March 2022

HIGHWOOD RIVER HAZARD STUDY

Open Water Flood Inundation Mapping

Submitted to:
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REPORT

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Golder Associates

Executive Summary

Alberta Environment and Parks (AEP) commissioned Golder Associates Ltd. (Golder) to undertake the Highwood River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Highwood River and the upper reach of the Little Bow River. The study is conducted under the provincial Flood Hazard Identification Program (FHIP), the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. Project stakeholders include the Government of Alberta, Foothills County, Town of High River (High River), Village of Longview, and the public.

The study consists of seven primary components: (i) Survey and Base Data Collection, (ii) Hydraulic Model Creation and Calibration, (iii) Open Water Flood Inundation Map Production, (iv) Open Water Flood Hazard Identification, (v) Governing Design Flood Hazard Map Production, (vi) Flood Risk Assessment & Inventory, and (vii) Channel Stability Investigation. A stand-alone report was prepared for each of these components.

This report documents the methodology and results of the open water flood inundation mapping component, including the inundation maps for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year open water floods. The study area includes the river reaches summarized in Table i.

Table i: River Reaches in the Study Area

River	Reach Description	Length
Highwood River	A location upstream of Longview to its confluence with Bow River	93 km
Little Bow River	An overland flow area south of High River to a location approximately 1 km downstream of Highway 2	14 km

The flood inundation maps were prepared in ArcGIS based on the results of model runs using a coupled 1D/2D hydraulic model for the study area (HEC-RAS Version 5.0.7). The edge of inundation was delineated by subtracting the LiDAR DTM from the simulated water surface. The following types of flood inundation were mapped:

- Direct inundation where there is a direct overland connection between the main river channels and inundated areas on the floodplains. This includes special areas where inundation is caused by single or multiple overtopping points.
- Flooding behind flood control structures (flood control structure failure inundation).

Based on the simulation results, the main residential areas to be affected by open water flooding along the Highwood River include those listed below:

- There are several farmhouses and buildings located on the right floodplain upstream of the Highwood Diversion Canal Headgates which would be inundated during the flood events with return periods of 35 years or higher.
- The residences between the Highwood Diversion Canal Headgates and 72nd Street E would be inundated during the flood events with return periods of 10 years or higher.

- The residential area in the community northwest of High River behind the Northwest Dike, Golf Course Dike and Lineham Canal Dike would be inundated during the flood events with return periods of 200 years or higher.
- The Golf Course south of the Golf Course Dike would be inundated during the flood events with return periods of 10 years or higher.
- The residential areas in the northwest community of the Town of High River would be inundated during the flood events with return periods of 200 years or higher.
- The residential area on the river floodplain east of Centre Street N in the Town of High River would be inundated during the flood events with return periods of 200 years or higher.
- Farmhouse behind the Southwest Dike would be inundated during the flood events with return periods of 200 years or higher.
- George Lane Park would be inundated during the flood events with return periods of 350 years or higher.
- High River General Hospital would be inundated during the flood events with return periods of 350 years or higher.
- Most of the residential area in the northeast community of the Town of High River including the Senator Riley School, would be inundated during the flood events with return periods of 350 years or higher.
- The Hampton Heights would be inundated during the flood events with return periods of 350 years or higher.
- Residences in the area downstream of the Town of High River (Highway 543) would be inundated during the flood events with return periods of 50 years or higher.

The main areas to be affected by open water flooding along the Little Bow River include the following:

- The new development area south of 12th Avenue SE between the 88th Street E and 104th Street E would be inundated during the flood events with return periods of 200 years or higher.

Acknowledgements

Golder Associates Ltd. (Golder) acknowledges the contributions of the following staff of Alberta Environment and Parks (AEP) to the component of Open Water Flood Inundation Mapping as part of the Highwood River Hazard Study:

- Mr. Jim Choles, AEP's project manager for the study, coordinated the participation from AEP, and provided technical advice and review comments on this report.
- Mr. Muhammad Durrani, AEP's project manager for the study, supplied the available and relevant information from AEP and provided technical advice and review comments on this report.
- Mr. Peter Onyshko, AEP's technical advisor for the study, provided study technical review and overall technical guidance.

The contributions of the following staff from Golder are acknowledged:

- Dr. Hua Zhang, Golder's project manager, was responsible for regular communications with AEP, and overseeing the HEC-RAS modelling, flood inundation mapping and preparation of this report.
- Dr. Dejiang Long, Golder's senior reviewer and director for the project, was responsible for providing senior inputs and review, quality control and assurance for the study, and reviewing this report.
- Dr. Wolf Ploeger, Golder's senior reviewer. He was involved in the conceptual planning for the model setup and reviewed the modelling and mapping results.
- Mr. Jie Chen, Golder's hydrodynamic modelling specialist and project engineer for this study, was responsible for conducting the HEC-RAS modelling, overseeing preparation of the flood inundation maps, and preparing this report.
- Mr. Amir Gharavi, Golder's hydrodynamic modelling specialist. He was responsible for the coupled 1D/2D model setup and calibration.
- Mr. Peter Thiede, Golder's GIS specialist, was responsible for preparation of the flood inundation maps and provided inputs to this report.
- Mr. Sean Kurash, Golder's GIS specialist, was involved with preparation of the flood inundation maps.

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1.0 INTRODUCTION

1.1 Study Objectives

Alberta Environment and Parks (AEP) initially commissioned Golder Associates Ltd. (Golder) in September 2015 to undertake the Highwood River Hazard Study. In May 2021, AEP retained Golder to update the HEC-RAS model and inundation maps due to the construction of dikes at Town of High River. The primary purpose of the study is to assess and identify river and flood hazards along the Highwood River and the upper reach of the Little Bow River. Project stakeholders include the Government of Alberta, Foothills County, Town of High River, Village of Longview, and the public.

The study was conducted under the provincial Flood Hazard Identification Program (FHIP). The study consists of seven primary components: (i) Survey & Base Data Collection, (ii) Hydraulic Model Creation and Calibration, (iii) Open Water Flood Inundation Map Production, (iv) Open Water Flood Hazard Identification, (v) Governing Design Flood Hazard Map Production, (vi) Flood Risk Assessment and Inventory, and (vii) Channel Stability Investigation. A stand-alone report was prepared for each of these components.

This report documents the methodology and results of the open water inundation mapping, which provides qualitative and limited quantitative information about flood inundation extents and special zones along the study reaches. The tasks associated with this component include a description of open water flood inundation map production, flood water surface TIN development, and flood depth grid creation for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500- , 750- and 1,000-year flood events.

1.2 Study Area and Reaches

The study area includes approximately 93 km of the Highwood River reach and approximately 14 km of the Little Bow River reach as shown in Table 1 and Figure 1. The Highwood River study reach extends from a location upstream of Longview to its confluence with the Bow River. There are two major tributaries along the Highwood River study reach (i.e., Stimson Creek and Sheep River). The Little Bow River study reach extends from the overland flow area south of the Town of High River to a location approximately 2 km downstream of Highway 2.

The study area includes the communities of Village of Longview, Town of High River, and Municipal District of Foothills.

Table 1: River Reaches in the Study Area

River	Reach Description	Length
Highwood River	A location upstream of Longview to its confluence with Bow River	93 km
Little Bow River	An overland flow area south of High River to a location approximately 1 km downstream of Highway 2	14 km

1.3 Work Scope

The scope of the open water flood inundation mapping component includes the following tasks:

- Open Water Flood Inundation Map Production,
- Flood Water Surface TIN Development, and
- Flood Depth Grid Creation.

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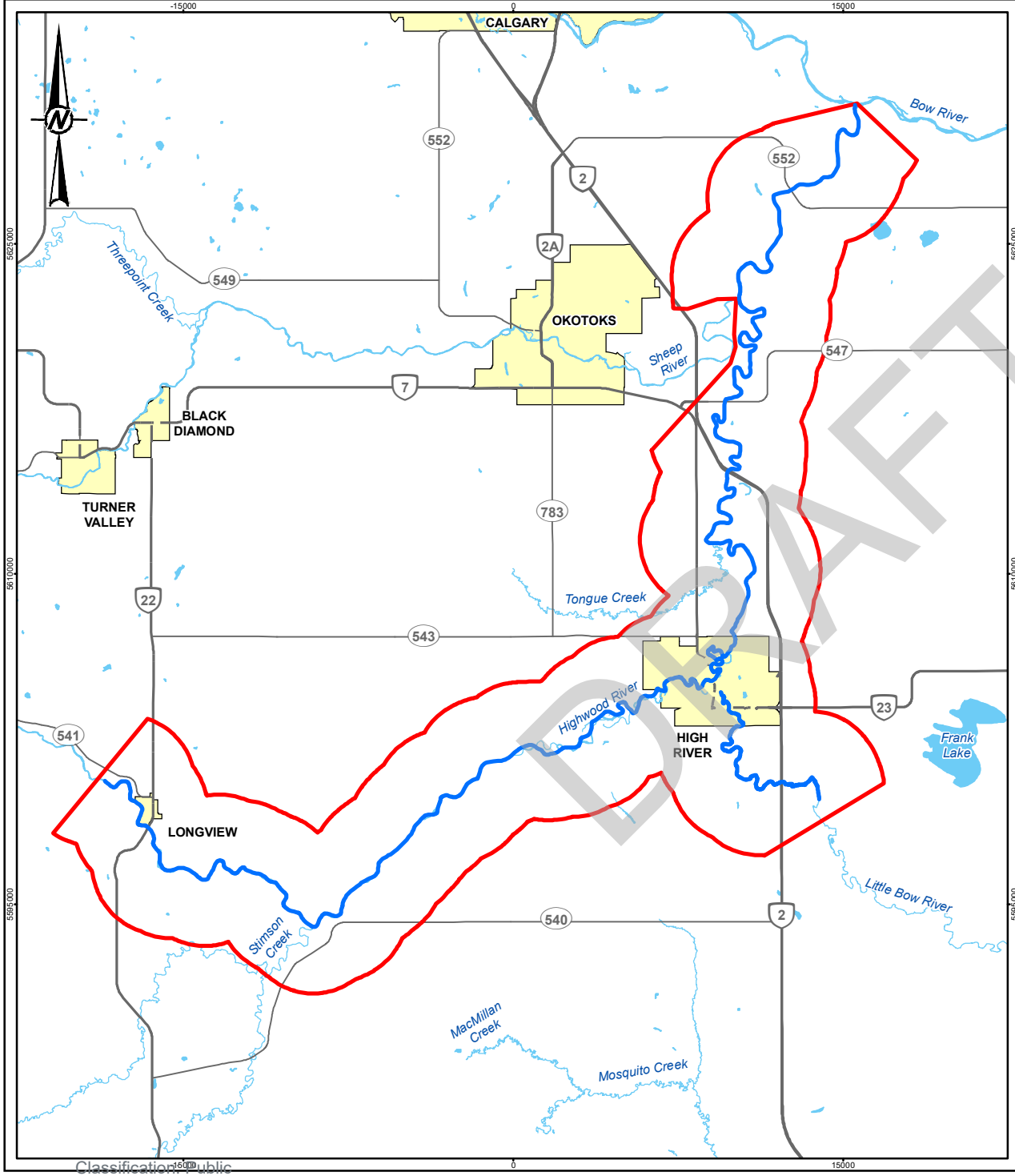

LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- STUDY REACH
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- RIVER HAZARD STUDY AREA

0 5 10

1:275,000 KILOMETRES

REFERENCE(S)

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DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

Alberta Government

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
STUDY AREA

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-03-10
DESIGNED	JC
PREPARED	PT
REVIEWED	JC
APPROVED	HZ

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2.0 AVAILABLE DATA

2.1 Flood Frequencies

The Highwood River watershed extends from the eastern slopes of the Rocky Mountains below Peter Lougheed Provincial Park, eastward to the Town of High River, and then north to the Highwood River confluence with the Bow River, southeast of Calgary. The Highwood River flows through the Village of Longview and Town of High River. The Highwood River has no major impoundments. The river water use consists primarily of diversions to the Little Bow, and licensed withdrawals for irrigation, livestock watering, and municipal purposes.

The Highwood River drains an area of 774 km^2 at the WSC gauge 05BL019 (Highwood River at Diebel's Ranch) and an area of 1950 km^2 at WSC gauge 05BL004 (Highwood River below Little Bow Canal). WSC gauge 05BL024 (Highwood River near the Mouth) is located near the Highwood River confluence with the Bow River, and has a reported drainage area of 3,950 km^2.

The Stimson Creek and Sheep River are the two major tributaries to the Highwood River within the study area. The Stimson Creek joins the Highwood River near Hogg Park with a drainage area of 468 km^2 based on the drainage basin delineation. The Sheep River flow into the Highwood River near Aldersyde with a drainage area of 1,570 km^2 at its confluence with the Highwood River.

Table 2 summarized the flood frequency estimates at key flow change locations used in this study. These estimates are the instantaneous flood peak discharges for the natural flow conditions, based on the Bow, Elbow, Highwood, and Sheep River Hydrology Assessment Report (Golder 2017a), regional hydrologic analysis, and the analysis presented in the Hydraulic Model Creation and Calibration for the Highwood River Hazard Study (Golder 2022).

2.2 DTM and Aerial Imagery

A detailed description of the LiDAR DTM data and survey data is provided in the Survey and Base Data Collection Report of the Highwood River Hazard Study (Golder 2017b). The High River Southwest Dike was constructed after completion of the Survey and Base Data Collection Report (Golder 2017a). This new dike was included in the updated hydraulic model and on the updated inundation maps.

The aerial imagery of the study area was collected on May 6, 2016. The imagery has a 30 cm Ground Sampling Distance (GSD) resolution and is delivered as 4-band orthophotos and stereo images. The deliverables include aerial triangulation data, metadata, camera calibration reports, flight report and an index of the aerial imagery tiles. A technical memorandum describing the 2016 aerial imagery acquisition is provided in Appendix E of the Survey and Base Data Collection Report of the Highwood River Hazard Study.

Table 2: Summary of Flood Peak Flows at the Flow Change Locations Used in the HEC-RAS Model

Location	River	HEC-RAS Cross Section	Discharges of Various Return Periods (m^3/s)													Notes
			2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1,000-year	
Highwood River Upstream Boundary	Highwood River	93299.49	78.9	165	251	377	516	627	860	1080	1700	2330	2780	3340	3830	
Highwood River Downstream of Stimson Creek Confluence	Highwood River	77157.94	118	231	342	508	696	849	1210	1560	2600	3630	4380	5330	6160	Added flow from Stimson Creek Confluence
Highwood River Downstream of Sheep River confluence	Highwood River	14238.65	213	400	575	836	1084	1285	1662	2004	2960	3792	4404	5099	5602	Added flow from Sheep River
Little Bow River	Little Bow River	2D Model Area	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Upstream of Little Bow Channel

2.3 HEC-RAS Model

2.3.1 HEC-RAS Program

The HEC-RAS program (Version 5.0.7) was used to develop a coupled one/two-dimensional (1D/2D) hydraulic model for the study area. The HEC-RAS program was developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE).

2.3.2 HEC-RAS Production Model

The HEC-RAS modelling approach included the following:

- 1D model for the full length of the Highwood River study reach based on surveyed river cross sections.
- 2D model for the right floodplain of the Highwood River from approximately 4 km upstream of the Town of High River to 1 km downstream of the Highway 2 Bridge and the full length of the Little Bow River.

The 1D and 2D model domains are connected using a series of lines (lateral structures) that first follow roughly the right top of bank for the Highwood River, then the Town Dikes and then again the right top of bank downstream of the Town. The Little Bow River was modelled in a full 2D model to avoid any further internal boundary conditions. The 2D model area and lateral structures are shown in Figure 2.

Two separate topographies were used for the hydraulic modelling:

- Pre-2013 flood dike conditions: Topography at the time of the 2013 flood event. At that time, limited flood control structures were place, resulting in wide-spread flowing towards the Town of High River and surrounding floodplains.
- Post-2013 flood dike conditions: Topography was updated to include recently completed flood control structures within the study area to account for current conditions.

The coupled 1D/2D model with pre-2013 flood dike conditions was calibrated using low flows conditions, 2005 and 2013 flood events, and rating curves at two hydrometric gauging stations (05BL004 and 05BL024). The topography of the calibrated model was then updated to include post-2013 flood dike conditions.

The production model developed based on the post-2013 flood dike conditions was used to simulate surface water levels for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750- and 1,000-year flood events. The model was run in unsteady-state mode with constant flows (quasi-steady). A detailed description of the hydraulic model creation and calibration is presented in the Hydraulic Model Creation and Calibration report (Golder 2022).

2.3.3 Modelling Results

The open water flood profiles for the 13 flood events along the study reaches of Highwood River and Little Bow River are presented in the Hydraulic Model Creation and Calibration report (Golder 2022).

The open water flood water levels for each cross section along the 1D study reach of Highwood River and for river station points along the Little Bow River in the 2D model area are listed in Appendix C of the Hydraulic Model Creation and Calibration report. The simulated surface water levels are used to prepare the flood inundation maps for each of the 13 flood events presented in this report.

2.4 Flood Control Structures

There are 13 flood control structures along the Highwood River study reach within the Town of High River (see Table 3). The flood control structures are mostly earthen barriers integrated within the pathway system in the Town of High River. The locations of these structures are presented in the Survey and Base Data Collection Report (Golder 2017b). The Southwest Dike was constructed after completion of the Survey and Base Data Collection Report. However, this new dike was included in the updated hydraulic model.

There is no flood control structure along the Little Bow River study reach.

Table 3: Flood Control Structures in the Study Area

River	No.	Side of River[a]	Length [m]	Name	Description	Type
Highwood River	1	Right	840	Hoeh Dyke 1	7.5 km Upstream of High River	Earthfill Barrier
	2	Right	635	Hoeh Dyke 2	6.5 km Upstream of High River	Earthfill Barrier
	3	Right	378	Bews Dyke	5.3 km Upstream of High River	Earthfill Barrier
	4	Right	283	Baker Creek Dyke 1	South of 12 Ave. SW and West of 72 Street E	Earthfill Barrier
	5	Right	70	Baker Creek Dyke 2	South of 12 Ave. SW and East of 72 Street E	Earthfill Barrier
	6	Right	2,190	Town Dike	Happy Trails from Center Street to 12 Ave. SW	Earthfill Barrier
	7	Left	2,050	Northwest Dyke	From South of Riverside Drive NW to South of Range Road 291	Earthfill Barrier
	8	Left	1,390	Golf Course Dyke	South of Highwood Golf & Country Club	Earthfill Barrier
	9	Left	366	Lineham Canal Dyke	Happy Trails Downstream of Happy Trails Bridge	Earthfill Barrier
	10	Right	1,100	Little Bow Canal Dyke	Happy Trails from Center Street to 96 Street E	Earthfill Barrier
	11	Right	2,590	Southwest Dike	From 12 Ave SW to Rang Rd 291 (88 Street E)	Earthfill Barrier
	12	Right	519	5 Street Dike North	West of 5 St NE and South of 498 Ave E	Earthfill Barrier
	13	Right	490	5 Street Dike South	West of 5 St NE	Earthfill Barrier

a) Right and left sides of the river are relative to an observer looking downstream.

3.0 FLOOD INUNDATION MAPS

3.1 Methodology

Flood inundation maps were prepared based on the following information:

- simulated water levels at individual cross sections (1D model reach) and within the 2D model area for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750- and 1,000-year flood events;
- locations and extents of individual cross sections along the Highwood River reach;
- topography from the recent LiDAR survey collected for this study;
- aerial imagery of the study area collected on May 6, 2016; and
- information about permanent flood control structures, including new dikes constructed after the 2013 flood event (post-2013 flood dike conditions).

The 1D model reach cross sections in ArcGIS were attributed with the water level output from the HEC-RAS production model. The model cross sections were extended where required to cover the maximum extents of inundated areas. Water levels between cross sections were linearly interpolated using a Triangulated Irregular Network (TIN) interpolation technique, and a water surface TIN was created.

Water levels within the 2D model area were extracted from the HEC-RAS model and combined with surface created along the 1D model reach to create combined surfaces for each of the 13 flood events that cover the entire study area.

Inundation extents were delineated by intersecting the water surface TINs and the DTM, which includes all relevant flood control structures. Direct flood inundation areas are identified either as being part of the actively-flowing river channels or flooded overbank areas directly connected to the actively-flowing areas.

The delineated inundation areas were then carefully reviewed and modified for the following scenarios:

- Scenario 1 – Single Overtopping Point: At locations where inundated areas are connected to the main channel at a single overtopping point (spill point), the inundation extent was re-evaluated using a constant water level which is equal to that at the spill point.
- Scenario 2 – Multiple Overtopping Points: If there are multiple overtopping points related to a single overflow area, the inundation extent was based on the hydraulic gradient in the main channel between the overtopping points. The inundation extent upstream of the most upstream overtopping point and downstream of the most downstream overtopping point were evaluated using the estimated water levels at these bounding spill points.
- Scenario 3 – Single Overtopping Point Causing Overtopping Downstream: At some locations, Scenario 1 can lead to the following situation: if the area behind the single overtopping location would be (after some time) completely inundated and pooled with a constant water level elevation similar to the water level at the spill point, this may cause a second overtopping further downstream and flow back into the main channel, because at that point the water level behind the embankment may be higher than that in the main channel. In this case, the inundation extent was re-evaluated using a linear interpolation between the water level at the upstream spill point and the ground elevation at the downstream re-entry point.

- Scenario 4 – Potential Flood Inundation due to Flood Control Structure Failure: In areas where permanent flood control structures (see Section 2.4) have been identified and are not overtopped, the protected areas are shown as potentially flooded. The inundation extent is determined by assuming that the flood control structure is ineffective.

  There are two large areas potentially protected by dikes: Town of High River and the community of Hampton Heights. Both areas are within the 2D model area and are protected by dikes up to the 200-year flood event. The 2D model does not show any direct inundation in these protected areas, therefore alternate methods for mapping were used.

Potential Inundation of the Town of High River from the Little Bow River North and South of 12th Avenue:

- Cross sections were created for flood control structure failure mapping proposes to cover the area behind the Southwest Dike, Baker Creek Dike 2, Town Dike and Little Bow Canal Dike. Alignment of these cross sections were carefully selected based on the overall land slopes and the 1,000-year flood inundation water surface elevation contours. For the 5- and 10-year floods, Town Dike failure inundation was mapped using Highwood water levels. For the 20- to 50-year floods, the dike failure inundation from these two dikes are disconnected and cross sections were sloped from the Highwood River water levels to the 2D model water levels near the Southwest Dike up to and including XS479. For the 75-year and higher floods, the Town Dike and Southwest Dike failure inundation is connected and the cross sections take the higher Highwood River water levels. Downstream of XS479 along the Little Bow reach, 2D model predicted water levels are used for all flood events.

  The majority of the above-mentioned overland flood flows would discharge back to the Little Bow River, because the overall land slopes eastward through the Town and towards the Little Bow River. The narrow overland area south of Highway 2A bridge crossing adjacent to the Little Bow Diversion Canal would convey a small portion of flood flows.

Potential Inundation of Hampton Heights:

- The 104th Street has a road section with a minimum crest elevation of 1034.8 m located south of the area of Hampton Estates and south of 12th Avenue. This road section is 0.7 m lower than the 498th Avenue crest elevation of 1035.5 m. For the 20-year to 200-year flood events, S4 (Potential Flood Inundation due to Flood Control Structure Failure) was used with an assumed pool level of 1035.0 m, which is 0.2 m above the minimum road crest elevation along the 104th Street, where there is potential dike failure flow into this area.

3.2 Preparation of Flood Inundation Maps

3.2.1 General

One set of flood inundation maps was prepared for each flood event. The study area is covered by a total of 32 sheets (11-inch x 17-inch). The mapping scale is 1:7,500 except for the Town of High River where the scale is 1:15,000. An additional map sheet shows an overview of the complex overflow area at and around the Town of High River in 1:40,000 scale. The maps were prepared using the local 3-Degree Transverse Mercator (3TM) zone and the Canadian Spatial Reference System North American Datum of 1983 (NAD83 CSRS) coordinate system and datum.

The maps include the 2016 aerial imagery and other base data (roads and railways) provided by AEP. The resulting inundation maps for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750- and 1,000-year flood events are presented in Appendix A.

The flood inundation maps were prepared in a geographical information system (ESRI ArcGIS 10.8). The maps including all layers were provided to AEP as digital files in the ESRI ArcGIS file format.

3.2.2 Manual Edits

3.2.2.1 Locations

Flood inundation mapping at a number of locations required some manual edits in those areas listed below:

- Some areas following under the five scenarios as described in Section 3.1;
- Some inundated areas along the major tributaries;
- Some areas close to residences or key structures which would be inundated due to backwater from downstream locations; and
- All areas behind the flood control structures which were not included in the recent LiDAR survey (e.g., a portion of the Lineham Canal Dike and the floodwall along the Beachwood Dike).

The details of manual edits for each flood event are discussed in the following sections.

3.2.2.2 2-Year Flood Event

The 2-year flood flows would be contained in the channels along most of the study reaches. Table 4 summarises the major manual edits made for the 2-year flood event.

Table 4: Manual Edits for the 2-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Channel between cross sections 304 - 310	Left	304 - 310	Inundated area mapped as backwater
	Tongue Creek	Left	559 - 603	Inundated area mapped as backwater
	North of Sheep River and East of 338 Ave SW	Left	756 - 759	Inundated area mapped as backwater
Little Bow River	None			

3.2.2.3 5-Year Flood Event

The major manual edits made for the 5-year flood event are summarized in Table 5.

Table 5: Manual Edits for the 5-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Channel between cross sections 304 - 310	Left	304 - 310	Inundated area mapped as backwater
	Between Highwood River and 32001 Coal Trail East	Left	349 - 367	Inundated area mapped as backwater
	East of 56 Street East	Right	393 - 400	Inundated area mapped as backwater
	Areas between the Little Bow Canal Dike and right bank of the Little Bow Canal in the Town of High River	Right	473 - 498	Scenario 4
	Channel between cross sections 553 - 578	Left	553 - 578	Inundated area mapped as backwater
	Tongue Creek	Left	559 - 603	Inundated area mapped as backwater

River	Location	Floodplain	Closest Cross Section Number	Description
	South of 2253 Drive East, area between cross sections 844 to 848	Left	844 - 848	Inundated area mapped as backwater
Little Bow River	None			

3.2.2.4 10-Year Flood Event

The major manual edits made for the 10-year flood event are summarized in Table 6.

Table 6: Manual Edits for the 10-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Between Highwood River and 32001 Coal Trail East	Left	349 - 367	Inundated area mapped as backwater
	Area behind the Hoeh Dike 2	Right	362 - 369	Inundated area mapped as backwater
	Community behind the Northwest Dike, Golf Course Dike and Lineham Canal Dike in the Town of High River	Left	425 - 477	Scenario 4
	Community behind the Town Dike in the Town of High River	Right	436 - 472	Scenario 4
	Areas between the Little Bow Canal Dike and right bank of the Little Bow Canal in the Town of High River	Right	473 - 498	Scenario 4
	Channel between cross sections 553 - 578	Left	553 - 578	Inundated area mapped as backwater
	Tongue Creek	Left	559 - 603	Inundated area mapped as backwater
	South of 2253 Drive East, area between cross sections 844 to 848	Left	844 - 848	Inundated area mapped as backwater
Little Bow River	None			

3.2.2.5 20-Year Flood Event

During the 20-year flood event, overland flows would occur in the area south of the 12th Avenue in the Town of High River and spill to the Little Bow River basin. The major manual edits made for the 20-year flood event are summarized in Table 7.

Table 7: Manual Edits for the 20-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Area behind the Hoeh Dike 2	Right	362 - 369	Inundated area mapped as backwater
	Community behind the Northwest Dike, Golf Course Dike and Lineham Canal Dike in the Town of High River	Left	425 - 477	Scenario 4
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels and the overland flood route 2D model water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing

River	Location	Floodplain	Closest Cross Section Number	Description
	Channel between cross sections 553 - 578	Left	553 - 578	Inundated area mapped as backwater
	Tongue Creek	Left	559 - 603	Inundated area mapped as backwater
	South of 2253 Drive East, area between cross sections 844 to 848	Left	844 - 848	Inundated area mapped as backwater
	Stimson Creek	Right	197	Inundated area mapped as backwater
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.6 35-Year Flood Event

The major manual edits made for the 35-year flood event are summarized in Table 8.

Table 8: Manual Edits for the 35-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Area behind the Hoeh Dike 2	Right	362 - 369	Inundated area mapped as backwater
	Community behind the Northwest Dike, Golf Course Dike and Lineham Canal Dike in the Town of High River	Left	425 - 477	Scenario 4
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels and the overland flood route 2D model water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Channel between cross sections 553 - 578	Left	553 - 578	Inundated area mapped as backwater
	Tongue Creek	Left	559 - 603	Inundated area mapped as backwater
	Area between Cross Sections 837 and 846	Right	837 - 846	Inundated area mapped as backwater
	South of 2253 Drive East, area between cross sections 844 to 848	Left	844 - 848	Inundated area mapped as backwater
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.7 50-Year Flood Event

The major manual edits made for the 50-year flood event are summarized in Table 9.

Table 9: Manual Edits for the 50-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Area Northeast of North end of 16th Street West	Right	294 - 297	Scenario 2
	Area behind the Hoeh Dike 2	Right	362 - 369	Inundated area mapped as backwater
	Community behind the Northwest Dike, Golf Course Dike and Lineham Canal Dike in the Town of High River	Left	425 - 477	Scenario 4
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels and the overland flood route 2D model water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Channel between cross sections 553 - 578	Left	553 - 578	Inundated area mapped as backwater
	Tongue Creek	Left	559 - 603	Inundated area mapped as backwater
	Area between Cross Sections 837 and 846	Right	837 - 846	Inundated area mapped as backwater
	South of 2253 Drive East, area between cross sections 844 to 848	Left	844 - 848	Inundated area mapped as backwater
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.8 75-Year Flood Event

The major manual edits made for the 75-year flood event are summarized in Table 10.

Table 10: Manual Edits for the 75-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Left	197	Inundated area mapped as backwater
	Area between cross sections 290 – 293, south of 16 street West	Left	290-293	Inundated area mapped as backwater
	Area between Cross Sections 308 and 313	Right	308 - 313	Inundated area mapped as backwater
	Community behind the Northwest Dike, Golf Course Dike and Lineham Canal Dike in the Town of High River	Left	425 - 477	Scenario 4
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Tongue Creek	Left	559 - 603	Inundated area mapped as backwater
	South of 2253 Drive East, area between cross sections 844 to 848	Left	844 - 848	Inundated area mapped as backwater

River	Location	Floodplain	Closest Cross Section Number	Description
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.9 100-Year Flood Event

The major manual edits made for the 100-year flood event are summarized in Table 11.

Table 11: Manual Edits for the 100-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Left	197	Inundated area mapped as backwater
	Area between Cross Sections 308 and 313	Right	308 - 313	Inundated area mapped as backwater
	Community behind the Northwest Dike, Golf Course Dike and Lineham Canal Dike in the Town of High River	Left	425 - 477	Scenario 4
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Tongue Creek	Left	559 - 603	Inundated area mapped as backwater
	South of 2253 Drive East, area between cross sections 844 to 848	Left	844 - 848	Inundated area mapped as backwater
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.10 200-Year Flood Event

The major manual edits made for the 200-year flood event are summarized in Table 12.

Table 12: Manual Edits for the 200-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Area between Cross Section 282 - 285	Left	282 - 285	Inundated area mapped as backwater
	Back Channel between Cross-Sections 289 and 293	Left	289 - 293	Inundated area mapped as backwater
	Back Channel between Cross-Sections 293 and 296	Left	293 - 296	Inundated area mapped as backwater
	Area between Cross Sections 294 and 295	Left	294 - 295	Inundated area mapped as backwater
	Community behind the Northwest Dike, Golf Course Dike and Lineham Canal Dike in the Town of High River	Left	425 - 477	Scenario 4
	Area behind the Golf Course Dike and Lineham Canal Dike	Left	459- 477	Inundated area mapped as backwater
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest

River	Location	Floodplain	Closest Cross Section Number	Description
				elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Tongue Creek	Left	555 - 573	Inundated area mapped as backwater
	Highwood River Confluence	Right	852	Scenario 3 to Bow River
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.11 350-Year Flood Event

The major manual edits made for the 350-year flood event are summarized in Table 13.

Table 13: Manual Edits for the 350-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Area between Cross Sections 148 and 152	Right	148 - 152	Inundated area mapped as backwater
	Stimson Creek	Right	197	Inundated area mapped as backwater
	Area between Cross Sections 270 and 272	Left	270 - 272	Inundated area mapped as backwater
	Area between Cross Sections 348 and 356	Left	348 - 356	Inundated area mapped as backwater
	Community behind the Northwest Dike in the Town of High River	Left	425 - 442	Scenario 4
	Area behind the Northwest Dike	Left	433- 442	Inundated area mapped as backwater
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Tongue Creek	Left	555 - 573	Inundated area mapped as backwater
	Highwood River Confluence	Right	852	Scenario 4 to Bow River
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.12 500-Year Flood Event

The major manual edits made for the 500-year flood event are summarized in Table 14.

Table 14: Manual Edits for the 500-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Area between Cross Sections 148 and 152	Right	148 - 152	Inundated area mapped as backwater
	Stimson Creek	Right	197	Inundated area mapped as backwater
	Area between Cross Sections 244 and 245	Left	244 - 246	Inundated area mapped as backwater
	Area between Cross Sections 270 and 272	Left	270 - 272	Inundated area mapped as backwater
	Area between Cross Sections 348 and 356	Left	348 - 356	Inundated area mapped as backwater
	Community behind the Northwest Dike in the Town of High River	Left	425 - 442	Scenario 4
	Area behind the Northwest Dike	Left	433- 442	Inundated area mapped as backwater
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels

River	Location	Floodplain	Closest Cross Section Number	Description
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Tongue Creek	Left	555 - 573	Inundated area mapped as backwater
	Highwood River Confluence	Right	852	Scenario 4 to Bow River
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.13 750-Year Flood Event

The major manual edits made for the 750-year flood event are summarized in Table 15.

Table 15: Manual Edits for the 750-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Tongue Creek	Left	544 - 577	Inundated area mapped as backwater
	Highwood River Confluence	Right	852	Scenario 4 to Bow River
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.2.2.14 1,000-Year Flood Event

The major manual edits made for the 1,000-year flood event are summarized in Table 16.

Table 16: Manual Edits for the 1,000-Year Flood Event

River	Location	Floodplain	Closest Cross Section Number	Description
Highwood River	Stimson Creek	Right	197	Inundated area mapped as backwater
	Area bounded by the Town Dike, Southwest Dike, Centre Street and Railway Street	Right	436 - 479	Scenario 4 using cross sections with Highwood River water levels
	Area south of Highway 543	Right	-	Scenario 4 using the water level of 1035.0 m, which is 0.2 m above the 104th Street (or 10th St SE) crest elevation of 1034.8 m at the Little Bow Diversion Canal crossing
	Tongue Creek	Left	544 - 577	Inundated area mapped as backwater
	Highwood River Confluence	Right	852	Scenario 4 to Bow River
Little Bow River	Little Bow River Stations 12500 to 5700	-	-	Scenario 4 using cross sections with Little Bow River water levels from the 2D model

3.3 Direct Flood Inundation Areas

3.3.1 Major Direct Inundation Areas for the 2- to 75-year Flood Events

3.3.1.1 Highwood River

Reach between Upstream Boundary and Highwood Diversion Headgates

This river reach has an incised channel confined on both sides by the valley walls. It has limited floodplains. The inundated areas are direct flood inundation areas. There are only a few small low-lying areas where ponding water would occur.

Reach between Highwood Diversion Headgates and the Upstream End of the Town of High River

For the 2-year and 5-year flood events, small portions of the floodplains would be flooded. The areas behind the Hoeh Dike 1, Hoeh Dike 2, Bews Dike, Baker Creek Dike 1, and Baker Creek Dike 2 would not be flooded.

For the 10-year and 35-year flood events, portions of the floodplains would be flooded. Most of the areas behind the Hoeh Dike 2, Bews Dike, Baker Creek Dike 1, and Baker Creek Dike 2 would be flooded. Areas behind the Hoeh Dike 1 would not be flooded.

For the 50-year and 75-year flood events, large portions of the floodplains would be flooded, including the areas behind the Hoeh Dike 1, Hoeh Dike 2, Bews Dike, Baker Creek Dike 1, and Baker Creek Dike 2. The Bews Dike, Baker Creek Dike 1 and Baker Creek Dike 2 would be overtopped. Although the flood water would not overtop the Hoeh Dike 1, Hoeh Dike 2, the flood water from upstream would flow into the areas behind these dikes.

Reach within the Town of High River

The Town of High River is protected from flooding by the dikes constructed on the left and right floodplains. The dikes on the left floodplain include the Northwest Dike, Golf Course Dike, and Lineham Canal Dike. The dikes on the right floodplain include the Southwest Dike, Town Dike and Little Bow Canal Dike. The Highwood River flood flows would be contained within the dikes. The entire floodplains within the dikes would be direct flood inundation areas for the 75-year flood event, including the golf course area south of Golf Course Dike.

The Southwest Dike protects the town area north of the 12th Avenue from direct flooding due to overland flow south of the 12th Avenue from the Little Bow River during the flood events with return periods of 100 years or lower.

Reach between the Downstream End of the Town of High River and Highway 543

For the 5- to 50-year flood events, portions of the left floodplain would be direct inundation areas. The left floodplain east of the abandoned railway would not be flooded. For the 75-year flood event, most of the left floodplain would be direct inundation areas.

Reach between Highway 543 and Highway 2 Bridge

During floods with return periods of 20 years or higher, portions of the left floodplain, east of the abandoned railway and upstream of Tongue Creek confluence, would be direct inundation areas, and the floodplain near the south end of 96th Street would be inundated. For the 50-year flood event and higher, large portions of the cultivated areas east of the Highwood River would be inundated, the low-lying area southwest of the Train Bridge on the right floodplain would be inundated. Portions of the right floodplain between the Train Bridge and Highway 2 would be direct inundation areas for return periods of 35 years or higher.

Reach between Highway 2 and Highwood River Confluence

This river reach is mainly confined on both sides by the valley walls. It has limited floodplains. The inundated areas on the floodplains would be direct inundation areas. There are several small low-lying areas where ponding water would occur during the floods with return periods of 20 years or higher.

3.3.1.2 Little Bow River

Reach between the Upstream Boundary and 104 Street E

For the 2- to 5-year floods, the Highwood River flood water would not overflow to the Little Bow River.

For the 10- to 75-year floods, portions of the flood flows from the Highwood River would overflow in the area south of the Southwest Dike to the Little Bow River, as summarized below:

- The flood water would be ponding in the area upstream of the 88th Street E before it could overtop the road embankment. After overtopping the 88th Street E, the flood flow would discharge into the Little Bow River. For the 20- to 75-year floods increasing portions of the area between 88th Street E and the Little Bow River would be inundated.
- The farmyard between the abandoned railway and Range Road 291 across from Township Road 185 would be inundated.
- The community of Montrose is protected from overland flood water from the Highwood River by the Southwest Dike.
- Sections of the 104th Street embankment would be overtopped, including the bridge crossing.

Reach between 104 Street E and the Downstream Boundary

For the 20- to 75-year floods, portions of the floodplain areas between the 104th Street E and Highway 2 would be inundated. The flood water would be ponding in this area due to Highway 2 embankment. The Highway 2 bridge would not be overtopped. Portions of the floodplains downstream of Highway 2 would be flooded.

3.3.2 Major Direct Inundation Areas for the 100-year Flood Event

3.3.2.1 Highwood River

Reach between the Upstream Boundary and Highwood Diversion Headgates

There are a number of small low-lying areas where ponding water would occur. The inundated areas on the floodplains would be direct flood inundation areas.

Reach between Highwood Diversion Headgates and the Upstream End of the Town of High River

Most of the floodplains would be flooded, including the areas behind the Hoeh Dike 1, Hoeh Dike 2, Bews Dike, Baker Creek Dike 1, and Baker Creek Dike 2. The Bews Dike, Baker Creek Dike 1 and Baker Creek Dike 2 would be overtopped. Although the flood water would not overtop the Hoeh Dike 1 and Hoeh Dike 2, the upstream flood water would flow into the areas behind these dikes.

Reach within the Town of High River

The flood flow in the Highwood River would be contained by the dikes. The entire floodplains within the dikes would be direct flood inundation areas, including the golf course area south of Golf Course Dike and Lineham Canal Dike, and North of the Town Dike and Little Bow Cana Dike.

Reach between the Downstream End of High River and Highway 543

The left floodplains would be direct inundation areas.

Reach between Highway 543 and Highway 2 Bridge.

Large portions of the left floodplains, east of the abandoned railway and upstream of Tongue Creek confluence, would be direct inundation areas. The low-lying area in the right floodplain would be inundated. Large portions of the right floodplains between the Train Bridge and Highway 2 would be the direct inundation areas.

Reach between Highway 2 and the Highwood River Confluence with the Bow River

The inundated areas on the floodplains would be direct inundation areas.

3.3.2.2 Little Bow River

Reach between the Upstream Boundary and 104 Street E

During the 100-year flood, portions of the flood flows in the Highwood River would overflow in the area south of the 12th Avenue SW, as summarized below:

- The flood would overtop the 88th Street E embankment, then discharge into the Little Bow River.
- Sections of the 104th Street embankment would be overtopped, including the bridge crossing.

Reach between 104 Street E and the Downstream Boundary

Most of the floodplain areas between the 104th Street E and Highway 2 would be inundated. The flood water would be ponding in this area due to the Highway 2 embankment. A small low section of Highway 2 embankment north of Highway 2 bridge would be flooded. Large portions of the floodplains downstream of Highway 2 would be flooded.

3.3.3 Major Direct Inundation Areas for the 200-year to 1,000-year Flood Event

3.3.3.1 Highwood River

Reach between the Upstream Boundary and Highwood Diversion Headgates

The inundated areas on the floodplains would be direct flood inundation areas. The flood flows would be contained by the valley walls. The Highway 22 bridge and embankment would not be overtopped for flood events up to the 1,000-year flood. The Highwood Diversion structures would be flooded.

Reach between Highwood Diversion Headgates and the Upstream End of the Town of High River

The inundated areas on the floodplains would be direct flood inundation areas, including the areas behind the Hoeh Dike 1, Hoeh Dike 2, Bews Dike, Baker Creek Dike 1, and Baker Creek Dike 2. Most of the dikes would be overtopped if not all.

Reach within the Town of High River

For both the 200-year and 350-year flood events, the flood flows in the Highwood River would be contained by the dikes on the right side. However, sections of the Golf Course Dike would be overtopped. The entire floodplains within the dikes would be direct flood inundation areas, including the golf course area, Highway 2A section between the dikes, and one residential area east of Highway 2A. Large portions of the High River area north of the 12th Avenue would be flooded due to Town Dike overtopping and Southwest Dike overtopping during the 350-year flood event.

During the flood events with return periods of 500 years or higher, the flood flows in the Highwood River could not be fully contained within the dikes. The entire floodplains within the dikes and very large portions of the Town of High River would be direct flood inundation areas except for some areas with higher ground elevations.

Reach between the Downstream End of the Town of High River and Highway 543

The floodplains on both sides would be direct inundation areas. The area of Hampton Estates would not be flooded by the overland flows from the 200-year flood event. However, it would be flooded mainly due to the overland flows from the Highwood River for the flood events with return periods of 350 years or higher.

Reach between Highway 543 and Highway 2 Bridge

The left floodplains, east of the abandoned railway and upstream of Tongue Creek confluence, would be direct inundation areas. The low-lying area in the right floodplains would be inundated. The right floodplains between the Train Bridge and Highway 2 would be direct inundation areas. Some sections of the railway and Highway 2 embankments would be overtopped.

Reach between Highway 2 and the Highwood River Confluence with the Bow River

The inundated areas on the floodplains would be direct inundation areas. There are several small low-lying areas where ponding water would occur. The flood flows would be contained by the valley walls. Small section of Highway 547 embankment would be overtopped. Portions of the flood flows would be conveyed through a high ground channel on the right floodplains immediately upstream of the Highwood River confluence with the Bow River.

3.3.3.2 Little Bow River

Reach between the Upstream Boundary and 104th Street E

For the 200- to 1,000-year floods, portions of the flood flows in the Highwood River would overtop the Southwest Dike and overflow in the area south of the 12th Avenue SW, as summarized below:

- The flood water would overtop the 88th Street embankment and discharge into the Little Bow River.
- For the 200-year flood, portions of the flood flows would not overtop the 12th Avenue and flow into the Town of High River. The Southwest Dike would also prevent flooding north of 12th Avenue, however the dikes would be overtopped and flow to the area between the Southwest dike and south of 12th Avenue.
- The entire area west of the 88th Street E would be flooded except for some areas with higher ground elevations. Most of the area east of the 88th Street E would be inundated.
- Large sections of the 104th Street embankment would be overtopped, including the bridge crossing.

Reach between 104th Street E and the Downstream Boundary

The floodplain areas between the 104th Street E and Highway 2 would be inundated. The flood water would be ponding in this area due to the Highway 2 embankment. A large section of Highway 2 embankment north of Highway 2 bridge would be flooded. The entire floodplains downstream of Highway 2 would be flooded.

3.4 Inundation Due to Potential Flood Control Structure Failure

3.4.1 Mapping Approach

Inundation due to potential flood control structure failures was mapped based on main channel water levels (Highwood River) and water levels outside of the flood control structures (2D model areas) as shown in Figure 2.

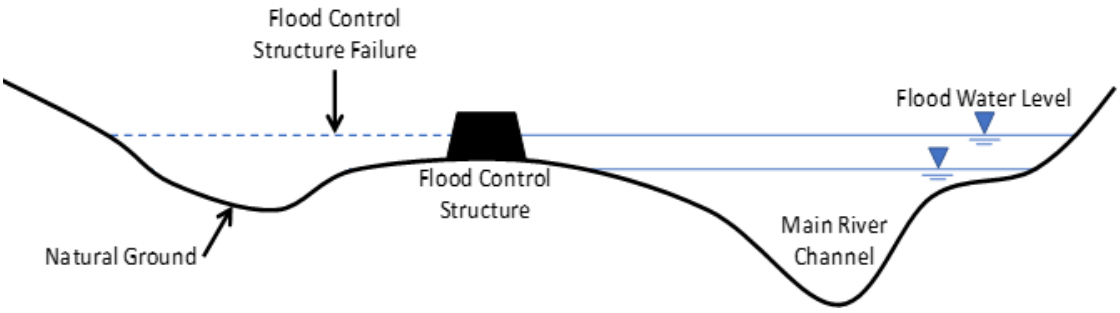

Figure 2: Illustration of Flood Control Structure Failure Inundation

3.4.1.1 Highwood River

13 dikes have been identified by M.D. Foothills and Town of High River as flood control structures along the Highwood River. The areas protected by Hoeh Dike 1, Hoeh Dike 2, Bews Dike, Baker Creek Dike 1 and Baker Creek Dike 2 could become direct inundation areas due to upstream flood flows or flow overtopping (see Section 3.3). The northwest and south communities in the Town of High River are protected by the Northwest Dike, Golf Course Dike, Lineham Canal Dike, Town Dike, and Little Bow Canal Dike. These two communities could be subject to potential flood control structure failure.

Northwest Community in the Town of High River

This community is protected by Northwest Dike, Golf Course Dike, and Lineham Canal Dike. Some areas of this community would become flood control structure failure areas were the dikes to fail during flood events with return periods ranging from 10 to 500 years. The flooding could be caused by the upstream flows crossing the Range Road 291 or through the breach of Northwest Dike, Golf Course Dike or Lineham Canal Dike. If such flooding would occur, the Riverside Blvd NW, Riverside Drive NW and High Park Way NW would be affected, majority of the area east of Riverside Dr. NW would be inundated, and some of the flood flows would travel north crossing the Longview Trail.

South Community in the Town of High River

For the flood events with return periods ranging from 20 to 200 years, this community is protected by the Town Dike and Little Bow Canal Dike, would become flood control structure failure area were the dikes to fail. If such flooding would occur, the area west of the Center Street S would be inundated, and part of the area east of the Center Street S would be inundated except for some area with higher ground elevations, some of the flood flows would discharge into the Little Bow River basin, and some of the flood flows could enter into the area of Hampton Heights.

Area near Hampton Heights

For the flood events with return periods ranging from 20 to 200 years, the low-lying area situated south of Highway 543 and extending to north of 12th Avenue SE, would become flood control structure failure areas were the dikes to fail. This flood control structure failure area was conservatively delineated based on a water level equal to 0.2 m above the 104th Street crest elevation of 1034.8 m at the Little Bow Diversion Canal Crossing. If such flooding would occur, most of the residential area between the 5th Street and Highway 2 would be flooded, and the commercial and industrial areas along 12th Avenue SE and Highway 2 would likely be affected.

3.4.1.2 Little Bow River

There is no potential flood control structure failure area along the Little Bow River, because there is no flood control structure along the study river reach.

3.5 Areas Affected by Flooding

3.5.1 Residential Areas

3.5.1.1 Highwood River

Floodplains between the Upstream Boundary and Highwood Diversion Canal Headgates

There is no major residential area situated on the floodplains along this reach. A small residential area on the right floodplain (Cross sections 220 to 227) would not be inundated even during the 1,000-year flood event. However, several farm houses and buildings on the right floodplains would be inundated during the flood events with return periods of 35 years or higher.

Floodplains between the Highwood Diversion Canal Headgates and 72nd Street E

The residences on the floodplains along this river reach would be inundated during the flood events with return periods of 10 years or higher.

Northwest Community in the Town of High River

The residential area behind Northwest Dike, Golf Course Dike and Lineham Canal Dike would be protected from flooding by these dikes up to the 200-year flood event. Some of this residential area would be flooded during the flood events with return periods of 200 years or higher.

The Golf Course located south of Golf Course Dike would be flooded during the flood events with return periods of 10 years or higher.

Some of the following residential areas along the following roads would be inundated during the flood events with return periods of 200 years or higher:

- Riverside Boulevard NW,
- Riverside Drive NW,
- High Park Boulevard NW,
- High Park Way NW,
- High Country Drive NW, and
- Riverside Drive NW.

Northeast Community in the Town of High River

The residential area on the left floodplain east of Centre Street N would be inundated during the flood events with return periods of 350 years or higher.

Southwest Community in the Town of High River

The residential area in the community would be inundated by the flood flows crossing the 12th Avenue SW from the south side during the flood events with return periods of 350 years or higher.

Farm houses behind the Southwest Dike would be inundated during the flood events with return periods of 200 years or higher.

George Lane Park would be inundated during the flood events with return periods of 350 years or higher.

High River General Hospital and the area of Hampton Heights would be inundated during the flood events with return periods of 350 years or higher.

Most of the area in the community would be flooded were Town Dike to fail during the flood events with return periods of 50 years or higher.

Southeast Community in the Town of High River

Most of the residential area in the community including the Senator Riley School would be affected during the flood events with return periods of 350 years or higher.

Most of the area in the community would be flooded were Little Bow Canal Dike to fail.

Area between the Downstream End of the Town of High River and Highway 543

Several or most residences on the floodplains along this river reach would be affected during the flood events with return periods of 35 years or higher.

Other Residences

There are several other residences beyond those mentioned above that would be inundated during the flood events with return periods of 10 years or higher as shown in the flood inundation maps.

3.5.1.2 Little Bow River

Area West of 88th Street E

The farmland area, south of 12th Avenue SW and west of 88th Street E, would be inundated due to overflows from the Highwood River during the flood events with return periods of 20 years or higher. Farmland area behind the Southwest Dike will be protect during the flood events with return periods of 100 years or lower.

Area between 88th Street E and 104th Street E

The development area between south of 12th Avenue SE and Monterey Dr. SE would be flooded during the flood events with return periods of 200 years or higher, including part of farmlands located south of Monterey Dr. SE.

Part of Highwood High School on the left floodplain would be flooded during the flood events 350-year and higher.

Area East of the 104th Street E

Some of the area east of 104th Street E would be flooded. Some residences would be affected during the flood events with return periods of 20 years or higher.

3.5.2 Flooding of Commercial and Industrial Areas

3.5.2.1 Highwood River

Gravel Pit West of Longview

This gravel pit on the left floodplain would be inundated.

Longview Water Well

The pumping house and water well for the Village of Longview would be inundated.

Hogg Park

Some of the Hogg Park area would be inundated.

Gravel Pit near the 8th Street E

This gravel pit would not be inundated by directly by river flows. However, ponding water could occur in the gravel pit (isolated area) and a low-lying area.

Commercial Area along the Centre Street

Some of this commercial area would be inundated by the flood flows crossing the 12th Avenue SW from the south side.

Flooding would occur in this area were Town Dike and/or Little Bow Canal Dike to fail.

Commercial Area along the 12th Avenue SE

Some of the area south of the 12th Avenue SE between the Centre Street S and Little Bow River would be flooded due to overland flows from the south side.

Flooding in this area would occur were Town Dike, Little Bow Canal Dike and Highway 543 embankment to fail. If such flooding would occur, the affected areas include the following:

- Some of the area north of the 12th Avenue SE between the Centre Street S and Little Bow River,
- Most of the area north of the 12th Avenue SE between the 5th Street SE and Highway 2, and
- Some of the area south of the 12th Avenue SE between the 10th Street SE and Highway 2.

Commercial Area along Highway 2

Flooding in the area between the 20th Street SE and Highway 2 would occur were Town Dike, Little Bow Canal Dike or Highway 543 embankment to fail. If such flooding would occur, the affected areas would include most of the area between the 10th Avenue SE and 4th Avenue SE, Holy Spirit Academy, and some of the High River Autoplex & RV site.

Area near the Intersection Highway 2A and 466th Avenue E

Some of the area south of the 466th Avenue E would be flooded. Ponding water would occur in the low-lying areas. Some of the area north of the 466th Avenue E, including the area next to the Tongue Creek, would be flooded.

3.5.2.2 Little Bow River

There is no major commercial and industry area along the Little Bow River study reach.

3.5.3 Flooding of Bridges and Culverts

3.5.3.1 Considerations

A bridge is considered affected by flood when flood waters reach its low chord. A culvert is considered affected by flood when flood waters reach the road surface.

3.5.3.2 Highwood River

None of the bridges along the Highwood River would be affected during flood events with return periods of 10 years or lower.

Three bridges would be affected during the 100-year flood, including the Center Street Bridge, Highway 543 Bridge, and Highway 2 Bridge (South Bound).

Table 19 summarizes the simulated water levels at the eight bridges along the Highwood River for the various flood events, as well as the flow velocities and clearances during the 100-year flood event.

3.5.3.3 Little Bow River

None of the bridges along the Little Bow River reach would be affected during the flood events with return periods of 20 years or lower. None of the culverts along the Little Bow River reach would be affected during the flood events with return periods of 75 years or lower.

Two bridges would be affected by the 100-year flood, including the 5th Street SE Bridge and the Little Bow Range Road 290 Bridge. The 100-year flood flows would overtop the road surfaces at Hifab Culvert along the Little Bow River reach.

Table 20 summarizes the simulated water levels at the bridges and culverts along the Little Bow River reach for the 2-year to 1,000-year floods, as well as the flow velocities and bridge clearances or flow depths above the road surface for the 100-year flood event.

Table 17: Flooding at the Bridges along the Highwood River

Bridge Station (m)	Name	Minimum Deck Elevation (m)	Minimum Low Chord Elevation (m)	Simulated Water Levels at the Bridges for the Various Flood Events (m)												Average Flow Velocity for the 100-year Flood Event (m/s)	Clearance for the 100-year Flood Event[1] (m)	Flood Event Causing Pressure Flow (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	1,000-year			
89158	Highway 22 Bridge	1200.14	1198.38	1182.47	1183.29	1183.94	1184.78	1185.59	1185.83	1186.92	1187.86	1190.05	1191.89	1193.13	1194.54	1195.71	5.89	10.52	>1,000 years
48655	Center Street Bridge	1038.39	1037.17	1036.25	1036.86	1037.11	1037.27	1037.44	1037.55	1037.8	1038.02	1038.53	1038.92	1039.15	1039.3	1039.38	2.43	-0.85	20 years
43148	Highway 543 Bridge	1037.18	1034.46	1030.59	1031.55	1032.13	1032.93	1033.51	1033.93	1034.6	1034.97	1035.93	1036.22	1036.35	1036.36	1036.36	2.79	-0.51	75 years
32314	Train Bridge	1033.58	1030.75	1026.29	1027.21	1027.81	1028.54	1029.05	1029.42	1030.07	1031.14	1032.26	1033.02	1033.38	1033.64	1033.82	2.58	-0.39	100 years
30704	Highway 2 Bridge (South Bound)	1030.00	1028.04	1025.02	1025.78	1026.3	1027.02	1027.53	1027.91	1028.7	1030.08	1031.05	1031.31	1031.56	1031.8	1031.95	3.10	-2.04	75 years
30598	Highway 2 Bridge (North Bound)	1031.22	1029.27	1024.97	1025.72	1026.23	1026.94	1027.46	1027.83	1028.6	1029.24	1030.53	1030.75	1031.17	1031.57	1031.78	3.78	0.03	200 years
24613	Highway 547 Bridge	1025.53	1023.60	1015.93	1016.59	1017.04	1017.71	1018.22	1018.6	1019.39	1020.11	1021.68	1022.95	1023.82	1024.62	1024.93	4.50	3.49	500 years
6740	Highway 552 Bridge	978.01	976.68	963.04	963.94	964.43	965.16	965.81	966.24	966.98	967.54	969.03	970.18	971.47	972.23	972.78	6.72	9.14	>1,000 years

Note: The clearances for the 100-year flood event are the elevation differences between bridge low chord elevations and simulated water levels. A negative value indicates the water depth above the low chord for a bridge.

Table 18: Flooding at the Bridges and Culverts along the Little Bow River

Bridge/ Culvert Station (m)	Name	Minimum Deck/Road Surface Elevation (m)	Minimum Low Chord/ Culvert Top Elevation (m)	Simulated Water Levels at the Bridges/Culverts for the Various Flood Events (m)												Average Flow Velocity for the 100-year Flood Event (m/s)	Clearance for the 100-year Flood Event[1] (m)	Flood Event Causing Pressure Flow or Overtopping Road Surface (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	1,000-year			
11,500	12th Avenue Culvert	1034.90	1032.64	1031.83	1031.84	1031.84	1031.84	1031.84	1031.84	1031.84	1031.84	1031.84	1031.88	1034.67	1035.41	1036.06	1036.47	0.19	3.06	500 years
11,115	5th Street SE Bridge	1034.60	1033.70	1031.82	1031.83	1031.83	1031.83	1031.83	1031.83	1031.83	1031.83	1031.83	1031.87	1034.29	1035.27	1035.82	1036.15	0.16	1.87	350 years
10,470	Culvert to Residence in NE 36-18-29-4	1031.70	1030.84	1029.75	1029.76	1029.76	1029.76	1029.76	1029.76	1030.19	1030.48	1031.49	1033.82	1034.39	1034.93	1035.27	0.01	1.22	350 years
9,625	Culvert to Residence in NE 36-18-29-4	1031.10	1030.49	1029.27	1029.17	1029.17	1029.17	1029.40	1029.63	1030.18	1030.48	1031.46	1032.88	1033.21	1033.61	1033.95	0.02	0.62	200 years
6,875	Hifab Culvert	1027.62	1026.11	1024.92	1024.93	1025.29	1026.22	1026.72	1026.97	1027.60	1027.90	1028.66	1029.44	1029.78	1030.21	1030.57	0.8	-0.28	100 years
5,615	104th Street E (Range Road 290) Bridge	1026.56	1026.10	1023.91	1023.92	1024.79	1025.71	1026.31	1026.45	1026.64	1026.78	1027.07	1027.34	1027.51	1027.79	1028.10	1.8	-0.68	35 years
3,050	Highway 2 West Bridge	1025.45	1024.13	1018.87	1018.88	1019.63	1021.04	1021.85	1022.42	1023.55	1023.93	1024.56	1025.17	1025.52	1025.99	1026.41	2	0.2	200 years
3,030	Highway 2 East Bridge	1025.51	1024.13	1018.59	1018.60	1019.58	1020.93	1021.62	1022.12	1023.09	1023.42	1023.97	1024.54	1024.86	1025.33	1025.76	3	0.71	350 years

Note: The clearances for the 100-year flood event are the elevation differences between bridge low chord or culvert road surface elevations and simulated water levels. A negative value indicates the water depth above the low chord for a bridge or above the road surface for a culvert.

4.0 FLOOD DEPTH GRIDS

4.1 GIS Data Specifications

The following GIS data is provided to AEP for each of the 13 flood events:

- Inundation polygons,
- Flood water level triangulated irregular network,
- Flood water level raster, and
- Flood water depths raster.

All GIS data was created in ArcGIS 10.8 compatible format in the native study coordinate system (Canadian Spatial Reference System, North American Datum of 1983 (CSRS NAD83), Epoch 2002 and 3-Degree Transverse Mercator projection with the Central Meridian of 111° (3TM 111)). All raster files have a spatial resolution of 0.5 m.

The inundation polygons and raster files were stored in ArcGIS file geodatabases, Version 10.8. The flood water level TINs were stored as ArcGIS terrain datasets in the file geodatabases, Version 10.8.

4.2 General Comments

The flood water level data provided as Terrains and raster, cover all areas between cross section lines and in special inundation areas within the study area including dry areas.

The flood water depth raster only include the areas with a water depth of more than 0.01 m.

5.0 CONCLUSIONS

The calibrated HEC-RAS model and the LiDAR DTM provided a good basis for simulating the flood levels and preparing the flood inundation maps for the 13 open water flood events (i.e., 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year open water floods), including direct flood inundation areas and other indirect flood inundation areas.

Based on the simulation results, there are many residential and commercial/industrial areas along the Highwood River and Little Bow River within the study area that would be affected by open water flooding.

Report Signature Page

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https://golderassociates.sharepoint.com/sites/140764/project files/5 technical work/02_highwood/07_update reports/inundationmapreport/open water inundation mapping report 2022_02_24_hz_wp.docx

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REFERENCES

Golder 2017a. Bow, Elbow, Highwood and Sheep River Hydrology Assessment. Prepared for Alberta Environment and Parks. February 2017.

Golder 2017b. Highwood River Hazard Study - Survey and Base Data Collection. Prepared for Alberta Environment and Parks. November 2017.

Golder 2022. Hydraulic Model Creation and Calibration - Highwood River Hazard Study. Prepared for Alberta Environment and Parks. March 2022.

APPENDIX A

Open Water Flood Inundation Maps

(TO BE PROVIDED SEPARATELY)

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