XS-193	11757	survey/DTM	686.71	17.5	
XS-192	11627	survey/DTM	686.55	12.3	
XS-191	11439	survey/DTM	686.27	12.6	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Ross Creek					
XS-190	11270	survey/DTM	686.39	18.1	
XS-189	11101	survey/DTM	685.45	8.7	
XS-188	10922	survey/DTM	685.02	18.3	
XS-187	10738	survey/DTM	684.78	8.9	
XS-186	10635	survey/DTM	684.82	8.0	
XS-185	10434	survey/DTM	684.79	19.0	
XS-184	10269	survey/DTM	684.13	14.3	
XS-183	10264	survey/DTM	683.68	14.9	
XS-182	10171	survey/DTM	683.77	18.9	
XS-181	10007	survey/DTM	683.93	20.3	
XS-180	9923	survey/DTM	683.64	12.4	
XS-179	9907	survey/DTM	683.64	9.5	
XS-178	9740	survey/DTM	683.2	12.5	
XS-177	9597	survey/DTM	683.03	14.0	
XS-176	9458	survey/DTM	682.83	12.6	
XS-175	9311	survey/DTM	682.4	15.1	
XS-174	9201	survey/DTM	682.47	18.6	
XS-173	9081	survey/DTM	681.69	16.0	
XS-172	8929	survey/DTM	681.93	17.6	
XS-171	8801	survey/DTM	681.48	20.8	U/S of Bullshead Creek
XS-170	8553	survey/DTM	680.73	40.4	D/S of Bullshead Creek
XS-169	8324	survey/DTM	679.44	14.0	
XS-168	8108	survey/DTM	677.9	18.5	
XS-167	7695	survey/DTM	676.41	10.1	
XS-166	7286	survey/DTM	674.1	13.4	
XS-165	7051	survey/DTM	672.82	15.5	
XS-164	6863	survey/DTM	672.75	30.1	
XS-163	6733	survey/DTM	672.02	20.9	
XS-162	6294	survey/DTM	669.9	29.5	
XS-161	6066	survey/DTM	668.12	14.2	
XS-160	5846	survey/DTM	667.77	18.1	
XS-159	5538	survey/DTM	666.99	17.3	
XS-158	5170	survey/DTM	665.56	23.4	
XS-157	4558	survey/DTM	663.28	15.7	
XS-156	4293	survey/DTM	662.4	13.6	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Ross Creek					
XS-155	4061	survey/DTM	661.7	10.1	
XS-154	3824	survey/DTM	660.94	10.8	
XS-153	3693	survey/DTM	661.12	17.9	
XS-152	3546	survey/DTM	660.52	11.4	
XS-151	3440	survey/DTM	660.7	10.5	
XS-150	3384	survey/DTM	660.15	9.1	
XS-149	3256	survey/DTM	659.63	9.4	
XS-148	3057	survey/DTM	659.23	10.2	
XS-147	2925	survey/DTM	658.56	9.7	
XS-146	2915	survey/DTM	658.97	12.3	
XS-145	2772	survey/DTM	659.06	11.3	
XS-144	2572	survey/DTM	658.32	8.2	
XS-143	2370	survey/DTM	657.81	13.8	
XS-142	2261	survey/DTM	656.87	17.7	
XS-141	2161	survey/DTM	657.26	15.3	
XS-140	2145	survey/DTM	657.59	14.9	
XS-139	2032	survey/DTM	656.91	9.8	
XS-138	1780	survey/DTM	655.04	8.9	
XS-137	1675	survey/DTM	655.75	9.8	
XS-136	1611	survey/DTM	655.72	8.9	
XS-135	1596	survey/DTM	655.47	12.2	
XS-134	1527	survey/DTM	654.27	10.0	
XS-133	1488	survey/DTM	655.36	12.9	
XS-132	1437	survey/DTM	655	23.0	
XS-131	1300	survey/DTM	654.38	14.6	
XS-130	1282	survey/DTM	655.49	28.0	
XS-129	1278	survey/DTM	654.41	22.7	
XS-128	1247	survey/DTM	654.94	20.0	
XS-127	1118	survey/DTM	653.96	15.3	
XS-126	1025	survey/DTM	653.49	22.4	U/S of Seven Persons Creek
XS-125	880	survey/DTM	653.43	25.5	D/S of Seven Persons Creek
XS-124	757	survey/DTM	653.61	17.3	
XS-123	540	survey/DTM	653.12	23.4	
XS-122	431	survey/DTM	652.99	20.6	
XS-121	279	survey/DTM	653.17	17.8	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-559	24132	survey/DTM	707.32	24.6	Upstream Model Limit
XS-558	23979	survey/DTM	706.22	18.0	
XS-557	23814	survey/DTM	707.51	9.9	
XS-556	23806	survey/DTM	707.22	10.6	
XS-555	23647	survey/DTM	706.36	17.5	
XS-554	23493	survey/DTM	706.09	8.1	
XS-553	23470	survey/DTM	706.27	25.0	
XS-552	23465	survey/DTM	705.88	24.5	
XS-551	23401	survey/DTM	704.75	18.5	
XS-550	23369	survey/DTM	704.75	18.1	
XS-549	23292	survey/DTM	705.12	13.7	
XS-548	23260	survey/DTM	705.42	11.5	
XS-547	23215	survey/DTM	704.83	8.4	
XS-546	23117	survey/DTM	704.83	9.2	
XS-545	23034	survey/DTM	705.91	18.2	
XS-544	22948	survey/DTM	704.28	8.3	
XS-543	22873	survey/DTM	703.75	13.1	
XS-542	22771	survey/DTM	703.97	4.5	
XS-541	22664	survey/DTM	702.91	11.4	
XS-540	22575	survey/DTM	702.99	5.7	
XS-539	22464	survey/DTM	702.91	8.2	
XS-538	22361	survey/DTM	702.48	11.5	
XS-537	22267	survey/DTM	702.17	10.7	
XS-536	22142	survey/DTM	702.34	13.8	
XS-535	22050	survey/DTM	702.49	11.9	
XS-534	21928	survey/DTM	702.42	5.2	
XS-533	21803	survey/DTM	700.67	13.8	
XS-532	21685	survey/DTM	700.72	14.4	
XS-531	21588	survey/DTM	701.26	14.8	
XS-530	21553	survey/DTM	701.96	18.2	
XS-529	21455	survey/DTM	700.94	13.5	
XS-528	21316	survey/DTM	700.95	11.6	
XS-527	21210	survey/DTM	700.9	10.0	
XS-526	21109	survey/DTM	700.17	9.5	
XS-525	21010	survey/DTM	700.38	10.4	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-524	20908	survey/DTM	700.16	9.8	
XS-523	20811	survey/DTM	700.05	8.5	
XS-522	20688	survey/DTM	699.94	5.6	
XS-521	20604	survey/DTM	699.04	9.2	
XS-520	20492	survey/DTM	699.29	7.5	
XS-519	20389	survey/DTM	699.3	6.8	
XS-518	20205	survey/DTM	699.4	15.0	
XS-517	20050	survey/DTM	698.42	12.4	
XS-516	19964	survey/DTM	698.76	12.7	
XS-515	19854	survey/DTM	698.44	12.0	
XS-514	19715	survey/DTM	697.92	12.0	
XS-513	19604	survey/DTM	697.58	8.5	
XS-512	19456	survey/DTM	696.91	8.0	
XS-511	19328	survey/DTM	697.03	9.2	
XS-510	19216	survey/DTM	696.93	14.5	
XS-509	19152	survey/DTM	697.42	11.9	
XS-508	19111	survey/DTM	697.23	7.4	
XS-507	19002	survey/DTM	696.76	10.8	
XS-506	18890	survey/DTM	696.48	10.6	
XS-505	18787	survey/DTM	696.65	13.5	
XS-504	18675	survey/DTM	695.86	11.2	
XS-503	18565	survey/DTM	695.66	13.5	
XS-502	18494	survey/DTM	695.52	12.8	
XS-501	18486	survey/DTM	695.23	13.0	
XS-500	18434	survey/DTM	695.16	16.4	
XS-499	18351	survey/DTM	695.06	8.7	
XS-498	18280	survey/DTM	694.68	7.7	
XS-497	18275	survey/DTM	694.37	9.9	
XS-496	18219	survey/DTM	694.24	9.3	
XS-495	18130	survey/DTM	694.03	10.5	
XS-494	18126	survey/DTM	694.03	11.1	
XS-493	18004	survey/DTM	694.24	9.2	
XS-492	17905	survey/DTM	693.96	11.1	
XS-491	17802	survey/DTM	693.38	9.8	
XS-490	17798	survey/DTM	693.95	9.2	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-489	17719	survey/DTM	693.57	7.7	
XS-488	17604	survey/DTM	693.17	11.4	
XS-487	17598	survey/DTM	693.17	14.0	
XS-486	17499	survey/DTM	693.12	8.3	
XS-485	17357	survey/DTM	692.6	7.0	
XS-484	17263	survey/DTM	692.09	5.8	
XS-483	17143	survey/DTM	692.05	6.0	
XS-482	17043	survey/DTM	691.81	9.0	
XS-481	16936	survey/DTM	691.26	9.2	
XS-480	16931	survey/DTM	691.26	9.4	
XS-479	16848	survey/DTM	691.62	6.9	
XS-478	16772	survey/DTM	691.42	8.7	
XS-477	16640	survey/DTM	691.31	5.0	
XS-476	16542	survey/DTM	691.05	7.4	
XS-475	16415	survey/DTM	690.96	13.3	
XS-474	16312	survey/DTM	690.88	12.1	
XS-473	16208	survey/DTM	691.27	7.2	
XS-472	16142	survey/DTM	690.54	12.0	
XS-471	16136	survey/DTM	690.54	14.5	
XS-470	16093	survey/DTM	690.76	6.5	
XS-469	16003	survey/DTM	689.88	8.8	
XS-468	15897	survey/DTM	690.06	10.8	
XS-467	15790	survey/DTM	690.06	11.9	
XS-466	15677	survey/DTM	690.29	12.2	
XS-465	15553	survey/DTM	689.61	11.5	
XS-464	15468	survey/DTM	689.23	10.2	
XS-463	15462	survey/DTM	689.66	10.2	
XS-462	15421	survey/DTM	689.92	8.4	
XS-461	15330	survey/DTM	689.01	12.6	
XS-460	15270	survey/DTM	689.13	8.9	
XS-459	15169	survey/DTM	689.21	10.5	
XS-458	15148	survey/DTM	689.18	7.6	
XS-457	15076	survey/DTM	689.12	11.3	
XS-456	14959	survey/DTM	688.25	8.1	
XS-455	14861	survey/DTM	689	6.1	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-454	14749	survey/DTM	688.37	9.6	
XS-453	14610	survey/DTM	688.37	9.2	
XS-452	14511	survey/DTM	687.99	9.1	
XS-451	14406	survey/DTM	687.66	8.9	
XS-450	14327	survey/DTM	687.56	9.2	
XS-449	14247	survey/DTM	687.71	11.9	
XS-448	14233	survey/DTM	687.6	11.1	
XS-447	14108	survey/DTM	686.98	11.2	
XS-446	14000	survey/DTM	686.52	9.7	
XS-445	13839	survey/DTM	686.81	11.5	
XS-444	13689	survey/DTM	686.71	7.7	
XS-443	13570	survey/DTM	686.08	8.6	
XS-442	13465	survey/DTM	685.98	7.2	
XS-441	13347	survey/DTM	685.61	10.9	
XS-440	13258	survey/DTM	685.35	5.8	
XS-439	13121	survey/DTM	684.98	7.5	
XS-438	13053	survey/DTM	684.68	9.3	
XS-437	12911	survey/DTM	684.85	10.1	
XS-436	12787	survey/DTM	684.64	7.9	
XS-435	12635	survey/DTM	684.33	11.8	
XS-434	12461	survey/DTM	684.14	12.0	
XS-433	12300	survey/DTM	683.46	10.2	
XS-432	12200	survey/DTM	683.91	10.4	
XS-431	12119	survey/DTM	683.46	9.6	
XS-430	11921	survey/DTM	683.41	9.3	
XS-429	11798	survey/DTM	683.46	15.3	
XS-428	11676	survey/DTM	683.49	11.2	
XS-427	11519	survey/DTM	682.53	10.3	
XS-426	11372	survey/DTM	682.28	13.4	
XS-425	11253	survey/DTM	682.09	9.5	
XS-424	11204	survey/DTM	681.68	8.4	
XS-423	11095	survey/DTM	681.63	15.1	
XS-422	10959	survey/DTM	681.66	9.3	
XS-421	10871	survey/DTM	681.47	8.0	
XS-420	10865	survey/DTM	681.77	7.7	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-419	10775	survey/DTM	681.54	15.0	
XS-418	10671	survey/DTM	681.02	10.2	
XS-417	10533	survey/DTM	680.98	9.4	
XS-416	10429	survey/DTM	680.24	6.5	
XS-415	10290	survey/DTM	680.18	9.8	
XS-414	10140	survey/DTM	679.65	6.0	
XS-413	10024	survey/DTM	679.92	8.9	
XS-412	9910	survey/DTM	679.23	10.8	
XS-411	9797	survey/DTM	678.33	10.6	
XS-410	9668	survey/DTM	678.79	11.6	
XS-409	9490	survey/DTM	677.13	11.6	
XS-408	9399	survey/DTM	677.55	10.3	
XS-407	9262	survey/DTM	676.98	8.1	
XS-406	9139	survey/DTM	677.15	9.3	
XS-405	9099	survey/DTM	677.03	13.0	
XS-404	9091	survey/DTM	677.03	13.4	
XS-403	9009	survey/DTM	676.8	11.5	
XS-402	8998	survey/DTM	676.8	12.9	
XS-401	8932	survey/DTM	676.85	7.8	
XS-400	8858	survey/DTM	676.35	9.5	
XS-399	8817	survey/DTM	676.1	12.4	
XS-398	8778	survey/DTM	676.1	8.9	
XS-397	8773	survey/DTM	676.1	8.9	
XS-396	8621	survey/DTM	676.33	5.9	
XS-395	8548	survey/DTM	676.18	16.4	
XS-394	8469	survey/DTM	676.11	9.6	
XS-393	8342	survey/DTM	674.89	13.6	
XS-392	8336	survey/DTM	674.89	13.8	
XS-391	8330	survey/DTM	674.91	14.2	
XS-390	8322	survey/DTM	674.91	14.0	
XS-389	8269	survey/DTM	675.1	12.8	
XS-388	8118	survey/DTM	674.69	11.8	
XS-387	8114	survey/DTM	674.69	11.9	
XS-386	8097	survey/DTM	674.94	13.7	
XS-385	8019	survey/DTM	674.27	5.4	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-384	8016	survey/DTM	674.27	5.5	
XS-383	7936	survey/DTM	673.79	10.2	
XS-382	7853	survey/DTM	673.9	11.6	
XS-381	7849	survey/DTM	673.9	12.0	
XS-380	7744	survey/DTM	673.72	15.4	
XS-379	7660	survey/DTM	673.67	12.6	
XS-378	7583	survey/DTM	673.71	15.1	
XS-377	7519	survey/DTM	673.36	12.8	
XS-376	7363	survey/DTM	673.06	9.2	
XS-375	7248	survey/DTM	673.12	13.1	
XS-374	7243	survey/DTM	673.12	12.5	
XS-373	7224	survey/DTM	673.04	14.8	
XS-372	7190	survey/DTM	672.76	14.8	
XS-371	7180	survey/DTM	672.76	15.7	
XS-370	7064	survey/DTM	672.45	8.3	
XS-369	6925	survey/DTM	672.85	11.7	
XS-368	6795	survey/DTM	671.79	8.8	
XS-367	6751	survey/DTM	671.14	14.3	
XS-366	6744	survey/DTM	671.14	20.5	
XS-365	6699	survey/DTM	671.38	13.7	
XS-364	6635	survey/DTM	671.37	11.1	
XS-363	6630	survey/DTM	671.37	12.4	
XS-362	6546	survey/DTM	671.4	8.9	
XS-361	6454	survey/DTM	670.89	13.4	
XS-360	6366	survey/DTM	670.54	10.6	
XS-359	6303	survey/DTM	670.49	8.6	
XS-358	6295	survey/DTM	670.49	9.5	
XS-357	6248	survey/DTM	670.6	8.2	
XS-356	6151	survey/DTM	669.97	7.5	
XS-355	6147	survey/DTM	669.97	12.0	
XS-354	6034	survey/DTM	669.82	8.8	
XS-353	5749	survey/DTM	669.08	10.9	
XS-352	5594	survey/DTM	668.84	12.4	
XS-351	5443	survey/DTM	668.49	9.5	
XS-350	5281	survey/DTM	668.31	13.9	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-349	5265	survey/DTM	668.31	13.3	
XS-348	5177	survey/DTM	668.18	15.1	
XS-347	5038	survey/DTM	668.34	12.8	
XS-346	5032	survey/DTM	668.34	12.5	
XS-345	4920	survey/DTM	667.82	12.3	
XS-344	4783	survey/DTM	667.07	9.4	
XS-343	4651	survey/DTM	666.66	65.6	
XS-342	4565	survey/DTM	666.14	72.6	
XS-341	4546	survey/DTM	665.96	61.7	
XS-340	4527	survey/DTM	666.06	22.2	
XS-339	4522	survey/DTM	666.15	16.7	
XS-338	4514	survey/DTM	666.14	18.2	
XS-337	4417	survey/DTM	666.28	9.9	
XS-336	4329	survey/DTM	666.18	9.4	
XS-335	4207	survey/DTM	666.09	14.1	
XS-334	4205	survey/DTM	664.22	13.7	
XS-333	4149	survey/DTM	663.74	7.4	
XS-332	4109	survey/DTM	663.49	9.1	
XS-331	4106	survey/DTM	663.49	10.0	
XS-330	4046	survey/DTM	663.25	14.6	
XS-329	3949	survey/DTM	662.66	11.3	
XS-328	3829	survey/DTM	662.7	21.5	
XS-327	3737	survey/DTM	662.01	11.0	
XS-326	3726	survey/DTM	662.35	7.9	
XS-325	3723	survey/DTM	662.35	7.3	
XS-324	3618	survey/DTM	661.98	10.9	
XS-323	3483	survey/DTM	661	7.0	
XS-322	3457	survey/DTM	661.39	20.7	
XS-321	3412	survey/DTM	661.27	19.7	
XS-320	3308	survey/DTM	660.45	8.5	
XS-319	3223	survey/DTM	660.16	8.2	
XS-318	3212	survey/DTM	660.11	9.8	
XS-317	3079	survey/DTM	659.75	8.8	
XS-316	3006	survey/DTM	659.5	10.3	
XS-315	2995	survey/DTM	659.63	11.4	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-314	2981	survey/DTM	659.54	10.8	
XS-313	2975	survey/DTM	659.54	14.5	
XS-312	2847	survey/DTM	659.43	15.9	
XS-311	2730	survey/DTM	658.48	17.9	
XS-310	2719	survey/DTM	658.48	10.7	
XS-309	2606	survey/DTM	658.63	10.2	
XS-308	2510	survey/DTM	658.3	9.2	
XS-307	2476	survey/DTM	658.61	8.5	
XS-306	2432	survey/DTM	658.37	14.0	
XS-305	2402	survey/DTM	657.68	19.3	
XS-304	2266	survey/DTM	657.03	21.7	
XS-303	2138	survey/DTM	657.16	17.0	
XS-302	2019	survey/DTM	656.9	22.4	
XS-301	1915	survey/DTM	656.86	20.2	
XS-300	1788	survey/DTM	656.43	11.4	
XS-299	1783	survey/DTM	656.52	11.6	
XS-298	1671	survey/DTM	656.41	10.0	
XS-297	1554	survey/DTM	656.44	9.9	
XS-296	1444	survey/DTM	656.17	9.8	
XS-295	1317	survey/DTM	656.04	10.9	
XS-294	1201	survey/DTM	655.63	8.4	
XS-293	1155	survey/DTM	656	9.5	
XS-292	1134	survey/DTM	655.94	11.3	
XS-291	1106	survey/DTM	655.36	20.7	
XS-290	1072	survey/DTM	655.63	13.9	
XS-289	1056	survey/DTM	655.29	15.1	
XS-288	937	survey/DTM	654.9	8.5	
XS-287	812	survey/DTM	654.61	17.3	
XS-286	673	survey/DTM	654.55	16.7	
XS-285	547	survey/DTM	654.21	9.4	
XS-284	531	survey/DTM	654.49	14.3	
XS-283	445	survey/DTM	654.17	10.1	
XS-282	350	survey/DTM	654.12	14.9	
XS-281	337	survey/DTM	653.98	12.5	
XS-280	222	survey/DTM	653.43	12.4	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Seven Persons Creek					
XS-279	130	survey/DTM	653.76	11.4	
XS-278	112	survey/DTM	653.76	10.9	U/S of Ross Creek
Bullshead Creek					
XS-667	10054	survey/DTM	710	12.3	Upstream Model Limit
XS-666	9993	survey/DTM	709.61	11.2	
XS-665	9939	survey/DTM	709.64	11.2	
XS-664	9890	survey/DTM	709.5	9.7	
XS-663	9785	survey/DTM	709.24	11.7	
XS-662	9704	survey/DTM	709	10.0	
XS-661	9619	survey/DTM	709.17	8.9	
XS-660	9555	survey/DTM	709.09	9.9	
XS-659	9462	survey/DTM	708.21	9.5	
XS-658	9360	survey/DTM	708.38	10.0	
XS-657	9295	survey/DTM	708.41	9.4	
XS-656	9216	survey/DTM	708.25	10.9	
XS-655	9151	survey/DTM	708.31	12.0	
XS-654	9066	survey/DTM	708.26	11.9	
XS-653	8983	survey/DTM	707.75	13.8	
XS-652	8850	survey/DTM	707.71	8.9	
XS-651	8697	survey/DTM	707.19	14.7	
XS-650	8624	survey/DTM	707.49	16.6	
XS-649	8512	survey/DTM	707.12	20.2	
XS-648	8398	survey/DTM	707.06	9.2	
XS-647	8299	survey/DTM	706.73	10.4	
XS-646	8234	survey/DTM	706.95	10.4	
XS-645	8150	survey/DTM	706.78	8.8	
XS-644	8007	survey/DTM	706.62	13.1	
XS-643	7886	survey/DTM	706.55	10.5	
XS-642	7757	survey/DTM	706.31	11.3	
XS-641	7691	survey/DTM	706.06	9.4	
XS-640	7579	survey/DTM	705.97	12.9	
XS-639	7509	survey/DTM	705.49	7.6	
XS-638	7391	survey/DTM	705.68	6.9	
XS-637	7294	survey/DTM	705.41	9.2	
XS-636	7211	survey/DTM	705.4	8.4	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Bullshead Creek					
XS-635	7113	survey/DTM	705.21	9.3	
XS-634	6976	survey/DTM	705.07	8.5	
XS-633	6844	survey/DTM	705.17	9.2	
XS-632	6730	survey/DTM	705.03	8.4	
XS-631	6606	survey/DTM	704.84	10.3	
XS-630	6475	survey/DTM	704.7	10.3	
XS-629	6370	survey/DTM	704.28	7.0	
XS-628	6270	survey/DTM	704.34	8.4	
XS-627	6153	survey/DTM	704.22	11.0	
XS-626	6057	survey/DTM	703.97	7.4	
XS-625	5897	survey/DTM	704.11	10.3	
XS-624	5746	survey/DTM	703.42	11.5	
XS-623	5629	survey/DTM	703.41	9.4	
XS-622	5520	survey/DTM	703.39	9.1	
XS-621	5410	survey/DTM	702.95	9.4	
XS-620	5300	survey/DTM	703.05	10.9	
XS-619	5160	survey/DTM	702.43	13.6	
XS-618	5050	survey/DTM	701.75	8.4	
XS-617	4918	survey/DTM	701.88	8.1	
XS-616	4791	survey/DTM	701.65	6.6	
XS-615	4682	survey/DTM	701.64	8.4	
XS-614	4554	survey/DTM	701.63	11.6	
XS-613	4443	survey/DTM	701.45	7.7	
XS-612	4330	survey/DTM	701.5	10.4	
XS-611	4283	survey/DTM	701.37	11.2	
XS-610	4248	survey/DTM	701.11	16.5	
XS-609	4201	survey/DTM	701.2	4.9	
XS-608	4078	survey/DTM	700.65	5.9	
XS-607	3967	survey/DTM	700.85	11.5	
XS-606	3879	survey/DTM	700.56	9.3	
XS-605	3766	survey/DTM	700.17	8.4	
XS-604	3653	survey/DTM	700.05	7.3	
XS-603	3567	survey/DTM	699.93	11.6	
XS-602	3502	survey/DTM	699.76	8.5	
XS-601	3472	survey/DTM	699.87	10.6	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Bullshead Creek					
XS-600	3465	survey/DTM	699.82	9.7	
XS-599	3447	survey/DTM	699.74	10.5	
XS-598	3336	survey/DTM	699.43	8.1	
XS-597	3330	survey/DTM	699.43	9.5	
XS-596	3252	survey/DTM	698.95	8.3	
XS-595	3245	survey/DTM	698.95	8.2	
XS-594	3144	survey/DTM	699.11	6.4	
XS-593	3138	survey/DTM	699.11	6.4	
XS-592	3045	survey/DTM	698.46	7.3	
XS-591	2931	survey/DTM	698.19	6.8	
XS-590	2925	survey/DTM	698.19	10.5	
XS-589	2910	survey/DTM	698.23	15.0	
XS-588	2882	survey/DTM	698.16	15.8	
XS-587	2821	survey/DTM	698.09	8.9	
XS-586	2741	survey/DTM	697.78	6.5	
XS-585	2627	survey/DTM	696.88	7.9	
XS-584	2553	survey/DTM	696.76	4.9	
XS-583	2485	survey/DTM	696.33	5.6	
XS-582	2476	survey/DTM	696.51	5.7	
XS-581	2427	survey/DTM	695.91	6.9	
XS-580	2386	survey/DTM	695.34	7.3	
XS-579	2345	survey/DTM	695.59	10.6	
XS-578	2256	survey/DTM	695.34	8.0	
XS-577	2138	survey/DTM	694.44	7.5	
XS-576	2046	survey/DTM	694.24	5.6	
XS-575	1941	survey/DTM	693.29	7.5	
XS-574	1801	survey/DTM	692.47	9.0	
XS-573	1679	survey/DTM	692.09	9.4	
XS-572	1562	survey/DTM	691.38	8.5	
XS-571	1465	survey/DTM	691.13	6.7	
XS-570	1338	survey/DTM	690.07	9.8	
XS-569	1227	survey/DTM	689.67	6.0	
XS-568	1069	survey/DTM	689.15	7.8	
XS-567	983	survey/DTM	688.43	7.6	
XS-566	872	survey/DTM	687.97	8.5	

Table B-1 Model cross section details (Continued)

Cross Section	River Station (m)	Source data for Main Channel/Floodplain	Thalweg Elevation (m)	Channel Width (m)	Notes
Bullshead Creek					
XS-565	719	survey/DTM	686.82	8.5	
XS-564	603	survey/DTM	685.8	7.1	
XS-563	472	survey/DTM	685.15	16.0	
XS-562	310	survey/DTM	683.84	12.1	
XS-561	171	survey/DTM	683.2	7.6	
XS-560	42	survey/DTM	682.13	8.0	U/S of Ross Creek

Table B-2 Bridge details

Description	River Station (m)	Municipality	Owner	Design Drawing/Info	Span (m)	Width (m)	Number of Piers	Pier Width (m)	Deck Skew (°)	Pier Skew (°)	Minimum Elevation (m)		Low Flow Modelling Approach	High Flow Modelling Approach
											Top Chord	Low Chord		
South Saskatchewan River														
BF78572 - Trans-Canada Highway EB	32,888	Medicine Hat	Alberta Transportation	Yes	312.4	16.5	7	2.6	30	5	667.13	665.76	Momentum	Pressure and/or Weir
BF73802 - Trans-Canada Highway WB	32,857	Medicine Hat	Alberta Transportation	Yes	301.9	12.8	3	2.9	30	5	667.22	665.22	Momentum	Pressure and/or Weir
BF01114 - Finlay Bridge	29,902	Medicine Hat	Medicine Hat	Yes	277.1	8.1	4	varied (1.8/2.7)	N/A	N/A	665.79	664.21	Momentum	Pressure and/or Weir
CPR Bridge	29,692	Medicine Hat	CP Rail	No	313.4	6.0	9	3	N/A	N/A	665.50/667.55	664.4	Momentum	Pressure and/or Weir
BF77424 - Maple Avenue Bridge	29,476	Medicine Hat	Medicine Hat	Yes	266.7	21.6	6	1.2	N/A	N/A	665.1	663.05	Momentum	Pressure and/or Weir
Ross Creek														
BF75672 - Highway 41	24,494	Cypress County	Alberta Transportation	Yes	41.6	12.6	2	0.41	N/A	N/A	706.13	705.35	Highest Energy Answer	Pressure and/or Weir
Private Road 1	19,772	Cypress County	Landowner	No	9.9	5.7	0	N/A	N/A	N/A	696.79	696.26	Momentum	Pressure and/or Weir
Private Road 2	19,702	Cypress County	Landowner	No	22.1	1.3	0	N/A	N/A	N/A	697.38	696.78	Highest Energy Answer	Pressure and/or Weir
Range Road 51A	14,777	Cypress County	Cypress County	No	25.3	6.6	2	0.4	N/A	N/A	693.37	692.65	Highest Energy Answer	Pressure and/or Weir
Private Road 3	9,914	Cypress County	Landowner	No	6.8	3.9	0	N/A	N/A	N/A	684.90	684.50	Highest Energy Answer	Pressure and/or Weir
BF75576 - Day Street Bridge	2,921	Medicine Hat	Medicine Hat	Yes	24.9	5.6	2	Varied (1.4/1.5)	N/A	N/A	662.71	662.11	Highest Energy Answer	Pressure and/or Weir
BF00658 - Industrial Avenue Bridge	2,153	Medicine Hat	Medicine Hat	Yes	36.7	11.4	0	N/A	N/A	N/A	665.06	662.00	Highest Energy Answer	Pressure and/or Weir
Porcelain Avenue Bridge	1,603	Medicine Hat	Medicine Hat	Yes	34.6	11.1	0	N/A	N/A	N/A	663.32	659.99	Highest Energy Answer	Pressure and/or Weir
Seven Persons Creek														
Private Road 1	23,810	Cypress County	Landowner	No	18.3	4.2	0	N/A	N/A	N/A	710.68	709.75	Highest Energy Answer	Energy Only (Standard Step)
Desert Blume Golf Course Bridge 1	18,491	Cypress County	Landowner	No	19.2	1.9	1	0.6	N/A	N/A	698.30	697.99	Highest Energy Answer	Pressure and/or Weir
Desert Blume Golf Course Bridge 2	18,278	Cypress County	Landowner	No	19.5	2.1	1	0.6	N/A	N/A	696.85	696.53	Highest Energy Answer	Pressure and/or Weir
Desert Blume Golf Course Bridge 3	18,128	Cypress County	Landowner	No	15.7	2.4	0	N/A	N/A	N/A	696.74	696.44	Highest Energy Answer	Energy Only (Standard Step)
Desert Blume Golf Course Bridge 4	17,800	Cypress County	Landowner	No	17.5	3.0	0	N/A	N/A	N/A	695.94	695.61	Highest Energy Answer	Pressure and/or Weir
Desert Blume Golf Course Bridge 5	17,601	Cypress County	Landowner	No	9.8	2.1	0	N/A	N/A	N/A	695.76	695.42	Highest Energy Answer	Energy Only (Standard Step)

Table B-2 Bridge details (Continued)

Description	River Station (m)	Municipality	Owner	Design Drawing/Info	Span (m)	Width (m)	Number of Piers	Pier Width (m)	Deck Skew (°)	Pier Skew (°)	Minimum Elevation (m)		Low Flow Modelling Approach	High Flow Modelling Approach
											Top Chord	Low Chord		
Seven Persons Creek														
Desert Blume Golf Course Bridge 6	16,934	Cypress County	Landowner	No	19.4	2.4	0	N/A	N/A	N/A	694.12	693.92	Highest Energy Answer	Energy Only (Standard Step)
Desert Blume Golf Course Bridge 7	16,139	Cypress County	Landowner	No	17.4	3.7	0	N/A	N/A	N/A	693.63	693.24	Highest Energy Answer	Pressure and/or Weir
Desert Blume Golf Course Bridge 8	15,465	Cypress County	Landowner	No	15.2	1.9	1	0.6	N/A	N/A	692.13	691.83	Highest Energy Answer	Pressure and/or Weir
BF1155 - South Boundary Road	14,241	Medicine Hat	Medicine Hat	Yes	20.3	9.9	0	N/A	N/A	N/A	691.98	691.48	Highest Energy Answer	Pressure and/or Weir
Private Road 2	10,869	Medicine Hat	Landowner	No	10.6	3.2	0	N/A	N/A	N/A	683.86	683.68	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 1	9,095	Medicine Hat	Landowner	No	16.1	1.5	0	N/A	N/A	N/A	681.10	680.63	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 2	9,004	Medicine Hat	Landowner	No	18.2	2.0	0	N/A	N/A	N/A	681.33	680.91	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 3	8,844	Medicine Hat	Landowner	No	13.5	2.0	0	N/A	N/A	N/A	680.12	679.78	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 4	8,776	Medicine Hat	Landowner	No	16.4	1.5	0	N/A	N/A	N/A	679.51	678.87	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 5	8,338	Medicine Hat	Landowner	No	16.4	1.5	0	N/A	N/A	N/A	678.58	678.05	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 6	8,326	Medicine Hat	Landowner	No	17.9	4.2	0	N/A	N/A	N/A	678.98	678.10	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 7	8,116	Medicine Hat	Landowner	No	13.1	2.6	0	N/A	N/A	N/A	677.51	676.72	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 8	8,018	Medicine Hat	Landowner	No	16.4	1.5	0	N/A	N/A	N/A	676.93	676.33	Highest Energy Answer	Energy Only (Standard Step)
Cottonwood Coulee Golf Course Bridge 9	7,851	Medicine Hat	Landowner	No	12.6	1.5	0	N/A	N/A	N/A	676.78	676.41	Highest Energy Answer	Energy Only (Standard Step)
Paradise Valley Golf Course Bridge 1	7,245	Medicine Hat	Landowner	No	19.9	2.4	0	N/A	N/A	N/A	675.79	675.20	Highest Energy Answer	Energy Only (Standard Step)
Paradise Valley Golf Course Bridge 2	7,185	Medicine Hat	Landowner	No	18.4	2.4	0	N/A	N/A	N/A	675.84	675.20	Highest Energy Answer	Energy Only (Standard Step)
Paradise Valley Golf Course Bridge 3	6,748	Medicine Hat	Landowner	No	24.0	3.7	0	N/A	N/A	N/A	674.54	674.11	Highest Energy Answer	Energy Only (Standard Step)
Paradise Valley Golf Course Bridge 4	6,633	Medicine Hat	Landowner	No	19.4	2.4	0	N/A	N/A	N/A	674.43	673.75	Highest Energy Answer	Pressure and/or Weir
Paradise Valley Golf Course Bridge 5	6,299	Medicine Hat	Landowner	No	17.9	2.4	0	N/A	N/A	N/A	672.98	672.21	Highest Energy Answer	Pressure and/or Weir
Paradise Valley Golf Course Bridge 6	6,149	Medicine Hat	Landowner	No	17.6	2.4	0	N/A	N/A	N/A	672.72	671.96	Highest Energy Answer	Pressure and/or Weir

Table B-2 Bridge details (Continued)

Description	River Station (m)	Municipality	Owner	Design Drawing/Info	Span (m)	Width (m)	Number of Piers	Pier Width (m)	Deck Skew (°)	Pier Skew (°)	Minimum Elevation (m)		Low Flow Modelling Approach	High Flow Modelling Approach
											Top Chord	Low Chord		
Seven Persons Creek														
Pedestrian Bridge	5,273	Medicine Hat	Medicine Hat	No	24.3	2.4	0	N/A	N/A	N/A	671.48	671.23	Highest Energy Answer	Energy Only (Standard Step)
Pedestrian Bridge	5,035	Medicine Hat	Medicine Hat	No	24.1	2.4	0	N/A	N/A	N/A	671.37	671.12	Highest Energy Answer	Energy Only (Standard Step)
Kin Coulee Road	4,517	Medicine Hat	Medicine Hat	No	19.3	4.7	0	N/A	N/A	N/A	669.75	668.80	Highest Energy Answer	Pressure and/or Weir
Kin Coulee Park Pedestrian Bridge 1	4,108	Medicine Hat	Medicine Hat	No	21.3	1.3	0	N/A	N/A	N/A	666.81	666.61	Highest Energy Answer	Energy Only (Standard Step)
Kin Coulee Park Pedestrian Bridge 2	3,724	Medicine Hat	Medicine Hat	No	21.3	1.3	0	N/A	N/A	N/A	665.24	665.11	Highest Energy Answer	Energy Only (Standard Step)
Private Road 4	3,217	Medicine Hat	Landowner	No	20.7	5.4	0	N/A	N/A	N/A	664.68	663.73	Highest Energy Answer	Pressure and/or Weir
Private Rail Bridge	3,000	Medicine Hat	unknown	No	17.2	4.8	0	N/A	N/A	N/A	663.64	662.93	Highest Energy Answer	Pressure and/or Weir
Pedestrian Bridge	2,978	Medicine Hat	Medicine Hat	No	24.3	2.6	0	N/A	N/A	N/A	663.30	663.05	Highest Energy Answer	Energy Only (Standard Step)
Pedestrian Bridge	2,724	Medicine Hat	Medicine Hat	No	24.3	2.6	0	N/A	N/A	N/A	662.04	661.79	Highest Energy Answer	Energy Only (Standard Step)
Dunmore Road	2,453	Medicine Hat	Medicine Hat	Yes	47.6	23.4	1	0.3	N/A	N/A	662.37	661.21	Energy (Standard Step)	Pressure and/or Weir
Pedestrian Bridge	1,785	Medicine Hat	Medicine Hat	No	24.3	2.6	0	N/A	N/A	N/A	661.30	661.02	Highest Energy Answer	Energy Only (Standard Step)
BR-11 Carry Drive Bridge	1,144	Medicine Hat	Medicine Hat	Yes	22.5	14.9	0	N/A	N/A	N/A	659.58	658.61	Highest Energy Answer	Pressure and/or Weir
CPR Bridge	1,065	Medicine Hat	CP Rail	No	21.5	11.0	0	N/A	N/A	N/A	662.37	659.91	Highest Energy Answer	Pressure and/or Weir
Industrial Avenue Bridge	539	Medicine Hat	Medicine Hat	Yes	22.6	8.7	0	N/A	N/A	N/A	659.80	658.82	Highest Energy Answer	Pressure and/or Weir
Abandoned Piers	343	Medicine Hat	Medicine Hat	No	N/A	N/A	4	0.6	N/A	N/A	N/A	N/A	Highest Energy Answer	Energy Only (Standard Step)
Pedestrian Bridge	121	Medicine Hat	Medicine Hat	No	24.2	2.5	0	N/A	N/A	N/A	658.88	658.68	Highest Energy Answer	Energy Only (Standard Step)
Bullshead Creek														
BF493 - Trans-Canada Highway WB	3,457	Medicine Hat	Alberta Transportation	Yes	28.2	13.4	0	N/A	N/A	N/A	705.05	704.05	Highest Energy Answer	Pressure and/or Weir
Ross Creek Golf Course Bridge 1	3,333	Medicine Hat	Landowner	No	10.8	2.4	0	N/A	N/A	N/A	701.08	700.91	Highest Energy Answer	Energy Only (Standard Step)
Ross Creek Golf Course Bridge 2	3,248	Medicine Hat	Landowner	No	10.1	3.9	0	N/A	N/A	N/A	701.40	701.10	Highest Energy Answer	Energy Only (Standard Step)
Ross Creek Golf Course Bridge 3	3,141	Medicine Hat	Landowner	No	10.8	2.0	0	N/A	N/A	N/A	700.90	700.82	Highest Energy Answer	Energy Only (Standard Step)
Ross Creek Golf Course Bridge 4	2,928	Medicine Hat	Landowner	No	10.1	2.1	0	N/A	N/A	N/A	700.70	700.57	Highest Energy Answer	Energy Only (Standard Step)
CPR Bridge	2,480	Cypress County	CP Rail	No	59.3	4.9	2	2.3	N/A	N/A	706.50	704.20	Highest Energy Answer	Pressure and/or Weir

Table B-3 Culvert details

Reach	Description	River Station (m)	Municipality	Culvert Shape	Culvert Type	Entrance Condition	Number of Barrel	Barrel Length (m)	Diameter, Rise, or Height (m)	Span or Width (m)	Upstream Invert Elev (m)	Downstream Invert Elev (m)
Seven Persons Creek	BF2164 - Township Road 120	23,384	Cypress County	Horizontal Ellipse	CSP	headwall with bevel end	1	28.2	5.2	7.6	704.81	704.65
	BF73807 - Trans-Canada Highway	4,611	Medicine Hat	Vertical Ellipse/Arch	Concrete	headwall with square end	2	76.9	3.6	5.1	666.66	666.42
								69.9	4.5	5.1	666.79	666.70
	College Avenue Culvert	3,433	Medicine Hat	Circular	CSP	mitered to conform to slope	2	27.3	4.5	N/A	661.37	661.24
								28.6	4.5	N/A	661.46	661.31
Bullshead Creek	BF81332 - Township Road 120 2KM SW of Dunmore	9,962	Cypress County	Horizontal Ellipse	Concrete	headwall with bevel end	1	38.5	5.3	8.6	709.72	709.57
	CPR branch line	4,264	Cypress County	Circular	CSP	mitered to conform to slope	2	27.1	3.6	N/A	701.35	701.26
								28.2	3.6	N/A	701.10	701.21
	BF493 - Trans-Canada Highway EB	3,488	Medicine Hat	Horizontal Ellipse	CSP	headwall with bevel end	1	25.0	5.4	9.1	698.63	698.57
	54 Street SE (Location 1)	2,894	Medicine Hat	Circular	CSP	Headwall	3	20.2	2.4	N/A	698.17	698.10
								20.8	2.4	N/A	698.18	697.99
								19.9	2.4	N/A	698.06	697.93
	54 Street SE (Location 2)	2,364	Cypress County	Circular	CSP	mitered to conform to slope	2	30.8	1.6	N/A	695.60	695.60
								32.0	3.1	N/A	695.10	695.10

Table B-4 Computed flood frequency water levels – South Saskatchewan River

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-120	45,325	663.53	664.88	665.86	666.90	667.79	668.38	669.09	669.59	671.22	672.15	672.79	673.51	674.09
XS-119	44,679	663.25	664.58	665.54	666.57	667.45	668.03	668.74	669.22	670.88	671.77	672.38	673.07	673.63
XS-118	44,049	662.94	664.24	665.19	666.21	667.08	667.65	668.34	668.83	670.54	671.42	672.03	672.72	673.27
XS-117	43,533	662.65	664.01	665.01	666.07	666.98	667.58	668.30	668.81	670.59	671.50	672.13	672.84	673.40
XS-116	43,063	662.39	663.80	664.82	665.94	666.88	667.50	668.24	668.76	670.59	671.53	672.17	672.90	673.47
XS-115	42,640	662.13	663.59	664.68	665.82	666.78	667.40	668.15	668.67	670.52	671.46	672.10	672.84	673.42
XS-114	42,313	661.93	663.43	664.52	665.67	666.63	667.26	668.02	668.55	670.40	671.32	671.95	672.68	673.25
XS-113	41,994	661.78	663.30	664.38	665.49	666.43	667.04	667.76	668.27	670.10	670.98	671.59	672.28	672.84
XS-112	41,730	661.67	663.17	664.23	665.33	666.26	666.85	667.56	668.06	669.90	670.77	671.36	672.05	672.58
XS-111	41,467	661.56	663.05	664.10	665.20	666.13	666.72	667.43	667.93	669.83	670.69	671.29	671.98	672.51
XS-110	41,176	661.45	662.94	664.00	665.12	666.06	666.66	667.38	667.88	669.78	670.65	671.25	671.95	672.50
XS-109	40,727	661.32	662.78	663.81	664.90	665.80	666.39	667.09	667.58	669.49	670.29	670.86	671.51	672.00
XS-108	40,250	661.18	662.64	663.67	664.76	665.67	666.26	666.97	667.47	669.42	670.23	670.80	671.46	671.97
XS-107	39,686	660.94	662.35	663.35	664.39	665.26	665.83	666.51	666.98	668.98	669.72	670.25	670.88	671.36
XS-106	39,026	660.66	662.12	663.15	664.25	665.16	665.76	666.46	666.96	669.03	669.79	670.33	670.97	671.45
XS-105	38,613	660.40	661.84	662.89	664.01	664.93	665.53	666.23	666.73	668.91	669.68	670.24	670.90	671.39
XS-104	38,206	660.32	661.76	662.80	663.90	664.80	665.39	666.06	666.55	668.76	669.50	670.04	670.68	671.14
XS-103	37,769	660.16	661.55	662.56	663.62	664.50	665.07	665.74	666.22	668.53	669.25	669.79	670.44	670.92
XS-102	37,096	659.95	661.36	662.38	663.47	664.38	664.96	665.64	666.13	668.49	669.21	669.73	670.37	670.84
XS-101	36,628	659.81	661.24	662.28	663.39	664.30	664.89	665.58	666.08	668.46	669.17	669.69	670.33	670.80
XS-100	36,160	659.63	661.08	662.13	663.24	664.16	664.74	665.42	665.91	668.31	668.99	669.47	670.08	670.53
XS-99	35,711	659.47	660.94	661.99	663.11	664.02	664.61	665.29	665.78	668.22	668.90	669.39	670.02	670.47
XS-98	35,027	659.26	660.75	661.80	662.93	663.85	664.43	665.12	665.61	668.17	668.86	669.36	670.00	670.45
XS-97	34,794	659.17	660.62	661.66	662.77	663.68	664.24	664.93	665.41	668.07	668.75	669.25	669.89	670.35
XS-96	34,469	659.07	660.50	661.53	662.64	663.54	664.10	664.79	665.28	668.02	668.70	669.20	669.84	670.30
XS-95	34,035	658.97	660.39	661.42	662.54	663.44	663.99	664.67	665.17	667.96	668.62	669.11	669.73	670.18
XS-94	33,412	658.75	660.21	661.25	662.39	663.30	663.86	664.55	665.04	667.82	668.44	668.90	669.49	669.91
XS-93	32,996	658.65	660.09	661.12	662.23	663.11	663.66	664.32	664.80	667.60	668.16	668.59	669.13	669.52
XS-92	32,901	658.64	660.07	661.10	662.21	663.10	663.65	664.31	664.79	667.59	668.15	668.58	669.12	669.51
XS-91	32,874	658.61	660.03	661.05	662.14	663.02	663.55	664.20	664.67	667.46	667.73	668.08	668.60	668.97
XS-90	32,864	658.61	660.03	661.04	662.13	663.00	663.53	664.18	664.65	667.44	667.70	668.04	668.55	668.91
XS-89	32,841	658.54	659.96	660.97	662.07	662.94	663.47	664.12	664.58	666.38	667.22	667.48	667.91	668.24
XS-88	32,695	658.47	659.85	660.83	661.90	662.74	663.25	663.87	664.32	666.09	666.98	667.20	667.61	667.92
XS-87	32,232	658.35	659.72	660.69	661.77	662.62	663.13	663.76	664.21	666.02	666.92	667.13	667.54	667.83
XS-86	31,958	658.22	659.59	660.59	661.67	662.53	663.05	663.68	664.14	665.96	666.86	667.05	667.45	667.74

Table B-4 Computed flood frequency water levels – South Saskatchewan River (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-85	31,737	658.12	659.51	660.51	661.60	662.46	662.98	663.61	664.06	665.89	666.77	666.96	667.34	667.63
XS-84	31,302	657.98	659.40	660.41	661.52	662.39	662.91	663.54	664.00	665.87	666.75	666.94	667.33	667.62
XS-83	30,870	657.82	659.25	660.26	661.38	662.24	662.76	663.38	663.83	665.71	666.61	666.77	667.14	667.42
XS-82	30,568	657.70	659.12	660.12	661.22	662.07	662.58	663.20	663.65	665.57	666.46	666.60	666.94	667.20
XS-81	30,278	657.63	659.04	660.04	661.14	661.99	662.48	663.09	663.53	665.51	666.39	666.51	666.85	667.10
XS-80	30,073	657.56	658.94	659.90	660.98	661.80	662.27	662.85	663.28	665.23	666.11	666.17	666.45	666.66
XS-79	29,912	657.48	658.84	659.79	660.87	661.69	662.17	662.75	663.18	665.19	666.08	666.12	666.40	666.59
XS-78	29,893	657.46	658.82	659.76	660.84	661.67	662.14	662.73	663.16	665.00	665.89	665.91	666.20	666.42
XS-77	29,810	657.44	658.80	659.75	660.83	661.66	662.14	662.73	663.16	664.98	665.75	665.89	666.02	666.17
XS-76	29,705	657.41	658.77	659.73	660.82	661.65	662.13	662.72	663.15	664.98	665.74	665.87	665.99	666.16
XS-75	29,679	657.37	658.70	659.64	660.72	661.54	662.01	662.58	663.01	663.97	665.39	665.48	665.57	665.72
XS-74	29,586	657.33	658.65	659.59	660.67	661.49	661.95	662.53	662.95	663.91	665.34	665.44	665.53	665.74
XS-73	29,490	657.30	658.63	659.56	660.63	661.44	661.89	662.45	662.87	663.78	665.19	665.25	665.30	665.51
XS-72	29,458	657.28	658.58	659.50	660.56	661.36	661.81	662.36	662.77	663.67	664.28	664.55	664.88	665.14
XS-71	29,288	657.22	658.54	659.48	660.56	661.37	661.82	662.38	662.80	663.74	664.42	664.79	665.17	665.47
XS-70	28,982	657.11	658.36	659.23	660.25	660.99	661.38	661.87	662.24	663.00	663.56	663.83	664.15	664.39
XS-69	28,782	657.03	658.25	659.11	660.11	660.84	661.22	661.70	662.06	662.87	663.43	663.73	664.05	664.34
XS-68	28,518	656.95	658.16	659.00	660.02	660.75	661.13	661.61	661.97	662.79	663.41	663.72	664.09	664.39
XS-67	28,272	656.85	658.03	658.85	659.86	660.58	660.94	661.40	661.76	662.59	663.18	663.54	663.93	664.24
XS-66	27,944	656.65	657.81	658.64	659.69	660.42	660.77	661.24	661.59	662.47	663.07	663.45	663.85	664.17
XS-65	27,680	656.47	657.67	658.52	659.62	660.36	660.73	661.23	661.61	662.47	663.11	663.47	663.86	664.17
XS-64	27,421	656.23	657.35	658.19	659.38	660.11	660.49	661.03	661.43	662.33	663.06	663.44	663.85	664.16
XS-63	27,259	656.17	657.25	658.03	659.19	659.96	660.25	660.75	661.21	662.20	663.00	663.38	663.79	664.11
XS-62	27,103	656.07	657.14	657.92	659.11	659.89	660.19	660.70	661.15	662.14	662.96	663.34	663.75	664.07
XS-61	26,834	655.82	656.92	657.76	659.07	659.88	660.17	660.71	661.17	662.15	662.94	663.30	663.69	664.00
XS-60	26,592	655.69	656.91	657.81	658.70	659.40	659.88	660.40	660.82	661.71	662.43	662.77	663.13	663.42
XS-59	26,362	655.66	656.75	657.53	658.36	659.07	659.55	660.13	660.62	661.55	662.29	662.63	662.99	663.28
XS-58	25,869	655.44	656.56	657.39	658.26	659.01	659.51	660.10	660.58	661.51	662.25	662.59	662.95	663.23
XS-57	25,470	655.10	656.29	657.18	658.10	658.86	659.39	660.00	660.49	661.44	662.19	662.52	662.88	663.16
XS-56	25,260	654.92	656.14	657.04	657.97	658.75	659.28	659.88	660.38	661.31	662.05	662.37	662.71	662.98
XS-55	24,856	654.69	655.97	656.88	657.82	658.59	659.10	659.68	660.16	661.04	661.75	662.05	662.38	662.64
XS-54	24,346	654.40	655.61	656.48	657.37	658.12	658.62	659.18	659.66	660.52	660.93	661.27	661.64	661.96
XS-53	23,762	654.08	655.29	656.18	657.09	657.86	658.40	658.98	659.48	660.20	660.81	661.16	661.56	661.88
XS-52	23,368	653.85	655.10	656.02	656.95	657.74	658.28	658.85	659.38	660.28	660.88	661.22	661.61	661.92
XS-51	22,594	653.40	654.74	655.70	656.67	657.48	658.06	658.68	659.25	660.13	660.73	661.07	661.46	661.77
XS-50	22,345	653.19	654.57	655.53	656.54	657.41	658.01	658.63	659.21	660.10	660.71	661.05	661.43	661.75

Table B-4 Computed flood frequency water levels – South Saskatchewan River (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-49	21,960	652.96	654.36	655.33	656.34	657.22	657.82	658.43	659.03	659.94	660.56	660.91	661.30	661.62
XS-48	21,436	652.61	653.93	654.85	655.79	656.62	657.14	657.73	658.23	659.06	659.90	660.32	660.78	661.15
XS-47	21,170	652.59	653.88	654.77	655.67	656.41	656.89	657.48	657.91	658.97	659.78	660.21	660.67	661.05
XS-46	20,944	652.58	653.89	654.82	655.76	656.55	657.07	657.67	658.13	659.15	659.93	660.34	660.78	661.14
XS-45	20,505	652.36	653.75	654.71	655.67	656.48	657.00	657.62	658.08	659.11	659.90	660.30	660.75	661.11
XS-44	20,015	652.04	653.39	654.31	655.22	656.00	656.51	657.13	657.64	658.69	659.51	659.91	660.36	660.72
XS-43	19,627	651.83	653.17	654.10	655.02	655.80	656.31	656.92	657.36	658.43	659.26	659.65	660.08	660.43
XS-42	19,151	651.56	652.92	653.84	654.77	655.58	656.10	656.72	657.19	658.21	658.96	659.33	659.72	660.05
XS-41	18,687	651.30	652.68	653.60	654.54	655.33	655.86	656.47	656.94	657.98	658.77	659.13	659.53	659.87
XS-40	18,369	651.11	652.43	653.32	654.22	655.00	655.50	656.10	656.54	657.59	658.39	658.78	659.23	659.60
XS-39	17,911	650.87	652.12	652.98	653.87	654.60	655.10	655.70	656.08	657.11	657.82	658.29	658.80	659.23
XS-38	17,457	650.63	651.85	652.72	653.62	654.37	654.88	655.48	655.89	656.93	657.67	658.13	658.63	659.05
XS-37	16,987	650.32	651.57	652.47	653.40	654.17	654.70	655.31	655.73	656.70	657.46	657.90	658.39	658.79
XS-36	16,430	649.90	651.24	652.18	653.13	653.93	654.47	655.06	655.50	656.53	657.28	657.71	658.18	658.57
XS-35	15,922	649.56	650.93	651.86	652.79	653.57	654.11	654.73	655.15	656.13	656.97	657.43	657.93	658.35
XS-34	15,557	649.35	650.68	651.59	652.50	653.25	653.77	654.35	654.76	655.77	656.61	657.12	657.68	658.14
XS-33	15,200	649.14	650.45	651.35	652.27	653.03	653.55	654.15	654.56	655.56	656.41	656.96	657.55	658.02
XS-32	14,548	648.86	650.12	651.02	651.92	652.68	653.17	653.79	654.19	655.17	655.97	656.53	657.13	657.62
XS-31	14,068	648.67	649.91	650.80	651.71	652.46	652.96	653.56	653.96	654.90	655.68	656.21	656.77	657.24
XS-30	13,587	648.31	649.57	650.47	651.40	652.20	652.73	653.35	653.78	654.80	655.66	656.21	656.79	657.26
XS-29	13,257	648.04	649.37	650.31	651.27	652.09	652.62	653.24	653.67	654.69	655.56	656.10	656.68	657.16
XS-28	12,651	647.62	648.92	649.85	650.80	651.59	652.11	652.70	653.10	654.27	655.21	655.79	656.39	656.89
XS-27	12,272	647.48	648.74	649.64	650.56	651.32	651.82	652.44	652.88	654.04	654.96	655.53	656.11	656.57
XS-26	11,856	647.26	648.53	649.43	650.37	651.15	651.66	652.28	652.72	653.88	654.81	655.38	655.92	656.38
XS-25	11,401	646.97	648.25	649.16	650.10	650.88	651.40	652.02	652.46	653.61	654.52	655.07	655.68	656.12
XS-24	10,997	646.71	648.00	648.93	649.88	650.68	651.20	651.82	652.24	653.41	654.25	654.84	655.46	655.93
XS-23	10,616	646.50	647.75	648.64	649.56	650.31	650.81	651.41	651.82	652.90	653.68	654.20	654.81	655.28
XS-22	10,038	646.16	647.48	648.41	649.38	650.18	650.70	651.34	651.77	652.92	653.78	654.34	654.96	655.44
XS-21	9,344	645.69	646.98	647.88	648.81	649.59	650.09	650.71	651.15	652.33	653.24	653.84	654.50	655.02
XS-20	8,739	645.37	646.68	647.59	648.54	649.34	649.86	650.48	650.94	652.17	653.11	653.71	654.38	654.90
XS-19	8,061	644.92	646.35	647.33	648.33	649.17	649.71	650.36	650.83	652.06	652.99	653.59	654.24	654.76
XS-18	7,699	644.67	646.12	647.09	648.08	648.91	649.44	650.09	650.56	651.71	652.64	653.25	653.92	654.45
XS-17	7,319	644.49	645.89	646.81	647.74	648.53	649.04	649.63	650.07	651.18	652.04	652.64	653.36	653.89
XS-16	6,742	644.12	645.40	646.24	647.13	647.88	648.40	649.01	649.42	650.58	651.55	652.21	652.93	653.50
XS-15	6,324	643.92	645.27	646.18	647.14	647.95	648.50	649.13	649.56	650.77	651.71	652.36	653.07	653.60
XS-14	5,902	643.53	644.91	645.88	646.89	647.74	648.30	648.95	649.40	650.57	651.54	652.20	652.91	653.46

Table B-4 Computed flood frequency water levels – South Saskatchewan River (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-13	5,517	643.34	644.72	645.68	646.66	647.47	648.01	648.63	649.05	650.21	651.11	651.71	652.38	652.89
XS-12	5,143	643.12	644.51	645.46	646.42	647.21	647.74	648.34	648.75	649.85	650.71	651.30	651.94	652.45
XS-11	4,620	642.79	644.19	645.16	646.15	646.96	647.50	648.11	648.53	649.65	650.48	651.10	651.74	652.22
XS-10	3,946	642.39	643.83	644.81	645.79	646.60	647.14	647.76	648.17	649.26	650.11	650.71	651.37	651.88
XS-9	3,351	642.05	643.57	644.58	645.59	646.42	646.97	647.60	648.02	649.16	650.03	650.63	651.28	651.82
XS-8	2,779	641.62	643.00	643.92	644.85	645.63	646.17	646.78	647.21	648.25	649.12	649.72	650.22	650.55
XS-7	2,385	641.41	642.78	643.71	644.65	645.45	646.00	646.60	647.00	648.08	648.93	649.47	650.07	650.45
XS-6	1,981	641.23	642.61	643.54	644.50	645.29	645.84	646.44	646.86	647.92	648.77	649.33	649.94	650.40
XS-5	1,554	641.01	642.47	643.45	644.44	645.26	645.84	646.46	646.88	647.96	648.81	649.42	650.01	650.45
XS-4	1,188	640.59	642.05	643.10	644.14	644.98	645.57	646.19	646.62	647.70	648.55	649.14	649.70	650.10
XS-3	826	640.34	641.79	642.84	643.86	644.70	645.29	645.91	646.32	647.38	648.20	648.75	649.21	649.54
XS-2	434	640.10	641.56	642.63	643.66	644.50	645.08	645.68	646.09	647.13	647.89	648.47	649.00	649.33
XS-1	0	639.70	641.12	642.15	643.14	643.94	644.50	645.09	645.50	646.54	647.36	647.93	648.48	648.88

Table B-5 Computed flood frequency water levels – Ross Creek

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-277	25,004	702.29	703.08	703.48	703.80	704.04	704.16	704.31	704.40	704.62	704.79	704.89	705.01	705.08
XS-276	24,867	701.36	702.37	702.81	703.15	703.40	703.56	703.74	703.84	704.08	704.26	704.37	704.49	704.57
XS-275	24,755	701.41	702.42	702.87	703.21	703.47	703.61	703.79	703.88	704.12	704.31	704.41	704.53	704.61
XS-274	24,601	701.33	702.33	702.73	703.03	703.26	703.38	703.52	703.61	703.81	703.97	704.07	704.18	704.25
XS-273	24,504	701.27	702.25	702.62	702.90	703.10	703.21	703.35	703.42	703.61	703.75	703.83	703.92	703.98
XS-272	24,485	701.18	702.15	702.51	702.77	702.95	703.06	703.18	703.25	703.42	703.55	703.63	703.71	703.76
XS-271	24,367	701.07	702.02	702.33	702.56	702.73	702.82	702.93	702.99	703.14	703.25	703.33	703.40	703.44
XS-270	24,239	700.93	701.85	702.15	702.36	702.52	702.62	702.72	702.77	702.92	703.03	703.11	703.18	703.22
XS-269	24,049	700.54	701.37	701.73	701.97	702.13	702.22	702.34	702.40	702.55	702.67	702.73	702.80	702.85
XS-268	23,888	700.27	701.25	701.58	701.81	701.97	702.06	702.19	702.24	702.39	702.50	702.56	702.63	702.68
XS-267	23,758	700.18	701.13	701.41	701.62	701.76	701.84	701.94	701.99	702.13	702.24	702.31	702.38	702.43
XS-266	23,609	700.09	701.01	701.25	701.43	701.57	701.64	701.74	701.79	701.93	702.05	702.11	702.19	702.24
XS-265	23,458	699.92	700.84	701.08	701.26	701.39	701.46	701.56	701.61	701.75	701.87	701.93	702.01	702.06
XS-264	23,269	699.64	700.59	700.86	701.06	701.22	701.30	701.40	701.47	701.62	701.74	701.82	701.90	701.95
XS-263	23,072	699.38	700.40	700.71	700.93	701.08	701.17	701.27	701.34	701.50	701.62	701.69	701.78	701.83
XS-262	22,807	699.18	700.14	700.44	700.66	700.82	700.91	701.02	701.09	701.25	701.38	701.46	701.54	701.60
XS-261	22,662	699.10	700.02	700.32	700.54	700.70	700.79	700.91	700.97	701.14	701.27	701.34	701.43	701.49
XS-260	22,513	698.99	699.90	700.19	700.41	700.57	700.66	700.77	700.84	701.00	701.13	701.21	701.30	701.36
XS-259	22,349	698.86	699.74	700.03	700.25	700.42	700.50	700.62	700.69	700.86	701.00	701.08	701.17	701.23
XS-258	22,202	698.76	699.62	699.90	700.10	700.26	700.34	700.46	700.52	700.69	700.83	700.91	701.00	701.07
XS-257	22,052	698.63	699.47	699.75	699.95	700.10	700.18	700.30	700.36	700.54	700.68	700.77	700.86	700.93
XS-256	21,868	698.44	699.26	699.51	699.74	699.91	700.00	700.13	700.20	700.40	700.54	700.63	700.73	700.81
XS-255	21,732	698.23	699.10	699.40	699.65	699.83	699.93	700.06	700.13	700.34	700.49	700.58	700.68	700.75
XS-254	21,455	697.99	698.90	699.22	699.49	699.68	699.78	699.91	699.99	700.20	700.35	700.44	700.55	700.62
XS-253	21,284	697.86	698.79	699.14	699.41	699.61	699.71	699.84	699.92	700.13	700.29	700.38	700.48	700.56
XS-252	21,105	697.71	698.64	698.99	699.26	699.45	699.55	699.68	699.76	699.96	700.11	700.20	700.30	700.38
XS-251	20,942	697.46	698.42	698.80	699.08	699.28	699.39	699.52	699.60	699.80	699.96	700.05	700.15	700.22
XS-250	20,802	697.28	698.21	698.58	698.86	699.07	699.18	699.32	699.40	699.61	699.76	699.85	699.95	700.03
XS-249	20,619	697.10	698.06	698.44	698.74	698.96	699.08	699.23	699.31	699.53	699.69	699.78	699.89	699.96
XS-248	20,459	696.98	698.00	698.39	698.70	698.92	699.04	699.20	699.28	699.50	699.67	699.76	699.87	699.94
XS-247	20,238	696.81	697.84	698.21	698.51	698.74	698.85	699.01	699.09	699.31	699.47	699.57	699.67	699.74
XS-246	20,069	696.73	697.74	698.07	698.33	698.52	698.62	698.75	698.82	699.00	699.14	699.22	699.31	699.37
XS-245	19,885	696.63	697.64	697.94	698.16	698.31	698.40	698.50	698.56	698.72	698.83	698.90	698.97	699.02
XS-244	19,778	696.49	697.50	697.74	697.90	698.01	698.07	698.14	698.18	698.29	698.38	698.43	698.48	698.54
XS-243	19,768	696.19	697.03	697.41	697.66	697.83	697.91	698.01	698.07	698.22	698.33	698.40	698.48	698.53

Table B-5 Computed flood frequency water levels – Ross Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-242	19,704	696.18	697.03	697.36	697.58	697.74	697.81	697.90	697.96	698.10	698.21	698.28	698.34	698.39
XS-241	19,701	696.17	697.01	697.34	697.56	697.72	697.79	697.89	697.94	698.08	698.19	698.25	698.32	698.37
XS-240	19,632	696.08	696.93	697.25	697.47	697.63	697.70	697.78	697.83	697.96	698.07	698.13	698.19	698.24
XS-239	19,567	695.94	696.83	697.18	697.41	697.56	697.63	697.72	697.77	697.90	698.00	698.06	698.13	698.17
XS-238	19,419	695.72	696.66	697.03	697.28	697.44	697.52	697.61	697.66	697.80	697.91	697.98	698.04	698.09
XS-237	19,079	695.31	696.32	696.70	696.96	697.13	697.22	697.33	697.39	697.54	697.66	697.73	697.81	697.86
XS-236	18,934	695.11	696.15	696.49	696.71	696.85	696.92	697.01	697.05	697.17	697.27	697.32	697.39	697.43
XS-235	18,780	694.95	695.96	696.30	696.53	696.67	696.75	696.85	696.91	697.05	697.17	697.23	697.31	697.36
XS-234	18,614	694.77	695.73	696.08	696.34	696.51	696.60	696.71	696.78	696.94	697.06	697.13	697.21	697.26
XS-233	18,458	694.60	695.62	696.00	696.28	696.45	696.53	696.65	696.71	696.87	697.00	697.07	697.15	697.21
XS-232	18,303	694.40	695.44	695.82	696.09	696.25	696.34	696.45	696.51	696.66	696.78	696.85	696.93	696.98
XS-231	18,159	694.23	695.27	695.61	695.86	696.00	696.07	696.17	696.22	696.36	696.48	696.54	696.61	696.67
XS-230	18,042	694.11	695.13	695.43	695.61	695.74	695.81	695.91	695.96	696.10	696.21	696.28	696.36	696.41
XS-229	17,870	693.92	694.95	695.25	695.44	695.59	695.66	695.77	695.83	695.99	696.12	696.20	696.28	696.34
XS-228	17,609	693.70	694.77	695.11	695.33	695.49	695.57	695.69	695.76	695.93	696.06	696.14	696.23	696.30
XS-227	17,478	693.59	694.67	695.05	695.28	695.45	695.54	695.66	695.73	695.91	696.04	696.12	696.22	696.28
XS-226	17,291	693.45	694.55	694.98	695.24	695.41	695.51	695.63	695.70	695.88	696.02	696.10	696.19	696.26
XS-225	17,138	693.32	694.39	694.86	695.13	695.32	695.42	695.55	695.62	695.81	695.95	696.04	696.13	696.20
XS-224	16,928	693.13	694.12	694.52	694.81	695.01	695.12	695.25	695.33	695.52	695.67	695.75	695.85	695.92
XS-223	16,771	692.96	693.88	694.22	694.45	694.61	694.69	694.79	694.85	694.99	695.10	695.17	695.24	695.29
XS-222	16,622	692.75	693.70	694.01	694.22	694.36	694.43	694.52	694.57	694.69	694.79	694.84	694.91	694.95
XS-221	16,467	692.64	693.52	693.74	693.91	694.03	694.10	694.18	694.23	694.35	694.44	694.51	694.57	694.61
XS-220	16,275	692.54	693.33	693.52	693.68	693.79	693.84	693.91	693.95	694.06	694.16	694.21	694.27	694.31
XS-219	15,977	692.38	693.10	693.32	693.49	693.63	693.69	693.76	693.81	693.93	694.03	694.09	694.16	694.20
XS-218	15,802	692.24	692.92	693.17	693.35	693.49	693.56	693.65	693.70	693.83	693.95	694.02	694.08	694.13
XS-217	15,681	692.17	692.83	693.08	693.28	693.42	693.49	693.58	693.64	693.77	693.90	693.97	694.03	694.07
XS-216	15,510	692.07	692.75	693.00	693.20	693.33	693.41	693.50	693.56	693.69	693.82	693.89	693.96	694.00
XS-215	15,213	691.90	692.55	692.78	692.94	693.06	693.13	693.21	693.26	693.39	693.52	693.60	693.67	693.72
XS-214	14,983	691.76	692.46	692.71	692.87	693.00	693.06	693.15	693.20	693.33	693.47	693.55	693.63	693.67
XS-213	14,783	691.59	692.29	692.56	692.73	692.86	692.93	693.02	693.07	693.21	693.37	693.44	693.52	693.57
XS-212	14,771	691.57	692.24	692.47	692.65	692.79	692.86	692.97	693.03	693.19	693.35	693.43	693.51	693.56
XS-211	14,537	691.32	691.92	692.17	692.38	692.55	692.64	692.76	692.84	693.02	693.21	693.29	693.37	693.42
XS-210	14,376	691.17	691.80	692.04	692.26	692.43	692.52	692.65	692.73	692.91	693.11	693.20	693.28	693.33
XS-209	14,120	690.83	691.63	691.93	692.18	692.37	692.47	692.60	692.68	692.87	693.08	693.17	693.24	693.30
XS-208	14,052	690.76	691.61	691.92	692.17	692.36	692.46	692.59	692.68	692.87	693.07	693.16	693.24	693.29
XS-207	13,881	690.53	691.50	691.85	692.12	692.31	692.42	692.55	692.64	692.83	693.04	693.14	693.21	693.26
XS-206	13,834	690.54	691.50	691.84	692.10	692.30	692.40	692.54	692.62	692.82	693.03	693.12	693.19	693.24

Table B-5 Computed flood frequency water levels – Ross Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-205	13,620	690.45	691.43	691.78	692.06	692.25	692.36	692.50	692.58	692.78	692.99	693.08	693.16	693.21
XS-204	13,411	690.25	691.30	691.68	691.96	692.16	692.27	692.41	692.50	692.70	692.92	693.01	693.09	693.14
XS-203	13,230	690.06	691.10	691.47	691.75	691.94	692.04	692.17	692.27	692.44	692.59	692.73	692.82	692.88
XS-202	13,068	689.86	690.85	691.20	691.46	691.65	691.76	691.89	691.96	692.16	692.32	692.50	692.60	692.66
XS-201	12,896	689.78	690.78	691.10	691.33	691.50	691.59	691.71	691.77	691.95	692.10	692.27	692.35	692.41
XS-200	12,731	689.70	690.69	690.98	691.20	691.35	691.44	691.55	691.62	691.79	691.93	692.02	692.11	692.17
XS-199	12,542	689.51	690.45	690.76	691.00	691.17	691.27	691.38	691.45	691.63	691.79	691.88	691.97	692.03
XS-198	12,386	689.42	690.35	690.64	690.88	691.06	691.15	691.27	691.33	691.52	691.67	691.76	691.86	691.92
XS-197	12,229	689.28	690.16	690.51	690.77	690.95	691.05	691.17	691.24	691.42	691.56	691.65	691.76	691.82
XS-196	12,101	689.15	690.04	690.38	690.64	690.81	690.90	691.02	691.08	691.26	691.37	691.42	691.53	691.59
XS-195	12,034	689.10	689.99	690.32	690.56	690.72	690.80	690.91	690.96	691.10	691.21	691.27	691.39	691.46
XS-194	11,884	688.93	689.82	690.12	690.33	690.48	690.55	690.65	690.70	690.83	690.95	691.00	691.06	691.10
XS-193	11,757	688.78	689.65	689.93	690.14	690.28	690.35	690.45	690.50	690.63	690.75	690.80	690.86	690.89
XS-192	11,627	688.61	689.48	689.82	690.05	690.20	690.28	690.38	690.43	690.57	690.70	690.75	690.81	690.84
XS-191	11,439	688.36	689.25	689.57	689.78	689.93	690.01	690.11	690.17	690.30	690.47	690.53	690.59	690.63
XS-190	11,270	688.07	689.00	689.30	689.48	689.61	689.67	689.76	689.81	689.92	690.03	690.08	690.13	690.17
XS-189	11,101	687.62	688.52	688.91	689.11	689.24	689.32	689.40	689.46	689.56	689.64	689.69	689.74	689.78
XS-188	10,922	687.43	688.35	688.75	688.96	689.09	689.16	689.25	689.29	689.41	689.49	689.54	689.60	689.63
XS-187	10,738	687.23	688.17	688.67	688.88	689.02	689.09	689.17	689.22	689.35	689.43	689.48	689.54	689.58
XS-186	10,635	687.05	687.95	688.40	688.63	688.75	688.81	688.88	688.92	689.03	689.10	689.14	689.18	689.20
XS-185	10,434	686.54	687.37	687.73	687.99	688.17	688.24	688.36	688.41	688.52	688.64	688.68	688.72	688.76
XS-184	10,269	686.05	686.91	687.28	687.56	687.78	687.89	688.01	688.09	688.26	688.35	688.42	688.48	688.53
XS-183	10,264	686.08	686.96	687.33	687.62	687.83	687.93	688.05	688.12	688.28	688.38	688.44	688.50	688.54
XS-182	10,171	686.04	686.89	687.22	687.45	687.64	687.73	687.84	687.90	688.05	688.13	688.21	688.26	688.30
XS-181	10,007	685.83	686.69	687.04	687.28	687.45	687.54	687.66	687.74	687.92	688.02	688.11	688.17	688.20
XS-180	9,923	685.69	686.61	686.97	687.22	687.40	687.49	687.61	687.69	687.86	687.95	688.05	688.11	688.14
XS-179	9,907	685.64	686.59	686.95	687.20	687.38	687.47	687.59	687.67	687.85	687.94	688.04	688.10	688.13
XS-178	9,740	685.30	686.33	686.71	686.96	687.13	687.23	687.34	687.41	687.58	687.73	687.80	687.88	687.92
XS-177	9,597	685.04	686.02	686.42	686.69	686.86	686.95	687.06	687.12	687.31	687.48	687.53	687.64	687.67
XS-176	9,458	684.74	685.65	686.09	686.38	686.52	686.59	686.69	686.74	686.88	686.98	687.02	687.08	687.11
XS-175	9,311	684.37	685.13	685.53	685.84	686.05	686.16	686.25	686.30	686.42	686.51	686.56	686.62	686.67
XS-174	9,201	683.88	684.64	685.06	685.40	685.65	685.75	685.85	685.92	686.06	686.13	686.17	686.22	686.26
XS-173	9,081	683.64	684.36	684.75	685.07	685.29	685.41	685.54	685.61	685.77	685.89	685.96	686.04	686.09
XS-172	8,929	683.45	684.01	684.30	684.52	684.68	684.75	684.87	684.93	685.06	685.17	685.25	685.31	685.36
XS-171	8,801	683.34	683.84	684.09	684.28	684.44	684.49	684.62	684.68	684.77	684.86	684.95	684.98	685.01
XS-170	8,553	682.03	682.53	682.79	683.00	683.19	683.25	683.45	683.51	683.62	683.73	683.86	683.90	683.94
XS-169	8,324	680.65	681.28	681.63	681.91	682.10	682.16	682.35	682.42	682.56	682.70	682.82	682.86	682.89

Table B-5 Computed flood frequency water levels – Ross Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-168	8,108	679.60	680.17	680.48	680.70	680.94	681.00	681.13	681.19	681.25	681.36	681.48	681.51	681.54
XS-167	7,695	677.66	678.09	678.38	678.62	678.92	679.04	679.18	679.22	679.35	679.40	679.49	679.51	679.54
XS-166	7,286	675.44	676.02	676.33	676.57	676.79	676.86	677.02	677.09	677.22	677.31	677.43	677.46	677.50
XS-165	7,051	674.49	675.05	675.35	675.57	675.76	675.82	675.99	676.03	676.10	676.15	676.23	676.25	676.27
XS-164	6,863	673.97	674.43	674.66	674.84	675.01	675.05	675.18	675.23	675.31	675.38	675.49	675.51	675.54
XS-163	6,733	673.39	673.85	674.13	674.34	674.53	674.58	674.72	674.78	674.87	674.96	675.07	675.11	675.14
XS-162	6,294	670.98	671.50	671.74	671.91	672.06	672.10	672.22	672.27	672.35	672.42	672.52	672.55	672.57
XS-161	6,066	670.08	670.65	670.87	671.03	671.18	671.22	671.33	671.38	671.46	671.53	671.62	671.64	671.67
XS-160	5,846	669.54	669.94	670.13	670.27	670.37	670.39	670.48	670.51	670.57	670.62	670.69	670.71	670.73
XS-159	5,538	668.53	668.89	669.03	669.13	669.25	669.29	669.40	669.44	669.52	669.58	669.67	669.70	669.72
XS-158	5,170	667.17	667.81	668.13	668.40	668.54	668.58	668.70	668.75	668.84	668.90	668.98	669.00	669.02
XS-157	4,558	665.30	665.95	666.16	666.32	666.47	666.52	666.65	666.70	666.79	666.87	666.97	667.00	667.03
XS-156	4,293	664.67	665.48	665.81	666.00	666.14	666.18	666.32	666.37	666.45	666.53	666.62	666.65	666.67
XS-155	4,061	663.98	664.70	665.01	665.23	665.46	665.48	665.54	665.57	665.64	665.70	665.78	665.81	665.84
XS-154	3,824	663.26	664.03	664.39	664.67	664.90	664.96	665.17	665.22	665.31	665.38	665.50	665.54	665.59
XS-153	3,693	662.96	663.70	664.05	664.31	664.57	664.64	664.93	664.99	665.08	665.17	665.30	665.36	665.41
XS-152	3,546	662.67	663.32	663.61	663.82	664.00	664.05	664.18	664.27	664.42	664.60	664.84	664.94	665.03
XS-151	3,440	662.46	663.15	663.44	663.65	663.84	663.89	664.06	664.15	664.29	664.48	664.71	664.82	664.91
XS-150	3,384	662.22	662.95	663.23	663.44	663.63	663.68	663.85	663.94	664.09	664.31	664.56	664.68	664.79
XS-149	3,256	661.83	662.61	662.92	663.16	663.36	663.42	663.61	663.72	663.89	664.16	664.44	664.57	664.69
XS-148	3,057	661.28	662.06	662.55	662.80	662.99	663.05	663.25	663.39	663.60	663.93	664.25	664.41	664.54
XS-147	2,925	661.02	661.73	662.00	662.50	662.68	662.74	662.96	663.16	663.42	663.82	664.16	664.33	664.47
XS-146	2,915	660.98	661.66	662.03	662.32	662.59	662.66	662.89	663.11	663.38	663.78	664.14	664.31	664.45
XS-145	2,772	660.67	661.28	661.63	661.92	662.17	662.24	662.46	662.76	663.05	663.54	663.91	664.10	664.25
XS-144	2,572	660.13	660.81	661.20	661.54	661.78	661.86	662.12	662.56	662.91	663.46	663.85	664.05	664.21
XS-143	2,370	659.69	660.45	660.89	661.28	661.50	661.58	661.87	662.41	662.78	663.37	663.77	663.98	664.14
XS-142	2,261	659.49	660.29	660.77	661.17	661.39	661.47	661.78	662.36	662.74	663.35	663.71	663.95	664.11
XS-141	2,161	659.24	660.07	660.56	660.97	661.14	661.21	661.51	662.18	662.57	663.20	663.58	663.71	663.95
XS-140	2,145	659.18	659.96	660.43	660.83	660.98	661.06	661.35	661.76	662.41	662.97	663.32	663.72	664.01
XS-139	2,032	658.74	659.57	660.08	660.61	660.77	660.88	661.28	661.77	662.44	663.03	663.38	663.75	664.04
XS-138	1,780	658.14	659.04	659.58	660.25	660.48	660.68	661.19	661.72	662.42	663.02	663.37	663.74	664.04
XS-137	1,675	657.87	658.79	659.35	659.92	660.21	660.52	661.11	661.68	662.38	663.01	663.36	663.74	664.04
XS-136	1,611	657.73	658.64	659.23	659.88	660.13	660.43	661.01	661.60	662.11	662.99	663.35	663.73	664.03
XS-135	1,596	657.45	658.35	658.93	659.57	660.13	660.37	660.85	661.37	662.20	662.98	663.35	663.73	664.03
XS-134	1,527	657.35	658.25	658.85	659.52	660.11	660.37	660.87	661.40	662.23	662.98	663.35	663.73	664.03
XS-133	1,488	657.22	658.15	658.76	659.36	660.08	660.34	660.86	661.39	662.22	662.98	663.34	663.73	664.03
XS-132	1,437	657.11	658.04	658.67	659.35	660.05	660.32	660.84	661.38	662.21	662.98	663.34	663.73	664.03

Table B-5 Computed flood frequency water levels – Ross Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-131	1,300	656.80	657.85	658.53	659.26	660.02	660.30	660.82	661.37	662.20	662.97	663.34	663.72	664.03
XS-130	1,282	656.77	657.83	658.51	659.25	660.01	660.29	660.81	661.36	662.20	662.97	663.33	663.72	664.02
XS-129	1,278	656.78	657.84	658.52	659.26	660.01	660.29	660.81	661.36	662.20	662.97	663.34	663.72	664.02
XS-128	1,247	656.74	657.82	658.52	659.26	660.01	660.29	660.81	661.36	662.20	662.97	663.34	663.72	664.02
XS-127	1,118	656.58	657.65	658.40	659.21	659.98	660.26	660.79	661.34	662.20	662.97	663.33	663.72	664.02
XS-126	1,025	656.49	657.56	658.31	659.13	659.92	660.21	660.75	661.31	662.18	662.96	663.33	663.72	664.02
XS-125	880	656.32	657.45	658.23	659.14	659.94	660.22	660.76	661.22	662.19	662.96	663.33	663.72	664.02
XS-124	757	656.23	657.38	658.21	659.14	659.94	660.23	660.76	661.23	662.19	662.96	663.33	663.72	664.02
XS-123	540	656.14	657.32	658.17	659.11	659.92	660.21	660.74	661.21	662.18	662.96	663.32	663.71	664.02
XS-122	431	656.11	657.29	658.14	659.09	659.90	660.19	660.73	661.18	662.16	662.95	663.32	663.71	664.01
XS-121	279	656.05	657.24	658.10	659.07	659.88	660.17	660.71	661.17	662.15	662.94	663.30	663.69	664.00

Table B-6 Computed flood frequency water levels – Seven Persons Creek

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-559	24,132	709.01	709.84	710.33	710.76	711.48	711.54	711.62	711.66	711.77	711.87	712.04	712.21	712.28
XS-558	23,979	708.98	709.78	710.27	710.70	711.45	711.51	711.58	711.62	711.72	711.82	711.99	712.16	712.23
XS-557	23,814	708.79	709.40	709.70	710.12	711.29	711.33	711.37	711.39	711.45	711.52	711.77	711.99	712.06
XS-556	23,806	708.53	709.13	709.32	709.54	709.77	709.89	710.04	710.14	710.49	711.36	711.71	711.94	712.02
XS-555	23,647	707.85	708.59	709.03	709.43	709.79	710.03	710.31	710.51	711.01	711.47	711.76	711.97	712.05
XS-554	23,493	707.40	708.17	708.74	709.24	709.66	709.93	710.22	710.43	710.95	711.43	711.65	711.90	711.99
XS-553	23,470	707.15	708.12	708.69	709.17	709.58	709.84	710.14	710.35	710.87	711.35	711.62	711.85	711.93
XS-552	23,465	707.23	708.15	708.72	709.19	709.60	709.86	710.15	710.36	710.88	711.36	711.63	711.86	711.93
XS-551	23,401	707.14	707.99	708.53	709.01	709.43	709.70	710.01	710.23	710.77	711.27	711.56	711.79	711.89
XS-550	23,369	707.11	707.85	708.23	708.50	708.71	708.84	708.97	709.06	709.26	709.43	709.52	709.64	709.71
XS-549	23,292	707.05	707.77	708.10	708.33	708.52	708.64	708.77	708.86	709.07	709.24	709.34	709.46	709.55
XS-548	23,260	706.98	707.66	708.03	708.28	708.49	708.62	708.76	708.86	709.09	709.28	709.38	709.51	709.60
XS-547	23,215	706.93	707.64	708.00	708.24	708.44	708.56	708.70	708.80	709.02	709.21	709.31	709.45	709.54
XS-546	23,117	706.85	707.47	707.82	708.09	708.31	708.45	708.60	708.70	708.94	709.14	709.25	709.39	709.48
XS-545	23,034	706.47	706.85	707.17	707.45	707.67	707.80	707.94	708.04	708.25	708.43	708.53	708.67	708.75
XS-544	22,948	705.65	706.17	706.54	706.80	707.02	707.14	707.32	707.42	707.63	707.77	707.84	707.93	707.99
XS-543	22,873	705.55	705.99	706.37	706.68	706.93	707.08	707.28	707.39	707.63	707.79	707.87	707.98	708.05
XS-542	22,771	705.07	705.78	706.24	706.57	706.83	706.99	707.16	707.29	707.55	707.71	707.80	707.91	707.98
XS-541	22,664	704.84	705.59	706.01	706.32	706.56	706.71	706.86	706.96	707.23	707.37	707.44	707.54	707.61
XS-540	22,575	704.62	705.34	705.78	706.07	706.29	706.43	706.57	706.67	706.89	707.07	707.16	707.28	707.36
XS-539	22,464	704.28	705.06	705.48	705.79	706.02	706.16	706.30	706.42	706.66	706.83	706.92	707.03	707.10
XS-538	22,361	704.13	704.88	705.26	705.51	705.69	705.81	705.92	706.03	706.19	706.32	706.39	706.48	706.54
XS-537	22,267	704.06	704.77	705.12	705.38	705.58	705.70	705.83	705.96	706.14	706.29	706.36	706.46	706.52
XS-536	22,142	704.00	704.70	705.05	705.28	705.47	705.59	705.71	705.85	706.02	706.15	706.22	706.32	706.38
XS-535	22,050	703.92	704.59	704.90	705.09	705.26	705.38	705.50	705.60	705.79	705.94	706.02	706.12	706.19
XS-534	21,928	703.33	704.07	704.26	704.56	704.81	704.95	705.10	705.20	705.44	705.62	705.70	705.80	705.87
XS-533	21,803	702.96	703.69	704.09	704.38	704.59	704.72	704.85	704.94	705.16	705.31	705.39	705.48	705.54
XS-532	21,685	702.91	703.59	703.97	704.22	704.41	704.52	704.63	704.71	704.90	705.03	705.09	705.18	705.24
XS-531	21,588	702.86	703.50	703.86	704.10	704.26	704.37	704.47	704.54	704.69	704.86	704.95	705.06	705.12
XS-530	21,553	702.66	703.42	703.81	704.06	704.25	704.37	704.49	704.57	704.76	704.91	704.99	705.10	705.16
XS-529	21,455	702.53	703.28	703.68	703.97	704.17	704.29	704.42	704.50	704.70	704.85	704.94	705.04	705.11
XS-528	21,316	702.36	703.07	703.45	703.71	703.91	704.02	704.14	704.22	704.41	704.56	704.63	704.73	704.80
XS-527	21,210	702.09	702.88	703.24	703.48	703.66	703.76	703.87	703.94	704.11	704.25	704.31	704.40	704.46
XS-526	21,109	701.96	702.75	703.08	703.30	703.45	703.53	703.62	703.68	703.83	703.94	704.00	704.07	704.11
XS-525	21,010	701.85	702.59	702.89	703.09	703.22	703.29	703.38	703.43	703.57	703.67	703.72	703.78	703.82

Table B-6 Computed flood frequency water levels – Seven Persons Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-524	20,908	701.74	702.45	702.73	702.91	703.03	703.09	703.17	703.22	703.33	703.43	703.47	703.53	703.57
XS-523	20,811	701.62	702.27	702.54	702.72	702.83	702.89	702.96	703.00	703.12	703.23	703.28	703.34	703.37
XS-522	20,688	701.22	701.92	702.19	702.38	702.52	702.60	702.69	702.75	702.89	703.03	703.08	703.14	703.18
XS-521	20,604	701.20	701.81	702.01	702.17	702.30	702.38	702.47	702.53	702.66	702.80	702.86	702.93	702.97
XS-520	20,492	701.08	701.55	701.81	701.99	702.15	702.23	702.33	702.39	702.53	702.68	702.74	702.81	702.85
XS-519	20,389	700.85	701.39	701.68	701.87	702.02	702.12	702.22	702.28	702.43	702.59	702.65	702.72	702.76
XS-518	20,205	700.41	701.06	701.36	701.59	701.76	701.87	701.97	702.04	702.18	702.35	702.42	702.49	702.53
XS-517	20,050	700.10	700.76	701.16	701.42	701.62	701.74	701.84	701.91	702.06	702.22	702.27	702.34	702.39
XS-516	19,964	699.95	700.62	701.06	701.32	701.52	701.62	701.73	701.80	701.96	702.15	702.20	702.27	702.31
XS-515	19,854	699.71	700.49	700.93	701.19	701.40	701.51	701.62	701.69	701.86	702.05	702.11	702.17	702.22
XS-514	19,715	699.46	700.24	700.68	700.93	701.12	701.21	701.32	701.39	701.53	701.63	701.69	701.77	701.81
XS-513	19,604	699.26	700.03	700.49	700.71	700.87	700.97	701.07	701.14	701.29	701.41	701.47	701.55	701.60
XS-512	19,456	699.02	699.74	700.20	700.39	700.53	700.61	700.69	700.75	700.89	700.99	701.03	701.08	701.11
XS-511	19,328	698.80	699.44	699.79	700.00	700.15	700.24	700.34	700.40	700.54	700.72	700.76	700.81	700.84
XS-510	19,216	698.68	699.24	699.54	699.73	699.86	699.94	700.03	700.08	700.19	700.27	700.32	700.40	700.45
XS-509	19,152	698.61	699.18	699.51	699.70	699.84	699.92	700.01	700.06	700.18	700.29	700.34	700.42	700.46
XS-508	19,111	698.42	699.11	699.45	699.63	699.76	699.83	699.91	699.96	700.07	700.17	700.22	700.29	700.34
XS-507	19,002	698.12	698.86	699.21	699.37	699.49	699.56	699.64	699.70	699.83	699.93	699.99	700.07	700.12
XS-506	18,890	697.88	698.54	698.95	699.16	699.33	699.41	699.51	699.58	699.72	699.84	699.90	699.99	700.04
XS-505	18,787	697.61	698.32	698.74	698.98	699.18	699.28	699.39	699.46	699.63	699.76	699.82	699.91	699.97
XS-504	18,675	697.30	698.02	698.52	698.76	699.03	699.15	699.27	699.35	699.52	699.66	699.73	699.82	699.88
XS-503	18,565	697.02	697.75	698.32	698.50	698.74	698.83	698.90	698.94	699.05	699.15	699.19	699.26	699.31
XS-502	18,494	696.86	697.57	698.15	698.23	698.51	698.57	698.63	698.66	698.76	698.83	698.83	698.86	698.86
XS-501	18,486	696.62	697.32	697.65	697.87	698.06	698.14	698.24	698.27	698.47	698.60	698.66	698.75	698.80
XS-500	18,434	696.56	697.28	697.61	697.85	698.05	698.16	698.28	698.35	698.55	698.68	698.75	698.83	698.88
XS-499	18,351	696.31	697.09	697.45	697.70	697.90	698.02	698.15	698.23	698.45	698.58	698.64	698.73	698.78
XS-498	18,280	696.01	696.92	697.29	697.55	697.77	697.90	698.03	698.12	698.27	698.43	698.50	698.60	698.65
XS-497	18,275	696.01	696.84	697.23	697.51	697.71	697.83	697.96	698.04	698.20	698.34	698.42	698.53	698.58
XS-496	18,219	695.91	696.76	697.14	697.39	697.57	697.66	697.77	697.83	697.97	698.08	698.14	698.22	698.27
XS-495	18,130	695.83	696.65	697.03	697.29	697.48	697.59	697.71	697.78	697.93	698.06	698.14	698.22	698.28
XS-494	18,126	695.82	696.64	697.01	697.27	697.46	697.56	697.68	697.75	697.91	698.04	698.11	698.20	698.25
XS-493	18,004	695.63	696.47	696.86	697.11	697.29	697.39	697.50	697.59	697.76	697.90	697.98	698.08	698.13
XS-492	17,905	695.45	696.35	696.75	697.01	697.18	697.29	697.40	697.49	697.66	697.80	697.88	697.98	698.03
XS-491	17,802	695.34	696.23	696.60	696.82	696.96	697.04	697.13	697.19	697.36	697.51	697.60	697.69	697.75
XS-490	17,798	695.31	695.95	696.39	696.69	696.88	696.99	697.10	697.18	697.37	697.51	697.58	697.68	697.75
XS-489	17,719	695.00	695.79	696.29	696.59	696.78	696.88	697.00	697.07	697.25	697.40	697.48	697.58	697.65
XS-488	17,604	694.69	695.50	696.01	696.33	696.49	696.61	696.73	696.81	697.01	697.17	697.25	697.36	697.43

Table B-6 Computed flood frequency water levels – Seven Persons Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-487	17,598	694.68	695.45	695.85	696.13	696.34	696.47	696.60	696.69	696.91	697.09	697.17	697.29	697.36
XS-486	17,499	694.46	695.29	695.72	696.03	696.25	696.37	696.50	696.59	696.79	696.96	697.05	697.16	697.23
XS-485	17,357	694.17	694.95	695.33	695.60	695.84	695.98	696.13	696.23	696.46	696.65	696.75	696.88	696.97
XS-484	17,263	694.00	694.82	695.20	695.51	695.77	695.92	696.07	696.18	696.41	696.60	696.70	696.84	696.92
XS-483	17,143	693.70	694.51	695.01	695.37	695.66	695.82	695.99	696.09	696.34	696.54	696.64	696.78	696.86
XS-482	17,043	693.55	694.44	694.93	695.29	695.57	695.73	695.90	696.02	696.27	696.47	696.57	696.71	696.80
XS-481	16,936	693.47	694.33	694.81	695.14	695.41	695.56	695.73	695.83	696.07	696.26	696.36	696.50	696.58
XS-480	16,931	693.47	694.32	694.78	695.10	695.35	695.50	695.65	695.75	695.98	696.17	696.27	696.41	696.50
XS-479	16,848	693.35	694.13	694.54	694.81	695.03	695.17	695.30	695.38	695.57	695.72	695.80	695.90	695.96
XS-478	16,772	693.28	694.05	694.43	694.68	694.89	695.02	695.13	695.20	695.38	695.52	695.59	695.69	695.74
XS-477	16,640	693.01	693.81	694.27	694.54	694.77	694.92	695.04	695.13	695.32	695.48	695.57	695.68	695.74
XS-476	16,542	692.84	693.62	694.09	694.44	694.71	694.86	694.99	695.08	695.28	695.45	695.53	695.64	695.71
XS-475	16,415	692.73	693.48	693.95	694.30	694.56	694.72	694.85	694.93	695.13	695.29	695.38	695.49	695.56
XS-474	16,312	692.66	693.38	693.84	694.18	694.44	694.59	694.70	694.77	694.95	695.09	695.16	695.26	695.31
XS-473	16,208	692.35	693.19	693.69	694.05	694.32	694.47	694.57	694.64	694.81	694.95	695.02	695.12	695.18
XS-472	16,142	692.34	693.12	693.59	693.91	694.15	694.29	694.37	694.42	694.55	694.67	694.72	694.81	694.85
XS-471	16,136	692.34	693.11	693.51	693.80	694.06	694.22	694.30	694.36	694.50	694.62	694.69	694.78	694.83
XS-470	16,093	692.23	693.01	693.43	693.74	693.96	694.18	694.26	694.32	694.48	694.62	694.69	694.79	694.85
XS-469	16,003	692.07	692.89	693.30	693.60	693.82	693.93	694.07	694.16	694.37	694.53	694.61	694.72	694.78
XS-468	15,897	691.94	692.77	693.17	693.45	693.65	693.77	693.89	693.98	694.16	694.31	694.39	694.50	694.56
XS-467	15,790	691.83	692.65	693.06	693.33	693.52	693.64	693.76	693.84	694.01	694.16	694.23	694.34	694.40
XS-466	15,677	691.68	692.49	692.90	693.17	693.37	693.49	693.61	693.69	693.87	694.02	694.10	694.19	694.25
XS-465	15,553	691.48	692.31	692.73	692.98	693.16	693.27	693.38	693.46	693.62	693.75	693.82	693.91	693.97
XS-464	15,468	691.38	692.19	692.56	692.77	692.92	693.01	693.10	693.16	693.31	693.45	693.52	693.62	693.68
XS-463	15,462	691.36	692.10	692.47	692.71	692.89	693.00	693.10	693.17	693.34	693.48	693.55	693.65	693.71
XS-462	15,421	691.12	691.94	692.36	692.63	692.82	692.94	693.05	693.12	693.29	693.43	693.50	693.60	693.66
XS-461	15,330	691.03	691.79	692.21	692.47	692.67	692.79	692.90	692.97	693.14	693.28	693.36	693.46	693.52
XS-460	15,270	690.95	691.67	692.07	692.33	692.51	692.61	692.71	692.78	692.94	693.07	693.15	693.25	693.31
XS-459	15,169	690.79	691.54	691.94	692.21	692.42	692.53	692.65	692.72	692.89	693.04	693.12	693.23	693.30
XS-458	15,148	690.74	691.46	691.85	692.12	692.34	692.47	692.58	692.66	692.85	693.00	693.08	693.19	693.26
XS-457	15,076	690.65	691.37	691.74	692.02	692.24	692.37	692.49	692.56	692.74	692.90	692.98	693.09	693.16
XS-456	14,959	690.52	691.22	691.59	691.84	692.03	692.17	692.28	692.35	692.52	692.67	692.74	692.85	692.92
XS-455	14,861	690.29	691.11	691.49	691.75	691.96	692.11	692.22	692.29	692.47	692.62	692.70	692.82	692.89
XS-454	14,749	690.07	690.90	691.28	691.54	691.74	691.85	691.97	692.06	692.25	692.42	692.51	692.64	692.72
XS-453	14,610	689.79	690.60	691.03	691.27	691.46	691.57	691.68	691.76	691.95	692.12	692.21	692.34	692.42
XS-452	14,511	689.61	690.45	690.85	691.10	691.30	691.41	691.54	691.63	691.85	692.03	692.13	692.27	692.36
XS-451	14,406	689.42	690.24	690.67	690.95	691.18	691.31	691.45	691.55	691.78	691.97	692.08	692.23	692.32

Table B-6 Computed flood frequency water levels – Seven Persons Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-450	14,327	689.20	689.94	690.40	690.74	691.01	691.16	691.31	691.42	691.67	691.87	691.98	692.14	692.24
XS-449	14,247	688.94	689.70	690.15	690.37	690.54	690.62	690.71	690.77	690.91	691.01	691.07	691.19	691.27
XS-448	14,233	688.84	689.60	690.04	690.25	690.40	690.47	690.55	690.59	690.70	690.77	690.81	690.85	690.87
XS-447	14,108	688.60	689.39	689.80	689.99	690.14	690.22	690.31	690.36	690.49	690.60	690.66	690.73	690.78
XS-446	14,000	688.42	689.12	689.54	689.79	689.97	690.06	690.16	690.23	690.37	690.49	690.54	690.62	690.67
XS-445	13,839	688.20	688.89	689.32	689.55	689.72	689.79	689.88	689.93	690.06	690.16	690.21	690.28	690.32
XS-444	13,689	687.89	688.62	689.07	689.33	689.53	689.60	689.68	689.73	689.85	689.95	690.00	690.07	690.11
XS-443	13,570	687.63	688.36	688.81	689.12	689.40	689.45	689.51	689.57	689.69	689.79	689.84	689.92	689.96
XS-442	13,465	687.33	688.12	688.60	688.92	689.13	689.21	689.31	689.41	689.57	689.68	689.74	689.82	689.87
XS-441	13,347	687.11	687.92	688.41	688.73	688.97	689.09	689.20	689.30	689.49	689.61	689.67	689.76	689.81
XS-440	13,258	686.97	687.83	688.33	688.67	688.92	689.04	689.16	689.25	689.46	689.58	689.65	689.74	689.79
XS-439	13,121	686.68	687.53	688.03	688.43	688.70	688.84	689.00	689.11	689.32	689.47	689.55	689.65	689.71
XS-438	13,053	686.60	687.50	688.00	688.38	688.63	688.77	688.91	689.01	689.21	689.37	689.44	689.55	689.62
XS-437	12,911	686.41	687.29	687.82	688.21	688.50	688.65	688.80	688.90	689.11	689.26	689.33	689.44	689.50
XS-436	12,787	686.14	687.01	687.53	687.90	688.15	688.31	688.46	688.54	688.75	688.92	689.01	689.14	689.21
XS-435	12,635	685.92	686.81	687.32	687.67	687.90	688.04	688.17	688.24	688.40	688.51	688.56	688.64	688.68
XS-434	12,461	685.68	686.57	687.05	687.36	687.55	687.65	687.75	687.81	687.99	688.07	688.11	688.16	688.19
XS-433	12,300	685.52	686.38	686.81	687.08	687.25	687.35	687.44	687.50	687.66	687.83	687.89	687.96	688.01
XS-432	12,200	685.40	686.25	686.72	686.99	687.18	687.26	687.36	687.43	687.58	687.76	687.82	687.90	687.95
XS-431	12,119	685.27	686.10	686.54	686.84	687.04	687.15	687.26	687.34	687.51	687.68	687.75	687.84	687.89
XS-430	11,921	685.01	685.74	686.14	686.42	686.65	686.78	686.93	687.02	687.22	687.44	687.52	687.63	687.69
XS-429	11,798	684.87	685.56	685.96	686.25	686.48	686.61	686.76	686.84	687.03	687.24	687.32	687.41	687.46
XS-428	11,676	684.49	685.25	685.72	686.03	686.26	686.40	686.55	686.63	686.80	686.94	687.02	687.11	687.17
XS-427	11,519	683.95	684.83	685.32	685.65	685.90	686.04	686.19	686.27	686.45	686.59	686.66	686.75	686.81
XS-426	11,372	683.82	684.72	685.20	685.51	685.73	685.86	685.99	686.05	686.21	686.33	686.40	686.49	686.54
XS-425	11,253	683.64	684.52	684.96	685.24	685.45	685.59	685.72	685.81	686.00	686.15	686.22	686.32	686.38
XS-424	11,204	683.55	684.42	684.83	685.12	685.34	685.47	685.58	685.65	685.83	685.97	686.03	686.12	686.17
XS-423	11,095	683.46	684.32	684.72	684.98	685.18	685.31	685.40	685.47	685.64	685.77	685.83	685.91	685.96
XS-422	10,959	683.31	684.08	684.40	684.65	684.84	684.97	685.11	685.21	685.42	685.56	685.62	685.71	685.75
XS-421	10,871	683.07	683.79	684.14	684.40	684.63	684.77	684.92	685.03	685.26	685.39	685.45	685.53	685.57
XS-420	10,865	683.03	683.66	684.05	684.35	684.58	684.72	684.88	684.99	685.23	685.36	685.42	685.50	685.55
XS-419	10,775	682.81	683.47	683.81	684.08	684.28	684.41	684.56	684.64	684.82	685.08	685.15	685.26	685.31
XS-418	10,671	682.63	683.27	683.58	683.81	684.00	684.12	684.27	684.35	684.50	684.63	684.70	684.79	684.85
XS-417	10,533	682.36	683.00	683.22	683.40	683.56	683.65	683.75	683.83	684.03	684.21	684.31	684.43	684.51
XS-416	10,429	682.03	682.62	682.97	683.21	683.41	683.53	683.66	683.75	683.97	684.16	684.26	684.39	684.46
XS-415	10,290	681.79	682.41	682.74	682.97	683.16	683.28	683.40	683.49	683.71	683.90	684.00	684.13	684.20
XS-414	10,140	681.46	682.03	682.34	682.60	682.82	682.96	683.11	683.21	683.47	683.67	683.78	683.92	684.00

Table B-6 Computed flood frequency water levels – Seven Persons Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-413	10,024	680.84	681.47	681.88	682.19	682.45	682.60	682.76	682.88	683.15	683.36	683.47	683.61	683.69
XS-412	9,910	680.42	681.15	681.56	681.89	682.15	682.31	682.48	682.60	682.89	683.10	683.22	683.35	683.43
XS-411	9,797	680.24	680.87	681.22	681.50	681.73	681.89	682.05	682.16	682.41	682.63	682.79	682.95	683.05
XS-410	9,668	679.52	680.44	680.96	681.33	681.62	681.81	682.00	682.13	682.42	682.67	682.82	682.99	683.09
XS-409	9,490	679.23	680.17	680.72	681.14	681.46	681.66	681.87	682.00	682.30	682.55	682.72	682.88	682.98
XS-408	9,399	679.11	680.02	680.54	680.94	681.25	681.44	681.63	681.75	682.04	682.26	682.42	682.57	682.65
XS-407	9,262	678.86	679.70	680.18	680.53	680.81	680.96	681.14	681.26	681.52	681.72	681.81	681.94	682.03
XS-406	9,139	678.65	679.50	679.98	680.36	680.65	680.83	681.02	681.15	681.43	681.65	681.77	681.91	682.00
XS-405	9,099	678.60	679.43	679.88	680.23	680.48	680.64	680.81	680.92	681.18	681.38	681.50	681.63	681.71
XS-404	9,091	678.59	679.42	679.87	680.22	680.48	680.63	680.78	680.87	681.08	681.22	681.30	681.41	681.49
XS-403	9,009	678.47	679.25	679.66	679.99	680.24	680.38	680.51	680.59	680.76	680.84	680.90	680.98	681.05
XS-402	8,998	678.45	679.23	679.66	680.00	680.25	680.39	680.54	680.62	680.79	680.88	680.94	681.01	681.06
XS-401	8,932	678.24	679.01	679.47	679.84	680.10	680.24	680.39	680.46	680.62	680.68	680.72	680.77	680.80
XS-400	8,858	678.09	678.81	679.18	679.47	679.70	679.87	680.10	680.21	680.44	680.44	680.48	680.51	680.53
XS-399	8,817	678.05	678.76	679.13	679.43	679.67	679.79	679.94	680.00	680.08	680.15	680.19	680.25	680.30
XS-398	8,778	677.99	678.66	679.04	679.35	679.56	679.69	679.85	679.91	679.96	680.01	680.04	680.08	680.11
XS-397	8,773	677.98	678.64	678.95	679.18	679.34	679.45	679.55	679.64	679.79	679.91	679.97	680.05	680.10
XS-396	8,621	677.53	678.20	678.61	678.88	679.06	679.16	679.27	679.38	679.51	679.62	679.66	679.73	679.77
XS-395	8,548	677.39	678.02	678.42	678.71	678.88	678.98	679.08	679.13	679.29	679.43	679.48	679.56	679.61
XS-394	8,469	676.90	677.83	678.30	678.61	678.79	678.90	679.01	679.08	679.23	679.36	679.41	679.48	679.53
XS-393	8,342	676.77	677.64	678.09	678.39	678.56	678.68	678.78	678.85	679.00	679.14	679.17	679.25	679.29
XS-392	8,336	676.76	677.63	678.07	678.36	678.52	678.63	678.73	678.80	678.94	679.08	679.11	679.18	679.22
XS-391	8,330	676.75	677.61	678.05	678.34	678.49	678.60	678.70	678.76	678.89	679.04	679.06	679.13	679.17
XS-390	8,322	676.74	677.60	678.03	678.29	678.43	678.52	678.61	678.68	678.82	678.93	678.98	679.05	679.09
XS-389	8,269	676.66	677.51	677.97	678.25	678.39	678.49	678.58	678.65	678.78	678.89	678.95	679.02	679.06
XS-388	8,118	676.17	676.98	677.54	677.88	677.93	678.04	678.15	678.21	678.35	678.46	678.52	678.60	678.64
XS-387	8,114	676.17	676.96	677.36	677.69	677.87	677.98	678.08	678.15	678.29	678.40	678.46	678.53	678.58
XS-386	8,097	676.12	676.95	677.38	677.68	677.88	678.00	678.11	678.18	678.32	678.44	678.49	678.57	678.62
XS-385	8,019	675.79	676.64	677.24	677.58	677.82	677.94	678.06	678.12	678.27	678.39	678.44	678.52	678.56
XS-384	8,016	675.77	676.63	677.13	677.51	677.77	677.90	678.03	678.10	678.25	678.36	678.42	678.50	678.54
XS-383	7,936	675.62	676.50	676.99	677.35	677.58	677.72	677.86	677.93	678.09	678.20	678.26	678.34	678.38
XS-382	7,853	675.46	676.28	676.77	677.14	677.35	677.47	677.64	677.72	677.89	678.02	678.09	678.17	678.22
XS-381	7,849	675.45	676.26	676.72	677.06	677.29	677.43	677.55	677.64	677.82	677.97	678.03	678.12	678.17
XS-380	7,744	675.33	676.13	676.58	676.90	677.11	677.23	677.35	677.43	677.59	677.71	677.77	677.85	677.89
XS-379	7,660	675.24	675.99	676.39	676.67	676.84	676.94	677.04	677.10	677.25	677.36	677.42	677.49	677.54
XS-378	7,583	675.15	675.89	676.27	676.55	676.70	676.79	676.88	676.93	677.06	677.15	677.19	677.24	677.27
XS-377	7,519	675.01	675.76	676.17	676.45	676.63	676.72	676.82	676.88	677.02	677.13	677.17	677.22	677.26

Table B-6 Computed flood frequency water levels – Seven Persons Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-376	7,363	674.60	675.25	675.62	675.86	676.00	676.08	676.16	676.21	676.34	676.45	676.52	676.60	676.65
XS-375	7,248	674.30	674.90	675.24	675.52	675.71	675.79	675.90	675.97	676.13	676.26	676.34	676.42	676.47
XS-374	7,243	674.29	674.89	675.22	675.48	675.67	675.76	675.86	675.94	676.10	676.23	676.31	676.40	676.45
XS-373	7,224	674.25	674.87	675.21	675.45	675.65	675.74	675.84	675.92	676.08	676.22	676.30	676.38	676.44
XS-372	7,190	674.20	674.79	675.10	675.39	675.61	675.69	675.80	675.87	676.04	676.17	676.26	676.34	676.39
XS-371	7,180	674.19	674.77	675.09	675.37	675.59	675.68	675.78	675.85	676.02	676.15	676.24	676.32	676.38
XS-370	7,064	674.03	674.53	674.88	675.19	675.44	675.53	675.64	675.71	675.89	676.03	676.13	676.21	676.26
XS-369	6,925	673.62	674.20	674.65	675.00	675.24	675.37	675.52	675.61	675.81	675.96	676.04	676.13	676.19
XS-368	6,795	673.09	673.90	674.43	674.88	675.14	675.27	675.42	675.51	675.74	675.89	675.97	676.07	676.13
XS-367	6,751	673.04	673.84	674.35	674.79	675.04	675.18	675.33	675.43	675.65	675.80	675.87	675.97	676.02
XS-366	6,744	673.04	673.83	674.34	674.73	675.01	675.16	675.31	675.41	675.63	675.78	675.85	675.94	676.00
XS-365	6,699	672.99	673.77	674.29	674.70	674.97	675.13	675.27	675.37	675.59	675.74	675.81	675.89	675.95
XS-364	6,635	672.91	673.65	674.14	674.51	674.75	674.89	675.01	675.10	675.29	675.40	675.44	675.49	675.52
XS-363	6,630	672.91	673.65	674.00	674.25	674.43	674.53	674.62	674.67	674.82	674.93	674.99	675.06	675.11
XS-362	6,546	672.61	673.28	673.63	673.89	674.04	674.12	674.22	674.28	674.43	674.54	674.60	674.69	674.75
XS-361	6,454	672.42	673.13	673.44	673.69	673.83	673.90	673.98	674.03	674.18	674.27	674.32	674.40	674.46
XS-360	6,366	672.32	672.98	673.25	673.42	673.55	673.63	673.73	673.79	673.96	674.06	674.10	674.19	674.27
XS-359	6,303	672.19	672.78	673.03	673.30	673.44	673.54	673.64	673.70	673.89	673.98	674.03	674.11	674.20
XS-358	6,295	672.18	672.77	673.07	673.30	673.44	673.53	673.62	673.69	673.87	673.96	674.00	674.08	674.17
XS-357	6,248	671.97	672.69	673.01	673.24	673.36	673.45	673.54	673.60	673.80	673.87	673.91	673.98	674.08
XS-356	6,151	671.65	672.40	672.71	672.87	673.11	673.22	673.34	673.41	673.65	673.72	673.75	673.82	673.95
XS-355	6,147	671.64	672.28	672.63	672.91	673.11	673.22	673.33	673.40	673.64	673.70	673.74	673.81	673.94
XS-354	6,034	671.35	671.91	672.17	672.36	672.53	672.61	672.69	672.72	672.83	672.99	673.10	673.35	673.64
XS-353	5,749	670.81	671.50	671.86	672.10	672.29	672.38	672.47	672.52	672.64	672.79	672.93	673.22	673.55
XS-352	5,594	670.44	671.12	671.48	671.71	671.91	672.01	672.10	672.16	672.32	672.56	672.74	673.13	673.50
XS-351	5,443	670.12	670.75	671.10	671.34	671.55	671.64	671.74	671.82	672.04	672.38	672.59	673.07	673.46
XS-350	5,281	669.84	670.50	670.88	671.15	671.35	671.47	671.58	671.69	671.95	672.33	672.56	673.05	673.45
XS-349	5,265	669.81	670.45	670.81	671.07	671.28	671.38	671.50	671.62	671.91	672.30	672.53	673.03	673.44
XS-348	5,177	669.69	670.29	670.66	670.93	671.17	671.28	671.41	671.54	671.86	672.27	672.51	673.02	673.43
XS-347	5,038	669.28	669.78	670.09	670.40	670.69	670.93	671.17	671.32	671.77	672.23	672.48	673.01	673.42
XS-346	5,032	669.26	669.74	670.04	670.32	670.59	670.73	671.04	671.25	671.74	672.22	672.48	673.00	673.42
XS-345	4,920	668.97	669.52	669.88	670.19	670.58	670.75	671.06	671.26	671.74	672.21	672.47	673.00	673.42
XS-344	4,783	668.41	668.90	669.41	669.90	670.44	670.63	670.98	671.20	671.69	672.17	672.44	672.98	673.40
XS-343	4,651	667.82	668.65	669.24	669.76	670.33	670.52	670.87	671.09	671.63	672.14	672.41	672.96	673.39
XS-342	4,565	667.71	668.31	668.68	668.98	669.50	669.60	669.69	669.79	669.96	670.09	670.14	670.23	670.29
XS-341	4,546	667.70	668.30	668.68	668.98	669.49	669.59	669.68	669.78	669.96	670.08	670.13	670.23	670.28
XS-340	4,527	667.68	668.26	668.62	668.90	669.43	669.52	669.61	669.71	669.88	670.00	670.05	670.14	670.19

Table B-6 Computed flood frequency water levels – Seven Persons Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-339	4,522	667.64	668.15	668.45	668.68	669.26	669.31	669.36	669.44	669.55	669.61	669.61	669.66	669.68
XS-338	4,514	667.60	668.07	668.32	668.52	668.72	668.81	668.87	668.92	669.00	669.05	669.07	669.17	669.24
XS-337	4,417	667.46	667.94	668.19	668.39	668.56	668.65	668.74	668.80	668.94	669.07	669.12	669.19	669.23
XS-336	4,329	667.31	667.76	667.99	668.18	668.32	668.40	668.48	668.53	668.66	668.78	668.83	668.90	668.94
XS-335	4,207	667.00	667.27	667.44	667.56	667.66	667.72	667.78	667.82	667.92	668.00	668.04	668.09	668.11
XS-334	4,205	665.35	665.96	666.33	666.62	666.82	666.96	667.06	667.13	667.29	667.43	667.50	667.60	667.65
XS-333	4,149	664.94	665.65	666.09	666.43	666.67	666.88	667.01	667.11	667.30	667.45	667.52	667.63	667.68
XS-332	4,109	664.84	665.55	665.96	666.25	666.45	666.63	666.77	666.90	667.12	667.28	667.36	667.48	667.53
XS-331	4,106	664.84	665.54	665.96	666.24	666.45	666.56	666.71	666.82	667.05	667.22	667.30	667.42	667.48
XS-330	4,046	664.69	665.43	665.86	666.15	666.37	666.49	666.62	666.71	666.91	667.06	667.12	667.22	667.26
XS-329	3,949	664.41	665.12	665.55	665.86	666.08	666.20	666.32	666.40	666.57	666.70	666.77	666.85	666.90
XS-328	3,829	664.12	664.84	665.33	665.65	665.88	665.99	666.12	666.19	666.38	666.51	666.58	666.67	666.72
XS-327	3,737	663.85	664.66	665.23	665.58	665.81	665.92	666.05	666.12	666.30	666.43	666.49	666.57	666.62
XS-326	3,726	663.82	664.55	665.05	665.46	665.71	665.82	665.96	666.03	666.21	666.33	666.39	666.46	666.51
XS-325	3,723	663.81	664.54	665.02	665.43	665.68	665.80	665.93	666.00	666.17	666.29	666.35	666.42	666.47
XS-324	3,618	663.51	664.20	664.74	665.21	665.46	665.55	665.65	665.72	665.91	666.03	666.09	666.16	666.21
XS-323	3,483	662.88	663.83	664.47	664.99	665.22	665.28	665.34	665.38	665.45	665.47	665.50	665.56	665.57
XS-322	3,457	662.87	663.83	664.47	664.99	665.23	665.29	665.36	665.40	665.49	665.55	665.59	665.65	665.67
XS-321	3,412	662.60	663.38	663.83	664.17	664.59	664.70	664.86	664.94	665.14	665.25	665.32	665.45	665.48
XS-320	3,308	662.27	663.11	663.56	663.91	664.39	664.48	664.51	664.62	664.78	664.93	665.07	665.14	665.19
XS-319	3,223	661.89	662.74	663.17	663.52	664.17	664.22	664.22	664.30	664.40	664.40	664.40	664.47	664.54
XS-318	3,212	661.86	662.72	663.15	663.49	663.69	663.87	664.01	664.11	664.28	664.42	664.49	664.56	664.62
XS-317	3,079	661.29	662.03	662.48	662.84	663.28	663.55	663.72	663.78	663.93	664.04	664.17	664.36	664.46
XS-316	3,006	661.08	661.92	662.38	662.75	663.18	663.45	663.61	663.67	663.76	663.87	664.00	664.21	664.32
XS-315	2,995	661.05	661.85	662.29	662.64	662.94	663.13	663.27	663.34	663.50	663.64	663.86	664.14	664.26
XS-314	2,981	661.00	661.77	662.19	662.53	662.83	663.03	663.17	663.22	663.35	663.50	663.69	664.01	664.18
XS-313	2,975	660.98	661.76	662.18	662.53	662.84	663.04	663.17	663.23	663.35	663.46	663.61	663.83	664.12
XS-312	2,847	660.62	661.39	661.87	662.27	662.63	662.89	663.04	663.11	663.27	663.45	663.66	663.92	664.16
XS-311	2,730	660.41	661.19	661.69	662.12	662.52	662.78	662.93	663.00	663.16	663.34	663.60	663.88	664.14
XS-310	2,719	660.39	661.15	661.65	662.06	662.44	662.71	662.85	662.91	663.05	663.28	663.57	663.87	664.13
XS-309	2,606	660.24	660.91	661.35	661.75	662.14	662.39	662.67	662.77	662.94	663.22	663.54	663.85	664.12
XS-308	2,510	660.04	660.65	661.11	661.59	662.05	662.34	662.55	662.65	662.83	663.14	663.50	663.82	664.09
XS-307	2,476	659.83	660.41	660.93	661.44	661.93	662.23	662.47	662.55	662.71	663.06	663.47	663.81	664.09
XS-306	2,432	659.36	660.24	660.81	661.29	661.59	661.77	661.97	662.14	662.50	663.06	663.40	663.77	664.06
XS-305	2,402	659.23	660.16	660.72	661.21	661.50	661.67	661.88	662.07	662.48	663.07	663.40	663.77	664.06
XS-304	2,266	658.99	659.92	660.49	660.97	661.28	661.46	661.69	661.90	662.37	663.03	663.38	663.75	664.05
XS-303	2,138	658.83	659.73	660.28	660.75	661.05	661.23	661.48	661.75	662.32	663.01	663.36	663.74	664.04

Table B-6 Computed flood frequency water levels – Seven Persons Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-302	2,019	658.71	659.61	660.17	660.67	660.98	661.16	661.42	661.69	662.27	663.00	663.35	663.74	664.04
XS-301	1,915	658.58	659.46	660.03	660.54	660.85	661.03	661.30	661.60	662.25	662.99	663.35	663.73	664.03
XS-300	1,788	658.44	659.29	659.85	660.38	660.67	660.84	661.12	661.45	662.24	662.99	663.35	663.73	664.03
XS-299	1,783	658.43	659.28	659.83	660.36	660.65	660.81	661.06	661.48	662.24	662.99	663.35	663.73	664.03
XS-298	1,671	658.29	659.12	659.68	660.24	660.51	660.65	661.09	661.49	662.23	662.98	663.35	663.73	664.03
XS-297	1,554	658.16	658.96	659.53	660.11	660.37	660.61	661.08	661.49	662.23	662.98	663.35	663.73	664.03
XS-296	1,444	658.00	658.81	659.39	660.07	660.38	660.60	661.07	661.48	662.23	662.98	663.34	663.73	664.03
XS-295	1,317	657.80	658.60	659.20	659.92	660.32	660.57	661.06	661.48	662.23	662.98	663.34	663.73	664.03
XS-294	1,201	657.48	658.31	658.99	659.79	660.25	660.53	661.05	661.48	662.23	662.98	663.34	663.73	664.03
XS-293	1,155	657.30	658.19	658.90	659.73	660.18	660.49	661.02	661.45	662.22	662.98	663.34	663.73	664.03
XS-292	1,134	657.11	658.14	658.80	659.51	660.17	660.47	661.00	661.44	662.22	662.98	663.34	663.73	664.03
XS-291	1,106	657.11	658.12	658.79	659.50	660.16	660.45	660.98	661.42	662.22	662.98	663.34	663.73	664.03
XS-290	1,072	657.04	658.07	658.76	659.49	660.15	660.43	660.95	661.37	662.21	662.98	663.34	663.73	664.03
XS-289	1,056	657.02	658.06	658.75	659.48	660.10	660.36	660.84	661.34	662.21	662.98	663.34	663.73	664.03
XS-288	937	656.86	657.91	658.62	659.42	660.08	660.35	660.84	661.35	662.21	662.98	663.34	663.73	664.03
XS-287	812	656.77	657.85	658.58	659.40	660.06	660.33	660.82	661.34	662.20	662.97	663.34	663.73	664.03
XS-286	673	656.67	657.77	658.52	659.38	660.05	660.32	660.82	661.34	662.20	662.97	663.34	663.72	664.03
XS-285	547	656.58	657.68	658.44	659.31	659.94	660.28	660.81	661.33	662.20	662.97	663.34	663.72	664.03
XS-284	531	656.58	657.68	658.44	659.25	659.99	660.28	660.80	661.33	662.20	662.97	663.34	663.72	664.03
XS-283	445	656.54	657.64	658.40	659.23	660.00	660.28	660.80	661.33	662.20	662.97	663.34	663.72	664.03
XS-282	350	656.53	657.62	658.38	659.23	659.99	660.28	660.80	661.33	662.20	662.97	663.34	663.72	664.03
XS-281	337	656.53	657.61	658.38	659.21	659.99	660.27	660.80	661.33	662.20	662.97	663.34	663.72	664.03
XS-280	222	656.50	657.59	658.35	659.20	659.98	660.26	660.79	661.32	662.20	662.97	663.33	663.72	664.02
XS-279	130	656.49	657.56	658.31	659.18	659.96	660.25	660.78	661.31	662.19	662.97	663.33	663.72	664.02
XS-278	112	656.49	657.56	658.31	659.17	659.96	660.24	660.78	661.31	662.19	662.97	663.33	663.72	664.02

Table B-7 Computed flood frequency water levels – Bullshead Creek

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-667	10,054	711.24	712.07	712.54	712.92	713.01	713.04	713.09	713.12	713.17	713.21	713.24	713.26	713.28
XS-666	9,993	710.99	711.83	712.53	712.91	713.01	713.03	713.09	713.11	713.17	713.20	713.23	713.25	713.27
XS-665	9,939	710.93	711.46	711.60	711.69	711.76	711.78	711.84	711.86	711.91	711.94	711.98	712.00	712.02
XS-664	9,890	710.84	711.40	711.54	711.62	711.68	711.70	711.76	711.78	711.82	711.85	711.89	711.91	711.93
XS-663	9,785	710.56	710.91	711.18	711.28	711.39	711.44	711.50	711.53	711.59	711.63	711.68	711.70	711.72
XS-662	9,704	710.49	710.94	711.12	711.24	711.32	711.36	711.42	711.44	711.50	711.53	711.58	711.60	711.62
XS-661	9,619	710.37	710.86	711.03	711.14	711.21	711.24	711.30	711.32	711.38	711.41	711.45	711.47	711.49
XS-660	9,555	710.23	710.74	710.94	711.04	711.11	711.14	711.19	711.21	711.26	711.29	711.33	711.35	711.37
XS-659	9,462	710.12	710.57	710.75	710.86	710.93	710.96	711.02	711.04	711.08	711.11	711.14	711.16	711.17
XS-658	9,360	710.02	710.40	710.52	710.62	710.69	710.71	710.77	710.79	710.84	710.87	710.91	710.93	710.94
XS-657	9,295	709.93	710.27	710.37	710.44	710.50	710.52	710.57	710.59	710.64	710.67	710.71	710.74	710.75
XS-656	9,216	709.82	710.18	710.28	710.35	710.40	710.43	710.48	710.50	710.55	710.58	710.62	710.64	710.66
XS-655	9,151	709.70	710.10	710.18	710.23	710.27	710.29	710.33	710.35	710.40	710.43	710.48	710.50	710.52
XS-654	9,066	709.28	709.84	709.93	710.01	710.09	710.12	710.18	710.21	710.27	710.31	710.37	710.39	710.41
XS-653	8,983	709.22	709.66	709.81	709.92	710.02	710.05	710.12	710.15	710.22	710.26	710.32	710.34	710.36
XS-652	8,850	709.13	709.59	709.75	709.88	709.98	710.01	710.09	710.12	710.19	710.23	710.29	710.31	710.33
XS-651	8,697	708.98	709.54	709.72	709.85	709.96	709.99	710.07	710.10	710.17	710.21	710.27	710.29	710.32
XS-650	8,624	708.90	709.51	709.70	709.83	709.94	709.97	710.05	710.08	710.15	710.19	710.25	710.28	710.30
XS-649	8,512	708.79	709.47	709.67	709.81	709.92	709.95	710.03	710.06	710.13	710.17	710.23	710.26	710.28
XS-648	8,398	708.67	709.41	709.60	709.75	709.87	709.91	709.99	710.02	710.09	710.14	710.20	710.23	710.25
XS-647	8,299	708.56	709.31	709.51	709.67	709.80	709.84	709.93	709.97	710.04	710.09	710.15	710.18	710.20
XS-646	8,234	708.45	709.20	709.41	709.59	709.74	709.78	709.89	709.92	710.00	710.05	710.11	710.14	710.17
XS-645	8,150	708.18	708.98	709.30	709.52	709.68	709.73	709.84	709.88	709.95	710.00	710.07	710.09	710.12
XS-644	8,007	708.06	708.88	709.20	709.43	709.60	709.65	709.76	709.80	709.87	709.92	709.98	710.01	710.04
XS-643	7,886	707.90	708.66	708.96	709.19	709.35	709.41	709.52	709.59	709.68	709.75	709.83	709.87	709.90
XS-642	7,757	707.70	708.44	708.71	708.88	709.01	709.06	709.16	709.21	709.30	709.42	709.51	709.56	709.60
XS-641	7,691	707.62	708.36	708.60	708.77	708.88	708.93	709.01	709.05	709.13	709.29	709.39	709.43	709.48
XS-640	7,579	707.54	708.25	708.45	708.58	708.69	708.72	708.80	708.83	708.90	709.18	709.28	709.33	709.38
XS-639	7,509	707.48	708.13	708.29	708.41	708.50	708.53	708.60	708.63	708.69	709.11	709.22	709.27	709.32
XS-638	7,391	707.31	707.88	708.02	708.12	708.19	708.21	708.26	708.29	708.42	709.07	709.18	709.23	709.28
XS-637	7,294	707.18	707.65	707.78	707.86	707.93	707.96	708.01	708.04	708.32	709.05	709.16	709.21	709.27
XS-636	7,211	707.11	707.53	707.64	707.73	707.80	707.83	707.90	707.93	708.29	709.05	709.16	709.21	709.27
XS-635	7,113	707.02	707.44	707.55	707.64	707.73	707.76	707.83	707.87	708.27	709.05	709.16	709.21	709.26
XS-634	6,976	706.85	707.30	707.43	707.54	707.64	707.68	707.76	707.80	708.25	709.04	709.15	709.20	709.26
XS-633	6,844	706.72	707.17	707.31	707.43	707.54	707.58	707.66	707.71	708.23	709.04	709.15	709.20	709.26

Table B-7 Computed flood frequency water levels – Bullshead Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-632	6,730	706.52	706.95	707.12	707.24	707.35	707.39	707.47	707.52	708.19	709.03	709.14	709.19	709.25
XS-631	6,606	706.27	706.81	706.98	707.10	707.20	707.23	707.31	707.36	708.16	709.03	709.14	709.19	709.24
XS-630	6,475	706.12	706.68	706.83	706.93	707.01	707.04	707.10	707.18	708.14	709.02	709.13	709.18	709.24
XS-629	6,370	706.00	706.52	706.66	706.75	706.80	706.82	706.88	707.06	708.14	709.02	709.13	709.18	709.24
XS-628	6,270	705.86	706.25	706.35	706.44	706.55	706.58	706.73	707.01	708.13	709.02	709.13	709.18	709.24
XS-627	6,153	705.69	706.05	706.20	706.35	706.45	706.50	706.69	707.00	708.13	709.02	709.13	709.18	709.24
XS-626	6,057	705.54	705.96	706.15	706.31	706.42	706.47	706.67	707.00	708.13	709.02	709.13	709.18	709.24
XS-625	5,897	705.22	705.82	706.06	706.24	706.36	706.41	706.65	706.99	708.13	709.02	709.13	709.18	709.24
XS-624	5,746	704.98	705.64	705.87	706.05	706.18	706.23	706.58	706.97	708.13	709.02	709.13	709.18	709.24
XS-623	5,629	704.80	705.43	705.61	705.75	705.88	705.98	706.53	706.95	708.13	709.02	709.13	709.18	709.24
XS-622	5,520	704.52	705.12	705.35	705.57	705.78	705.91	706.52	706.95	708.13	709.02	709.13	709.18	709.24
XS-621	5,410	704.24	704.81	705.11	705.40	705.68	705.84	706.51	706.94	708.13	709.02	709.13	709.18	709.24
XS-620	5,300	703.93	704.59	704.94	705.21	705.57	705.79	706.50	706.94	708.13	709.02	709.13	709.18	709.23
XS-619	5,160	703.71	704.44	704.80	705.08	705.52	705.76	706.49	706.94	708.12	709.02	709.13	709.18	709.23
XS-618	5,050	703.58	704.27	704.64	705.00	705.51	705.75	706.49	706.93	708.12	709.02	709.13	709.18	709.23
XS-617	4,918	703.43	704.02	704.43	704.92	705.49	705.74	706.49	706.93	708.12	709.01	709.13	709.18	709.23
XS-616	4,791	703.23	703.78	704.28	704.87	705.47	705.73	706.48	706.93	708.12	709.01	709.13	709.17	709.23
XS-615	4,682	703.09	703.68	704.26	704.86	705.47	705.73	706.48	706.93	708.12	709.01	709.12	709.17	709.23
XS-614	4,554	702.98	703.65	704.25	704.86	705.47	705.73	706.48	706.93	708.12	709.01	709.12	709.17	709.23
XS-613	4,443	702.84	703.63	704.24	704.85	705.46	705.73	706.48	706.93	708.12	709.01	709.12	709.17	709.23
XS-612	4,330	702.69	703.62	704.24	704.85	705.46	705.72	706.48	706.93	708.12	709.01	709.12	709.17	709.23
XS-611	4,283	702.67	703.61	704.24	704.85	705.46	705.72	706.48	706.93	708.12	709.01	709.12	709.17	709.23
XS-610	4,248	702.51	703.10	703.35	703.54	703.74	703.84	704.02	704.13	704.45	704.72	705.10	705.31	705.48
XS-609	4,201	702.38	703.07	703.33	703.52	703.72	703.83	704.00	704.12	704.44	704.71	705.10	705.30	705.48
XS-608	4,078	702.05	702.71	702.98	703.20	703.45	703.56	703.81	703.96	704.35	704.65	705.06	705.27	705.45
XS-607	3,967	701.85	702.35	702.60	702.89	703.24	703.38	703.72	703.90	704.31	704.63	705.05	705.26	705.44
XS-606	3,879	701.66	702.16	702.44	702.79	703.16	703.33	703.69	703.88	704.30	704.62	705.04	705.25	705.44
XS-605	3,766	701.48	702.05	702.39	702.77	703.16	703.32	703.68	703.87	704.30	704.62	705.04	705.25	705.44
XS-604	3,653	701.21	701.95	702.36	702.76	703.15	703.31	703.68	703.87	704.29	704.61	705.03	705.25	705.44
XS-603	3,567	701.12	701.87	702.30	702.72	703.12	703.29	703.66	703.85	704.28	704.61	705.03	705.25	705.43
XS-602	3,502	701.03	701.70	702.08	702.48	702.90	703.09	703.57	703.79	704.25	704.58	705.02	705.23	705.42
XS-601	3,472	701.00	701.57	701.83	702.05	702.27	702.36	702.60	702.74	703.03	703.24	703.51	703.64	703.75
XS-600	3,465	700.99	701.57	701.83	702.06	702.28	702.38	702.61	702.74	703.02	703.21	703.46	703.58	703.68
XS-599	3,447	700.96	701.51	701.72	701.87	701.97	702.00	702.05	702.06	702.18	702.30	702.43	702.50	702.56
XS-598	3,336	700.74	701.31	701.57	701.75	701.89	701.94	702.04	702.09	702.19	702.26	702.35	702.38	702.42
XS-597	3,330	700.74	701.29	701.55	701.73	701.87	701.92	702.03	702.08	702.18	702.25	702.33	702.37	702.40
XS-596	3,252	700.58	701.07	701.28	701.48	701.63	701.68	701.79	701.83	701.93	701.99	702.07	702.11	702.14

Table B-7 Computed flood frequency water levels – Bullshead Creek (Continued)

Cross Section	River Station (m)	Flood Return Period												
		2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
		Water Surface Elevation (m)												
XS-595	3,245	700.56	701.06	701.24	701.39	701.52	701.57	701.67	701.72	701.82	701.88	701.97	702.01	702.04
XS-594	3,144	700.22	700.86	700.97	701.12	701.26	701.31	701.41	701.45	701.55	701.62	701.70	701.74	701.77
XS-593	3,138	700.13	700.61	700.87	701.06	701.21	701.26	701.36	701.41	701.50	701.57	701.65	701.68	701.71
XS-592	3,045	699.84	700.49	700.79	700.98	701.12	701.18	701.27	701.31	701.40	701.47	701.54	701.57	701.59
XS-591	2,931	699.30	700.17	700.67	700.86	700.98	701.03	701.13	701.16	701.24	701.30	701.36	701.39	701.41
XS-590	2,925	699.17	699.78	700.17	700.49	700.70	700.71	700.82	700.87	700.92	700.95	701.08	701.12	701.14
XS-589	2,910	699.26	699.68	699.89	700.05	700.17	700.21	700.30	700.34	700.40	700.47	700.55	700.59	700.63
XS-588	2,882	699.10	699.35	699.48	699.60	699.73	699.79	699.91	699.97	700.10	700.21	700.34	700.42	700.48
XS-587	2,821	698.95	699.17	699.29	699.45	699.62	699.69	699.83	699.90	700.04	700.16	700.30	700.38	700.44
XS-586	2,741	698.65	698.96	699.16	699.37	699.56	699.64	699.79	699.86	700.01	700.13	700.28	700.36	700.42
XS-585	2,627	698.14	698.68	699.07	699.32	699.52	699.59	699.75	699.82	699.98	700.10	700.25	700.33	700.39
XS-584	2,553	697.86	698.64	699.04	699.29	699.50	699.57	699.73	699.80	699.95	700.07	700.23	700.31	700.37
XS-583	2,485	697.52	698.45	698.89	699.13	699.30	699.37	699.50	699.56	699.69	699.79	699.93	700.01	700.07
XS-582	2,476	697.29	698.40	698.84	699.05	699.20	699.25	699.34	699.39	699.45	699.51	699.57	699.58	699.59
XS-581	2,427	697.09	698.39	698.83	699.05	699.22	699.28	699.38	699.43	699.52	699.59	699.67	699.70	699.72
XS-580	2,386	696.99	698.33	698.77	698.98	699.13	699.18	699.28	699.33	699.42	699.50	699.59	699.62	699.64
XS-579	2,345	696.84	697.32	697.51	697.70	697.84	697.88	697.93	697.97	698.04	698.08	698.13	698.14	698.19
XS-578	2,256	696.31	696.81	696.94	697.01	697.08	697.11	697.17	697.20	697.25	697.29	697.34	697.36	697.38
XS-577	2,138	695.80	696.11	696.23	696.35	696.42	696.45	696.50	696.52	696.58	696.62	696.66	696.68	696.70
XS-576	2,046	695.01	695.60	695.71	695.77	695.86	695.88	695.93	695.95	696.01	696.05	696.09	696.11	696.13
XS-575	1,941	694.25	694.63	694.79	694.93	695.04	695.08	695.17	695.20	695.25	695.28	695.32	695.34	695.36
XS-574	1,801	693.73	694.08	694.24	694.34	694.43	694.47	694.59	694.61	694.67	694.70	694.75	694.77	694.78
XS-573	1,679	693.06	693.65	693.85	693.99	694.10	694.15	694.26	694.30	694.37	694.41	694.47	694.49	694.50
XS-572	1,562	692.60	692.98	693.14	693.25	693.35	693.38	693.45	693.49	693.56	693.64	693.70	693.73	693.78
XS-571	1,465	691.98	692.43	692.59	692.70	692.79	692.81	692.86	692.89	692.94	692.98	693.04	693.06	693.07
XS-570	1,338	691.15	691.50	691.67	691.77	691.88	691.93	692.03	692.05	692.11	692.15	692.18	692.21	692.23
XS-569	1,227	690.76	691.06	691.21	691.31	691.38	691.41	691.48	691.51	691.57	691.60	691.65	691.67	691.68
XS-568	1,069	689.96	690.24	690.38	690.45	690.51	690.54	690.59	690.61	690.66	690.69	690.73	690.75	690.77
XS-567	983	689.30	689.53	689.64	689.72	689.80	689.82	689.88	689.91	689.96	690.00	690.06	690.08	690.11
XS-566	872	688.64	688.87	688.98	689.08	689.16	689.20	689.24	689.27	689.33	689.37	689.41	689.43	689.45
XS-565	719	687.70	688.15	688.27	688.35	688.40	688.40	688.46	688.48	688.51	688.54	688.58	688.60	688.62
XS-564	603	686.71	687.31	687.52	687.62	687.75	687.80	687.89	687.92	687.97	688.04	688.11	688.13	688.15
XS-563	472	685.77	686.40	686.57	686.71	686.80	686.84	686.92	686.96	687.12	687.14	687.18	687.22	687.25
XS-562	310	685.07	685.55	685.72	685.85	685.95	685.99	686.07	686.11	686.18	686.22	686.26	686.28	686.30
XS-561	171	683.93	684.66	684.77	684.86	684.93	684.96	685.03	685.04	685.11	685.15	685.25	685.28	685.31
XS-560	42	683.34	683.84	684.09	684.28	684.44	684.49	684.62	684.68	684.77	684.86	684.95	684.98	685.01

Appendix C
Sensitivity Analysis Results

Table C1: Sensitivity Analysis results for downstream boundary conditions

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
South Saskatchewan River			
45324.6	669.59	669.59	669.59
44678.6	669.22	669.22	669.22
44049.3	668.83	668.83	668.83
43532.6	668.81	668.81	668.81
43062.9	668.76	668.76	668.76
42639.9	668.67	668.67	668.67
42313.3	668.55	668.55	668.55
41994.2	668.27	668.27	668.27
41730.3	668.06	668.06	668.06
41467.0	667.93	667.93	667.93
41175.8	667.88	667.88	667.88
40727.5	667.58	667.58	667.58
40249.7	667.47	667.47	667.47
39686.1	666.98	666.98	666.98
39025.7	666.96	666.96	666.96
38612.5	666.73	666.73	666.73
38206.1	666.55	666.55	666.55
37769.2	666.22	666.22	666.22
37095.7	666.13	666.13	666.12
36628.4	666.08	666.08	666.07
36160.1	665.91	665.91	665.91
35710.7	665.78	665.78	665.77
35027.4	665.61	665.61	665.61
34794.0	665.41	665.41	665.41
34468.8	665.28	665.28	665.27
34034.8	665.17	665.17	665.17
33412.2	665.04	665.04	665.04
32996.3	664.80	664.80	664.79
32901.4	664.79	664.79	664.78
32873.5	664.67	664.67	664.67
32864.5	664.65	664.65	664.64
32840.8	664.58	664.58	664.58
32694.6	664.32	664.32	664.32
32231.8	664.21	664.21	664.21
31957.8	664.14	664.14	664.13
31736.9	664.06	664.06	664.07
31302.5	664.00	664.00	664.00
30869.7	663.83	663.83	663.83
30568.2	663.65	663.65	663.65
30278.1	663.53	663.53	663.53
30073.4	663.28	663.28	663.28
29912.2	663.18	663.18	663.18
29893.3	663.16	663.16	663.16
29809.9	663.16	663.16	663.16
29704.8	663.15	663.15	663.15
29678.6	663.01	663.01	663.01
29585.9	662.95	662.95	662.95
29489.8	662.87	662.87	662.86
29458.4	662.77	662.77	662.77
29287.6	662.80	662.80	662.80
28981.6	662.24	662.24	662.23
28781.7	662.06	662.06	662.06
28518.1	661.97	661.97	661.97
28272.2	661.76	661.76	661.76
27943.7	661.59	661.59	661.59
27680.4	661.61	661.61	661.60

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
South Saskatchewan River			
27421.4	661.43	661.43	661.43
27258.8	661.21	661.21	661.21
27102.7	661.15	661.15	661.15
26834.0	661.17	661.17	661.17
26592.1	660.82	660.82	660.82
26361.6	660.62	660.62	660.62
25868.7	660.58	660.58	660.58
25469.9	660.49	660.49	660.49
25260.1	660.38	660.38	660.38
24856.1	660.16	660.16	660.16
24346.3	659.66	659.66	659.66
23761.7	659.48	659.48	659.48
23368.0	659.38	659.38	659.38
22594.3	659.25	659.25	659.25
22344.9	659.21	659.21	659.21
21959.8	659.03	659.03	659.03
21435.8	658.23	658.23	658.23
21170.4	657.91	657.91	657.91
20943.9	658.13	658.13	658.13
20505.0	658.08	658.08	658.08
20015.1	657.63	657.64	657.64
19627.4	657.36	657.36	657.36
19150.9	657.19	657.19	657.19
18687.0	656.94	656.94	656.94
18369.4	656.54	656.54	656.54
17911.3	656.08	656.08	656.08
17456.9	655.89	655.89	655.89
16987.2	655.73	655.73	655.73
16429.6	655.50	655.50	655.50
15922.3	655.15	655.15	655.16
15557.2	654.76	654.76	654.76
15199.7	654.55	654.56	654.56
14547.7	654.19	654.19	654.20
14067.7	653.96	653.96	653.97
13586.7	653.78	653.78	653.79
13257.0	653.67	653.67	653.68
12651.1	653.09	653.10	653.11
12272.3	652.87	652.88	652.90
11856.3	652.71	652.72	652.74
11400.9	652.44	652.46	652.47
10997.3	652.23	652.24	652.26
10615.6	651.81	651.82	651.85
10037.9	651.75	651.77	651.80
9344.0	651.13	651.15	651.19
8739.4	650.91	650.94	650.98
8060.7	650.80	650.83	650.88
7698.5	650.52	650.56	650.61
7318.5	650.03	650.07	650.13
6742.1	649.35	649.42	649.50
6324.0	649.50	649.56	649.65
5902.0	649.33	649.40	649.49
5517.4	648.98	649.05	649.16
5142.8	648.67	648.75	648.86
4619.6	648.44	648.53	648.65
3946.0	648.06	648.17	648.32
3350.6	647.90	648.02	648.18
2779.3	647.01	647.21	647.44
2384.9	646.80	647.00	647.27

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
South Saskatchewan River			
1980.8	646.63	646.86	647.14
1554.3	646.65	646.88	647.17
1188.3	646.35	646.62	646.93
825.9	646.02	646.32	646.67
434.2	645.75	646.09	646.47
0.0	645.00	645.50	646.00
Minimum Difference	0.00	0.00	-0.01
Average Difference	-0.03	0.00	0.03
Maximum Difference	-0.50	0.00	0.50
Ross Creek			
25004.1	704.40	704.40	704.40
24867.4	703.84	703.84	703.84
24755.5	703.88	703.88	703.88
24601.1	703.61	703.61	703.61
24504.3	703.42	703.42	703.42
24485.5	703.25	703.25	703.25
24367.1	702.99	702.99	702.99
24239.4	702.77	702.77	702.77
24049.3	702.40	702.40	702.40
23887.6	702.24	702.24	702.24
23758.2	701.99	701.99	701.99
23609.5	701.79	701.79	701.79
23457.8	701.61	701.61	701.61
23269.2	701.47	701.47	701.47
23072.0	701.34	701.34	701.34
22807.2	701.09	701.09	701.09
22662.1	700.97	700.97	700.97
22512.9	700.84	700.84	700.84
22348.8	700.69	700.69	700.69
22202.2	700.52	700.52	700.52
22051.8	700.36	700.36	700.36
21867.9	700.20	700.20	700.20
21732.1	700.13	700.13	700.13
21454.7	699.99	699.99	699.99
21283.7	699.92	699.92	699.92
21105.3	699.76	699.76	699.76
20941.9	699.60	699.60	699.60
20802.0	699.40	699.40	699.40
20619.0	699.31	699.31	699.31
20458.8	699.28	699.28	699.28
20238.1	699.09	699.09	699.09
20068.9	698.82	698.82	698.82
19885.4	698.56	698.56	698.56
19778.4	698.18	698.18	698.18
19767.9	698.07	698.07	698.07
19704.0	697.96	697.96	697.96
19700.7	697.94	697.94	697.94
19632.3	697.83	697.83	697.83
19566.8	697.77	697.77	697.77
19418.9	697.66	697.66	697.66
19079.3	697.39	697.39	697.39
18934.3	697.05	697.05	697.05
18780.0	696.91	696.91	696.91
18613.6	696.78	696.78	696.78
18457.7	696.71	696.71	696.71
18303.0	696.51	696.51	696.51
18159.0	696.22	696.22	696.22
18042.1	695.96	695.96	695.96

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Ross Creek			
17870.1	695.83	695.83	695.83
17608.9	695.76	695.76	695.76
17477.9	695.73	695.73	695.73
17290.6	695.70	695.70	695.70
17138.0	695.62	695.62	695.62
16928.3	695.33	695.33	695.33
16770.8	694.85	694.85	694.85
16621.8	694.57	694.57	694.57
16467.3	694.23	694.23	694.23
16274.8	693.95	693.95	693.95
15976.6	693.81	693.81	693.81
15801.9	693.70	693.70	693.70
15681.4	693.64	693.64	693.64
15510.3	693.56	693.56	693.56
15212.7	693.26	693.26	693.26
14983.1	693.20	693.20	693.20
14782.6	693.07	693.07	693.07
14771.3	693.03	693.03	693.03
14537.1	692.84	692.84	692.84
14375.9	692.73	692.73	692.73
14119.8	692.68	692.68	692.68
14052.0	692.68	692.68	692.68
13880.6	692.64	692.64	692.64
13833.6	692.62	692.62	692.62
13619.7	692.58	692.58	692.58
13410.7	692.50	692.50	692.50
13230.0	692.27	692.27	692.27
13068.3	691.96	691.96	691.96
12895.9	691.77	691.77	691.77
12730.9	691.62	691.62	691.62
12542.2	691.45	691.45	691.45
12386.3	691.33	691.33	691.33
12229.1	691.24	691.24	691.24
12101.4	691.08	691.08	691.08
12034.3	690.96	690.96	690.96
11883.8	690.70	690.70	690.70
11756.5	690.50	690.50	690.50
11627.5	690.43	690.43	690.43
11439.0	690.17	690.17	690.17
11269.6	689.81	689.81	689.81
11101.3	689.46	689.46	689.46
10922.0	689.29	689.29	689.29
10738.2	689.22	689.22	689.22
10635.4	688.92	688.92	688.92
10433.7	688.41	688.41	688.41
10269.2	688.09	688.09	688.09
10264.0	688.12	688.12	688.12
10171.3	687.90	687.90	687.90
10006.6	687.74	687.74	687.74
9922.9	687.69	687.69	687.69
9906.8	687.67	687.67	687.67
9739.5	687.41	687.41	687.41
9596.6	687.12	687.12	687.12
9458.2	686.74	686.74	686.74
9310.8	686.30	686.30	686.30
9200.8	685.92	685.92	685.92
9081.0	685.61	685.61	685.61
8929.1	684.93	684.93	684.93

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Ross Creek			
8801.4	684.68	684.68	684.68
8553.3	683.51	683.51	683.51
8324.0	682.42	682.42	682.42
8107.9	681.19	681.19	681.19
7695.0	679.22	679.22	679.22
7286.4	677.09	677.09	677.09
7051.3	676.03	676.03	676.03
6863.2	675.23	675.23	675.23
6733.0	674.78	674.78	674.78
6293.8	672.27	672.27	672.27
6065.7	671.38	671.38	671.38
5845.8	670.51	670.51	670.51
5538.4	669.44	669.44	669.44
5170.0	668.75	668.75	668.75
4558.3	666.70	666.70	666.70
4292.7	666.37	666.37	666.37
4061.2	665.57	665.57	665.57
3823.7	665.22	665.22	665.22
3693.4	664.99	664.99	664.99
3545.6	664.27	664.27	664.27
3439.6	664.15	664.15	664.15
3384.2	663.94	663.94	663.94
3255.6	663.72	663.72	663.72
3057.0	663.39	663.39	663.39
2925.3	663.16	663.16	663.16
2915.3	663.11	663.11	663.11
2772.2	662.76	662.76	662.76
2571.8	662.56	662.56	662.56
2370.4	662.41	662.41	662.41
2261.4	662.36	662.36	662.36
2160.5	662.18	662.18	662.18
2144.8	661.76	661.76	661.76
2032.1	661.77	661.77	661.77
1780.2	661.72	661.72	661.72
1674.7	661.68	661.68	661.68
1611.1	661.60	661.60	661.60
1596.5	661.37	661.37	661.37
1527.2	661.40	661.40	661.40
1487.6	661.39	661.39	661.39
1436.9	661.38	661.38	661.38
1300.3	661.37	661.37	661.37
1282.3	661.36	661.36	661.36
1278.5	661.36	661.36	661.36
1246.6	661.36	661.36	661.36
1118.0	661.34	661.34	661.34
1024.6	661.31	661.31	661.31
880.3	661.22	661.22	661.22
756.7	661.23	661.23	661.23
540.2	661.21	661.21	661.21
430.8	661.18	661.18	661.18
278.9	661.17	661.17	661.17
Minimum Difference	0.00	0.00	0.00
Average Difference	0.00	0.00	0.00
Maximum Difference	0.00	0.00	0.00
Seven Persons Creek			
24132.0	711.66	711.66	711.66
23979.0	711.62	711.62	711.62
23814.3	711.39	711.39	711.39

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Seven Persons Creek			
23806.4	710.14	710.14	710.14
23646.6	710.51	710.51	710.51
23492.8	710.43	710.43	710.43
23469.9	710.35	710.35	710.35
23465.2	710.36	710.36	710.36
23401.0	710.23	710.23	710.23
23368.6	709.06	709.06	709.06
23292.4	708.86	708.86	708.86
23259.5	708.86	708.86	708.86
23215.0	708.80	708.8	708.80
23116.8	708.70	708.7	708.70
23034.0	708.04	708.04	708.04
22947.6	707.42	707.42	707.42
22873.0	707.39	707.39	707.39
22770.6	707.29	707.29	707.29
22664.2	706.96	706.96	706.96
22575.2	706.67	706.67	706.67
22463.8	706.42	706.42	706.42
22361.4	706.03	706.03	706.03
22267.2	705.96	705.96	705.96
22141.5	705.85	705.85	705.85
22049.5	705.60	705.6	705.60
21928.3	705.20	705.2	705.20
21802.7	704.94	704.94	704.94
21685.0	704.71	704.71	704.71
21587.7	704.54	704.54	704.54
21553.4	704.57	704.57	704.57
21455.3	704.50	704.5	704.50
21315.9	704.22	704.22	704.22
21210.3	703.94	703.94	703.94
21109.4	703.68	703.68	703.68
21009.9	703.43	703.43	703.43
20908.5	703.22	703.22	703.22
20811.2	703.00	703	703.00
20688.4	702.75	702.75	702.75
20603.5	702.53	702.53	702.53
20492.0	702.39	702.39	702.39
20389.2	702.28	702.28	702.28
20204.6	702.04	702.04	702.04
20050.3	701.91	701.91	701.91
19964.2	701.80	701.8	701.80
19853.8	701.69	701.69	701.69
19715.1	701.39	701.39	701.39
19603.7	701.14	701.14	701.14
19456.1	700.75	700.75	700.75
19327.9	700.40	700.4	700.40
19216.2	700.08	700.08	700.08
19152.2	700.06	700.06	700.06
19110.7	699.96	699.96	699.96
19001.8	699.70	699.7	699.70
18889.7	699.58	699.58	699.58
18787.3	699.46	699.46	699.46
18675.0	699.35	699.35	699.35
18564.5	698.94	698.94	698.94
18493.6	698.66	698.66	698.66
18486.4	698.27	698.27	698.27
18433.7	698.35	698.35	698.35
18350.8	698.23	698.23	698.23

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Seven Persons Creek			
18280.2	698.12	698.12	698.12
18275.2	698.04	698.04	698.04
18219.2	697.83	697.83	697.83
18130.4	697.78	697.78	697.78
18125.6	697.75	697.75	697.75
18003.8	697.59	697.59	697.59
17904.9	697.49	697.49	697.49
17802.4	697.19	697.19	697.19
17797.8	697.18	697.18	697.18
17719.1	697.07	697.07	697.07
17604.0	696.81	696.81	696.81
17597.6	696.69	696.69	696.69
17498.8	696.59	696.59	696.59
17356.6	696.23	696.23	696.23
17263.3	696.18	696.18	696.18
17143.1	696.09	696.09	696.09
17042.6	696.02	696.02	696.02
16936.4	695.83	695.83	695.83
16930.8	695.75	695.75	695.75
16848.0	695.38	695.38	695.38
16772.0	695.20	695.2	695.20
16639.9	695.13	695.13	695.13
16542.3	695.08	695.08	695.08
16415.3	694.93	694.93	694.93
16311.9	694.77	694.77	694.77
16207.6	694.64	694.64	694.64
16142.0	694.42	694.42	694.42
16135.6	694.36	694.36	694.36
16093.3	694.32	694.32	694.32
16002.5	694.16	694.16	694.16
15896.8	693.98	693.98	693.98
15789.6	693.84	693.84	693.84
15677.4	693.69	693.69	693.69
15552.8	693.46	693.46	693.46
15468.3	693.16	693.16	693.16
15462.3	693.17	693.17	693.17
15421.3	693.12	693.12	693.12
15329.5	692.97	692.97	692.97
15269.9	692.78	692.78	692.78
15168.7	692.72	692.72	692.72
15148.4	692.66	692.66	692.66
15076.5	692.56	692.56	692.56
14958.9	692.35	692.35	692.35
14861.4	692.29	692.29	692.29
14748.8	692.06	692.06	692.06
14609.8	691.76	691.76	691.76
14511.3	691.63	691.63	691.63
14406.1	691.55	691.55	691.55
14327.1	691.42	691.42	691.42
14247.1	690.77	690.77	690.77
14233.3	690.59	690.59	690.59
14107.9	690.36	690.36	690.36
14000.3	690.23	690.23	690.23
13838.9	689.93	689.93	689.93
13689.0	689.73	689.73	689.73
13570.5	689.57	689.57	689.57
13465.0	689.41	689.41	689.41
13347.3	689.30	689.3	689.30

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Seven Persons Creek			
13257.6	689.25	689.25	689.25
13120.9	689.11	689.11	689.11
13053.1	689.01	689.01	689.01
12910.6	688.90	688.9	688.90
12787.5	688.54	688.54	688.54
12634.7	688.24	688.24	688.24
12461.4	687.81	687.81	687.81
12300.2	687.50	687.5	687.50
12199.8	687.43	687.43	687.43
12118.9	687.34	687.34	687.34
11920.7	687.02	687.02	687.02
11797.6	686.84	686.84	686.84
11676.2	686.63	686.63	686.63
11518.8	686.27	686.27	686.27
11372.4	686.05	686.05	686.05
11252.6	685.81	685.81	685.81
11204.4	685.65	685.65	685.65
11094.5	685.47	685.47	685.47
10959.3	685.21	685.21	685.21
10870.9	685.03	685.03	685.03
10864.9	684.99	684.99	684.99
10774.9	684.64	684.64	684.64
10671.2	684.35	684.35	684.35
10532.7	683.83	683.83	683.83
10428.8	683.75	683.75	683.75
10290.2	683.49	683.49	683.49
10139.9	683.21	683.21	683.21
10023.9	682.88	682.88	682.88
9909.5	682.60	682.6	682.60
9796.8	682.16	682.16	682.16
9668.4	682.13	682.13	682.13
9490.1	682.00	682	682.00
9399.0	681.75	681.75	681.75
9262.0	681.26	681.26	681.26
9138.7	681.15	681.15	681.15
9098.7	680.92	680.92	680.92
9091.1	680.87	680.87	680.87
9008.6	680.59	680.59	680.59
8998.5	680.62	680.62	680.62
8932.1	680.46	680.46	680.46
8858.1	680.21	680.21	680.21
8817.2	680.00	680	680.00
8778.3	679.91	679.91	679.91
8772.7	679.64	679.64	679.64
8621.0	679.38	679.38	679.38
8547.6	679.13	679.13	679.13
8469.2	679.08	679.08	679.08
8342.1	678.85	678.85	678.85
8336.0	678.80	678.8	678.80
8329.6	678.76	678.76	678.76
8322.1	678.68	678.68	678.68
8269.4	678.65	678.65	678.65
8118.4	678.21	678.21	678.21
8113.9	678.15	678.15	678.15
8096.6	678.18	678.18	678.18
8019.4	678.12	678.12	678.12
8015.7	678.10	678.1	678.10
7935.7	677.93	677.93	677.93

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Seven Persons Creek			
7853.4	677.72	677.72	677.72
7848.8	677.64	677.64	677.64
7744.0	677.43	677.43	677.43
7660.1	677.10	677.1	677.10
7582.7	676.93	676.93	676.93
7518.9	676.88	676.88	676.88
7362.8	676.21	676.21	676.21
7248.0	675.97	675.97	675.97
7243.0	675.94	675.94	675.94
7223.8	675.92	675.92	675.92
7189.7	675.87	675.87	675.87
7179.7	675.85	675.85	675.85
7063.7	675.71	675.71	675.71
6924.6	675.61	675.61	675.61
6795.3	675.51	675.51	675.51
6751.5	675.43	675.43	675.43
6743.6	675.41	675.41	675.41
6699.1	675.37	675.37	675.37
6635.3	675.10	675.1	675.10
6630.0	674.67	674.67	674.67
6545.6	674.28	674.28	674.28
6453.8	674.03	674.03	674.03
6366.3	673.79	673.79	673.79
6302.8	673.70	673.7	673.70
6294.7	673.69	673.69	673.69
6248.0	673.60	673.6	673.60
6151.5	673.41	673.41	673.41
6147.4	673.40	673.4	673.40
6033.8	672.72	672.72	672.72
5749.0	672.52	672.52	672.52
5594.2	672.16	672.16	672.16
5442.7	671.82	671.82	671.82
5281.5	671.69	671.69	671.69
5265.2	671.62	671.62	671.62
5177.1	671.54	671.54	671.54
5037.8	671.32	671.32	671.32
5031.7	671.25	671.25	671.25
4920.1	671.26	671.26	671.26
4783.1	671.20	671.2	671.20
4651.3	671.09	671.09	671.09
4564.5	669.79	669.79	669.79
4546.4	669.78	669.78	669.78
4527.2	669.71	669.71	669.71
4522.3	669.44	669.44	669.44
4514.5	668.92	668.92	668.92
4417.1	668.80	668.8	668.80
4328.8	668.53	668.53	668.53
4207.2	667.82	667.82	667.82
4204.8	667.13	667.13	667.13
4148.9	667.11	667.11	667.11
4108.8	666.90	666.9	666.90
4106.2	666.82	666.82	666.82
4046.3	666.71	666.71	666.71
3949.4	666.40	666.4	666.40
3828.7	666.19	666.19	666.19
3736.9	666.12	666.12	666.12
3725.7	666.03	666.03	666.03
3722.7	666.00	666	666.00

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Seven Persons Creek			
3617.9	665.72	665.72	665.72
3482.9	665.38	665.38	665.38
3457.0	665.40	665.4	665.40
3412.4	664.94	664.94	664.94
3308.0	664.62	664.62	664.62
3222.6	664.30	664.3	664.30
3212.0	664.11	664.11	664.11
3078.5	663.78	663.78	663.78
3005.7	663.67	663.67	663.67
2995.0	663.34	663.34	663.34
2981.1	663.22	663.22	663.22
2975.1	663.23	663.23	663.23
2847.3	663.11	663.11	663.11
2729.6	663.00	663	663.00
2718.7	662.91	662.91	662.91
2605.9	662.77	662.77	662.77
2510.0	662.65	662.65	662.65
2475.9	662.55	662.55	662.55
2432.0	662.14	662.14	662.14
2401.8	662.07	662.07	662.07
2265.7	661.90	661.9	661.90
2137.6	661.75	661.75	661.75
2019.5	661.69	661.69	661.69
1914.6	661.60	661.6	661.60
1787.7	661.45	661.45	661.45
1782.5	661.48	661.48	661.48
1670.8	661.49	661.49	661.49
1553.9	661.49	661.49	661.49
1444.1	661.48	661.48	661.48
1317.1	661.48	661.48	661.48
1201.0	661.48	661.48	661.48
1154.8	661.45	661.45	661.45
1133.6	661.44	661.44	661.44
1106.4	661.42	661.42	661.42
1072.4	661.37	661.37	661.37
1056.1	661.34	661.34	661.34
936.7	661.35	661.35	661.35
812.3	661.34	661.34	661.34
673.0	661.34	661.34	661.34
547.4	661.33	661.33	661.33
530.6	661.33	661.33	661.33
445.3	661.33	661.33	661.33
349.9	661.33	661.33	661.33
336.6	661.33	661.33	661.33
221.9	661.32	661.32	661.32
130.4	661.31	661.31	661.31
111.9	661.31	661.31	661.31
Minimum Difference	0.00	0.00	0.00
Average Difference	0.00	0.00	0.00
Maximum Difference	0.00	0.00	0.00
Bullshead Creek			
10053.5	713.12	713.12	713.12
9993.1	713.11	713.11	713.11
9938.7	711.86	711.86	711.86
9890.4	711.78	711.78	711.78
9785.5	711.53	711.53	711.53
9703.5	711.44	711.44	711.44
9618.6	711.32	711.32	711.32

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Bullshead Creek			
9554.6	711.21	711.21	711.21
9462.0	711.04	711.04	711.04
9359.6	710.79	710.79	710.79
9294.5	710.59	710.59	710.59
9216.0	710.50	710.50	710.50
9151.3	710.35	710.35	710.35
9065.8	710.21	710.21	710.21
8982.7	710.15	710.15	710.15
8850.0	710.12	710.12	710.12
8697.1	710.10	710.10	710.10
8623.6	710.08	710.08	710.08
8512.3	710.06	710.06	710.06
8398.1	710.02	710.02	710.02
8299.0	709.97	709.97	709.97
8234.5	709.92	709.92	709.92
8150.3	709.88	709.88	709.88
8006.8	709.80	709.80	709.80
7886.3	709.59	709.59	709.59
7757.4	709.21	709.21	709.21
7691.1	709.05	709.05	709.05
7578.9	708.83	708.83	708.83
7508.7	708.63	708.63	708.63
7390.9	708.29	708.29	708.29
7293.8	708.04	708.04	708.04
7211.3	707.93	707.93	707.93
7112.9	707.87	707.87	707.87
6975.5	707.80	707.80	707.80
6844.0	707.71	707.71	707.71
6730.1	707.52	707.52	707.52
6606.0	707.36	707.36	707.36
6475.0	707.18	707.18	707.18
6369.7	707.06	707.06	707.06
6270.0	707.01	707.01	707.01
6152.9	707.00	707.00	707.00
6056.7	707.00	707.00	707.00
5897.3	706.99	706.99	706.99
5745.9	706.97	706.97	706.97
5628.5	706.95	706.95	706.95
5520.0	706.95	706.95	706.95
5410.4	706.94	706.94	706.94
5300.0	706.94	706.94	706.94
5159.7	706.94	706.94	706.94
5050.0	706.93	706.93	706.93
4918.0	706.93	706.93	706.93
4790.7	706.93	706.93	706.93
4681.6	706.93	706.93	706.93
4553.6	706.93	706.93	706.93
4443.3	706.93	706.93	706.93
4329.7	706.93	706.93	706.93
4283.3	706.93	706.93	706.93
4247.5	704.13	704.13	704.13
4201.1	704.12	704.12	704.12
4078.5	703.96	703.96	703.96
3967.2	703.90	703.90	703.90
3879.3	703.88	703.88	703.88
3765.9	703.87	703.87	703.87
3652.8	703.87	703.87	703.87
3566.8	703.85	703.85	703.85

Table C1: Sensitivity Analysis results for downstream boundary conditions (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Downstream Boundary Condition		
	0.5 m Below Adopted S = 0.000996 m/m	Adopted Normal Depth S= 0.0008 m/m	0.5 m Above Adopted S = 0.000652 m/m
Bullshead Creek			
3502.4	703.79	703.79	703.79
3471.6	702.74	702.74	702.74
3464.9	702.74	702.74	702.74
3446.8	702.06	702.06	702.06
3336.1	702.09	702.09	702.09
3330.2	702.08	702.08	702.08
3251.6	701.83	701.83	701.83
3245.1	701.72	701.72	701.72
3144.1	701.45	701.45	701.45
3138.1	701.41	701.41	701.41
3045.3	701.31	701.31	701.31
2930.8	701.16	701.16	701.16
2924.8	700.87	700.87	700.87
2909.6	700.34	700.34	700.34
2882.2	699.97	699.97	699.97
2821.1	699.90	699.90	699.90
2741.3	699.86	699.86	699.86
2627.4	699.82	699.82	699.82
2553.4	699.80	699.80	699.80
2484.8	699.56	699.56	699.56
2475.5	699.39	699.39	699.39
2426.5	699.43	699.43	699.43
2385.7	699.33	699.33	699.33
2344.7	697.97	697.97	697.97
2256.0	697.20	697.20	697.20
2138.0	696.53	696.52	696.53
2046.2	695.95	695.95	695.95
1941.4	695.20	695.20	695.20
1800.7	694.61	694.61	694.61
1679.2	694.30	694.30	694.30
1562.4	693.49	693.49	693.49
1464.8	692.89	692.89	692.89
1337.7	692.05	692.05	692.05
1227.5	691.51	691.51	691.51
1068.7	690.61	690.61	690.61
982.6	689.91	689.91	689.91
872.0	689.27	689.27	689.27
719.4	688.48	688.48	688.48
603.0	687.92	687.92	687.92
471.9	686.96	686.96	686.96
310.3	686.11	686.11	686.11
170.8	685.04	685.04	685.04
41.6	684.68	684.68	684.68
Minimum Difference	0.00	0.00	0.00
Average Difference	0.00	0.00	0.00
Maximum Difference	0.01	0.00	0.01

Table C2: Sensitivity Analysis results for channel roughness

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
South Saskatchewan River			
45324.6	668.95	669.59	670.15
44678.6	668.57	669.22	669.80
44049.3	668.17	668.83	669.41
43532.6	668.18	668.81	669.37
43062.9	668.16	668.76	669.31
42639.9	668.08	668.67	669.21
42313.3	667.94	668.55	669.09
41994.2	667.65	668.27	668.82
41730.3	667.42	668.06	668.62
41467.0	667.29	667.93	668.51
41175.8	667.25	667.88	668.43
40727.5	666.95	667.58	668.14
40249.7	666.86	667.47	668.00
39686.1	666.34	666.98	667.54
39025.7	666.37	666.96	667.47
38612.5	666.09	666.73	667.29
38206.1	665.96	666.55	667.07
37769.2	665.60	666.22	666.76
37095.7	665.56	666.13	666.63
36628.4	665.53	666.08	666.56
36160.1	665.37	665.91	666.39
35710.7	665.24	665.78	666.25
35027.4	665.09	665.61	666.09
34794.0	664.86	665.41	665.92
34468.8	664.72	665.28	665.80
34034.8	664.63	665.17	665.68
33412.2	664.55	665.04	665.51
32996.3	664.31	664.80	665.25
32901.4	664.30	664.79	665.24
32873.5	664.17	664.67	665.13
32864.5	664.15	664.65	665.11
32840.8	664.08	664.58	665.05
32694.6	663.78	664.32	664.82
32231.8	663.70	664.21	664.69
31957.8	663.62	664.14	664.57
31736.9	663.56	664.06	664.49
31302.5	663.53	664.00	664.41
30869.7	663.37	663.83	664.24
30568.2	663.18	663.65	664.05
30278.1	663.08	663.53	663.93
30073.4	662.81	663.28	663.68
29912.2	662.71	663.18	663.58
29893.3	662.68	663.16	663.57
29809.9	662.69	663.16	663.56
29704.8	662.70	663.15	663.54
29678.6	662.56	663.01	663.39
29585.9	662.50	662.95	663.33
29489.8	662.44	662.87	663.23
29458.4	662.35	662.77	663.13
29287.6	662.39	662.80	663.14
28981.6	661.81	662.24	662.59
28781.7	661.62	662.06	662.42
28518.1	661.57	661.97	662.30
28272.2	661.35	661.76	662.08
27943.7	661.22	661.59	661.88

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
South Saskatchewan River			
27680.4	661.25	661.61	661.87
27421.4	661.01	661.43	661.74
27258.8	660.67	661.21	661.57
27102.7	660.65	661.15	661.50
26834.0	660.70	661.17	661.49
26592.1	660.41	660.82	661.09
26361.6	660.05	660.62	660.94
25868.7	660.09	660.58	660.88
25469.9	660.00	660.49	660.79
25260.1	659.87	660.38	660.67
24856.1	659.68	660.16	660.44
24346.3	659.11	659.66	659.95
23761.7	658.94	659.48	659.74
23368.0	658.85	659.38	659.64
22594.3	658.73	659.25	659.47
22344.9	658.69	659.21	659.42
21959.8	658.47	659.03	659.22
21435.8	657.61	658.23	658.57
21170.4	657.37	657.91	658.38
20943.9	657.64	658.13	658.52
20505.0	657.60	658.08	658.47
20015.1	657.02	657.64	658.11
19627.4	656.79	657.36	657.88
19150.9	656.61	657.19	657.68
18687.0	656.37	656.94	657.43
18369.4	655.93	656.54	657.10
17911.3	655.46	656.08	656.67
17456.9	655.29	655.89	656.43
16987.2	655.16	655.73	656.19
16429.6	654.96	655.50	655.98
15922.3	654.59	655.15	655.64
15557.2	654.16	654.76	655.29
15199.7	653.95	654.56	655.07
14547.7	653.61	654.19	654.68
14067.7	653.41	653.96	654.41
13586.7	653.20	653.78	654.25
13257.0	653.15	653.67	654.10
12651.1	652.55	653.10	653.65
12272.3	652.28	652.88	653.43
11856.3	652.17	652.72	653.23
11400.9	651.91	652.46	652.96
10997.3	651.73	652.24	652.75
10615.6	651.28	651.82	652.31
10037.9	651.29	651.77	652.23
9344.0	650.58	651.15	651.65
8739.4	650.40	650.94	651.42
8060.7	650.34	650.83	651.28
7698.5	650.04	650.56	651.03
7318.5	649.53	650.07	650.55
6742.1	648.82	649.42	650.01
6324.0	649.06	649.56	650.07
5902.0	648.83	649.40	649.91
5517.4	648.52	649.05	649.57
5142.8	648.24	648.75	649.25
4619.6	648.03	648.53	649.02
3946.0	647.70	648.17	648.63
3350.6	647.60	648.02	648.46
2779.3	646.52	647.21	647.78

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
South Saskatchewan River			
2384.9	646.40	647.00	647.57
1980.8	646.30	646.86	647.38
1554.3	646.38	646.88	647.35
1188.3	646.10	646.62	647.10
825.9	645.79	646.32	646.82
434.2	645.58	646.09	646.58
0.0	644.85	645.50	646.07
Average Difference	-0.53	0.00	0.45
Maximum Difference	-0.69	0.00	0.59
Ross Creek			
25004.1	704.23	704.40	704.56
24867.4	703.64	703.84	704.01
24755.5	703.76	703.88	704.01
24601.1	703.46	703.61	703.76
24504.3	703.31	703.42	703.53
24485.5	703.16	703.25	703.35
24367.1	702.92	702.99	703.06
24239.4	702.72	702.77	702.82
24049.3	702.34	702.40	702.45
23887.6	702.20	702.24	702.28
23758.2	701.92	701.99	702.05
23609.5	701.74	701.79	701.83
23457.8	701.57	701.61	701.65
23269.2	701.42	701.47	701.50
23072.0	701.29	701.34	701.38
22807.2	701.02	701.09	701.15
22662.1	700.91	700.97	701.02
22512.9	700.77	700.84	700.89
22348.8	700.62	700.69	700.75
22202.2	700.46	700.52	700.58
22051.8	700.30	700.36	700.42
21867.9	700.14	700.20	700.26
21732.1	700.08	700.13	700.19
21454.7	699.93	699.99	700.06
21283.7	699.86	699.92	699.99
21105.3	699.68	699.76	699.84
20941.9	699.51	699.60	699.69
20802.0	699.30	699.40	699.49
20619.0	699.22	699.31	699.40
20458.8	699.19	699.28	699.37
20238.1	698.96	699.09	699.22
20068.9	698.72	698.82	698.92
19885.4	698.51	698.56	698.62
19778.4	698.11	698.18	698.24
19767.9	697.93	698.07	698.17
19704.0	697.90	697.96	698.01
19700.7	697.88	697.94	697.99
19632.3	697.79	697.83	697.87
19566.8	697.73	697.77	697.80
19418.9	697.63	697.66	697.69
19079.3	697.34	697.39	697.43
18934.3	696.99	697.05	697.11
18780.0	696.86	696.91	696.95
18613.6	696.72	696.78	696.83
18457.7	696.66	696.71	696.76
18303.0	696.42	696.51	696.59
18159.0	696.15	696.22	696.29
18042.1	695.89	695.96	696.03

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Ross Creek			
17870.1	695.79	695.83	695.88
17608.9	695.71	695.76	695.80
17477.9	695.69	695.73	695.77
17290.6	695.66	695.70	695.75
17138.0	695.56	695.62	695.68
16928.3	695.24	695.33	695.41
16770.8	694.77	694.85	694.92
16621.8	694.51	694.57	694.62
16467.3	694.16	694.23	694.28
16274.8	693.93	693.95	693.98
15976.6	693.78	693.81	693.83
15801.9	693.66	693.70	693.73
15681.4	693.60	693.64	693.67
15510.3	693.53	693.56	693.58
15212.7	693.22	693.26	693.30
14983.1	693.17	693.20	693.23
14782.6	693.03	693.07	693.10
14771.3	692.98	693.03	693.07
14537.1	692.79	692.84	692.88
14375.9	692.67	692.73	692.77
14119.8	692.62	692.68	692.73
14052.0	692.61	692.68	692.72
13880.6	692.57	692.64	692.69
13833.6	692.56	692.62	692.67
13619.7	692.52	692.58	692.63
13410.7	692.41	692.50	692.56
13230.0	692.16	692.27	692.34
13068.3	691.85	691.96	692.06
12895.9	691.70	691.77	691.85
12730.9	691.55	691.62	691.68
12542.2	691.38	691.45	691.52
12386.3	691.27	691.33	691.40
12229.1	691.16	691.24	691.31
12101.4	690.99	691.08	691.16
12034.3	690.89	690.96	691.03
11883.8	690.64	690.70	690.76
11756.5	690.46	690.50	690.54
11627.5	690.40	690.43	690.46
11439.0	690.09	690.17	690.23
11269.6	689.76	689.81	689.85
11101.3	689.42	689.46	689.49
10922.0	689.30	689.29	689.30
10738.2	689.24	689.22	689.22
10635.4	688.85	688.92	688.98
10433.7	688.33	688.41	688.47
10269.2	687.99	688.09	688.16
10264.0	688.04	688.12	688.18
10171.3	687.81	687.90	687.97
10006.6	687.66	687.74	687.80
9922.9	687.62	687.69	687.74
9906.8	687.61	687.67	687.72
9739.5	687.32	687.41	687.49
9596.6	687.04	687.12	687.20
9458.2	686.67	686.74	686.81
9310.8	686.23	686.30	686.36
9200.8	685.80	685.92	685.99
9081.0	685.50	685.61	685.69
8929.1	684.77	684.93	685.07

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Ross Creek			
8801.4	684.56	684.68	684.78
8553.3	683.42	683.51	683.59
8324.0	682.28	682.42	682.56
8107.9	681.06	681.19	681.28
7695.0	679.20	679.22	679.29
7286.4	676.97	677.09	677.22
7051.3	675.95	676.03	676.10
6863.2	675.13	675.23	675.31
6733.0	674.71	674.78	674.84
6293.8	672.15	672.27	672.39
6065.7	671.34	671.38	671.42
5845.8	670.46	670.51	670.56
5538.4	669.40	669.44	669.48
5170.0	668.71	668.75	668.81
4558.3	666.62	666.70	666.77
4292.7	666.38	666.37	666.36
4061.2	665.56	665.57	665.65
3823.7	665.16	665.22	665.25
3693.4	664.87	664.99	665.02
3545.6	664.12	664.27	664.38
3439.6	664.09	664.15	664.19
3384.2	663.84	663.94	664.02
3255.6	663.61	663.72	663.78
3057.0	663.25	663.39	663.46
2925.3	662.94	663.16	663.23
2915.3	662.86	663.11	663.18
2772.2	662.44	662.76	662.81
2571.8	662.12	662.56	662.58
2370.4	661.87	662.41	662.42
2261.4	661.79	662.36	662.35
2160.5	661.49	662.18	662.18
2144.8	661.33	661.76	661.97
2032.1	661.29	661.77	661.97
1780.2	661.21	661.72	661.94
1674.7	661.10	661.68	661.90
1611.1	660.98	661.60	661.83
1596.5	660.83	661.37	661.59
1527.2	660.87	661.40	661.61
1487.6	660.86	661.39	661.60
1436.9	660.84	661.38	661.59
1300.3	660.82	661.37	661.58
1282.3	660.81	661.36	661.58
1278.5	660.81	661.36	661.58
1246.6	660.82	661.36	661.58
1118.0	660.79	661.34	661.56
1024.6	660.75	661.31	661.53
880.3	660.76	661.22	661.54
756.7	660.77	661.23	661.54
540.2	660.75	661.21	661.52
430.8	660.73	661.18	661.50
278.9	660.70	661.17	661.49
Average Difference	-0.14	0.00	0.08
Maximum Difference	-0.69	0.00	0.32
Seven Persons Creek			
24132.0	711.65	711.66	711.68
23979.0	711.62	711.62	711.63
23814.3	711.39	711.39	711.41
23806.4	710.14	710.14	710.14

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Seven Persons Creek			
23646.6	710.41	710.51	710.60
23492.8	710.33	710.43	710.53
23469.9	710.26	710.35	710.44
23465.2	710.27	710.36	710.45
23401.0	710.15	710.23	710.31
23368.6	708.91	709.06	709.20
23292.4	708.76	708.86	708.96
23259.5	708.77	708.86	708.95
23215.0	708.71	708.8	708.88
23116.8	708.63	708.7	708.78
23034.0	707.86	708.04	708.19
22947.6	707.24	707.42	707.57
22873.0	707.27	707.39	707.50
22770.6	707.17	707.29	707.40
22664.2	706.85	706.96	707.12
22575.2	706.49	706.67	706.81
22463.8	706.25	706.42	706.55
22361.4	705.88	706.03	706.13
22267.2	705.82	705.96	706.04
22141.5	705.72	705.85	705.92
22049.5	705.49	705.6	705.70
21928.3	704.99	705.2	705.36
21802.7	704.79	704.94	705.07
21685.0	704.59	704.71	704.81
21587.7	704.45	704.54	704.62
21553.4	704.48	704.57	704.64
21455.3	704.42	704.5	704.57
21315.9	704.11	704.22	704.32
21210.3	703.82	703.94	704.03
21109.4	703.59	703.68	703.76
21009.9	703.35	703.43	703.49
20908.5	703.16	703.22	703.26
20811.2	702.96	703	703.04
20688.4	702.68	702.75	702.79
20603.5	702.45	702.53	702.58
20492.0	702.33	702.39	702.44
20389.2	702.22	702.28	702.33
20204.6	701.97	702.04	702.09
20050.3	701.85	701.91	701.96
19964.2	701.72	701.8	701.86
19853.8	701.62	701.69	701.75
19715.1	701.30	701.39	701.46
19603.7	701.05	701.14	701.21
19456.1	700.68	700.75	700.83
19327.9	700.29	700.4	700.47
19216.2	700.01	700.08	700.14
19152.2	700.02	700.06	700.09
19110.7	699.91	699.96	699.99
19001.8	699.62	699.7	699.75
18889.7	699.50	699.58	699.64
18787.3	699.38	699.46	699.53
18675.0	699.25	699.35	699.42
18564.5	698.87	698.94	699.02
18493.6	698.57	698.66	698.75
18486.4	698.17	698.27	698.40
18433.7	698.27	698.35	698.42
18350.8	698.14	698.23	698.29
18280.2	698.03	698.12	698.18

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Seven Persons Creek			
18275.2	697.95	698.04	698.11
18219.2	697.74	697.83	697.90
18130.4	697.72	697.78	697.83
18125.6	697.67	697.75	697.81
18003.8	697.49	697.59	697.65
17904.9	697.41	697.49	697.54
17802.4	697.12	697.19	697.27
17797.8	697.08	697.18	697.26
17719.1	697.00	697.07	697.14
17604.0	696.73	696.81	696.88
17597.6	696.59	696.69	696.78
17498.8	696.52	696.59	696.65
17356.6	696.10	696.23	696.32
17263.3	696.09	696.18	696.25
17143.1	696.01	696.09	696.17
17042.6	695.92	696.02	696.09
16936.4	695.73	695.83	695.92
16930.8	695.65	695.75	695.85
16848.0	695.21	695.38	695.51
16772.0	695.08	695.2	695.30
16639.9	695.03	695.13	695.20
16542.3	694.98	695.08	695.16
16415.3	694.83	694.93	695.02
16311.9	694.69	694.77	694.85
16207.6	694.56	694.64	694.71
16142.0	694.36	694.42	694.49
16135.6	694.30	694.36	694.42
16093.3	694.25	694.32	694.39
16002.5	694.01	694.16	694.27
15896.8	693.85	693.98	694.07
15789.6	693.73	693.84	693.92
15677.4	693.59	693.69	693.77
15552.8	693.37	693.46	693.53
15468.3	693.06	693.16	693.25
15462.3	693.08	693.17	693.25
15421.3	693.04	693.12	693.18
15329.5	692.91	692.97	693.03
15269.9	692.69	692.78	692.85
15168.7	692.66	692.72	692.77
15148.4	692.58	692.66	692.73
15076.5	692.49	692.56	692.62
14958.9	692.28	692.35	692.41
14861.4	692.24	692.29	692.34
14748.8	691.95	692.06	692.14
14609.8	691.66	691.76	691.84
14511.3	691.54	691.63	691.70
14406.1	691.46	691.55	691.61
14327.1	691.32	691.42	691.50
14247.1	690.65	690.77	690.88
14233.3	690.48	690.59	690.69
14107.9	690.29	690.36	690.42
14000.3	690.15	690.23	690.28
13838.9	689.87	689.93	689.98
13689.0	689.69	689.73	689.77
13570.5	689.53	689.57	689.61
13465.0	689.28	689.41	689.47
13347.3	689.20	689.3	689.37
13257.6	689.16	689.25	689.33

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Seven Persons Creek			
13120.9	688.96	689.11	689.23
13053.1	688.88	689.01	689.11
12910.6	688.78	688.9	689.00
12787.5	688.33	688.54	688.70
12634.7	688.09	688.24	688.35
12461.4	687.69	687.81	687.91
12300.2	687.40	687.5	687.58
12199.8	687.34	687.43	687.50
12118.9	687.24	687.34	687.42
11920.7	686.87	687.02	687.13
11797.6	686.73	686.84	686.94
11676.2	686.51	686.63	686.73
11518.8	686.15	686.27	686.38
11372.4	685.99	686.05	686.13
11252.6	685.65	685.81	685.92
11204.4	685.51	685.65	685.78
11094.5	685.39	685.47	685.57
10959.3	685.05	685.21	685.33
10870.9	684.88	685.03	685.16
10864.9	684.81	684.99	685.14
10774.9	684.50	684.64	684.75
10671.2	684.21	684.35	684.43
10532.7	683.72	683.83	683.92
10428.8	683.67	683.75	683.83
10290.2	683.40	683.49	683.58
10139.9	683.09	683.21	683.32
10023.9	682.70	682.88	683.02
9909.5	682.42	682.6	682.75
9796.8	681.97	682.16	682.32
9668.4	681.97	682.13	682.26
9490.1	681.84	682	682.14
9399.0	681.57	681.75	681.91
9262.0	681.04	681.26	681.43
9138.7	680.97	681.15	681.29
9098.7	680.76	680.92	681.07
9091.1	680.74	680.87	680.99
9008.6	680.50	680.59	680.68
8998.5	680.53	680.62	680.69
8932.1	680.38	680.46	680.52
8858.1	680.12	680.21	680.28
8817.2	679.99	680	680.02
8778.3	679.91	679.91	679.92
8772.7	679.51	679.64	679.72
8621.0	679.24	679.38	679.43
8547.6	679.07	679.13	679.21
8469.2	679.01	679.08	679.13
8342.1	678.79	678.85	678.91
8336.0	678.73	678.8	678.86
8329.6	678.70	678.76	678.82
8322.1	678.61	678.68	678.75
8269.4	678.60	678.65	678.69
8118.4	678.14	678.21	678.27
8113.9	678.05	678.15	678.22
8096.6	678.11	678.18	678.23
8019.4	678.07	678.12	678.17
8015.7	678.02	678.1	678.15
7935.7	677.83	677.93	678.01
7853.4	677.58	677.72	677.82

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Seven Persons Creek			
7848.8	677.47	677.64	677.77
7744.0	677.32	677.43	677.52
7660.1	677.00	677.1	677.20
7582.7	676.90	676.93	676.98
7518.9	676.88	676.88	676.91
7362.8	676.07	676.21	676.31
7248.0	675.89	675.97	676.03
7243.0	675.85	675.94	676.00
7223.8	675.84	675.92	675.97
7189.7	675.81	675.87	675.93
7179.7	675.80	675.85	675.90
7063.7	675.66	675.71	675.77
6924.6	675.55	675.61	675.67
6795.3	675.46	675.51	675.59
6751.5	675.37	675.43	675.51
6743.6	675.36	675.41	675.48
6699.1	675.33	675.37	675.44
6635.3	675.07	675.1	675.18
6630.0	674.66	674.67	674.77
6545.6	674.09	674.28	674.40
6453.8	673.97	674.03	674.11
6366.3	673.71	673.79	673.86
6302.8	673.65	673.7	673.77
6294.7	673.65	673.69	673.75
6248.0	673.58	673.6	673.66
6151.5	673.36	673.41	673.51
6147.4	673.37	673.4	673.49
6033.8	672.61	672.72	672.82
5749.0	672.50	672.52	672.54
5594.2	672.06	672.16	672.22
5442.7	671.73	671.82	671.88
5281.5	671.62	671.69	671.73
5265.2	671.52	671.62	671.67
5177.1	671.45	671.54	671.59
5037.8	671.26	671.32	671.39
5031.7	671.13	671.25	671.30
4920.1	671.18	671.26	671.31
4783.1	671.11	671.2	671.24
4651.3	671.03	671.09	671.12
4564.5	669.66	669.79	669.84
4546.4	669.66	669.78	669.83
4527.2	669.57	669.71	669.77
4522.3	669.24	669.44	669.52
4514.5	668.80	668.92	669.02
4417.1	668.77	668.8	668.84
4328.8	668.54	668.53	668.57
4207.2	667.67	667.82	667.86
4204.8	667.03	667.13	667.22
4148.9	667.01	667.11	667.18
4108.8	666.69	666.9	667.02
4106.2	666.59	666.82	666.97
4046.3	666.57	666.71	666.82
3949.4	666.27	666.4	666.51
3828.7	666.12	666.19	666.26
3736.9	666.07	666.12	666.17
3725.7	665.95	666.03	666.10
3722.7	665.90	666	666.08
3617.9	665.62	665.72	665.80

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Seven Persons Creek			
3482.9	665.33	665.38	665.42
3457.0	665.38	665.4	665.43
3412.4	664.88	664.94	665.07
3308.0	664.50	664.62	664.77
3222.6	664.27	664.3	664.40
3212.0	663.94	664.11	664.24
3078.5	663.66	663.78	663.88
3005.7	663.57	663.67	663.74
2995.0	663.21	663.34	663.45
2981.1	663.08	663.22	663.35
2975.1	663.11	663.23	663.33
2847.3	663.02	663.11	663.19
2729.6	662.94	663	663.06
2718.7	662.84	662.91	662.98
2605.9	662.63	662.77	662.85
2510.0	662.53	662.65	662.73
2475.9	662.42	662.55	662.63
2432.0	661.88	662.14	662.30
2401.8	661.79	662.07	662.25
2265.7	661.62	661.9	662.04
2137.6	661.43	661.75	661.91
2019.5	661.40	661.69	661.83
1914.6	661.29	661.6	661.73
1787.7	661.11	661.45	661.66
1782.5	661.05	661.48	661.66
1670.8	661.11	661.49	661.66
1553.9	661.10	661.49	661.65
1444.1	661.09	661.48	661.65
1317.1	661.08	661.48	661.65
1201.0	661.07	661.48	661.64
1154.8	661.04	661.45	661.63
1133.6	661.01	661.44	661.62
1106.4	661.00	661.42	661.60
1072.4	660.96	661.37	661.57
1056.1	660.84	661.34	661.59
936.7	660.85	661.35	661.58
812.3	660.83	661.34	661.57
673.0	660.83	661.34	661.57
547.4	660.81	661.33	661.57
530.6	660.81	661.33	661.57
445.3	660.81	661.33	661.57
349.9	660.81	661.33	661.56
336.6	660.81	661.33	661.56
221.9	660.80	661.32	661.56
130.4	660.79	661.31	661.55
111.9	660.78	661.31	661.55
Average Difference	-0.13	0.00	0.09
Maximum Difference	-0.53	0.00	0.25
Bullshead Creek			
10053.5	713.12	713.12	713.12
9993.1	713.11	713.11	713.11
9938.7	711.83	711.86	711.88
9890.4	711.77	711.78	711.78
9785.5	711.51	711.53	711.54
9703.5	711.44	711.44	711.45
9618.6	711.31	711.32	711.33
9554.6	711.21	711.21	711.21
9462.0	711.05	711.04	711.04

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Bullshead Creek			
9359.6	710.77	710.79	710.80
9294.5	710.57	710.59	710.61
9216.0	710.49	710.50	710.50
9151.3	710.35	710.35	710.36
9065.8	710.20	710.21	710.22
8982.7	710.14	710.15	710.15
8850.0	710.11	710.12	710.12
8697.1	710.09	710.10	710.10
8623.6	710.08	710.08	710.09
8512.3	710.06	710.06	710.07
8398.1	710.01	710.02	710.03
8299.0	709.95	709.97	709.98
8234.5	709.90	709.92	709.94
8150.3	709.86	709.88	709.89
8006.8	709.79	709.80	709.81
7886.3	709.50	709.59	709.63
7757.4	709.13	709.21	709.26
7691.1	708.99	709.05	709.09
7578.9	708.81	708.83	708.85
7508.7	708.59	708.63	708.65
7390.9	708.27	708.29	708.30
7293.8	708.02	708.04	708.06
7211.3	707.92	707.93	707.95
7112.9	707.86	707.87	707.88
6975.5	707.78	707.80	707.81
6844.0	707.69	707.71	707.72
6730.1	707.49	707.52	707.54
6606.0	707.34	707.36	707.37
6475.0	707.16	707.18	707.20
6369.7	707.05	707.06	707.07
6270.0	707.01	707.01	707.01
6152.9	707.00	707.00	707.00
6056.7	707.00	707.00	707.00
5897.3	706.99	706.99	706.99
5745.9	706.97	706.97	706.97
5628.5	706.95	706.95	706.96
5520.0	706.95	706.95	706.95
5410.4	706.94	706.94	706.94
5300.0	706.94	706.94	706.94
5159.7	706.94	706.94	706.94
5050.0	706.94	706.93	706.93
4918.0	706.93	706.93	706.93
4790.7	706.93	706.93	706.93
4681.6	706.93	706.93	706.93
4553.6	706.93	706.93	706.93
4443.3	706.93	706.93	706.93
4329.7	706.93	706.93	706.93
4283.3	706.93	706.93	706.93
4247.5	704.12	704.13	704.15
4201.1	704.11	704.12	704.13
4078.5	703.92	703.96	703.99
3967.2	703.88	703.90	703.91
3879.3	703.86	703.88	703.89
3765.9	703.86	703.87	703.88
3652.8	703.85	703.87	703.88
3566.8	703.84	703.85	703.86
3502.4	703.76	703.79	703.81
3471.6	702.67	702.74	702.80

Table C2: Sensitivity Analysis results for channel roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Channel Roughness		
	Low Channel Roughness (-15%)	Adopted/Calibrated Roughness	High Channel Roughness (+15%)
Bullshead Creek			
3464.9	702.68	702.74	702.79
3446.8	702.01	702.06	702.17
3336.1	702.09	702.09	702.10
3330.2	702.07	702.08	702.09
3251.6	701.84	701.83	701.84
3245.1	701.67	701.72	701.75
3144.1	701.46	701.45	701.46
3138.1	701.40	701.41	701.41
3045.3	701.33	701.31	701.30
2930.8	701.20	701.16	701.13
2924.8	700.89	700.87	700.85
2909.6	700.31	700.34	700.36
2882.2	699.98	699.97	699.97
2821.1	699.92	699.90	699.89
2741.3	699.88	699.86	699.85
2627.4	699.85	699.82	699.81
2553.4	699.83	699.80	699.79
2484.8	699.56	699.56	699.57
2475.5	699.32	699.39	699.43
2426.5	699.42	699.43	699.44
2385.7	699.31	699.33	699.35
2344.7	698.01	697.97	697.96
2256.0	697.20	697.20	697.22
2138.0	696.50	696.52	696.53
2046.2	695.97	695.95	695.96
1941.4	695.17	695.20	695.21
1800.7	694.60	694.61	694.63
1679.2	694.26	694.30	694.30
1562.4	693.53	693.49	693.52
1464.8	692.89	692.89	692.90
1337.7	692.09	692.05	692.06
1227.5	691.51	691.51	691.51
1068.7	690.59	690.61	690.62
982.6	689.90	689.91	689.92
872.0	689.24	689.27	689.28
719.4	688.51	688.48	688.46
603.0	687.85	687.92	687.95
471.9	686.97	686.96	687.03
310.3	686.04	686.11	686.13
170.8	685.09	685.04	685.05
41.6	684.56	684.68	684.78
Average Difference	-0.01	0.00	0.01
Maximum Difference	-0.12	0.00	0.11

Table C3: Sensitivity Analysis results for overbank roughness

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
South Saskatchewan River			
45324.6	669.49	669.59	669.65
44678.6	669.13	669.22	669.29
44049.3	668.72	668.83	668.90
43532.6	668.70	668.81	668.88
43062.9	668.66	668.76	668.84
42639.9	668.57	668.67	668.75
42313.3	668.45	668.55	668.63
41994.2	668.17	668.27	668.34
41730.3	667.96	668.06	668.13
41467.0	667.83	667.93	668.00
41175.8	667.78	667.88	667.95
40727.5	667.48	667.58	667.65
40249.7	667.36	667.47	667.54
39686.1	666.87	666.98	667.06
39025.7	666.85	666.96	667.03
38612.5	666.67	666.73	666.77
38206.1	666.43	666.55	666.62
37769.2	666.11	666.22	666.29
37095.7	666.00	666.13	666.21
36628.4	665.95	666.08	666.16
36160.1	665.79	665.91	665.99
35710.7	665.65	665.78	665.86
35027.4	665.49	665.61	665.69
34794.0	665.30	665.41	665.49
34468.8	665.17	665.28	665.34
34034.8	665.06	665.17	665.24
33412.2	664.92	665.04	665.12
32996.3	664.67	664.80	664.88
32901.4	664.66	664.79	664.87
32873.5	664.53	664.67	664.75
32864.5	664.51	664.65	664.73
32840.8	664.45	664.58	664.67
32694.6	664.20	664.32	664.40
32231.8	664.09	664.21	664.29
31957.8	664.01	664.14	664.21
31736.9	663.94	664.06	664.14
31302.5	663.86	664.00	664.08
30869.7	663.70	663.83	663.91
30568.2	663.52	663.65	663.71
30278.1	663.39	663.53	663.61
30073.4	663.14	663.28	663.36
29912.2	663.04	663.18	663.26
29893.3	663.02	663.16	663.24
29809.9	663.02	663.16	663.24
29704.8	663.01	663.15	663.23
29678.6	662.86	663.01	663.09
29585.9	662.81	662.95	663.03
29489.8	662.71	662.87	662.96
29458.4	662.61	662.77	662.86
29287.6	662.64	662.80	662.90
28981.6	662.05	662.24	662.34
28781.7	661.88	662.06	662.16
28518.1	661.78	661.97	662.08
28272.2	661.56	661.76	661.86
27943.7	661.39	661.59	661.70
27680.4	661.39	661.61	661.71

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
South Saskatchewan River			
27421.4	661.25	661.43	661.51
27258.8	660.99	661.21	661.29
27102.7	660.94	661.15	661.22
26834.0	660.95	661.17	661.24
26592.1	660.63	660.82	660.89
26361.6	660.44	660.62	660.64
25868.7	660.40	660.58	660.61
25469.9	660.30	660.49	660.52
25260.1	660.19	660.38	660.40
24856.1	659.96	660.16	660.19
24346.3	659.46	659.66	659.65
23761.7	659.28	659.48	659.46
23368.0	659.15	659.38	659.35
22594.3	659.01	659.25	659.20
22344.9	658.98	659.21	659.15
21959.8	658.79	659.03	658.94
21435.8	658.15	658.23	658.20
21170.4	657.78	657.91	658.01
20943.9	658.00	658.13	658.23
20505.0	657.95	658.08	658.18
20015.1	657.51	657.64	657.72
19627.4	657.24	657.36	657.45
19150.9	657.07	657.19	657.27
18687.0	656.80	656.94	657.04
18369.4	656.41	656.54	656.63
17911.3	656.00	656.08	656.15
17456.9	655.79	655.89	655.97
16987.2	655.64	655.73	655.77
16429.6	655.40	655.50	655.56
15922.3	655.05	655.15	655.22
15557.2	654.65	654.76	654.83
15199.7	654.46	654.56	654.62
14547.7	654.09	654.19	654.26
14067.7	653.86	653.96	654.02
13586.7	653.69	653.78	653.84
13257.0	653.57	653.67	653.73
12651.1	653.02	653.10	653.17
12272.3	652.78	652.88	652.95
11856.3	652.61	652.72	652.80
11400.9	652.34	652.46	652.55
10997.3	652.13	652.24	652.32
10615.6	651.69	651.82	651.92
10037.9	651.63	651.77	651.88
9344.0	651.02	651.15	651.25
8739.4	650.79	650.94	651.04
8060.7	650.68	650.83	650.93
7698.5	650.42	650.56	650.65
7318.5	649.92	650.07	650.17
6742.1	649.31	649.42	649.52
6324.0	649.43	649.56	649.67
5902.0	649.31	649.40	649.45
5517.4	648.94	649.05	649.14
5142.8	648.61	648.75	648.85
4619.6	648.41	648.53	648.62
3946.0	648.05	648.17	648.27
3350.6	647.89	648.02	648.13
2779.3	647.15	647.21	647.24
2384.9	646.94	647.00	647.05

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
South Saskatchewan River			
1980.8	646.78	646.86	646.92
1554.3	646.80	646.88	646.94
1188.3	646.53	646.62	646.68
825.9	646.24	646.32	646.38
434.2	646.00	646.09	646.16
0.0	645.43	645.50	645.55
Average Difference	-0.13	0.00	0.07
Maximum Difference	-0.24	0.00	0.11
Ross Creek			
25004.1	704.32	704.40	704.47
24867.4	703.74	703.84	703.91
24755.5	703.80	703.88	703.96
24601.1	703.53	703.61	703.67
24504.3	703.32	703.42	703.51
24485.5	703.14	703.25	703.35
24367.1	702.87	702.99	703.09
24239.4	702.66	702.77	702.88
24049.3	702.26	702.40	702.51
23887.6	702.11	702.24	702.34
23758.2	701.88	701.99	702.09
23609.5	701.66	701.79	701.90
23457.8	701.48	701.61	701.73
23269.2	701.33	701.47	701.59
23072.0	701.20	701.34	701.45
22807.2	700.96	701.09	701.20
22662.1	700.84	700.97	701.09
22512.9	700.71	700.84	700.95
22348.8	700.56	700.69	700.80
22202.2	700.39	700.52	700.64
22051.8	700.23	700.36	700.49
21867.9	700.05	700.20	700.33
21732.1	699.99	700.13	700.27
21454.7	699.85	699.99	700.12
21283.7	699.78	699.92	700.05
21105.3	699.63	699.76	699.87
20941.9	699.49	699.60	699.70
20802.0	699.30	699.40	699.49
20619.0	699.22	699.31	699.40
20458.8	699.19	699.28	699.36
20238.1	699.03	699.09	699.15
20068.9	698.77	698.82	698.87
19885.4	698.53	698.56	698.62
19778.4	698.22	698.18	698.20
19767.9	697.97	698.07	698.16
19704.0	697.86	697.96	698.05
19700.7	697.82	697.94	698.04
19632.3	697.72	697.83	697.93
19566.8	697.66	697.77	697.86
19418.9	697.55	697.66	697.76
19079.3	697.27	697.39	697.49
18934.3	696.96	697.05	697.14
18780.0	696.80	696.91	697.00
18613.6	696.66	696.78	696.87
18457.7	696.61	696.71	696.80
18303.0	696.43	696.51	696.58
18159.0	696.13	696.22	696.30
18042.1	695.86	695.96	696.05
17870.1	695.72	695.83	695.94

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Ross Creek			
17608.9	695.64	695.76	695.86
17477.9	695.61	695.73	695.83
17290.6	695.58	695.70	695.80
17138.0	695.51	695.62	695.72
16928.3	695.23	695.33	695.42
16770.8	694.74	694.85	694.95
16621.8	694.48	694.57	694.64
16467.3	694.12	694.23	694.32
16274.8	693.86	693.95	694.05
15976.6	693.71	693.81	693.90
15801.9	693.59	693.70	693.80
15681.4	693.52	693.64	693.74
15510.3	693.45	693.56	693.66
15212.7	693.17	693.26	693.36
14983.1	693.12	693.20	693.29
14782.6	693.01	693.07	693.16
14771.3	692.89	693.03	693.15
14537.1	692.67	692.84	692.97
14375.9	692.56	692.73	692.86
14119.8	692.52	692.68	692.81
14052.0	692.51	692.68	692.80
13880.6	692.48	692.64	692.77
13833.6	692.46	692.62	692.75
13619.7	692.42	692.58	692.70
13410.7	692.34	692.50	692.61
13230.0	692.11	692.27	692.37
13068.3	691.84	691.96	692.07
12895.9	691.65	691.77	691.88
12730.9	691.49	691.62	691.72
12542.2	691.33	691.45	691.55
12386.3	691.23	691.33	691.43
12229.1	691.14	691.24	691.32
12101.4	691.00	691.08	691.15
12034.3	690.88	690.96	691.03
11883.8	690.61	690.70	690.78
11756.5	690.39	690.50	690.59
11627.5	690.33	690.43	690.52
11439.0	690.08	690.17	690.24
11269.6	689.71	689.81	689.89
11101.3	689.36	689.46	689.53
10922.0	689.20	689.29	689.38
10738.2	689.13	689.22	689.31
10635.4	688.85	688.92	688.98
10433.7	688.34	688.41	688.47
10269.2	688.00	688.09	688.16
10264.0	688.03	688.12	688.19
10171.3	687.79	687.90	687.99
10006.6	687.61	687.74	687.85
9922.9	687.56	687.69	687.78
9906.8	687.55	687.67	687.77
9739.5	687.31	687.41	687.48
9596.6	687.03	687.12	687.20
9458.2	686.66	686.74	686.80
9310.8	686.24	686.30	686.34
9200.8	685.88	685.92	685.95
9081.0	685.58	685.61	685.64
8929.1	684.86	684.93	684.98
8801.4	684.66	684.68	684.69

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Ross Creek			
8553.3	683.43	683.51	683.58
8324.0	682.36	682.42	682.48
8107.9	681.11	681.19	681.23
7695.0	679.12	679.22	679.36
7286.4	676.98	677.09	677.20
7051.3	676.01	676.03	676.06
6863.2	675.15	675.23	675.29
6733.0	674.73	674.78	674.82
6293.8	672.18	672.27	672.35
6065.7	671.29	671.38	671.46
5845.8	670.44	670.51	670.58
5538.4	669.34	669.44	669.53
5170.0	668.70	668.75	668.81
4558.3	666.56	666.70	666.82
4292.7	666.26	666.37	666.47
4061.2	665.49	665.57	665.66
3823.7	665.08	665.22	665.29
3693.4	664.81	664.99	665.05
3545.6	664.12	664.27	664.43
3439.6	663.98	664.15	664.29
3384.2	663.77	663.94	664.08
3255.6	663.54	663.72	663.85
3057.0	663.20	663.39	663.50
2925.3	662.94	663.16	663.27
2915.3	662.84	663.11	663.23
2772.2	662.39	662.76	662.86
2571.8	662.12	662.56	662.62
2370.4	661.92	662.41	662.44
2261.4	661.85	662.36	662.38
2160.5	661.61	662.18	662.18
2144.8	661.46	661.76	661.81
2032.1	661.45	661.77	661.80
1780.2	661.40	661.72	661.75
1674.7	661.35	661.68	661.69
1611.1	661.27	661.60	661.59
1596.5	661.05	661.37	661.39
1527.2	661.07	661.40	661.42
1487.6	661.06	661.39	661.41
1436.9	661.05	661.38	661.39
1300.3	661.04	661.37	661.37
1282.3	661.03	661.36	661.37
1278.5	661.03	661.36	661.37
1246.6	661.03	661.36	661.37
1118.0	661.01	661.34	661.35
1024.6	660.98	661.31	661.31
880.3	660.99	661.22	661.30
756.7	660.99	661.23	661.31
540.2	660.98	661.21	661.29
430.8	660.96	661.18	661.26
278.9	660.95	661.17	661.24
Average Difference	-0.15	0.00	0.08
Maximum Difference	-0.57	0.00	0.16
Seven Persons Creek			
24132.0	711.61	711.66	711.71
23979.0	711.57	711.62	711.66
23814.3	711.37	711.39	711.42
23806.4	710.15	710.14	710.14
23646.6	710.47	710.51	710.54

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Seven Persons Creek			
23492.8	710.41	710.43	710.45
23469.9	710.31	710.35	710.37
23465.2	710.33	710.36	710.39
23401.0	710.20	710.23	710.26
23368.6	708.99	709.06	709.12
23292.4	708.79	708.86	708.92
23259.5	708.80	708.86	708.91
23215.0	708.74	708.8	708.84
23116.8	708.67	708.7	708.73
23034.0	707.95	708.04	708.12
22947.6	707.24	707.42	707.55
22873.0	707.19	707.39	707.53
22770.6	707.12	707.29	707.44
22664.2	706.83	706.96	707.14
22575.2	706.56	706.67	706.74
22463.8	706.32	706.42	706.50
22361.4	705.90	706.03	706.11
22267.2	705.81	705.96	706.04
22141.5	705.69	705.85	705.92
22049.5	705.47	705.6	705.69
21928.3	705.12	705.2	705.26
21802.7	704.86	704.94	705.01
21685.0	704.61	704.71	704.78
21587.7	704.45	704.54	704.63
21553.4	704.46	704.57	704.66
21455.3	704.40	704.5	704.59
21315.9	704.12	704.22	704.31
21210.3	703.85	703.94	704.01
21109.4	703.60	703.68	703.76
21009.9	703.34	703.43	703.51
20908.5	703.13	703.22	703.29
20811.2	702.91	703	703.09
20688.4	702.64	702.75	702.84
20603.5	702.42	702.53	702.62
20492.0	702.27	702.39	702.49
20389.2	702.17	702.28	702.37
20204.6	701.94	702.04	702.12
20050.3	701.81	701.91	701.99
19964.2	701.71	701.8	701.88
19853.8	701.60	701.69	701.77
19715.1	701.29	701.39	701.47
19603.7	701.04	701.14	701.22
19456.1	700.67	700.75	700.84
19327.9	700.34	700.4	700.45
19216.2	699.96	700.08	700.17
19152.2	699.96	700.06	700.14
19110.7	699.86	699.96	700.03
19001.8	699.62	699.7	699.76
18889.7	699.51	699.58	699.64
18787.3	699.40	699.46	699.52
18675.0	699.29	699.35	699.39
18564.5	698.92	698.94	698.95
18493.6	698.68	698.66	698.67
18486.4	698.20	698.27	698.38
18433.7	698.25	698.35	698.44
18350.8	698.13	698.23	698.32
18280.2	698.03	698.12	698.19
18275.2	697.94	698.04	698.13

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Seven Persons Creek			
18219.2	697.74	697.83	697.91
18130.4	697.69	697.78	697.86
18125.6	697.67	697.75	697.83
18003.8	697.51	697.59	697.67
17904.9	697.42	697.49	697.57
17802.4	697.14	697.19	697.28
17797.8	697.07	697.18	697.28
17719.1	696.98	697.07	697.16
17604.0	696.71	696.81	696.91
17597.6	696.54	696.69	696.82
17498.8	696.46	696.59	696.70
17356.6	696.08	696.23	696.34
17263.3	696.03	696.18	696.29
17143.1	695.96	696.09	696.20
17042.6	695.89	696.02	696.12
16936.4	695.71	695.83	695.93
16930.8	695.64	695.75	695.85
16848.0	695.27	695.38	695.47
16772.0	695.09	695.2	695.30
16639.9	695.03	695.13	695.21
16542.3	694.99	695.08	695.15
16415.3	694.86	694.93	695.00
16311.9	694.70	694.77	694.83
16207.6	694.59	694.64	694.68
16142.0	694.38	694.42	694.47
16135.6	694.27	694.36	694.44
16093.3	694.24	694.32	694.39
16002.5	694.06	694.16	694.24
15896.8	693.88	693.98	694.06
15789.6	693.75	693.84	693.92
15677.4	693.61	693.69	693.77
15552.8	693.39	693.46	693.53
15468.3	693.11	693.16	693.24
15462.3	693.07	693.17	693.26
15421.3	693.02	693.12	693.21
15329.5	692.86	692.97	693.06
15269.9	692.67	692.78	692.87
15168.7	692.60	692.72	692.82
15148.4	692.54	692.66	692.76
15076.5	692.44	692.56	692.66
14958.9	692.24	692.35	692.45
14861.4	692.19	692.29	692.38
14748.8	691.96	692.06	692.14
14609.8	691.67	691.76	691.83
14511.3	691.55	691.63	691.70
14406.1	691.47	691.55	691.61
14327.1	691.36	691.42	691.47
14247.1	690.70	690.77	690.84
14233.3	690.52	690.59	690.66
14107.9	690.27	690.36	690.44
14000.3	690.13	690.23	690.31
13838.9	689.82	689.93	690.02
13689.0	689.63	689.73	689.81
13570.5	689.48	689.57	689.64
13465.0	689.29	689.41	689.49
13347.3	689.18	689.3	689.40
13257.6	689.15	689.25	689.35
13120.9	689.02	689.11	689.22

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Seven Persons Creek			
13053.1	688.92	689.01	689.10
12910.6	688.82	688.9	688.99
12787.5	688.50	688.54	688.57
12634.7	688.20	688.24	688.27
12461.4	687.75	687.81	687.87
12300.2	687.41	687.5	687.58
12199.8	687.34	687.43	687.51
12118.9	687.25	687.34	687.42
11920.7	686.93	687.02	687.09
11797.6	686.75	686.84	686.92
11676.2	686.55	686.63	686.69
11518.8	686.19	686.27	686.33
11372.4	685.98	686.05	686.12
11252.6	685.72	685.81	685.88
11204.4	685.59	685.65	685.72
11094.5	685.39	685.47	685.56
10959.3	685.08	685.21	685.31
10870.9	684.91	685.03	685.13
10864.9	684.88	684.99	685.09
10774.9	684.52	684.64	684.71
10671.2	684.21	684.35	684.42
10532.7	683.70	683.83	683.95
10428.8	683.61	683.75	683.87
10290.2	683.36	683.49	683.60
10139.9	683.09	683.21	683.31
10023.9	682.78	682.88	682.95
9909.5	682.51	682.6	682.67
9796.8	682.05	682.16	682.25
9668.4	682.03	682.13	682.20
9490.1	681.92	682	682.06
9399.0	681.68	681.75	681.81
9262.0	681.19	681.26	681.31
9138.7	681.10	681.15	681.18
9098.7	680.85	680.92	680.98
9091.1	680.81	680.87	680.93
9008.6	680.52	680.59	680.66
8998.5	680.55	680.62	680.68
8932.1	680.41	680.46	680.50
8858.1	680.17	680.21	680.25
8817.2	679.98	680	680.04
8778.3	679.91	679.91	679.93
8772.7	679.50	679.64	679.73
8621.0	679.25	679.38	679.43
8547.6	679.06	679.13	679.22
8469.2	679.00	679.08	679.14
8342.1	678.78	678.85	678.92
8336.0	678.73	678.8	678.86
8329.6	678.69	678.76	678.83
8322.1	678.60	678.68	678.75
8269.4	678.57	678.65	678.71
8118.4	678.11	678.21	678.28
8113.9	678.07	678.15	678.22
8096.6	678.10	678.18	678.24
8019.4	678.06	678.12	678.18
8015.7	678.04	678.1	678.14
7935.7	677.89	677.93	677.97
7853.4	677.69	677.72	677.75
7848.8	677.61	677.64	677.67

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Seven Persons Creek			
7744.0	677.39	677.43	677.46
7660.1	677.04	677.1	677.16
7582.7	676.85	676.93	677.00
7518.9	676.81	676.88	676.95
7362.8	676.15	676.21	676.27
7248.0	675.86	675.97	676.05
7243.0	675.84	675.94	676.01
7223.8	675.82	675.92	676.00
7189.7	675.78	675.87	675.96
7179.7	675.76	675.85	675.93
7063.7	675.64	675.71	675.78
6924.6	675.54	675.61	675.66
6795.3	675.46	675.51	675.56
6751.5	675.38	675.43	675.47
6743.6	675.36	675.41	675.45
6699.1	675.33	675.37	675.40
6635.3	675.07	675.1	675.13
6630.0	674.60	674.67	674.75
6545.6	674.22	674.28	674.34
6453.8	673.97	674.03	674.11
6366.3	673.69	673.79	673.90
6302.8	673.61	673.7	673.82
6294.7	673.59	673.69	673.81
6248.0	673.51	673.6	673.72
6151.5	673.34	673.41	673.54
6147.4	673.32	673.4	673.54
6033.8	672.61	672.72	672.82
5749.0	672.44	672.52	672.58
5594.2	672.08	672.16	672.23
5442.7	671.73	671.82	671.89
5281.5	671.60	671.69	671.75
5265.2	671.52	671.62	671.68
5177.1	671.45	671.54	671.61
5037.8	671.28	671.32	671.40
5031.7	671.19	671.25	671.28
4920.1	671.21	671.26	671.31
4783.1	671.16	671.2	671.23
4651.3	671.06	671.09	671.13
4564.5	669.72	669.79	669.85
4546.4	669.72	669.78	669.85
4527.2	669.65	669.71	669.78
4522.3	669.35	669.44	669.54
4514.5	668.74	668.92	669.06
4417.1	668.69	668.8	668.93
4328.8	668.43	668.53	668.68
4207.2	667.88	667.82	667.67
4204.8	667.03	667.13	667.20
4148.9	667.02	667.11	667.16
4108.8	666.80	666.9	666.95
4106.2	666.73	666.82	666.88
4046.3	666.62	666.71	666.77
3949.4	666.33	666.4	666.45
3828.7	666.10	666.19	666.27
3736.9	666.04	666.12	666.19
3725.7	665.96	666.03	666.09
3722.7	665.94	666	666.05
3617.9	665.67	665.72	665.76
3482.9	665.38	665.38	665.37

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Seven Persons Creek			
3457.0	665.39	665.4	665.41
3412.4	664.87	664.94	665.00
3308.0	664.58	664.62	664.64
3222.6	664.31	664.3	664.28
3212.0	664.05	664.11	664.15
3078.5	663.77	663.78	663.79
3005.7	663.67	663.67	663.67
2995.0	663.29	663.34	663.37
2981.1	663.19	663.22	663.25
2975.1	663.18	663.23	663.27
2847.3	663.06	663.11	663.15
2729.6	662.95	663	663.04
2718.7	662.88	662.91	662.94
2605.9	662.75	662.77	662.78
2510.0	662.65	662.65	662.64
2475.9	662.56	662.55	662.52
2432.0	662.09	662.14	662.15
2401.8	662.00	662.07	662.09
2265.7	661.81	661.9	661.92
2137.6	661.62	661.75	661.78
2019.5	661.56	661.69	661.72
1914.6	661.45	661.6	661.63
1787.7	661.20	661.45	661.48
1782.5	661.23	661.48	661.51
1670.8	661.28	661.49	661.52
1553.9	661.27	661.49	661.51
1444.1	661.27	661.48	661.51
1317.1	661.26	661.48	661.50
1201.0	661.26	661.48	661.50
1154.8	661.24	661.45	661.46
1133.6	661.22	661.44	661.45
1106.4	661.21	661.42	661.44
1072.4	661.18	661.37	661.39
1056.1	661.04	661.34	661.38
936.7	661.04	661.35	661.38
812.3	661.03	661.34	661.37
673.0	661.03	661.34	661.37
547.4	661.02	661.33	661.36
530.6	661.02	661.33	661.36
445.3	661.02	661.33	661.36
349.9	661.02	661.33	661.36
336.6	661.02	661.33	661.36
221.9	661.01	661.32	661.35
130.4	661.01	661.31	661.34
111.9	661.00	661.31	661.34
Average Difference	-0.10	0.00	0.06
Maximum Difference	-0.31	0.00	0.18
Bullshead Creek			
10053.5	713.11	713.12	713.12
9993.1	713.11	713.11	713.12
9938.7	711.81	711.86	711.90
9890.4	711.73	711.78	711.82
9785.5	711.46	711.53	711.59
9703.5	711.38	711.44	711.49
9618.6	711.27	711.32	711.37
9554.6	711.16	711.21	711.25
9462.0	711.00	711.04	711.07
9359.6	710.74	710.79	710.83

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Bullshead Creek			
9294.5	710.54	710.59	710.64
9216.0	710.45	710.50	710.54
9151.3	710.31	710.35	710.40
9065.8	710.14	710.21	710.27
8982.7	710.07	710.15	710.22
8850.0	710.04	710.12	710.18
8697.1	710.03	710.10	710.16
8623.6	710.01	710.08	710.14
8512.3	709.99	710.06	710.12
8398.1	709.95	710.02	710.08
8299.0	709.89	709.97	710.03
8234.5	709.85	709.92	709.98
8150.3	709.80	709.88	709.93
8006.8	709.73	709.80	709.85
7886.3	709.51	709.59	709.64
7757.4	709.13	709.21	709.26
7691.1	708.99	709.05	709.10
7578.9	708.77	708.83	708.88
7508.7	708.57	708.63	708.68
7390.9	708.24	708.29	708.34
7293.8	707.98	708.04	708.10
7211.3	707.86	707.93	708.01
7112.9	707.79	707.87	707.95
6975.5	707.71	707.80	707.87
6844.0	707.62	707.71	707.79
6730.1	707.43	707.52	707.59
6606.0	707.28	707.36	707.42
6475.0	707.12	707.18	707.23
6369.7	707.02	707.06	707.10
6270.0	706.98	707.01	707.04
6152.9	706.98	707.00	707.03
6056.7	706.97	707.00	707.02
5897.3	706.97	706.99	707.01
5745.9	706.95	706.97	706.99
5628.5	706.94	706.95	706.97
5520.0	706.94	706.95	706.96
5410.4	706.94	706.94	706.95
5300.0	706.93	706.94	706.95
5159.7	706.93	706.94	706.94
5050.0	706.93	706.93	706.94
4918.0	706.93	706.93	706.94
4790.7	706.93	706.93	706.94
4681.6	706.93	706.93	706.93
4553.6	706.93	706.93	706.93
4443.3	706.93	706.93	706.93
4329.7	706.93	706.93	706.93
4283.3	706.93	706.93	706.93
4247.5	704.06	704.13	704.20
4201.1	704.05	704.12	704.18
4078.5	703.92	703.96	703.99
3967.2	703.87	703.90	703.92
3879.3	703.85	703.88	703.89
3765.9	703.85	703.87	703.88
3652.8	703.85	703.87	703.88
3566.8	703.84	703.85	703.86
3502.4	703.79	703.79	703.77
3471.6	702.73	702.74	702.73
3464.9	702.74	702.74	702.73

Table C3: Sensitivity Analysis results for overbank roughness (continued)

River Station (m)	100-Year Flood Levels (m) for Varying Overbank Roughness		
	Low Overbank Roughness (-20%)	Adopted/Calibrated Roughness	High Overbank Roughness (+20%)
Bullshead Creek			
3446.8	701.99	702.06	702.18
3336.1	701.99	702.09	702.18
3330.2	701.98	702.08	702.16
3251.6	701.74	701.83	701.92
3245.1	701.62	701.72	701.80
3144.1	701.37	701.45	701.54
3138.1	701.31	701.41	701.49
3045.3	701.23	701.31	701.38
2930.8	701.10	701.16	701.21
2924.8	700.85	700.87	700.89
2909.6	700.36	700.34	700.33
2882.2	699.87	699.97	700.06
2821.1	699.80	699.90	699.99
2741.3	699.76	699.86	699.95
2627.4	699.73	699.82	699.91
2553.4	699.71	699.80	699.88
2484.8	699.51	699.56	699.61
2475.5	699.38	699.39	699.39
2426.5	699.42	699.43	699.44
2385.7	699.36	699.33	699.30
2344.7	697.93	697.97	698.02
2256.0	697.15	697.20	697.25
2138.0	696.46	696.52	696.58
2046.2	695.91	695.95	696.00
1941.4	695.12	695.20	695.24
1800.7	694.49	694.61	694.66
1679.2	694.19	694.30	694.36
1562.4	693.44	693.49	693.53
1464.8	692.82	692.89	692.94
1337.7	692.00	692.05	692.10
1227.5	691.43	691.51	691.57
1068.7	690.56	690.61	690.65
982.6	689.85	689.91	689.96
872.0	689.20	689.27	689.33
719.4	688.44	688.48	688.51
603.0	687.85	687.92	687.97
471.9	686.96	686.96	686.99
310.3	686.04	686.11	686.16
170.8	684.98	685.04	685.11
41.6	684.66	684.68	684.69
Average Difference	-0.05	0.00	0.04
Maximum Difference	-0.12	0.00	0.12

Appendix D
Open Water Flood Inundation Map Library

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