November 2017

HIGHWOOD RIVER HAZARD STUDY

Survey and Base Data Collection Report

Submitted to:
Alberta Environment and Parks
James Choles/Muhammad Durrani
11th Floor, Oxbridge Place
9820 - 106 Street NW
Edmonton, AB T5K 2J6

REPORT

Report Number: 1536669_R0001 Rev. 0

Distribution:

1 Copy: Alberta Environment and Parks
1 Copy: Golder Associates Ltd.

Golder Associates

Executive Summary

Alberta Environment and Parks (AEP) commissioned Golder Associates Ltd. (Golder) in September 2015 to undertake the Highwood River Hazard Study. The study area includes the Highwood River between the Village of Longview and its confluence with the Bow River, and the Little Bow River between the Town of High River and approximately 3 km downstream of Highway 2 Bridge. The overall goal of the study is to enhance public safety and support the identification of river hazards in the study areas.

The river hazard study has ten components, including the survey and base data collection component. This report documents the methodology and results of the survey and base data collection component for supporting hydraulic modelling, flood mapping, flood risk assessment, and channel stability investigation. It includes surveys of river cross sections, hydraulic structures, and flood control structures. The aerial photography of the study area was acquired on May 6, 2016. The base data collected in this study includes administrative, cadastral, transportation data, structural design drawings, and other data.

The river and hydraulic structure surveys were conducted using Real Time Kinematics (RTK) GPS units (Trimble R8 and R10), an Acoustic Doppler Profiler (ADP) (Sontek M9) in combination with a RTK unit on a boat, and a total station for bridge surveys.

The total length of the Highwood River study reach is 93 km. The total length of the Little Bow River study reach is 15 km. The number of cross sections surveyed to date are listed in Table i. There are several hydraulic structures and flood control structures in the Study area as listed in Table i.

Table i: Numbers of Cross Sections and Hydraulic and Flood Control Structures in the Study Area

	Highwood River	Little Bow River
Main Channel Cross Sections	856	138
Side Channel Cross Sections	23	1
Bridges	11	4
Culverts	-	4
Weir	1	-
Flood Control Structures	11	-

Acknowledgements

This component of the Highwood River Hazard Study (i.e., survey and base data collection) was managed by Hua Zhang. Overall direction and senior review for this component was provided by Dejiang Long. The field survey was conducted by Carmen Orosz, Karlen Lowes, Jason Fregoe, Ashley Eckford, Amy Cardinal, Beth Jim, Sarah Vanden Brink, and Tayler Hamilton.

The authors express their special thanks to Jim Choles and Muhammad Durrani, Project Managers of Alberta Environment and Parks, who provided overall project direction, background data and technical guidance.

The authors express their thanks to Sheri Burt with the Town of High River, and Robert Miller with Municipal District of Foothills for their support to this survey program, supply of additional background information, and guidance during a site reconnaissance of the study area.

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Study Objectives

In the fall of 2015, Alberta Environment and Parks (AEP) commissioned a number of river hazard studies for communities in Alberta. AEP commissioned Golder Associates Ltd. (Golder) to conduct the Highwood River Hazard Study.

The overall goal of the study is to enhance public safety and to support identification of river hazards in the study area. The study deliverables are intended to reduce potential future flood damages and associated disaster assistance costs. They will be used to mitigate flood impacts by informing land use planning decisions.

The purpose of the Study is to assess and identify river and flood hazards along the study reaches of the Highwood River and Little Bow River, including the Village of Longview and Town of High River. Hydraulic modelling and flood mapping are required for the study reaches.

The river hazard study consists of ten components, including the survey and base data collection component. The relevant survey and base data are required to support hydraulic modelling, flood mapping, flood risk assessment, and channel stability investigation.

This report documents the methods and results of the survey and base data collection conducted during the study. This report is one of the deliverables required by AEP for the study.

1.2 Study Area and Reaches

The study area includes 93 km of the Highwood River reach between the Village of Longview and its confluence with the Bow River, and 15 km of the Little Bow River reach as shown in Figure 1.

1.3 Scope of Work

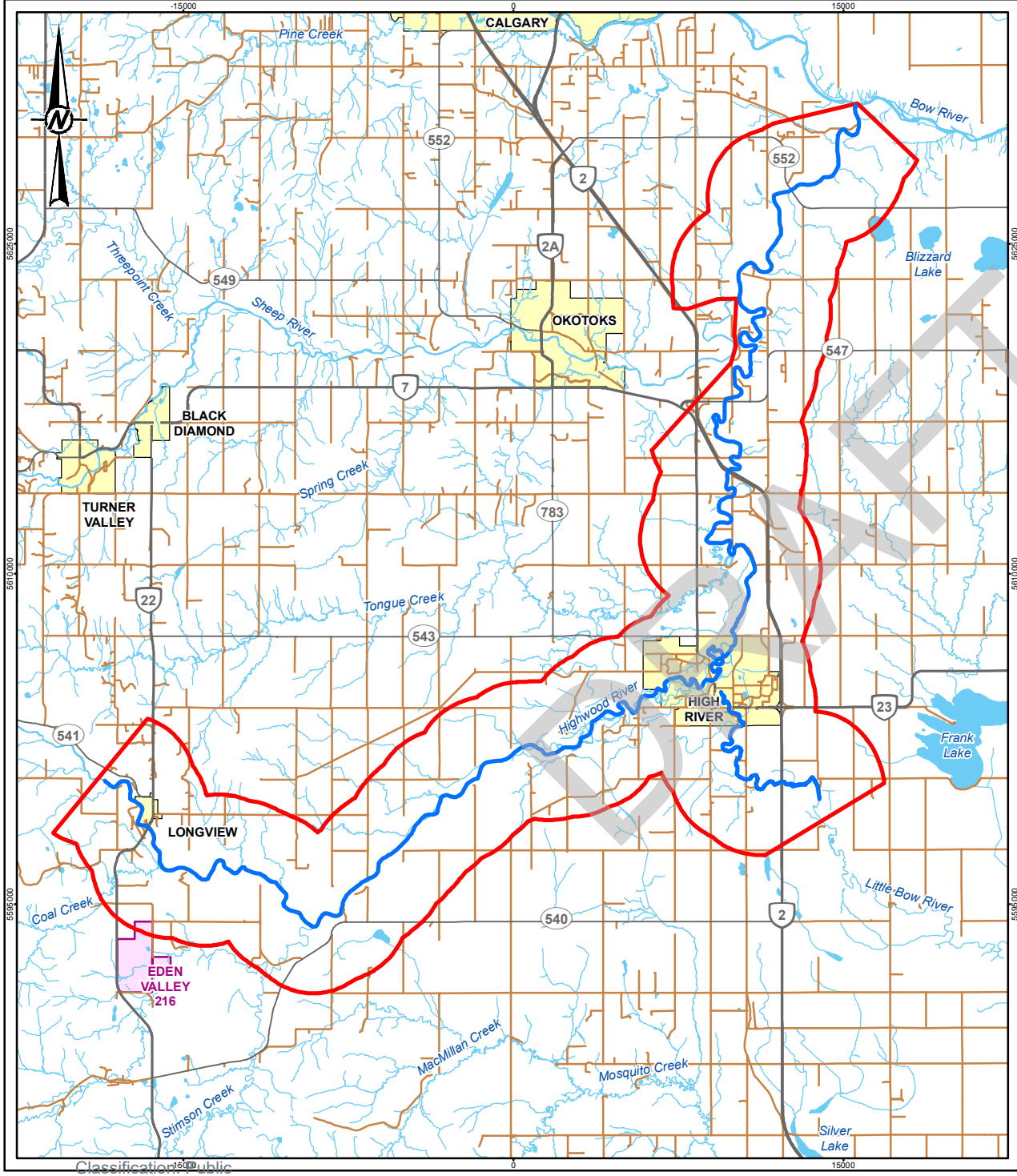
1.3.1 Survey Program

The program includes surveys of river cross sections, hydraulic structures, and flood control structures.

Prior to this study, Golder already surveyed portions of the Highwood River in October 2013 as part of the Highwood River Open-Water Survey for AEP (Golder 2013), and the Little Bow River reach near the Town of High River in August 2015 as part of the Little Bow River Bathymetric and Hydraulic Survey for AEP (Golder 2015). These survey data are used in this Study and included in this report.

As part of this survey program and in the fall of 2015, Golder conducted surveys of the 10 km reach of the Little Bow River and the 25 km reach of the Highwood River between the Women's Coulee Diversion and Highway 547 bridge crossing. Golder surveyed a 2 km reach of the Bow below the Highwood River confluence in October 2015. The remaining reaches of the Highwood River were surveyed during the spring and summer of 2016 (Table 1).

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Fig1_Study-Area_Rev0.mxd PRINTED ON: 2017-10-03 AT: 9:58:27 AM



LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- INDIAN RESERVE
- POPULATED PLACE
- SURVEY REACH
- RIVER HAZARD STUDY AREA

0 5 10

1:275,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATION MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-03
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

Table 1: River Survey Coverage

River	Reach	Timing of Survey
Highwood River	Upstream Study Boundary to Pekisko Creek Confluence	May to September 2016
	Pekisko Creek Confluence to a Location Immediately Upstream of High River	October 2015; May and August 2016
	Town of High River	October and November 2015
	A Location Immediately Downstream of High River to Tongue Creek Confluence	October and November 2015
	Tongue Creek Confluence to Sheep River Confluence	October 2015; April and September 2016
	Sheep River Confluence to Bow River Confluence	April 2016
Little Bow River	Little Bow River Reach	October 2015
Bow River	Bow River Reach of Approximately 2 km in Length Immediately Downstream of Highwood River Confluence	October 2015

1.3.2 Aerial Imagery Acquisition

The scope of work includes acquisition of new aerial imagery of the study area, which was acquired on May 6, 2016.

1.3.3 Additional Base Data Collection

The additional base data collected for this study includes the following:

- administrative, cadastral, transportation and other provincially available data sets;
- supplementary survey data;
- infrastructure datasets;
- design drawings; and
- other data.

2.0 SURVEY DATA

2.1 Procedures and Methodology

2.1.1 Bathymetric and Structure Surveys

The following survey techniques were used to collect the survey data for the study. The same techniques were used in the 2013 and 2015 surveys previously conducted:

- Used Real Time Kinematics (RTK) GPS units (Trimble R8 and R10) where the river flows were shallow enough to wade.
- Used Acoustic Doppler Profiler (ADP) (Sontek M9) in combination with RTK unit on a boat where river flows were too deep to wade.
- Used total station for bridge surveys.

The RTK data were referenced to geodetic positions using one of the following methods:

- The Cansel Can-net Virtual Reference Station (VRS) System (Can-net) was used where available. This system uses correctional data calculated at multiple fixed base units positioned across Canada and broadcast via cellular network to generate an accurate position (with an accuracy of ±2 cm). When using Can-net, each rover was calibrated daily to an Alberta Survey Control Marker (ASCM) or a Golder established temporary benchmark that had been tied to an ASCM.
- Where cellular coverage was not available, the RTK base station was set up over a temporary benchmark (TBM) and calibrated to an ASCM that was close to each survey reach. The resulting accuracy of the RTK unit was ±2 cm.
- The RTK data was acquired by RTK rovers with geoid files loaded and applied. The RTK data output is in orthometric elevation with correct northing and easting values. All survey data was collected in 3TM CM-114° projection with the NAD83 CSRS datum.

Can-net was used for all Highwood and Little Bow River surveys. The RTK base was used for portions of the Bow River reach where cell coverage (and thus Can-net coverage) was not available.

Each RTK survey point was attributed with a specific code value in the field. A complete list of RTK codes is summarized in Table 2. A schematic of survey point locations is shown in Figure 2.

Table 2: RTK Survey Data Codes

Primary Code	Description
b	Bank (a surveyed point on the river bank)
g	Ground (a survey point above the top of bank)
sb	Stream Bottom (a survey point below the water line)
tb	Top of Bank (locations where bank slope transitions to ground)
toe	Toe of Bank (locations where steep bank slope transitions to stream bottom slope)
wl	Water Level (a survey point where water meets the bank)
wl long	Water Level (as part of longitudinal profile to be used for model calibration)
Secondary Code	**Description**
1	Sediment Description - Mud/Silt
2	Sediment Description - Gravel
3	Sediment Description - Cobble
4	Sediment Description - Boulder
5	Sediment Description - Bedrock
G	Grass - Grasses and Fescues
Rip	Riprap
T	Trees (larger mature trees with tree trunk greater than 20 cm in diameter)
W	Willows (shrubs, willow plants, and smaller trees less than 3 m in height and or less than 20 cm in diameter)

For example: **sb 3** denotes stream bottom - cobble substrate, and **tb w** denotes top of bank – willow cover.

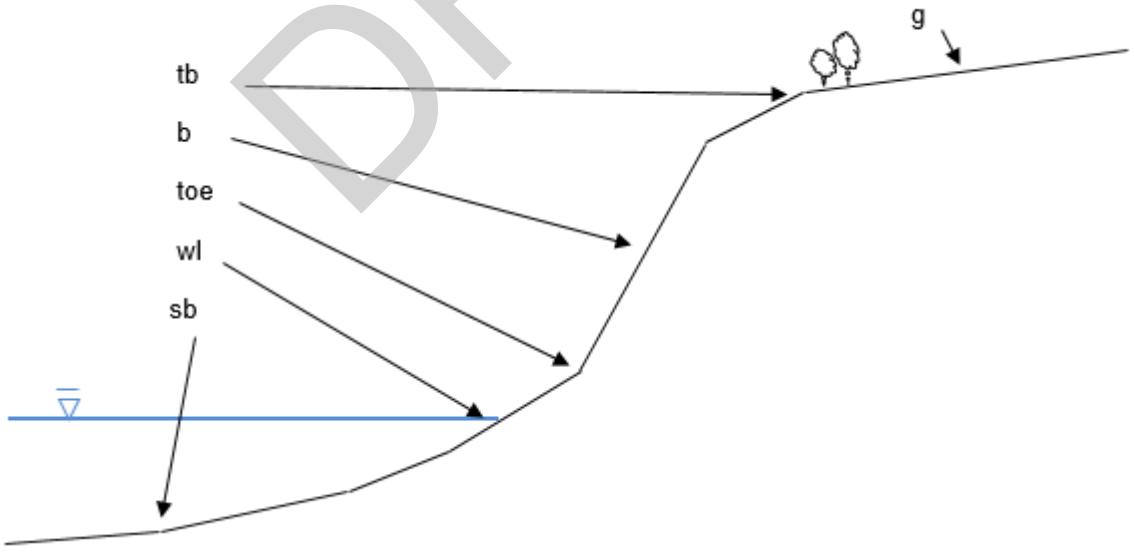


Figure 2: Schematic of Survey Point Locations

Highwood and Little Bow Rivers

Because the Highwood and Little Bow Rivers were relatively shallow at the time of the survey, most of the cross sections of the Highwood and Little Bow River reaches were surveyed on foot (by wading) as follows:

- the field data were collected by surveying river cross sections perpendicular to the river flow;
- cross-sectional information was collected from a location beyond top of one bank to another location beyond top of the other bank;
- special attention was paid to surveying topographic slope breaks;
- topographic survey points were attributed in the field with codes that described substrate and vegetation types;
- water surface elevations were surveyed using the RTK Rover at each bank and each channel if the section is braided; and
- discharge measurements were taken daily by wading at a suitable cross section.

At some cross sections where water was too deep to wade through, a Sontek M9 Acoustic Doppler Profiler (ADP) mounted on a portable trimarran was used to obtain the data in the deep areas. Survey technicians stood on each side of the channel and pulled the ADP across using tether lines. The RTK Rover was used to collect coordinates at each water edge of the survey transect to combine the RTK and ADP datasets.

Daily measurements were conducted by each survey crew using a Sontek Flowtracker. The following standard Alberta Water Survey of Canada (WSC) discharge protocols were used for each measurement:

- a minimum of 20 panels (velocity measurements) across the channel;
- no one panel to exceed 10 percent of total flow;
- velocity measurements at 60 percent of water depth when the depth was less than 1 m; and
- velocity measurements at 20 and 80 percent of water depth when the depth was greater than 1 m.

Bow River Downstream of the Highwood River Confluence

The Bow River reach was surveyed using a combination of boat and on-the-foot survey methods. The on-the-foot method described above for the Highwood and Little Bow Rivers applies to the Bow River survey where only the bank portions of the cross sections were surveyed using on-the-foot method.

The boat survey method is described below:

- A Sontek M9 Acoustic Doppler Profiler (ADP) was mounted onto a frame, which was fastened on top of an inflatable zodiac. Once the ADP was securely mounted on the boat, it was deployed in the water and the distance from the sensor to the water surface was measured.
- The RTK unit was placed on top of the ADP mount at a measured offset from the water surface which was recorded daily.

- The ADP and RTK units were connected to a laptop for data storage. The system was checked to make sure that both units were communicating properly.
- A brief calibration file was run to verify the recorded equipment offset values.
- The bathymetric data were collected along the select cross sections (perpendicular to the river flow). In shallow water areas (< .5 m of depth), survey points were collected by wading.
- Bank topographic data were obtained using RTK rover units as described above.
- Water surface elevations were surveyed using the RTK rover at the points where the water met the bank.
- Water Survey of Canada (WSC) discharge protocols were followed when conducting discharge measurements using the ADP (i.e., an even number of transects, an equal number of transects moving each direction across the channel, and all transects within 5 percent standard deviation).

Hydraulic Structures

The hydraulic structures (i.e., bridges) on the Highwood and Little Bow Rivers were surveyed as required by AEP. The required survey features of the bridges are:

- length of span (corner points, abutment to abutment);
- width of bridge (corner points, outside to outside);
- top of curb or solid guard rail elevations (upstream and downstream sides);
- low chord elevations (upstream and downstream sides);
- number and width of piers;
- location of piers and the distance of each pier from the abutment;
- type of piers (i.e., concrete, pile bent);
- shape of pier (i.e., round nose, wedge shape); and
- top of roadway/path profile.

The structures were surveyed using RTK or total station units or a combination of both. The RTK unit was used to collect data on structure points with a clear view of the sky (i.e., bridge decks, railings, etc.). The total station (Nikon Nivo) was used in reflector-less mode to collect survey points underneath the main bridge structure. In reflector-less mode the user aligns the unit cross hairs on the point that is to be surveyed and a laser beam is transmitted to the structure and reflected from the structure without using a traditional total station prism or reflector target.

Geo-located photos of all hydraulic structures were taken.

Flood Control Structures

Flood control structures such as berms and dikes along the Highwood River were surveyed using RTK to verify the as-built heights of the structures. Although previous surveys of these structures were partly available, all flood control structures that were identified in the study area, were surveyed in the fall of 2015.

The survey of flood control structures included collection of the following information:

- crest of structure in regular intervals (approximately 50 m interval); and
- culverts, gates and other openings if present.

Geo-located photos of all flood control structures were taken.

Survey Data Processing and Quality Control

Primary QA/QC of RTK data were conducted in the field by calibrating to a known point and surveying this point at the beginning and end of each day. In the office, the accuracy of the RTK daily open and close data was verified before being considered final. Following the field program, the RTK data were inspected for quality and points with poor positional data were removed from the data. Poor positional data are defined as those where a RTK lock was not acquired (typically under vegetation cover where the number of satellites available to the RTK rover is decreased). The attribute codes assigned to each RTK survey point were reviewed and standardized for consistency.

The ADP bathymetric and flow velocity data were collected and exported using the Sontek RiverSurveyorLive software (Version 2.50.0.00). The exported data were processed in a spreadsheet application as follows:

- Data were sorted using the UTM easting values and any points with UTM coordinates of zero were removed (<1% of the points had that issue).
- Data were sorted by altitude[1], and values where RTK coverage was lost were removed (these cannot be corrected as the Altitude values drift out of lock when RTK coverage is lost, <1%).
- Data were sorted by combined depth and those points with a zero depth or depths well outside of the possible range were removed (<1%).
- Data were sorted by difference in depth. This column is the difference between the vertical beam (VB) depth and the averaged bottom track (BT) depth[2]. If in shallow water the VB beam occasionally returns an inaccurate value, the BT depth was used.
- Data were sorted by mean velocity. The ADP returns a value of zero when it cannot compute a velocity and direction. These values were removed (<5%), and the rest of the point's values were retained.

In total less than 5% of the collected data were removed during the above-mentioned processes.

All survey data collected were imported into a Geographic Information System (ArcGIS) to allow for validation and further processing. In addition to the field data quality control procedures, the survey data were checked in ArcGIS against outliers and through visual inspection of created triangulated irregular network surfaces. Similar steps were undertaken to ensure accurate matches between all datasets collected on different dates and with different survey equipment.

[1] The Altitude is the elevation value supplied to the ADP from the RTK via a GGA NMEA data string. Golder's Trimble RTK unit returns a value equal to the head of the unit only, no offset can be entered. Therefore an offset must be applied to the data after the field work.

[2] The ADP unit returns both a VB (vertical beam- single downward viewing beam) and BT (Bottom track – average of 4 slanted velocity beams) depth in its data file. The vertical beam data is the more accurate in all but a few cases. The MatLab program returns a VB value when both were present and a BT value when no BT values were available. Manual sorting was then required to select cases where the VB data was erroneous and then BT was inserted. This scenario appeared in less than 5 percent of the data points and only in shallow water.

2.1.2 Discharge Measurements

Highwood and Little Bow Rivers

Daily discharges in the Highwood River were taken using a Sontek Flowtracker (Software version 2.20) adhering to Water Survey of Canada practices (WSC, 1999). This flow measurement method is considered to result in an accuracy of ±5% of the measured discharge.

Bow River Downstream of Highwood River Confluence

Discharge measurements in the Bow River Downstream of Highwood River Confluence were taken using the ADP. The crew ensured that an even number of transects (a minimum of four) with equal left to right transects as right to left transects, all within 5% variation in discharge, were taken each day at a suitable location. This procedure ensures that any ADP unit compass bias was removed. This flow measurement method is considered to result in an accuracy of ±5% of the measured discharge.

Discharge Data Processing and Quality Control

Tables 3 and 4 present measured flows along the Highwood and Little Bow River reaches. The measured flows will be compared to the available gauging data at Highwood River below Little Bow Canal (WSC# 05BL004) once it becomes available (Table 3). The WSC gauge data for 2015 and 2016 is considered to be preliminary, and only mean daily flows were available at the time of the comparison of flow values.

Table 3: Comparison of Measured Highwood River Flows during the Survey and Mean Daily Flows at Gauge WSC# 05BL004 (Highwood River below Little Bow Canal)

Date	Time	Daily Flow at WSC# 05BL004 [m^3/s]	Measured Flow [m^3/s]		Difference	
					[m^3/s]	(-)
10/13/2015	17:11:47	Not Available	6.83		Not Available	Not Available
10/14/2015	14:47:51	Not Available	6.61		Not Available	Not Available
10/15/2015	12:11:10	Not Available	6.37		Not Available	Not Available
10/16/2015	11:35:58	Not Available	6.34		Not Available	Not Available
10/19/2015	13:42:59	Not Available	5.27	Not Available	Not Available	Not Available
	13:43:04		4.86			
10/20/2015	13:42:27	Not Available	4.63	Not Available	Not Available	Not Available
	15:21:45		4.79			
10/21/2015	12:18:45	Not Available	6.53	Not Available	Not Available	Not Available
	13:02:58		4.73			
10/22/2015	9:19:45	Not Available	5.65		Not Available	Not Available
10/23/2015	8:57:32	Not Available	6.03	Not Available	Not Available	Not Available
	13:04:39		4.18			
10/26/2015	14:17:39	Not Available	5.58		Not Available	Not Available
10/27/2015	9:13:22	Not Available	5.52		Not Available	Not Available
10/28/2015	15:16:51	Not Available	4.19		Not Available	Not Available
10/29/2015	16:08:22	Not Available	3.84		Not Available	Not Available
10/30/2015	13:06:24	Not Available	3.60		Not Available	Not Available
4/18/2016	10:26:32	Not Available	5.38		Not Available	Not Available
4/19/2016	9:54:05	Not Available	5.05		Not Available	Not Available
4/20/2016	14:31:34	Not Available	6.69		Not Available	Not Available
4/21/2016	10:15:54	Not Available	5.83		Not Available	Not Available
5/2/2016	13:14:13	Not Available	9.64		Not Available	Not Available
5/3/2016	12:35:31	Not Available	9.75		Not Available	Not Available
5/4/2016	16:50:16	Not Available	12.72		Not Available	Not Available
5/6/2016	10:57:53	Not Available	17.21		Not Available	Not Available
7/12/2016	10:02:43	Not Available	6.47		Not Available	Not Available
7/26/2016	10:51:38	Not Available	11.02		Not Available	Not Available
7/29/2016	14:06:02	Not Available	9.60		Not Available	Not Available
9/2/2016	16:20:17	Not Available	5.31		Not Available	Not Available
Average						

Note: Average of two flow measurements measured on the same day.

Table 4: Measured Little Bow River Flows during the Survey

Date	Time	Measured Flow [m^3/s]
10/13/2015	12:31:23	0.01
10/14/2015	13:20:44	1.01
10/15/2015	16:00:40	1.07

2.2 Cross Sections

The length of the Highwood River study reach is 93 km. A total number of 525 river channel cross sections were surveyed in 2015. The remaining 354 cross sections were surveyed in the spring and summer of 2016.

The length of the Little Bow River study reach is 15 km. A total of 139 river channel cross sections were surveyed in 2015 and 2016.

A summary of the surveyed river cross sections is provided in Table 5, including the five cross sections surveyed on the Bow River. The surveyed main river channel thalweg and survey water elevations along the Highwood and Little Bow River reaches are presented in Appendix A. An overview of the surveyed cross sections is provided in Appendix B.

Figure B-3 in Appendix B indicates that the survey cross sections in the north side channel opposite to Hoeh Dike are located outside of the original water course for the north side channel due to channel migration. Similarly, Figure B-4 in Appendix B indicates that the surveyed cross sections in the south side channel near Bews Dike are located outside of the original water course for the south side channel.

Table 5: 2016 Surveyed Cross Sections along the Highwood and Little Bow Study Reaches

River	Reach Number and Description		Total Number of Cross Sections Surveyed	Number of Cross Sections Surveyed in 2016	Average Reach Length [km]
Highwood River	1	Upstream Study Boundary to Pekisko Creek Confluence	185	185	15.5
	2	Pekisko Creek Confluence to a Location Immediately Upstream of High River	251	74	22.4
	3	Town of High River	132	2	9.8
	4	A Location Immediately Downstream of High River to Tongue Creek Confluence	58	1	6.9
	5	Tongue Creek Confluence to Sheep River Confluence	151	13	21.6
	6	Sheep River Confluence to Bow River Confluence	79	79	13.8
		High River Side Channels	23	0	N/A
Little Bow River	7	Upper Reach	99	22	10.6
	8	Lower Reach	39	1	1.9
		Lower Reach Side Channel	1	0	N/A
		TOTAL	**1,018**	**377**	

2.3 Hydraulic Structures

2.3.1 Bridges

In the Study area there are 14 bridges along the Highwood and the Little Bow River reaches as shown in Table 6. A new bridge on the Little Bow River was constructed in 2014 at 104 Street E. The old bridge was damaged during the June 2013 flood. There are two pedestrian bridges on the Happy Trails Pathways in the Town of High River. The south bridge was damaged during the June 2013 flood.

The locations of the bridges are shown in the map sheets in Appendix B. For each bridge a summary data sheet was prepared as shown in Appendix C.

Table 6: List of Bridges on the Highwood River and the Little Bow River Study Reaches

Bridge No.	River Name	River Station [m][(a)]	Name	Description	Type
1	Highwood River	85,947	Highway 22 Bridge	1 km South of Village of Longview	4-Span
2		47,687	Center Street Bridge	Center Street and Happy Trail	2-Span
3		Not Applicable	Happy Trails Bridge[(b)]	Pedestrian Bridge West of Center Street N	Pedestrian
4		Not Applicable	Lineham Bridge	Happy Trails and Center Street N, North of 1st Avenue NE	3-Span
5		Not Applicable	Lineham Pedestrian Bridge	Happy Trails and Center Street N, North of 1st Avenue NE	Pedestrian
6		42,344	George Groeneveld Crossing	498 Ave E / 2 km North of High River	2-Span
7		31,612	Train Bridge	Between Township Road 195a and Township Road 200	3-Span
8		30,025	Highway 2 South Bridge	1.5 km Southeast of Aldersyde	4-Span
9		29,921	Highway 2 North Bridge	1.5 km Southeast of Aldersyde	3-Span
10		24,052	Highway 547 Bridge	Highway 547 and South of Range Road 285	3-Span
11		6,439	Highway 552 Bridge	Upstream of Bow River Confluence	2-Span
12	Little Bow River [(c)]	11,013	Little Bow at 5 Street SE	Between 12 Ave SE And Monteith Drive	N/A
13		5,541	Little Bow at 104 Street E	5.5 km South of High River	3-Span
14		2,989	Highway 2 West Bridge	5.5 km South of High River	3-Span
15		2,962	Highway 2 East Bridge	5.5 km South of High River	3-Span

(a) Preliminary river station needs to be confirmed and finalized based on post-flood aerial imagery.

(b) Old Happy Trail Bridge located adjacent to the new Happy Trail Bridge was damaged and abandoned.

(c) There are several other pedestrian bridges on the Little Bow River upstream of the 12 Ave SE.

2.3.2 Culvert

There is no culvert along the Highwood River reach. There are four culverts along the Little Bow River (Table 7). The location of the culvert is shown in Appendix B. A summary data sheet was provided in Appendix C.

Table 7: List of Culverts on the Little Bow River Study Reach

No.	River	River Station [m][(a)]	Name	Description	Type
1	Little Bow River [(b)]	11,375	12th Avenue Culvert	12 Ave SE at High River	Culvert
2		10,375	Local Culvert to a Residence	NE 36-18-29-4	Culvert
3		9,539	Local Culvert to a Residence	SE 36-18-29-4	Culvert
4		6,801	Local Culvert to a Residence	Hifab High River Transport	Culvert

(a) Preliminary river station needs to be confirmed and finalized based on post-flood aerial imagery.

(b) There are other culverts (e.g., 8th Ave SE) on the Little Bow River upstream of the 12 Ave SE.

2.3.3 Weir and Dam

There is no weir or dam structure along the study reach of the Little Bow River. There is one weir structure along the study reach of the Highwood River as shown in Table 8.

The location of the culvert is shown in Appendix B. A summary data sheet was provided in Appendix C.

Table 8: List of Weir on the Highwood River Study Reach

No.	River	River Station [m][(a)]	Name	Description	Type
1	Highwood River	6,591	A Weir at Water Survey of Canada Station	Upstream of Highway 552 Bridge Crossing	Weir

(a) Preliminary river station needs to be confirmed and finalized based on post-flood aerial imagery.

2.4 Flood Control Structures

There are 11 flood control structures along the Highwood River reach within the Town of High River (Table 9). The locations of these flood control structures are presented in Appendix B. Appendix D presents a summary data sheet for each flood control structure.

The flood control structures are mostly earthen barriers or structures that were integrated in the pathway system in the Town of High River.

Table 9: Flood Control Structures in and near the Town of High River

River	No.	Side of River	Length [m]	Name	Description	Type
Highwood River	1	Right	2,194	Town Dike	Happy Trails from Center Street to 12 Ave. SW	Earthen Barrier
	2	Left	2,051	West Town Dike	From South of Riverside Drive NW to South of Range Road 291	
	3	High River	1,330	Beachwood Dike	Beach Way SW and Macleod Trail SW	
	4	Left	366	Lineham Canal Dike	Happy Trails Downstream of Happy Trails Bridge	
	5	Right	1,101	Little Bow Canal Dike	Happy Trails from Center Street to 96 Street E	
	6	Left	1,393	Golf Course Dike	South of Highwood Golf & Country Club	
	7	Right	283	Baker Creek Dike 1	South of 12 Ave. SW and West of 72 Street E	
	8	Right	70	Baker Creek Dike 2	South of 12 Ave. SW and East of 72 Street E	
	9	Right	378	Bews Dike	5.3 km Upstream of High River	
	10	Right	840	Hoeh Dike 1	7.5 km Upstream of High River	
	11	Right	635	Hoeh Dike 2	6.5 km Upstream of High River	

2.5 Accuracy

The survey accuracy for all points collected using the RTK GPS system with either the Can-net Virtual Reference Station (VRS) System or using a base station, is considered to be within ±2 cm in horizontal and vertical direction. The RTK Unit was calibrated daily to an ASCM benchmark. The daily survey was opened and closed on a common point (preferably the ASCM used to calibrate) to maintain an accuracy of ±2 cm.

The bridge surveys were conducted using a reflectorless total station that was set up over a temporary benchmark that was established using RTK GPS. The temporary benchmark setup and Total Station combined accuracy ranged between ±2 cm and ±5 cm. The exact accuracy for each point varies subject to the distance between the target and the Total Station.

The river survey conducted using an ADP and RTK combination on a boat has an overall reduced accuracy due to the following:

- While the RTK signal accuracy is considered to be within ±2 cm in horizontal and vertical direction, the constant movement of the boat on the water surface creates roll, pitch and yaw rotation that influences the angle of the ADP beam. Depending on the water depth and the angle deviation from vertical, the accuracy can be reduced by a few centimetres.
- The river bed materials in the Highwood River consist of gravels and cobbles. The ADP will return a somewhat averaged depth signal so that small variations in the river bed may not be fully recognized.

Overall the river bed survey using a boat and a RTK/ADP combination is considered to have an accuracy of ±10 cm in horizontal and vertical direction.

2.6 LiDAR DTM Quality Check

Ground control points were surveyed at least every kilometre and within a distance of less than 100 m from the river. These ground control points will be used as an additional quality check for the LiDAR DTM provided by AEP. The average difference between the ground control points and the LiDAR DTM is 1 cm and the associated mean absolute difference is 6 cm (Table 10).

Table 10: Comparison between Surveyed Ground Control Points and LiDAR DTM

River	Reach Number and Description		Number of Control Points	Average Difference between Ground Survey and LiDAR [m]	Mean Absolute Difference Between Ground Survey and LiDAR [m]	Minimum Difference Between Ground Survey and LiDAR	Maximum Difference Between Ground Survey and LiDAR
Highwood River	1	Upstream Study Boundary to Pekisko Creek Confluence	24	0.02	0.06	-0.17	0.18
	2	Pekisko Creek Confluence to a Location Immediately Upstream of High River	27	0.02	0.05	-0.08	0.13
	3	Town of High River	11	-0.02	0.03	-0.09	0.05
	4	A Location Immediately Downstream of High River to Tongue Creek Confluence	8	-0.03	0.05	-0.11	0.08
	5	Tongue Creek Confluence to Sheep River Confluence	26	-0.06	0.09	-1.12	0.08
	6	Sheep River Confluence to Bow River Confluence	16	0.02	0.08	-0.14	0.56
Little Bow River	7	Upper Reach	14	-0.01	0.04	-0.09	0.07
	8	Lower Reach	2	-0.01	0.06	-0.08	0.05

3.0 AERIAL IMAGERY

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.

4.0 OTHER BASE DATA

The other base data collected in this Study includes the following:

- LiDAR data provided by AEP;
- available survey data and as-built drawings provided by Alberta Transportation for the bridges; and
- available GIS data provided by the Province, Town of Highwood River, and Municipal District of Foothills, including administrative, cadastral, transportation, water resources, land use and buildings data.

5.0 CONCLUSIONS

The river survey and base data have been collected in this Study in accordance with the requirements by AEP for supporting hydraulic modelling, flood mapping, flood risk assessment, and channel stability investigation. The following conclusions are made:

- **River Cross Section Survey:** The river survey data meet the Study requirements with regards to cross-sectional spacing and alignment, extents of cross sections on the floodplains, labeling of survey points, and survey accuracy.
- **Hydraulic and Flood Control Structure Surveys:** The hydraulic and flood control structure survey data collected for this study in 2015 and 2016 meet the study requirements and include the required details for hydraulic modelling.
- **Digital Terrain Model:** The accuracy of the digital terrain model provided by AEP meets the requirements for provincial flood hazard studies.
- **Aerial Imagery:** Aerial imagery with a ground resolution of 30 cm collected on May 6, 2016 meets the current study requirement.

6.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

Prepared by:

Hua Zhang, Ph.D., P.Eng.
Senior River Engineer, Project Manager

Reviewed by:

Dejiang Long, Ph.D., P.Eng.
Principal, Project Director

HZ/DL/ak/jlb

r:\active_2015\3 proj\1536669 aep highwood river hazard study\06_ph 1000_data collection and review\reporting\final final report_november 2017\final_report_highwood_river_survey_november 15, 2017.docx

THIRD PARTY DISCLAIMER

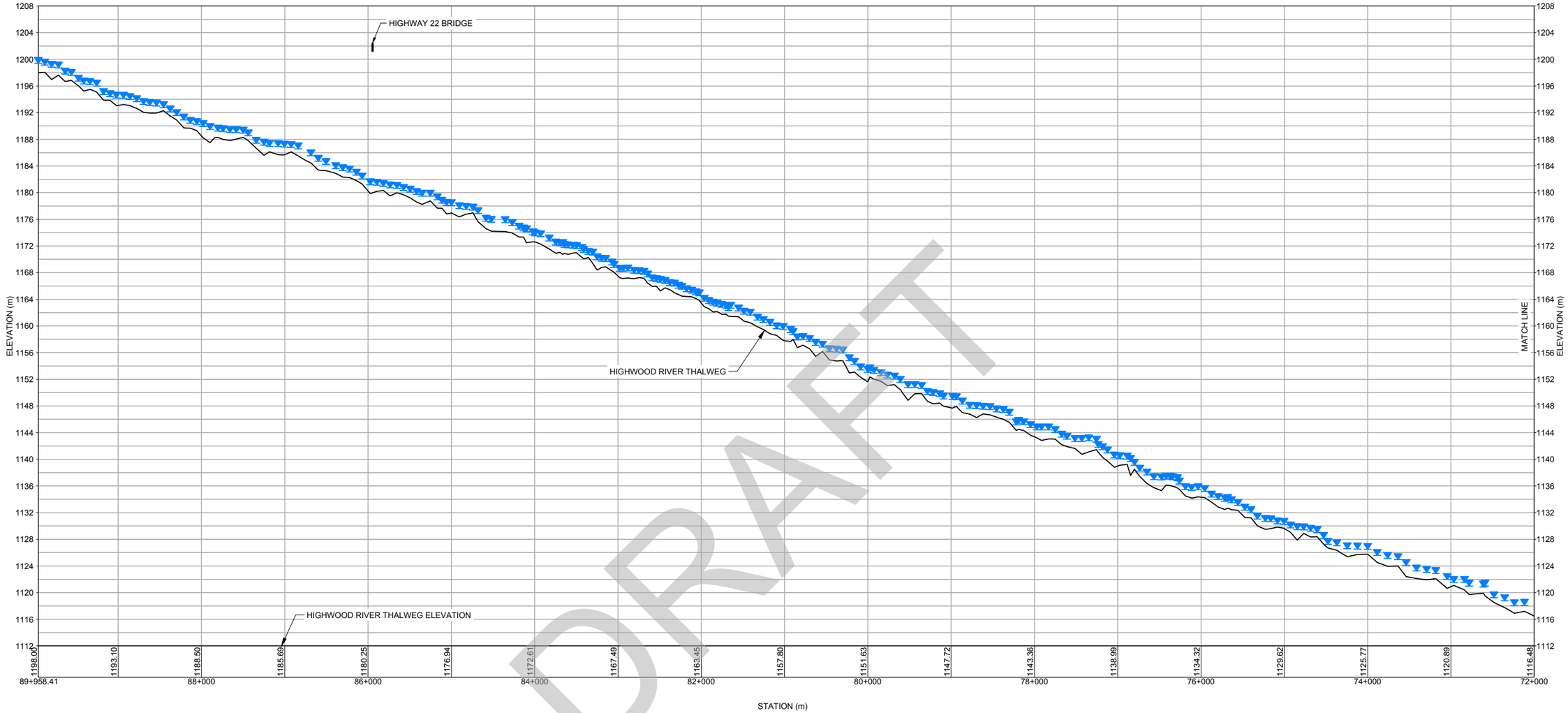
This report has been prepared by Golder Associates Ltd. (Golder) for the benefit of the client to whom it is addressed. The information and data contained herein represent Golder's best professional judgment in light of the knowledge and information available to Golder at the time of preparation. Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the client, its officers and employees. Golder denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents without the express written consent of Golder and the client.

REFERENCES

Golder (Golder Associated Ltd.). January 2014. Highwood River Open-Water Survey: Bathymetry, Sediment and Vegetation. Prepared for Alberta Environment and Parks.

APPENDIX A

Surveyed Thalweg and Water Level Profiles



LEGEND

MEASURED WATER LEVELS DURING SURVEY

REFERENCE

SURVEY DATA COLLECTED BY GOLDER IN OCTOBER TO NOVEMBER 2015 (HIGHWOOD RIVER AND LITTLE BOW RIVER)

0 1,000 2,000 METRES

HORIZONTAL SCALE 1:50,000
VERTICAL EXAGERATION = 80X

CLIENT
ALBERTA ENVIRONMENTS AND PARKS

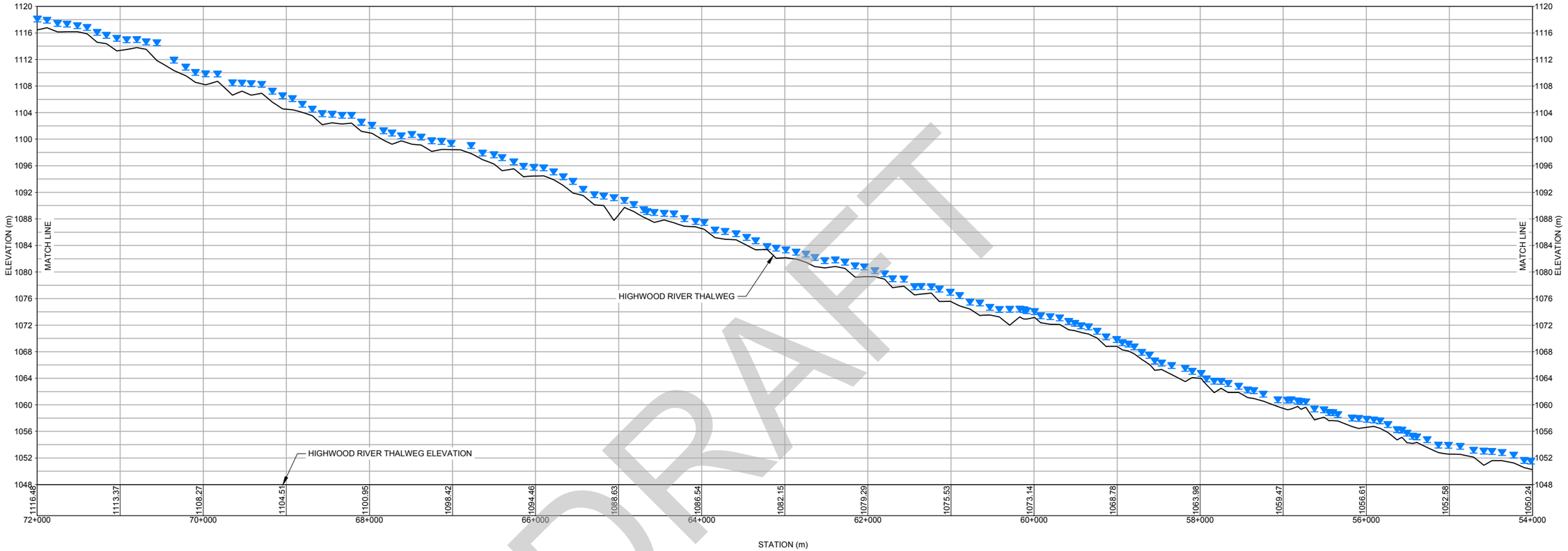
PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
HIGHWOOD RIVER THALWEG PROFILES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
PREPARED	MKH
DESIGN	PT
REVIEW	HZ
APPROVED	DL

PROJECT No.	CONTROL	Rev.	FIGURE
1536669	1000	0	A-1



LEGEND

▼ MEASURED WATER LEVELS DURING SURVEY

REFERENCE

SURVEY DATA COLLECTED BY GOLDER IN OCTOBER TO NOVEMBER 2015 (HIGHWOOD RIVER AND LITTLE BOW RIVER)

0 1,000 2,000

HORIZONTAL SCALE 1:50,000 METRES
VERTICAL EXAGERATION = 80X

CLIENT
ALBERTA ENVIRONMENTS AND PARKS

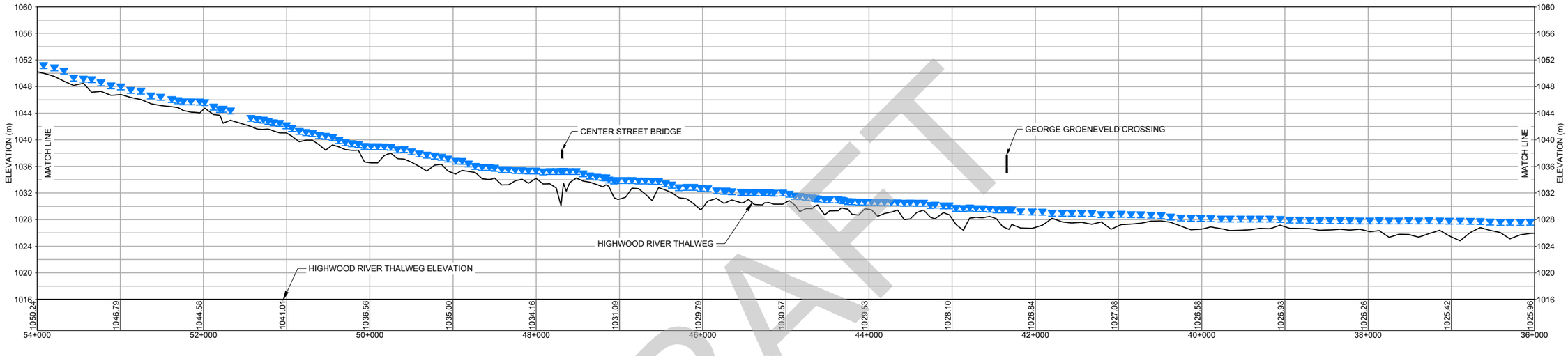
PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
HIGHWOOD RIVER THALWEG PROFILES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
PREPARED	MKH
DESIGN	PT
REVIEW	HZ
APPROVED	DL

PROJECT No.	CONTROL	Rev.	FIGURE
1536669	1000	0	A-2



LEGEND

MEASURED WATER LEVELS DURING SURVEY

REFERENCE

SURVEY DATA COLLECTED BY GOLDER IN OCTOBER TO NOVEMBER 2015 (HIGHWOOD RIVER AND LITTLE BOW RIVER)

0 1,000 2,000 METRES

HORIZONTAL SCALE 1:50,000
VERTICAL EXAGERATION = 80X

CLIENT
ALBERTA ENVIRONMENTS AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
HIGHWOOD RIVER THALWEG PROFILES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
PREPARED	MKH
DESIGN	PT
REVIEW	HZ
APPROVED	DL

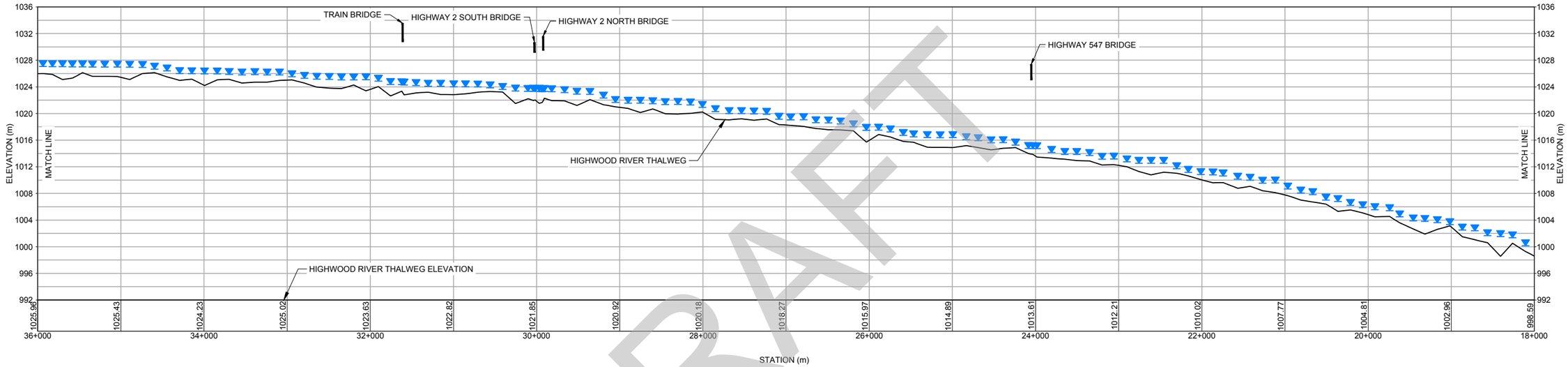
PROJECT No.	CONTROL	Rev.	FIGURE
1536669	1000	0	A-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

0

Path: \\golder.gds\gal\saskatoon\gis\2015\15-36669 Highwood River Hazard Study\Figures\ | File Name: 1536669 Highwood - Fall 2016.dwg



LEGEND

▼ MEASURED WATER LEVELS DURING SURVEY

REFERENCE

SURVEY DATA COLLECTED BY GOLDER IN OCTOBER TO NOVEMBER 2015 (HIGHWOOD RIVER AND LITTLE BOW RIVER)

0 1,000 2,000 METRES

HORIZONTAL SCALE 1:50,000
VERTICAL EXAGERATION = 80X

CLIENT
ALBERTA ENVIRONMENTS AND PARKS

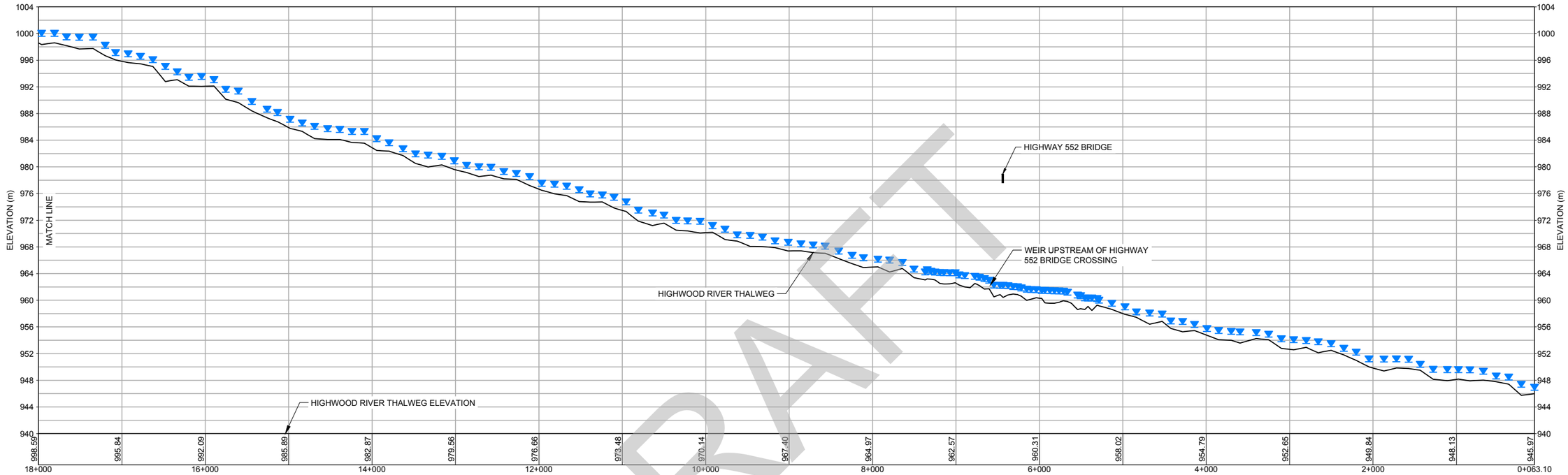
PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
HIGHWOOD RIVER THALWEG PROFILES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
PREPARED	MKH
DESIGN	PT
REVIEW	HZ
APPROVED	DL

PROJECT No.	CONTROL	Rev.	FIGURE
1536669	1000	0	A-4



LEGEND

MEASURED WATER LEVELS DURING SURVEY

REFERENCE

SURVEY DATA COLLECTED BY GOLDER IN OCTOBER TO NOVEMBER 2015 (HIGHWOOD RIVER AND LITTLE BOW RIVER)

HORIZONTAL SCALE 1:50,000
VERTICAL EXAGERATION = 80X

0 1,000 2,000 METRES

CLIENT
ALBERTA ENVIRONMENTS AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
HIGHWOOD RIVER THALWEG PROFILES

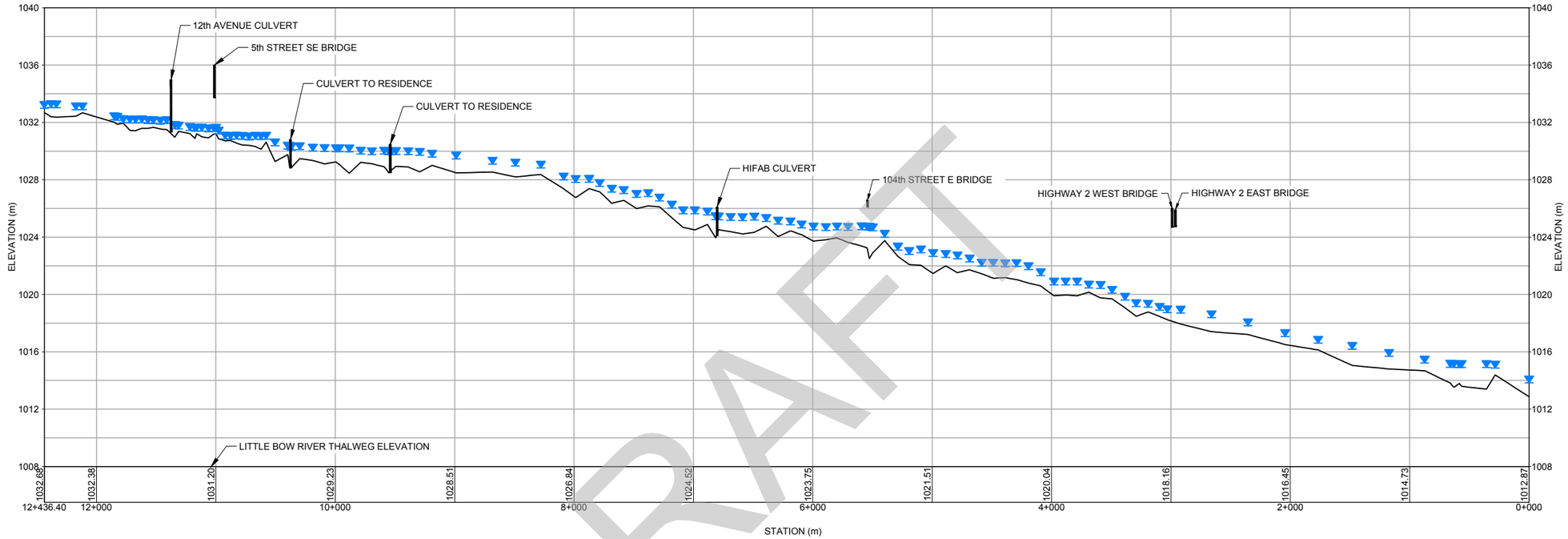
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
PREPARED	MKH
DESIGN	PT
REVIEW	HZ
APPROVED	DL

PROJECT No.	CONTROL	Rev.	FIGURE
1536669	1000	0	A-5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

25 mm



LEGEND

▼ MEASURED WATER LEVELS DURING SURVEY

REFERENCE

SURVEY DATA COLLECTED BY GOLDER IN OCTOBER TO NOVEMBER 2015 (HIGHWOOD RIVER AND LITTLE BOW RIVER)

0 1,000 2,000 METRES

HORIZONTAL SCALE 1:40,000
VERTICAL EXAGERATION = 120X

CLIENT
ALBERTA ENVIRONMENTS AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LITTLE BOW RIVER THALWEG PROFILE

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
PREPARED	MKH
DESIGN	PT
REVIEW	HZ
APPROVED	DL

PROJECT No.	CONTROL	Rev.	FIGURE
1536669	1000	0	A-6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

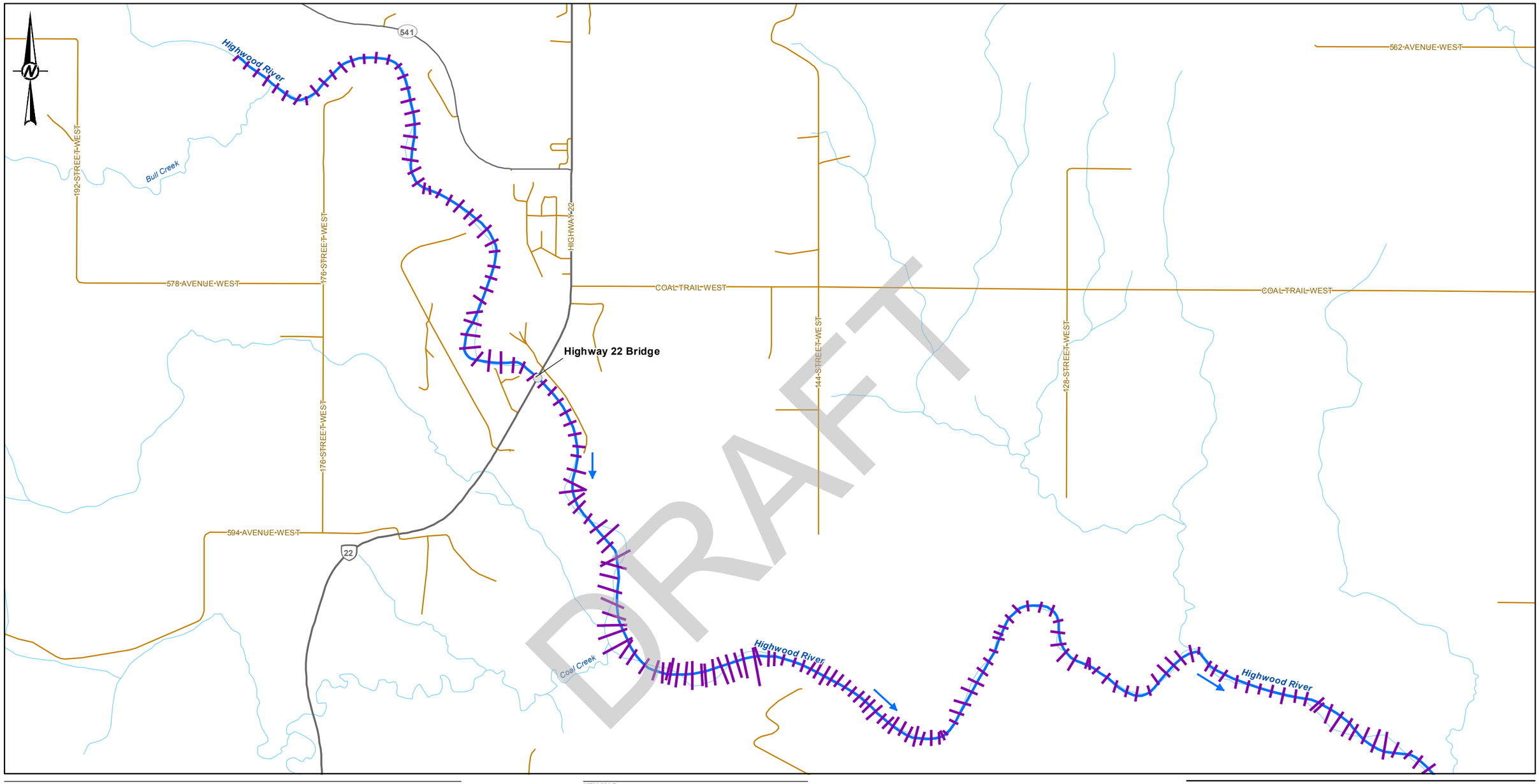
25 mm

0

Path: \\golder.gds\gal\saskatoon\gis\2015\15-36669 Highwood River Hazard Study\Figures\ | File Name: 1536669 Little Bow - Fall 2016.dwg

APPENDIX B

Cross Section, Hydraulic Structure and Flood Control Structure Locations



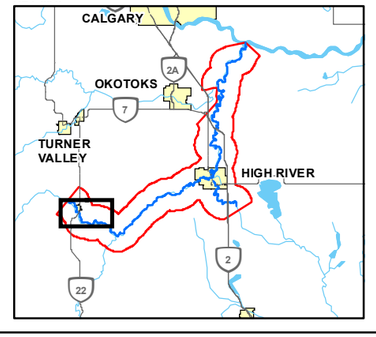
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

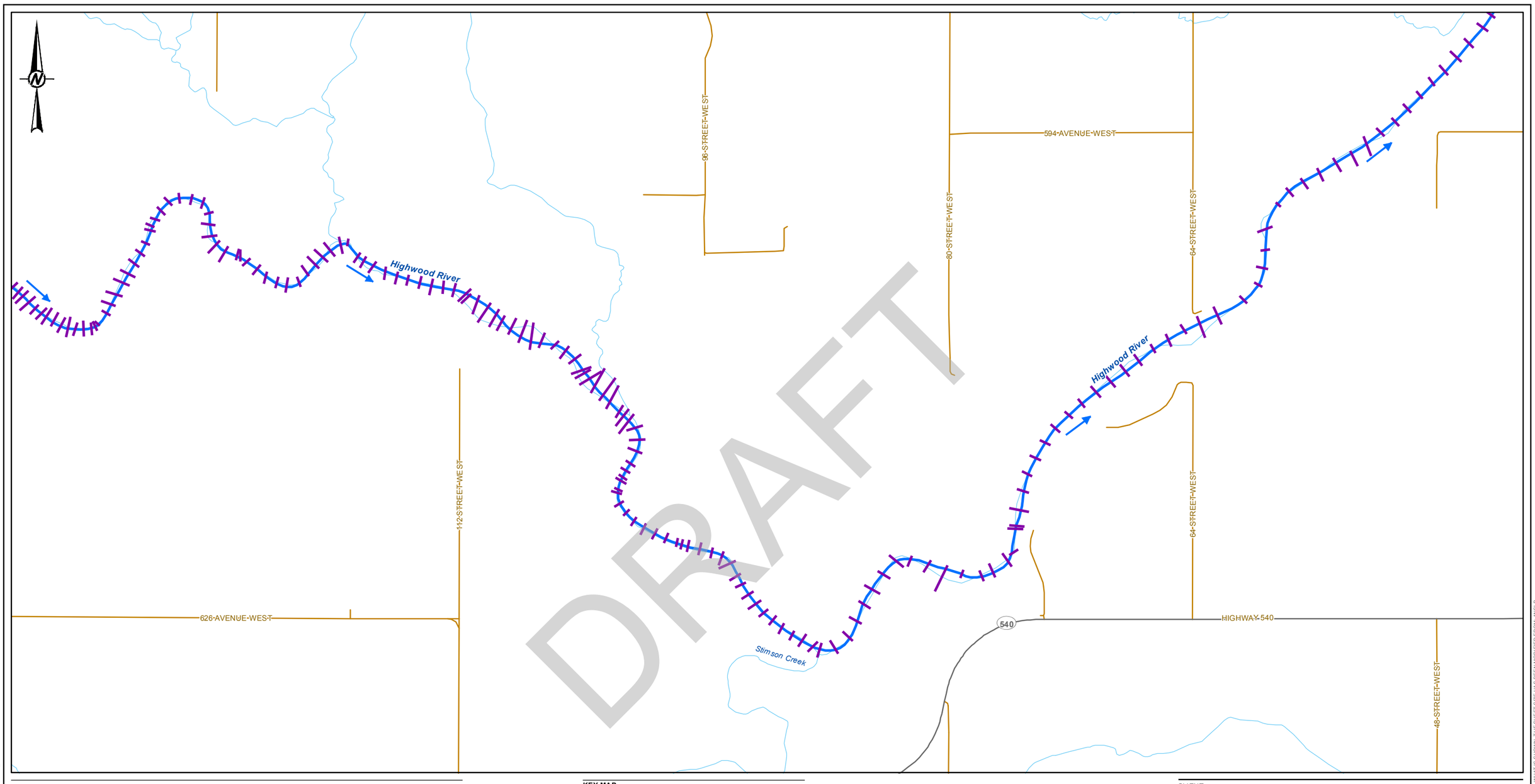
PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	B-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

PATH: I:\2015\1536\669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT 2:37:12 PM



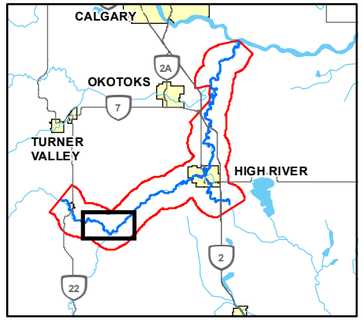
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

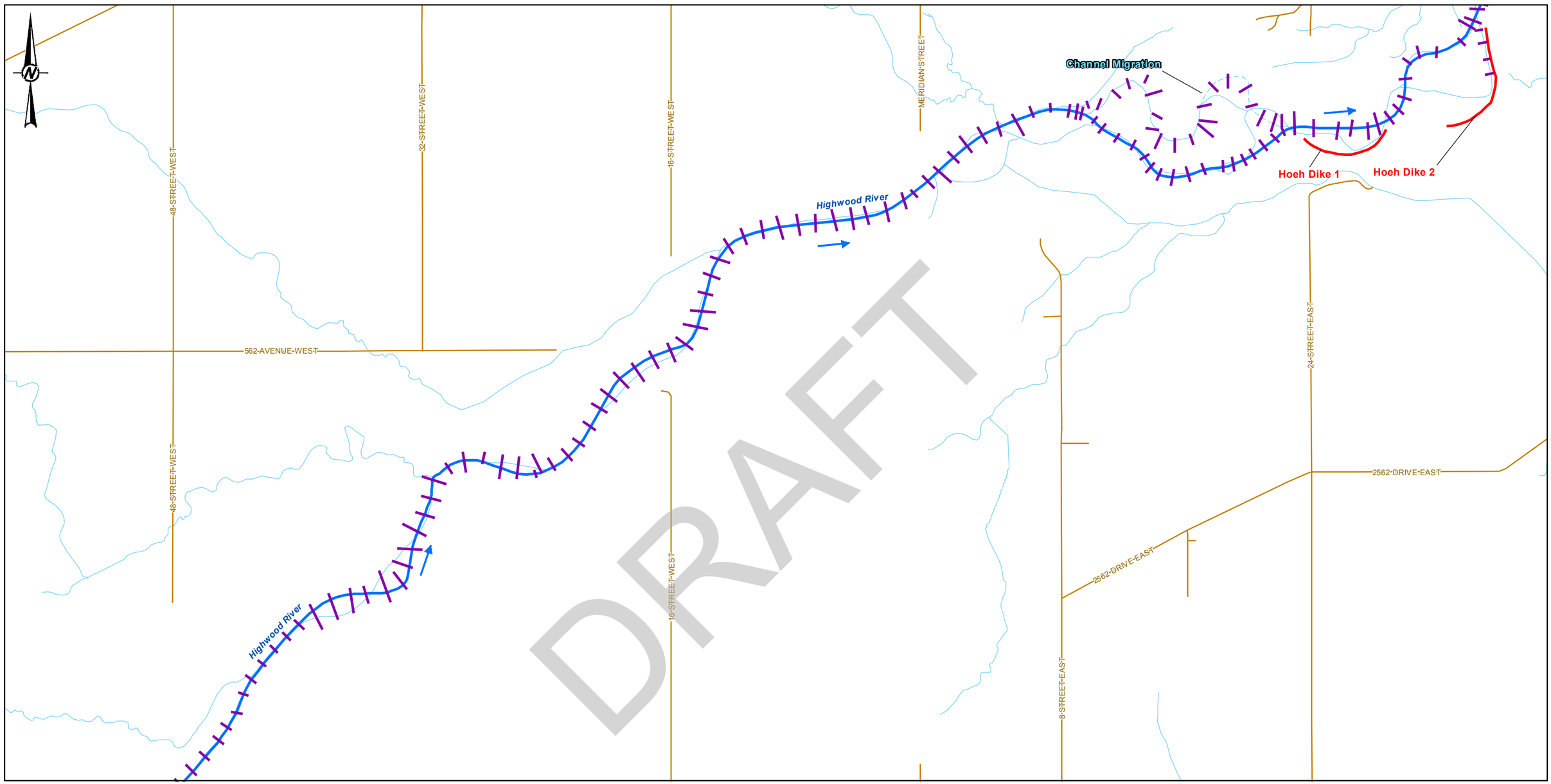
PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	B-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT: 2:37:16 PM



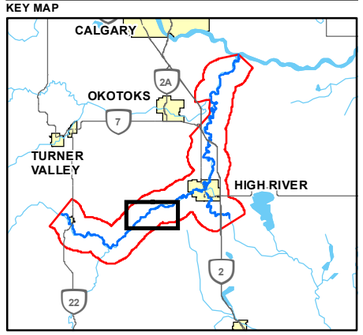
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

CONSULTANT
Golder Associates

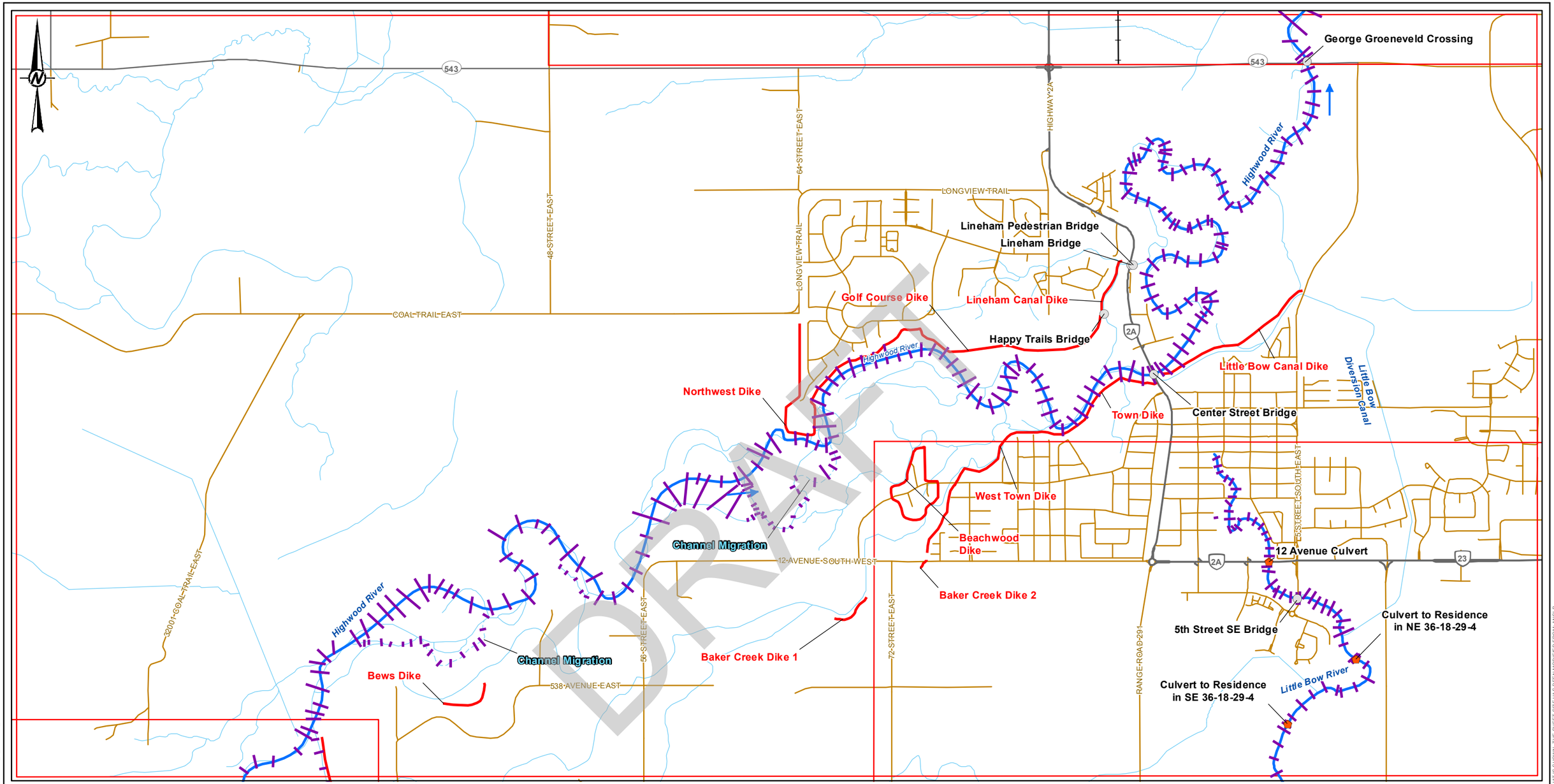
YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO. 1536669 | CONTROL | REV. 0 | FIGURE **B-3**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm

PATH: I:\2015\1\1536669\Mapping\MXD\Hydrology\River Surveys\1536969_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT: 2:37:20 PM



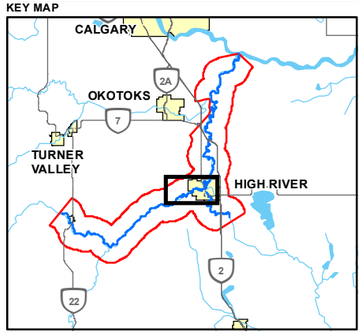
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

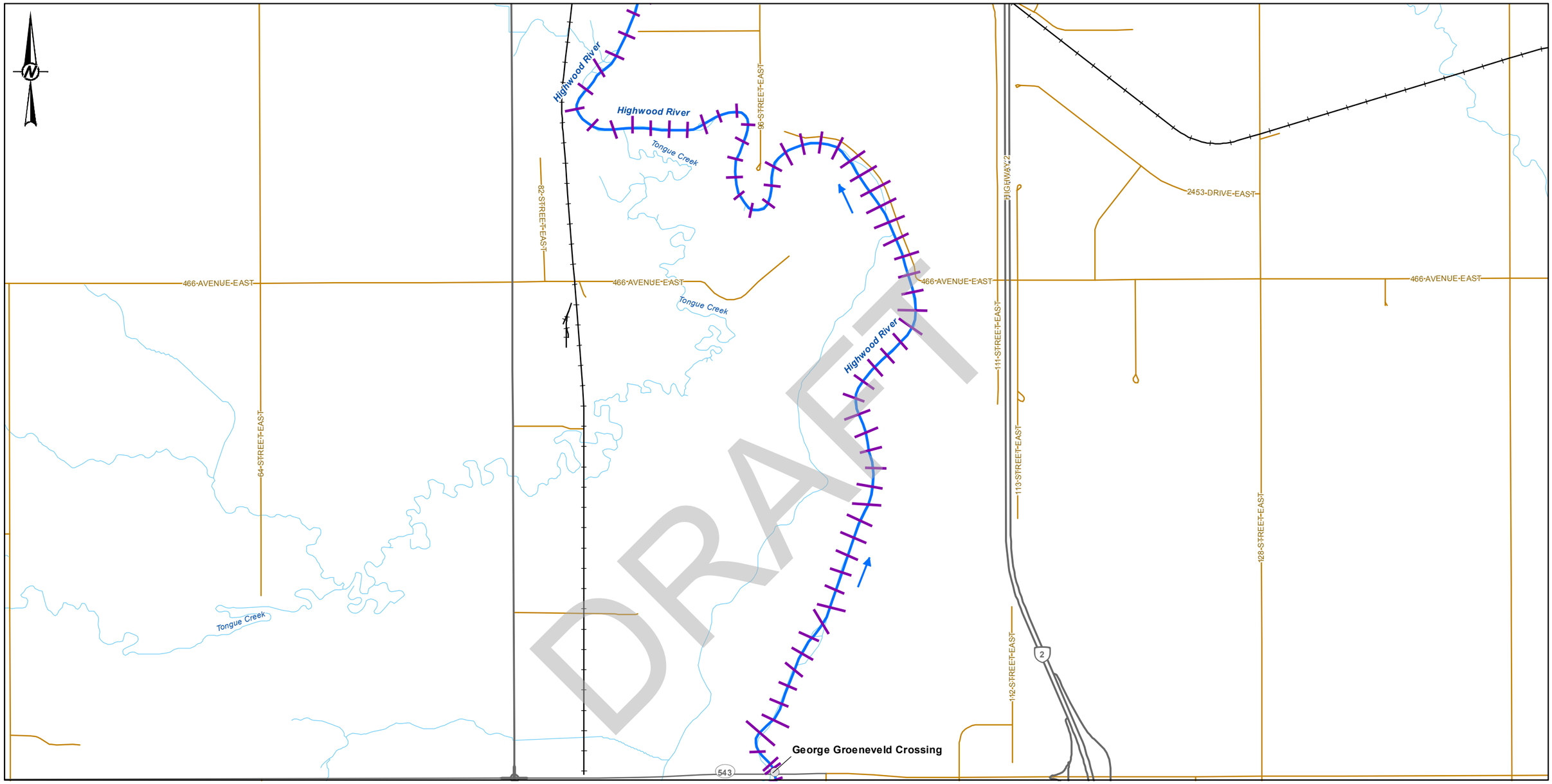
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO. 1536669 | CONTROL | REV. 0 | FIGURE **B-4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\02_Survey & Base Data Collection\1536669_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-11-16 AT: 11:10:07 PM



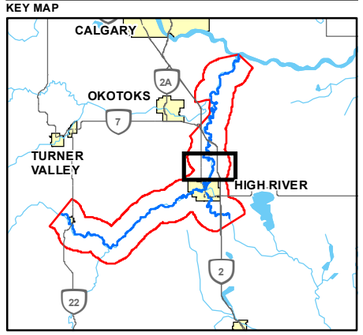
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

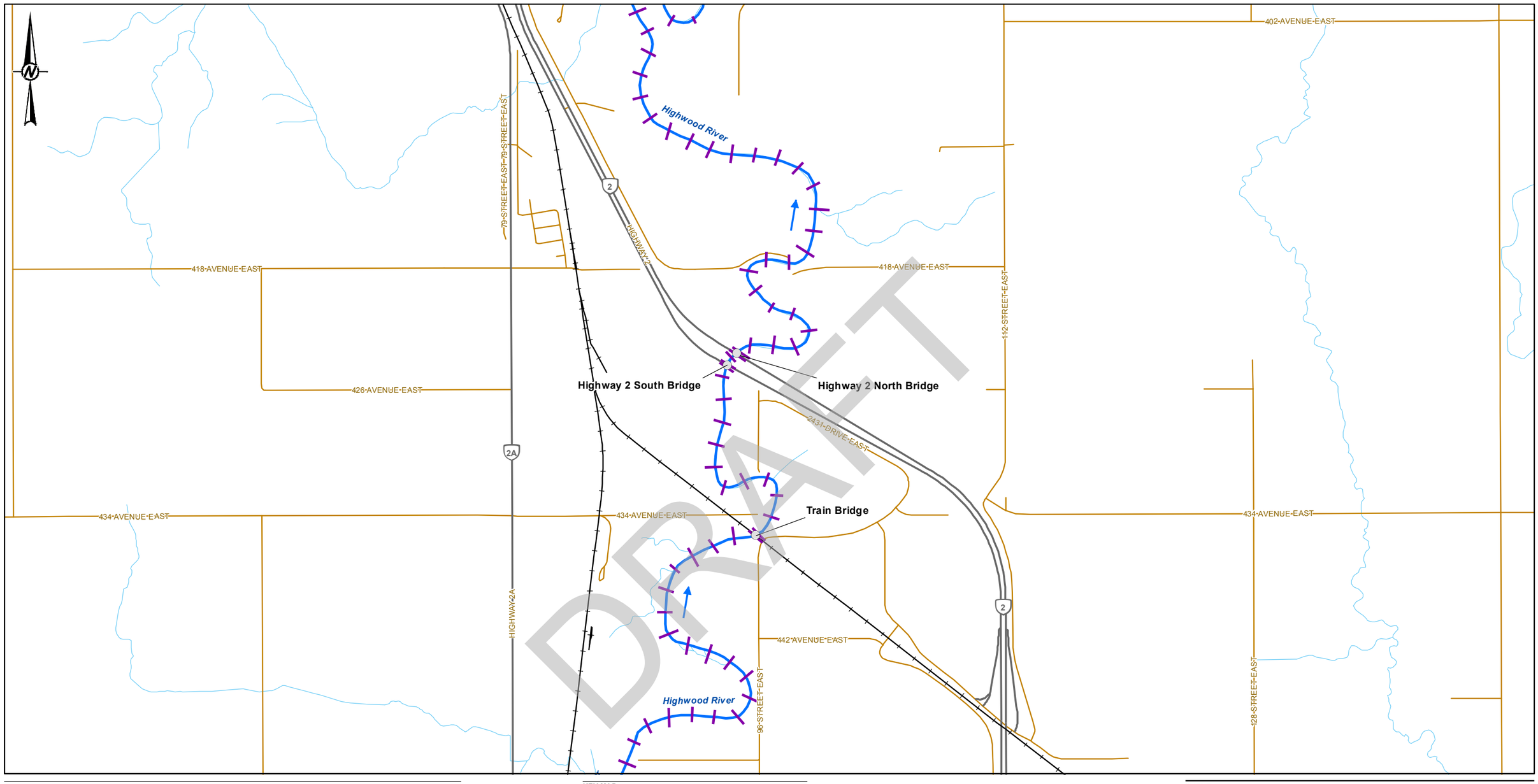
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO. 1536669 | CONTROL | REV. 0 | FIGURE **B-5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT 2:37:28 PM



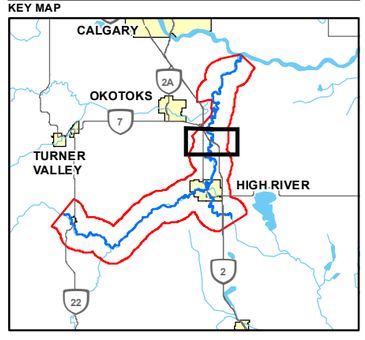
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

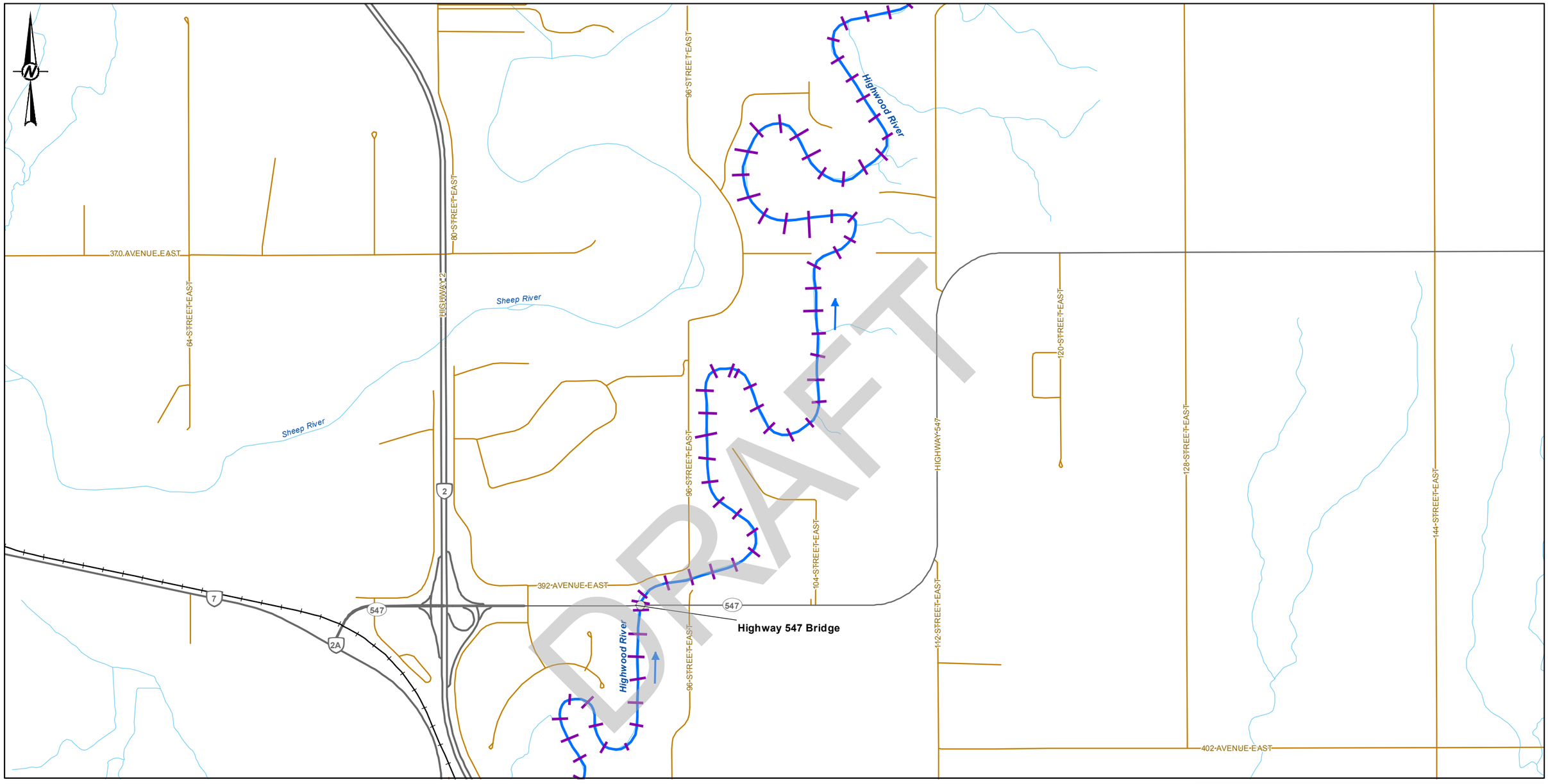
PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	B-6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT: 2:37:33 PM



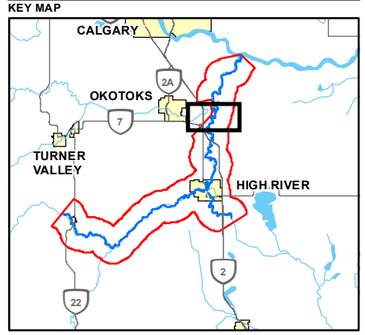
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

CONSULTANT
Golder Associates

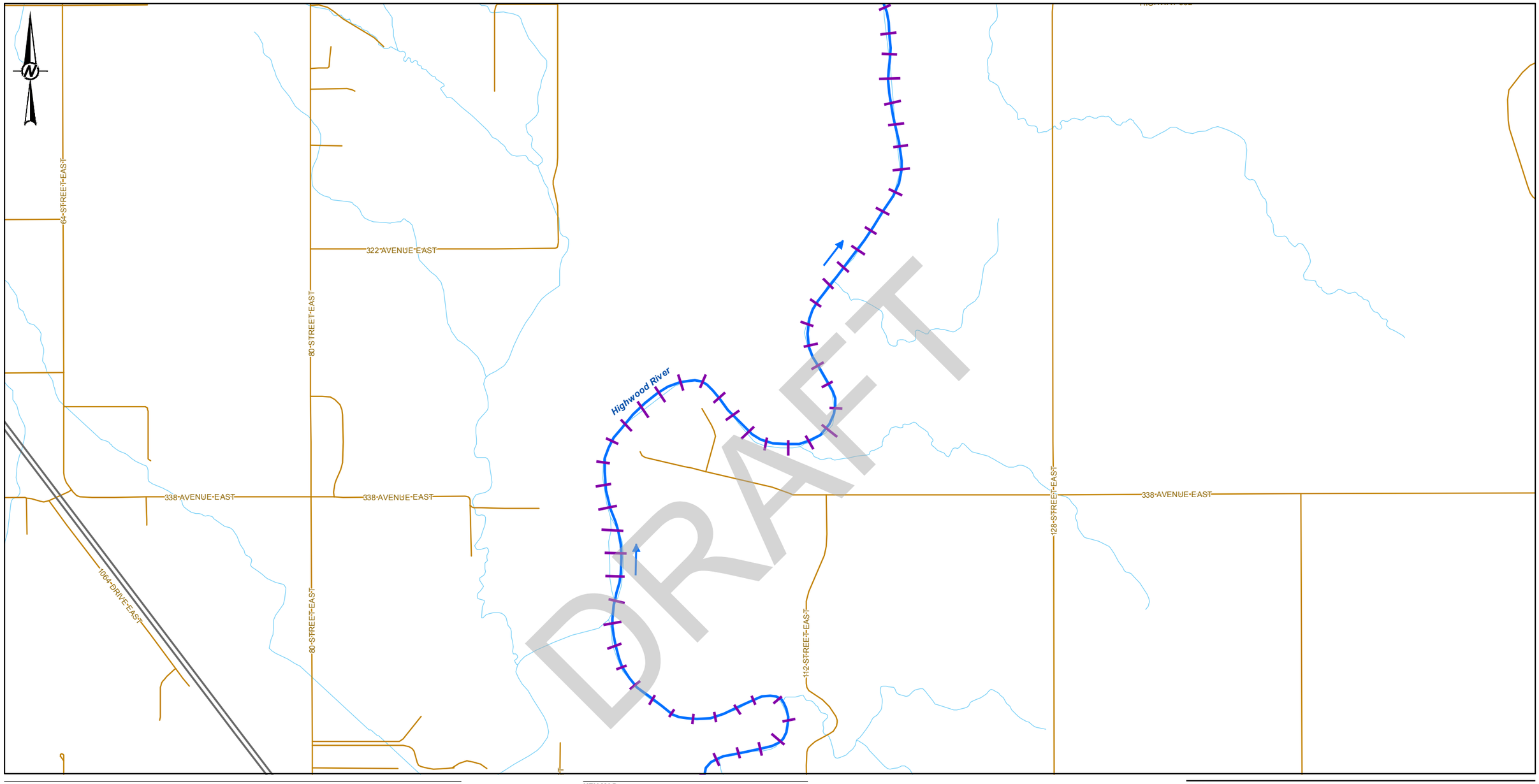
YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO. 1536669 | CONTROL | REV. 0 | FIGURE **B-7**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm

PATH: I:\2015\1536869\Mapping\MXD\Hydrology\River Surveys\1536869_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT 2:37:37 PM



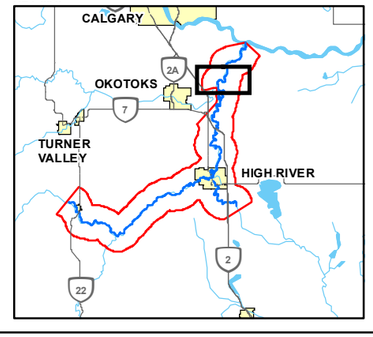
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

CONSULTANT
Golder Associates

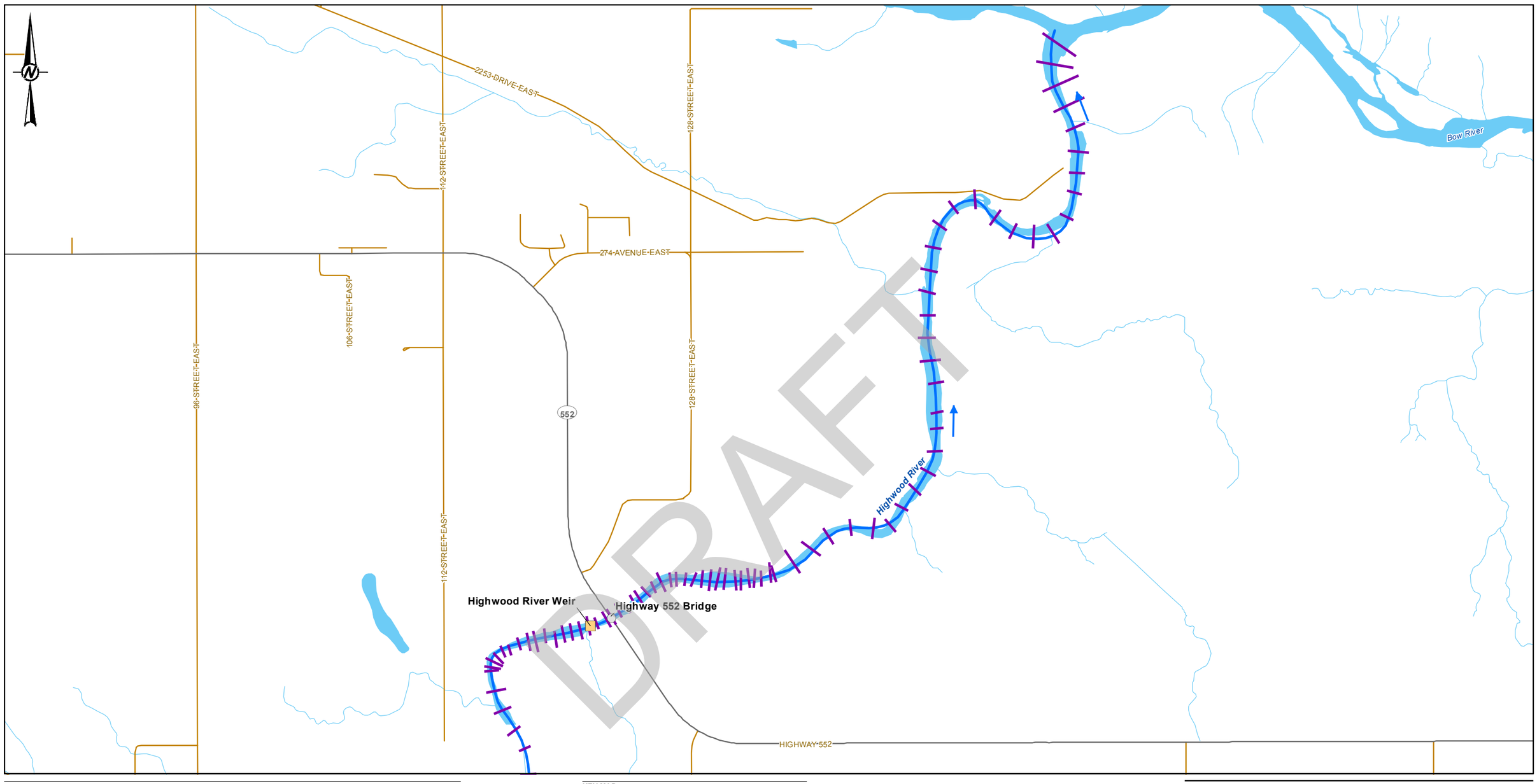
YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	B-8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536969_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT 2:37:41 PM



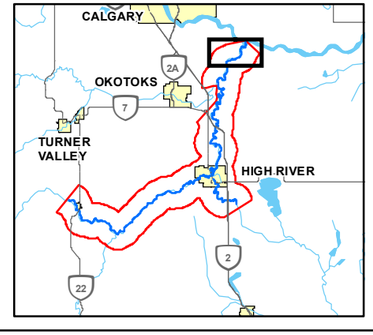
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

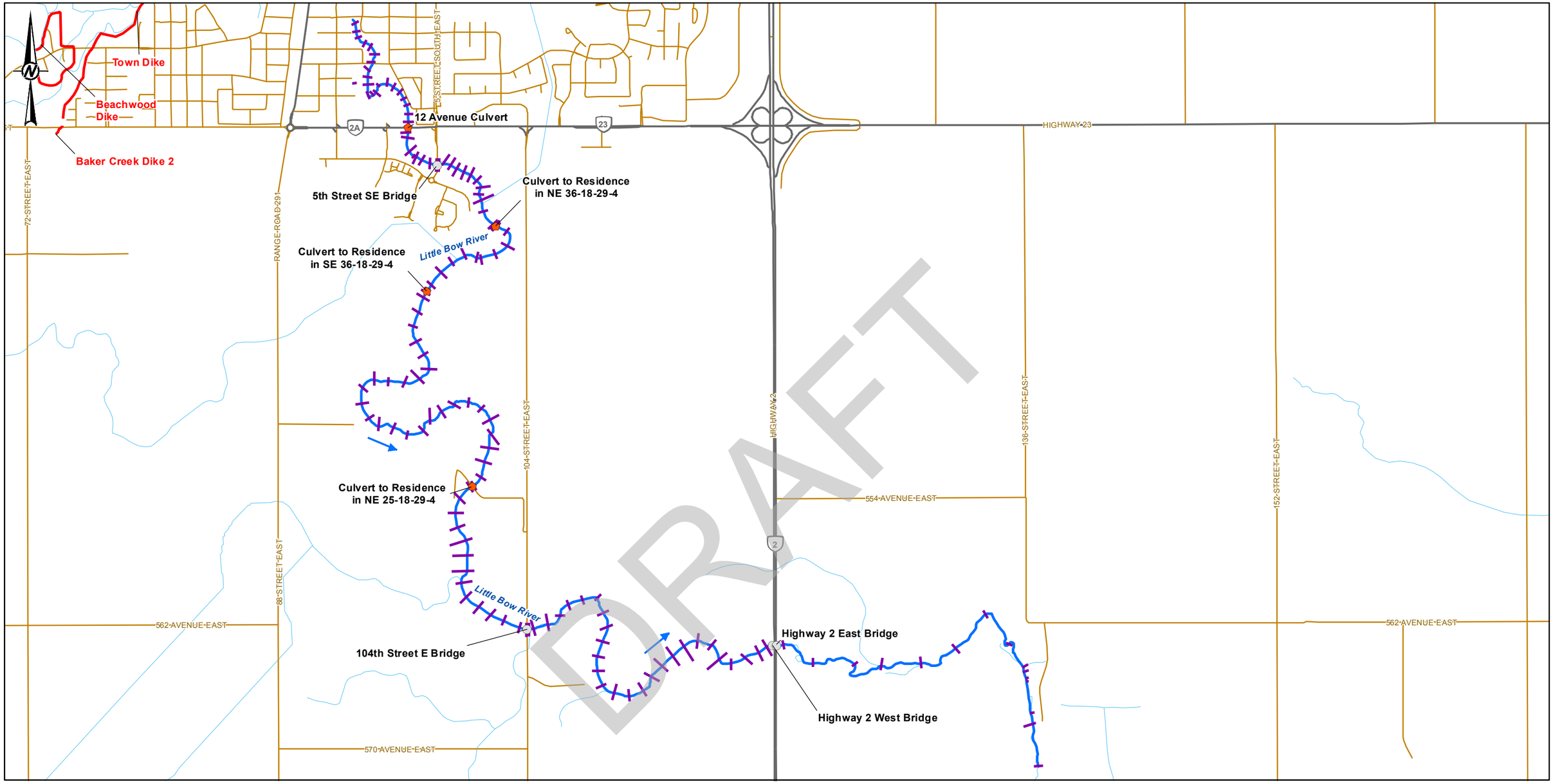
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	**B-9**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: I:\2015\1\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT: 2:37:45 PM



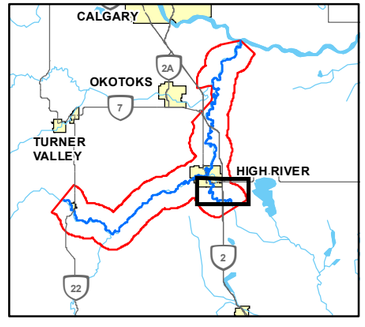
LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- CHANNEL MIGRATION
- WATERBODY

HYDRAULIC STRUCTURES

- BRIDGE
- CULVERT
- WEIR
- FLOOD CONTROL STRUCTURE
- SURVEY REACH
- SURVYED CROSS SECTION
- FLOW DIRECTION

KEY MAP



0 1 2

1:25,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS AND RAILWAYS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	B-10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536969_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2017-10-02 AT 2:37:49 PM

APPENDIX C

Bridge/Culvert Datasheets

TITLE

HIGHWAY 22 BRIDGE

DESCRIPTION	1 KM SOUTH OF VILLIAGE OF LONGVIEW
YEAR BUILT	1961
TOTAL LENGTH OF SPAN (m)	105.9
DECK WIDTH OF BRIDGE (m)	9.4
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,202.4
AVERAGE LOW CHORD ELEVATION (m)	1,201.2
AVERAGE DECK HEIGHT	1.2
NUMBER OF PIERS	4

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	10.11	1.17	CONCRETE	RECTANGULAR
2	36.15	2.00	CONCRETE	TRIANGULAR NOSE
3	63.59	1.96	CONCRETE	TRIANGULAR NOSE
4	85.84	1.54	CONCRETE	RECTANGULAR

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-1

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_C_Bridges-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 2:44:31 PM

0 100 200

1:5,000 METRES

TITLE

CENTER STREET BRIDGE

DESCRIPTION	CENTER STREET AND HAPPY TRAIL
YEAR BUILT	1964
TOTAL LENGTH OF SPAN (m)	62.2
DECK WIDTH OF BRIDGE (m)	13.6
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,038.5
AVERAGE LOW CHORD ELEVATION (m)	1,037.3
AVERAGE DECK HEIGHT	1.2
NUMBER OF PIERS	1

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	31.50	1.02	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
2	-	-	-	-
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

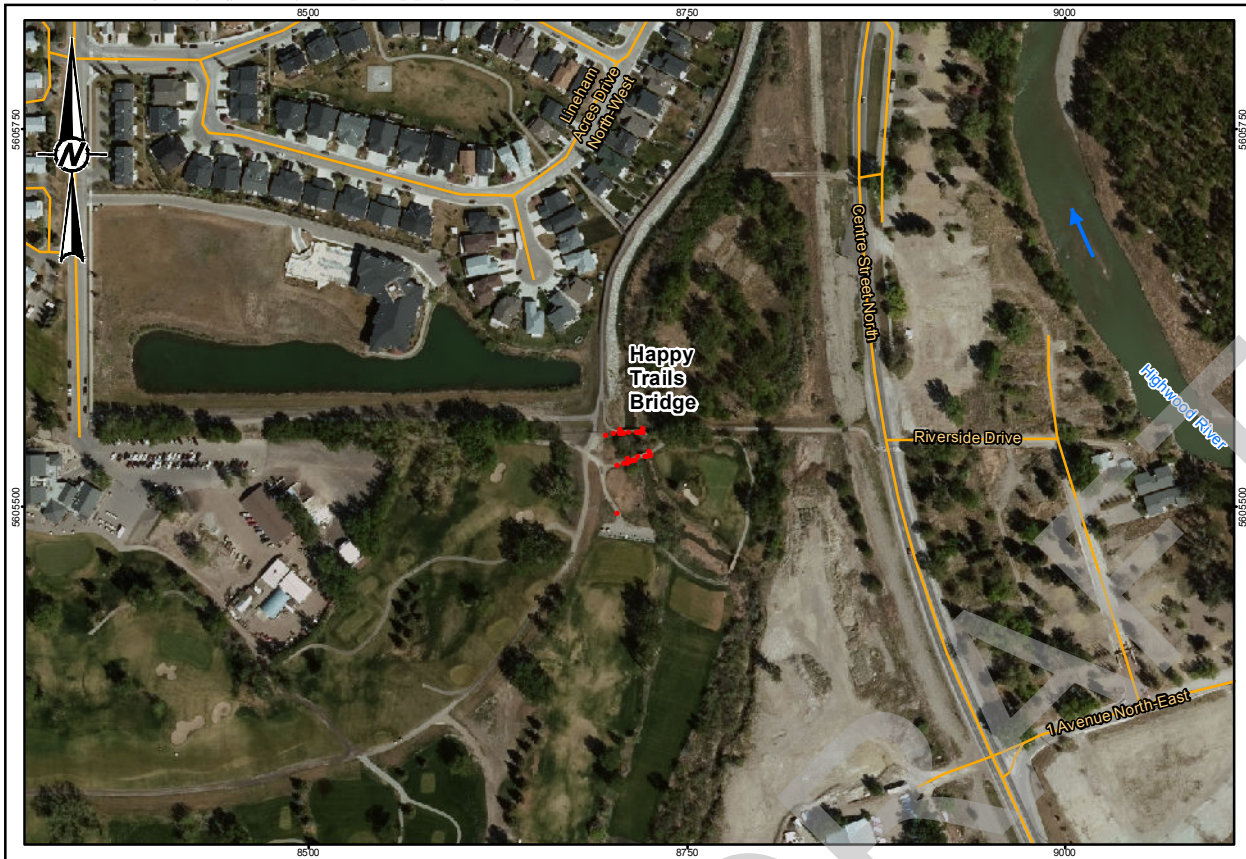
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A 25mm 0



0 100 200
1:5,000 METRES

TITLE
HAPPY TRAILS BRIDGE

DESCRIPTION	PEDESTRIAN BRIDGE/ WEST OF CENTER STREET N
YEAR BUILT	NOT AVAILABLE
TOTAL LENGTH OF SPAN (m)	15.2
DECK WIDTH OF BRIDGE (m)	2.1
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,037.3
AVERAGE LOW CHORD ELEVATION (m)	1,036.2
AVERAGE DECK HEIGHT	1.1
NUMBER OF PIERS	0

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A
25mm
0

TITLE

LINEHAM BRIDGE

DESCRIPTION	HAPPY TRAILS AND CENTER STREET N, NORTH OF 1 AVENUE NE
YEAR BUILT	NOT AVAILABLE
TOTAL LENGTH OF SPAN (m)	24.6
DECK WIDTH OF BRIDGE (m)	11.3
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,037.5
AVERAGE LOW CHORD ELEVATION (m)	1,036.7
AVERAGE DECK HEIGHT	0.8
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	7.91	0.52	STEEL/WOOD	RECTANGULAR
2	8.48	0.52	STEEL/WOOD	RECTANGULAR
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-4

TITLE

LINEHAM PEDESTRIAN BRIDGE

DESCRIPTION	HAPPY TRAILS AND CENTER STREET N, NORTH OF 1 AVENUE NE
YEAR BUILT	NOT AVAILABLE
TOTAL LENGTH OF SPAN (m)	30.5
DECK WIDTH OF BRIDGE (m)	5.1
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,036.4
AVERAGE LOW CHORD ELEVATION (m)	1,036
AVERAGE DECK HEIGHT	0.5
NUMBER OF PIERS	0

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

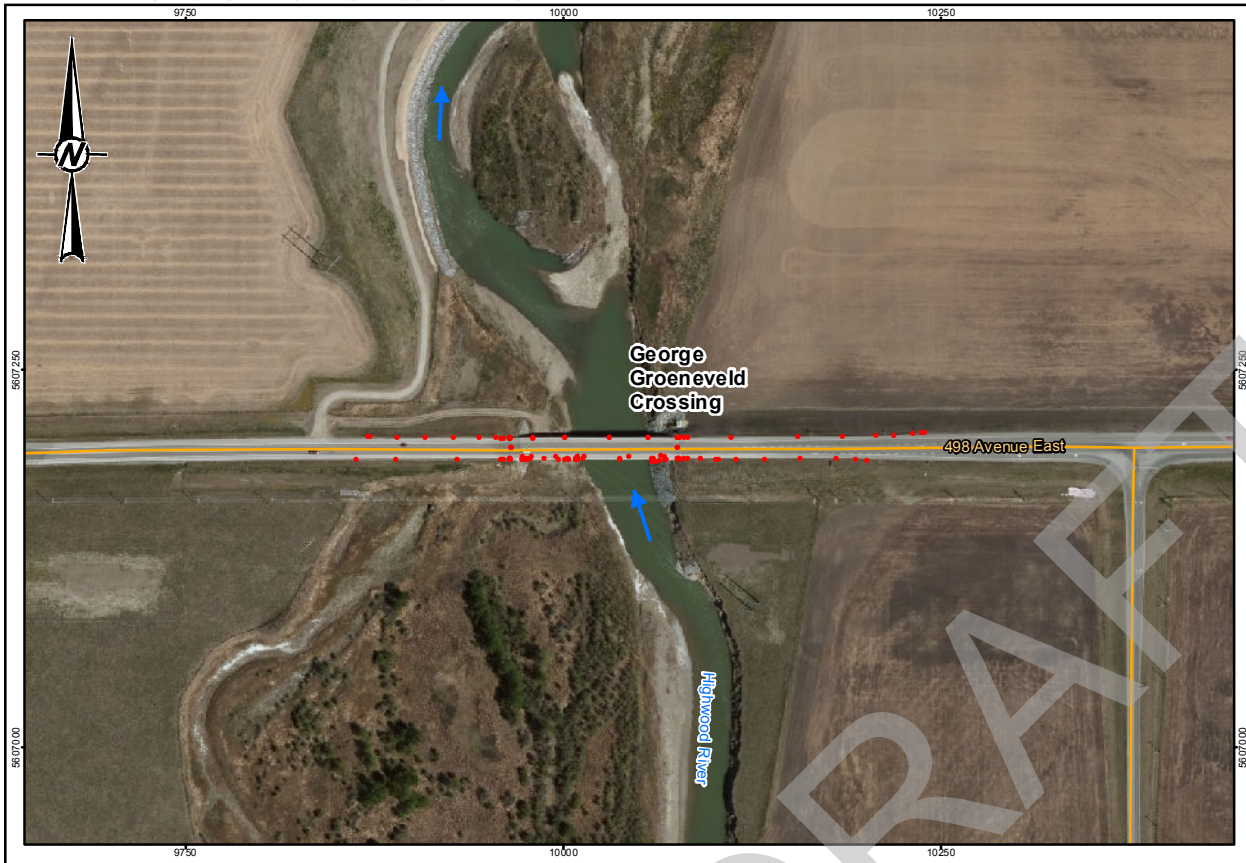
YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0



0 100 200

1:5,000 METRES

TITLE

GEORGE GROENEVELD CROSSING

DESCRIPTION	498TH AVE E / 2 KM NORTH OF TOWN OF HIGH RIVER
YEAR BUILT	2011
TOTAL LENGTH OF SPAN (m)	112.0
DECK WIDTH OF BRIDGE (m)	14.4
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,037.7
AVERAGE LOW CHORD ELEVATION (m)	1,035
AVERAGE DECK HEIGHT	2.7
NUMBER OF PIERS	1

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	44.59	1.43	CONCRETE	CYLINDER
2	-	-	-	-
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-6

TITLE

TRAIN BRIDGE

DESCRIPTION	BETWEEN TOWNSHIP ROAD 195A AND TOWNSHIP ROAD 200
YEAR BUILT	NOT AVAILABLE
TOTAL LENGTH OF SPAN (m)	79.6
DECK WIDTH OF BRIDGE (m)	3.7
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,033.6
AVERAGE LOW CHORD ELEVATION (m)	1,030.8
AVERAGE DECK HEIGHT	2.8
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	24.90	2.71	CONCRETE	TRIANGULAR NOSE
2	26.06	2.45	CONCRETE	TRIANGULAR NOSE
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-7

TITLE

HIGHWAY 2 SOUTH BRIDGE

DESCRIPTION	1.5 KM SOUTHEAST OF ALDERSYDE
YEAR BUILT	1997
TOTAL LENGTH OF SPAN (m)	86.0
DECK WIDTH OF BRIDGE (m)	16.9
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,030.7
AVERAGE LOW CHORD ELEVATION (m)	1,029.1
AVERAGE DECK HEIGHT	1.5
NUMBER OF PIERS	3

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	16.82	0.75	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
2	25.62	0.87	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
3	24.62	0.80	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

PHOTO 1

PHOTO 2

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-8

TITLE

HIGHWAY 2 NORTH BRIDGE

DESCRIPTION	1.5 KM SOUTHEAST OF ALDERSYDE
YEAR BUILT	1957
TOTAL LENGTH OF SPAN (m)	89.5
DECK WIDTH OF BRIDGE (m)	15.6
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,031.6
AVERAGE LOW CHORD ELEVATION (m)	1,029.5
AVERAGE DECK HEIGHT	2.1
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	28.09	1.30	CONCRETE	CYLINDER
2	33.74	1.21	CONCRETE	CYLINDER
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-9

TITLE

HIGHWAY 547 BRIDGE

DESCRIPTION	HIGHWAY 547 AND SOUTH OF RANGE ROAD 285
YEAR BUILT	1963
TOTAL LENGTH OF SPAN (m)	100.8
DECK WIDTH OF BRIDGE (m)	7.9
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,027.4
AVERAGE LOW CHORD ELEVATION (m)	1,025
AVERAGE DECK HEIGHT	2.4
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	33.68	1.11	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
2	33.94	1.07	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-10

0 100 200
1:5,000 METRES

TITLE
WEIR UPSTREAM OF HIGHWAY 552 BRIDGE CROSSING

LOCATION	150 M UPSTREAM OF HIGHWAY 552 BRIDGE
DESCRIPTION	WATER SURVEY OF CANADA GAUGE
WEIR LENGTH (m)	40.5
WEIR WIDTH (m)	1.7
WEIR TYPE	CONCRETE FOR FLOW MEASUREMENT
WEIR CREST ELEVATION (m)	962.3

LEGEND

- WEIR SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF CULVERT SURVEY WILL BE USED FOR HYDRAULIC MODELLING.

PHOTO 1

PHOTO 2

REFERENCE(S)

CULVERT SURVEY AND CULVERT PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-11

0 100 200
1:5,000 METRES

TITLE
HIGHWAY 552 BRIDGE

DESCRIPTION	UPSTREAM OF BOW RIVER CONFLUENCE
YEAR BUILT	1924
TOTAL LENGTH OF SPAN (m)	120.7
DECK WIDTH OF BRIDGE (m)	7.7
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	978.9
AVERAGE LOW CHORD ELEVATION (m)	977.6
AVERAGE DECK HEIGHT	1.3
NUMBER OF PIERS	1

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	61.15	2.01	CONCRETE	TRIANGULAR NOSE
2	-	-	-	-
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-12

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A
25mm
0

0 100 200
1:5,000 METRES

TITLE
12 AVENUE CULVERT

DESCRIPTION	LITTLE BOW RIVER ON 12 AVENUE SOUTHEAST
TOTAL LENGTH OF CULVERT (m)	51.9
DIAMETER OF CULVERT (m)	1.2
CULVERT TYPE	12 mm WALL THICKNESS CORRUGATED STEEL PIPE
CULVERT INVERT ELEVATION - SOUTH END (m)	1031.3
CULVERT INVERT ELEVATION - NORTH END (m)	1031.4

LEGEND
- CULVERT SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)
ALL DETAILS OF CULVERT SURVEY WILL BE USED FOR HYDRAULIC MODELLING.

PHOTO 1

PHOTO 2

REFERENCE(S)
CULVERT SURVEY AND CULVERT PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-13

TITLE

5TH STREET SE BRIDGE

DESCRIPTION	BETWEEN 12TH AVE SE AND MONTEITH DRIVE
YEAR BUILT	2014
TOTAL LENGTH OF SPAN (m)	13.7
DECK WIDTH OF BRIDGE (m)	14.4
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,036
AVERAGE LOW CHORD ELEVATION (m)	1,033.7
AVERAGE DECK HEIGHT	0.9
NUMBER OF PIERS	0

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

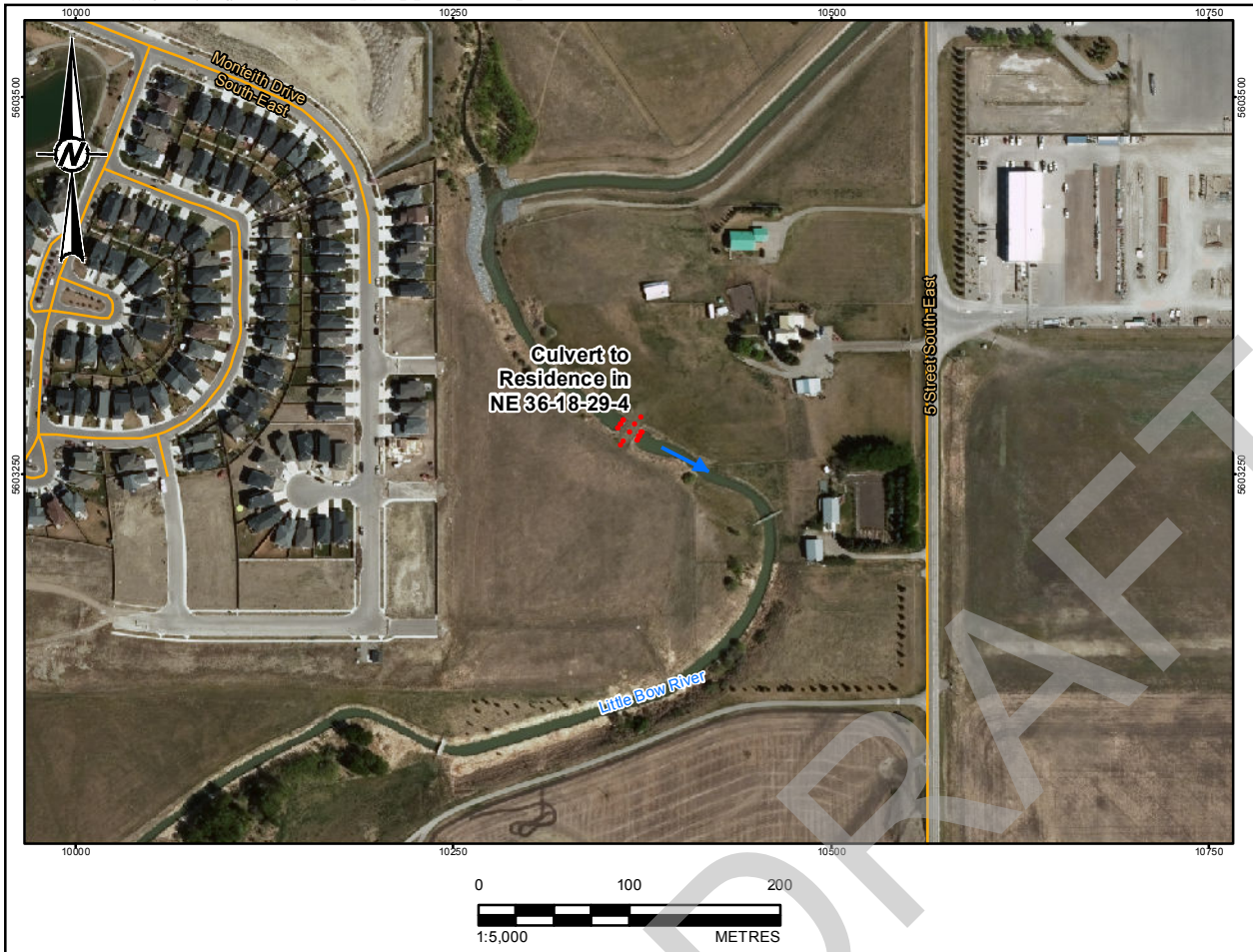
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-14

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_C_Culverts-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 2:51:23 PM



TITLE

CULVERT TO RESIDENCE IN NE 36-18-29-4

DESCRIPTION	LOCAL CULVERT TO THE RESIDENCE IN NE 36-18-29-4
TOTAL LENGTH OF CULVERT (m)	14.3
DIAMETER OF CULVERT (m)	2.0
CULVERT TYPE	CORRUGATED STEEL PIPE
CULVERT INVERT ELEVATION - SOUTH END (m)	1028.8
CULVERT INVERT ELEVATION - NORTH END (m)	1028.8

LEGEND

- CULVERT SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF CULVERT SURVEY WILL BE USED FOR HYDRAULIC MODELLING.

PHOTO 1

PHOTO 2

REFERENCE(S)

CULVERT SURVEY AND CULVERT PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

TITLE

CULVERT TO RESIDENCE IN SE 36-18-29-4

DESCRIPTION	LOCAL CULVERT TO THE RESIDENCE IN SE 36-18-29-4
TOTAL LENGTH OF CULVERT (m)	14.4
DIAMETER OF CULVERT (m)	2.0
CULVERT TYPE	CORRUGATED STEEL PIPE
CULVERT INVERT ELEVATION - SOUTH END (m)	1028.5
CULVERT INVERT ELEVATION - NORTH END (m)	1028.5

LEGEND

- CULVERT SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF CULVERT SURVEY WILL BE USED FOR HYDRAULIC MODELLING.

PHOTO 1

PHOTO 2

REFERENCE(S)

CULVERT SURVEY AND CULVERT PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

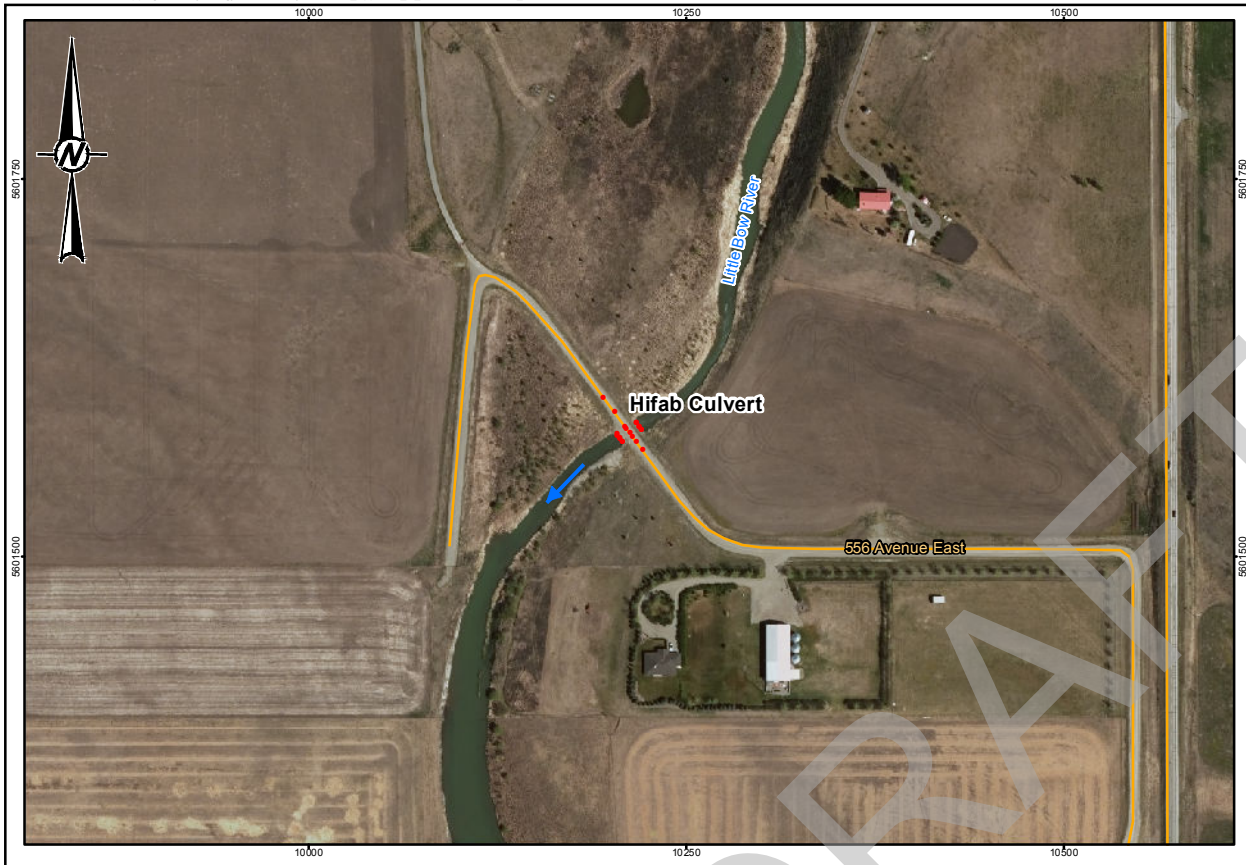
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-16



TITLE

HIFAB CULVERT

DESCRIPTION	LOCAL CULVERT TO THE RESIDENCE OPPOSITE TO HIFAB TRANSPORT
TOTAL LENGTH OF CULVERT (m)	14.5
DIAMETER OF CULVERT (m)	2.0
CULVERT TYPE	CORRUGATED STEEL PIPE
CULVERT INVERT ELEVATION - SOUTH END (m)	1024.1
CULVERT INVERT ELEVATION - NORTH END (m)	1024.1

LEGEND

- CULVERT SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF CULVERT SURVEY WILL BE USED FOR HYDRAULIC MODELLING.

PHOTO 1

PHOTO 2

REFERENCE(S)

CULVERT SURVEY AND CULVERT PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-17

0 100 200
1:5,000 METRES

TITLE
104TH STREET E BRIDGE

DESCRIPTION	5.5 KM SOUTH OF TOWN OF HIGH RIVER
YEAR BUILT	2014
TOTAL LENGTH OF SPAN (m)	27.5
DECK WIDTH OF BRIDGE (m)	9.7
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,026.6
AVERAGE LOW CHORD ELEVATION (m)	1,026.1
AVERAGE DECK HEIGHT	0.5
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	7.85	0.31	STEEL	ROUND NOSE
2	11.86	0.31	STEEL	ROUND NOSE
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

PHOTO 1

PHOTO 2

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-18

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A
25mm
0

TITLE

HIGHWAY 2 WEST BRIDGE

DESCRIPTION	5.5 KM SOUTH OF TOWN OF HIGH RIVER
YEAR BUILT	1960
TOTAL LENGTH OF SPAN (m)	39.6
DECK WIDTH OF BRIDGE (m)	13.1
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,026
AVERAGE LOW CHORD ELEVATION (m)	1,024.7
AVERAGE DECK HEIGHT	1.3
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	11.57	0.44	CONCRETE	CYLINDER
2	16.36	0.55	CONCRETE	CYLINDER
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

PHOTO 1

PHOTO 2

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-19

0 100 200

1:5,000 METRES

TITLE

HIGHWAY 2 EAST BRIDGE

DESCRIPTION	5.5 KM SOUTH OF TOWN OF HIGH RIVER
YEAR BUILT	1960
TOTAL LENGTH OF SPAN (m)	39.5
DECK WIDTH OF BRIDGE (m)	13.1
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1,025.9
AVERAGE LOW CHORD ELEVATION (m)	1,024.7
AVERAGE DECK HEIGHT	1.2
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	11.55	0.63	CONCRETE	CYLINDER
2	16.48	0.58	CONCRETE	CYLINDER
3	-	-	-	-
4	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD
- FLOW DIRECTION

NOTE(S)

ALL DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIERS HAVE VARIED WIDTH, ONLY LARGEST WIDTH IS SHOWN IN TABLE. PIER CENTRE STATION REFERS TO STATION IN THE HYDRAULIC MODEL.

PHOTO 1

PHOTO 2

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD. 2016. IMAGERY PROVIDED BY AEP. HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	C-20

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

APPENDIX D

Flood Control Structure Datasheets

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:39 PM

LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	634
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:2,500 METRES

TITLE
HOEH DIKE 1

DESCRIPTION
7.5 KM UPSTREAM OF TOWN OF HIGH RIVER

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A 25mm 0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:40 PM

LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	839
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:7,500 METRES

TITLE
HOEH DIKE 2

DESCRIPTION
6.5 KM UPSTREAM OF TOWN OF HIGH RIVER

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	378
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:1,500 <Null> METRES

TITLE
BEWS DIKE

DESCRIPTION
5.3 KM UPSTREAM OF TOWN OF HIGH RIVER

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:42 PM

LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	283
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:1,500 <Null> METRES

TITLE
BAKER CREEK DIKE 1

DESCRIPTION
SOUTH OF 12 AVE SW AND WEST OF 72 STREET E

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:43 PM

LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	70
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:1,500 <Null> METRES

TITLE
BAKER CREEK DIKE 2

DESCRIPTION
SOUTH OF 12 AVE SW AND EAST OF 72 STREET E

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

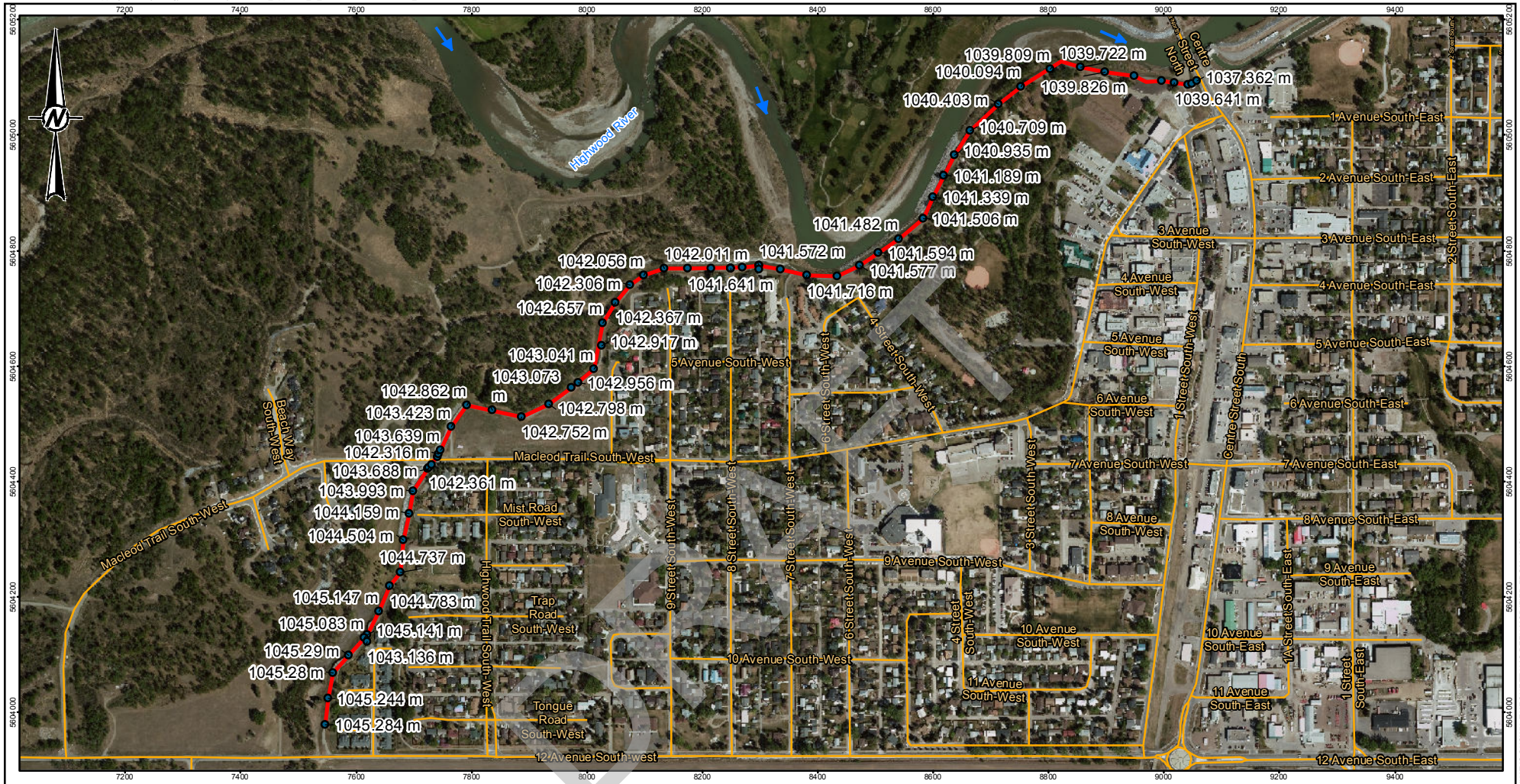
PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:44 PM



LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	2193
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:10,000 METRES

TITLE
TOWN DIKE

DESCRIPTION
HAPPY TRAILS FROM CENTER STREET TO 12 AVE SW

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

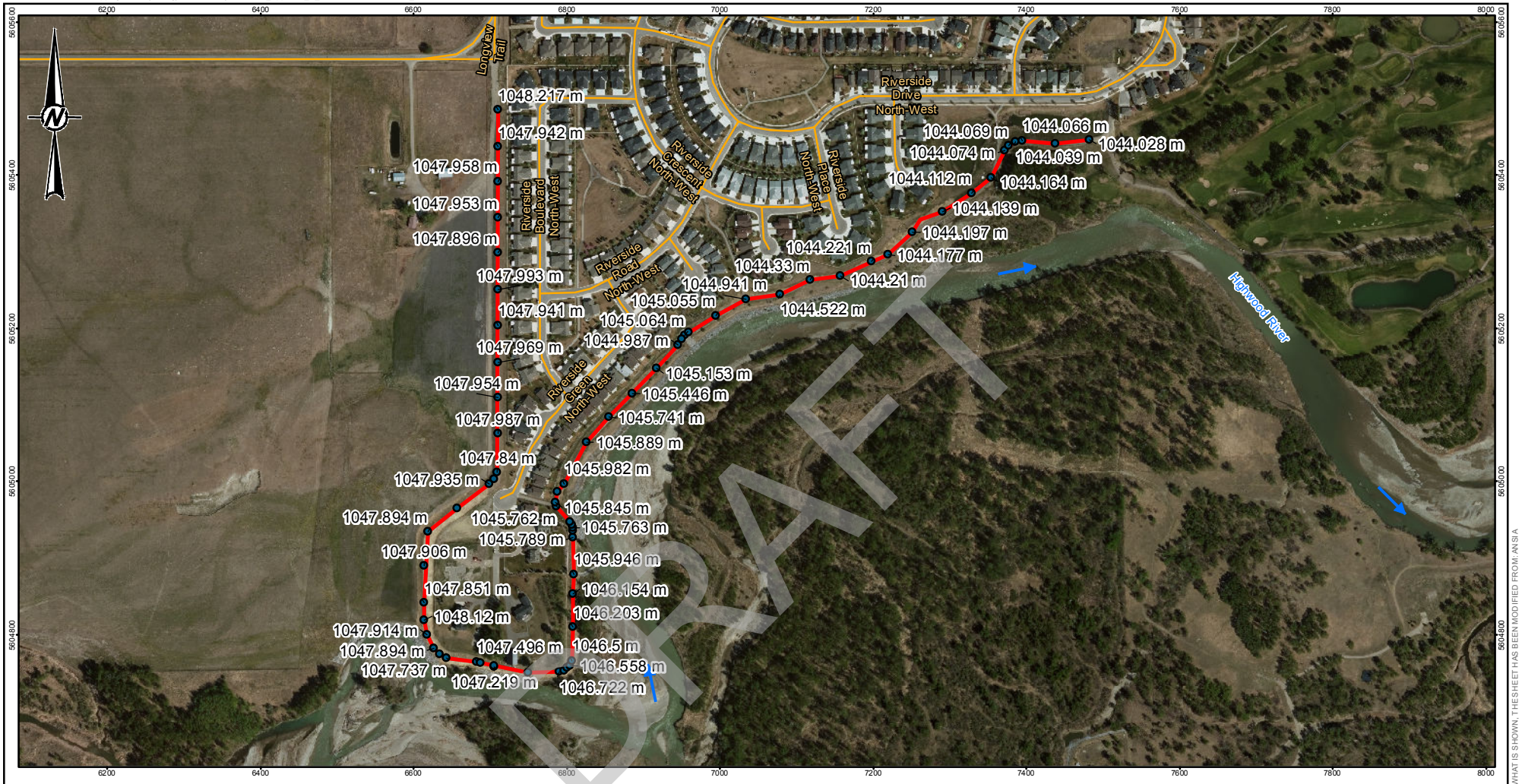
PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:45 PM



LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	2051
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:7,500 METRES

TITLE
WEST TOWN DIKE

DESCRIPTION
FROM SOUTH OF RIVERSIDE DRIVE NW TO SOUTH OF RANGE ROAD

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

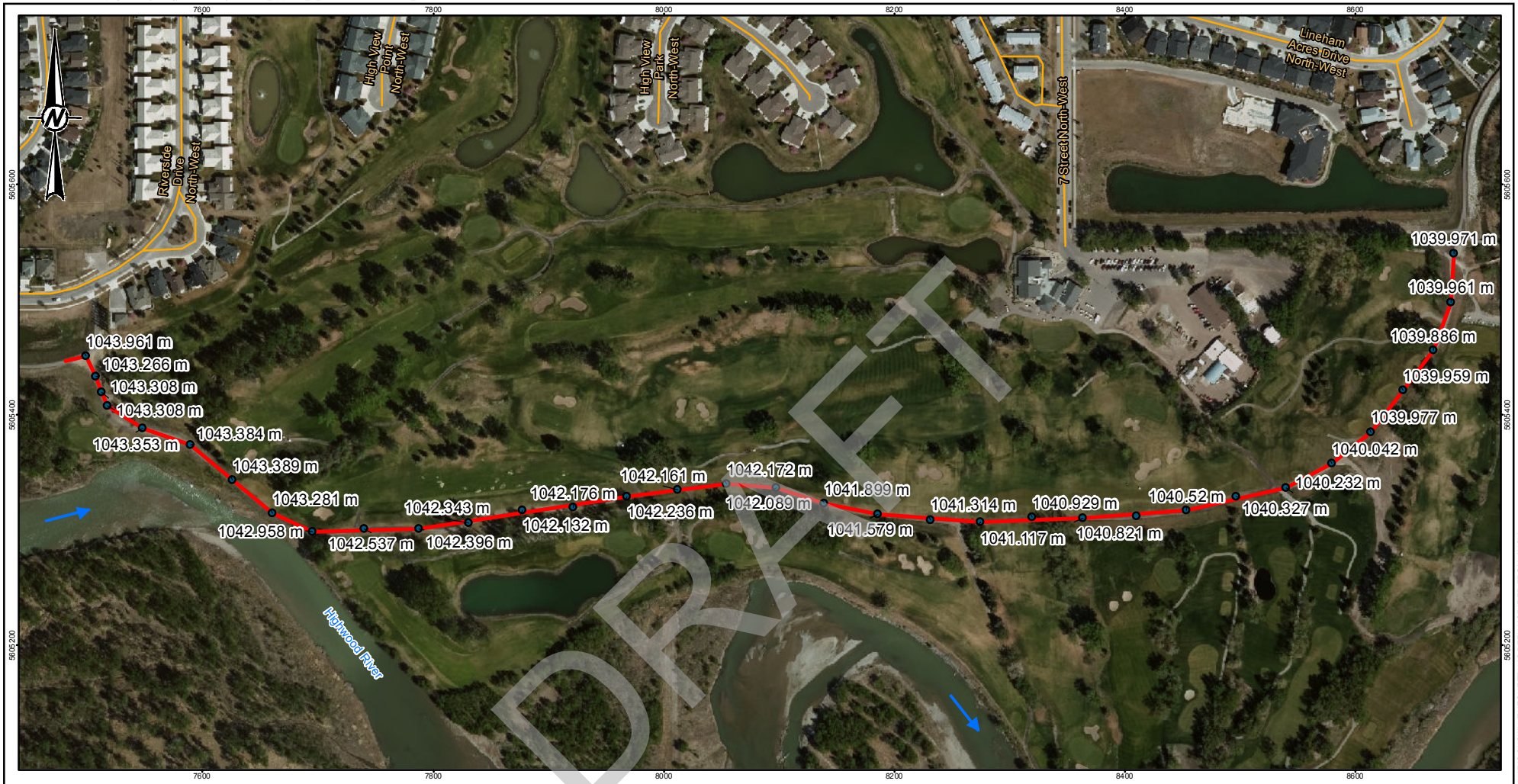
PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:46 PM



LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	1393
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:5,000 METRES

TITLE
GOLDER COURSE DIKE

DESCRIPTION
SOUTH OF HIGHWOOD GOLF & COUNTRY CLUB

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:47 PM

LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

<Null>

APPROX. LENGTH OF STRUCTURE (m)	366
TYPE OF STRUCTURE	EARTHFILL BARRIER AND RIPRAP

0 100 200

1:5,000 METRES

TITLE
LINEHAM CANAL DIKE

DESCRIPTION
HAPPY TRAILS DOWNSTREAM OF HAPPY TRAILS BRIDGE

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:48 PM

LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	1101
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:5,000 METRES

TITLE
LITTLE BOW CANAL DIKE

DESCRIPTION
HAPPY TRAILS FROM CENTER STREET TO 96 STREET E

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

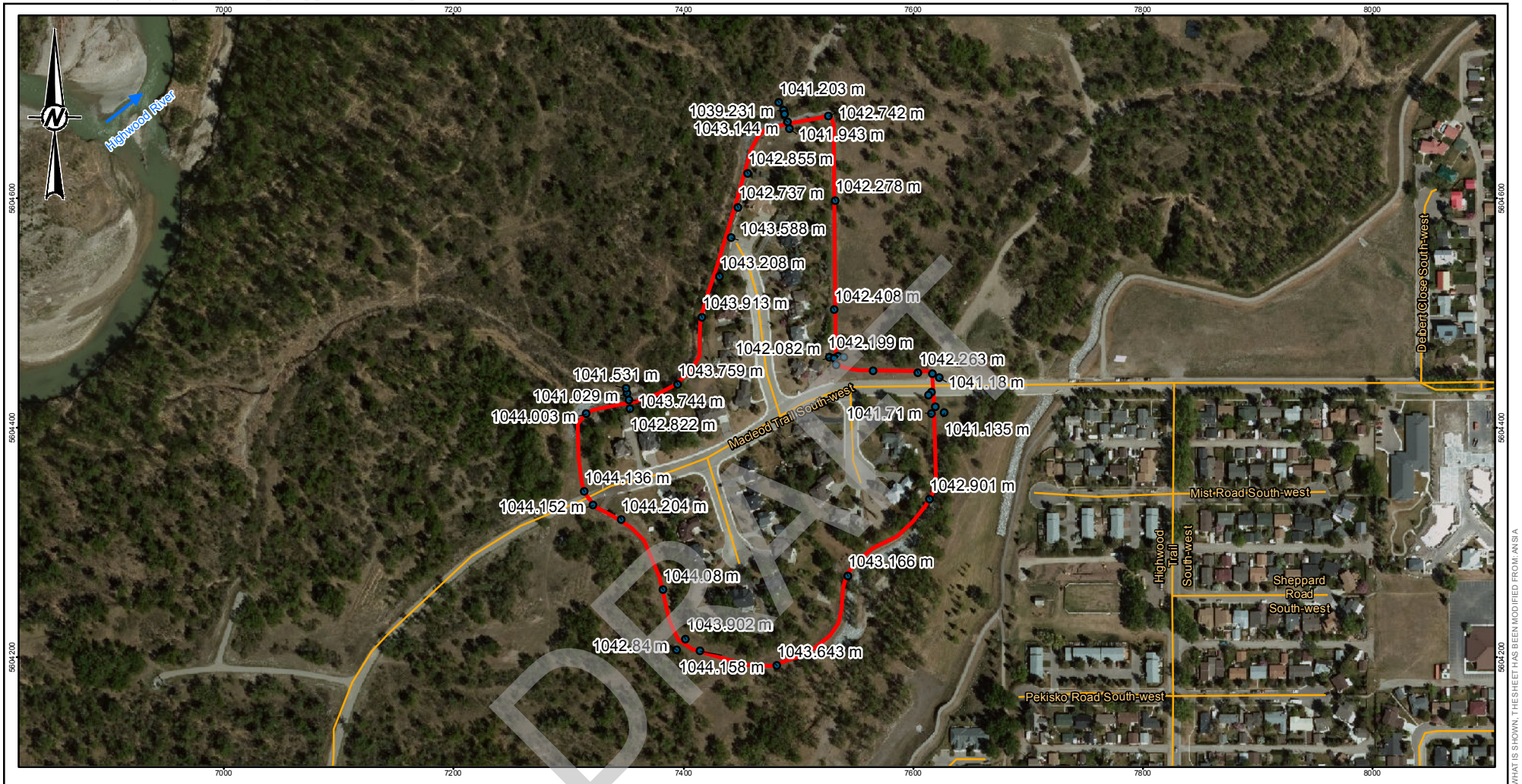
PROJECT NO. 1536669 | CONTROL | REV. 0 | FIGURE **D-10**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI

25mm

0

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_D_FloodControl-Datasheets_Rev0.mxd PRINTED ON: 2017-10-02 AT: 3:05:49 PM



LEGEND

- FLOOD CONTROL STRUCTURE SURVEY POINT
- FLOOD CONTROL STRUCTURE
- ROAD
- FLOW DIRECTION

NOTE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED TO SUPPORT HYDRAULIC MODELLING AND FLOODPLAIN MAPPING.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY COMPLETED IN NOVEMBER 2015 BY GOLDER ASSOCIATES LTD. IMAGERY PROVIDED BY AEP. ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

APPROX. LENGTH OF STRUCTURE (m)	1330
TYPE OF STRUCTURE	EARTHFILL BARRIER

0 100 200

1:5,000 <Null> METRES

TITLE
BEACHWOOD DIKE

DESCRIPTION
BEACH WAY SW AND MACLEOD TRAIL SW

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-10-02
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	D-11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI

25mm

0

APPENDIX E

2016 Aerial Imagery Acquisition Memorandum

TECHNICAL MEMORANDUM

DATE November 24, 2016 **PROJECT No.** 1536669 / 1000

TO James Choles, Project Manager
Alberta Environment and Parks (AEP)

CC Muhammad Durrani (AEP), Hua Zhang

FROM Vanessa Vallis, Golder Associates Ltd. (Golder) **EMAIL** vanessa_vallis@golder.com

2016 AERIAL IMAGERY ACQUISITION MEMORANDUM – HIGHWOOD RIVER HAZARD STUDY

1.0 BACKGROUND

The Survey and Base Data Collection component of the Highwood River Hazard Study requires the collection of current aerial photography. This aerial imagery was acquired on May 6, 2016 and is intended to be used for project analysis and mapping activities. This memorandum gives a high-level overview of the processing methodology, quality assurance results and related deliverables.

2.0 METHODOLOGY

As proposed, GeodesyGroup Inc. was retained to carry out acquisition and processing of the aerial photography, while Golder Associates Ltd. (hereafter 'Golder') was responsible for process oversight and review of deliverables. Prior to commencing image acquisition, the proposed flight plan and schedule was reviewed with the client. During the flight planning process Golder verified that the image collection parameters would meet Alberta Environment and Parks (AEP) specifications as stated in the Terms of Reference (TOR) and the guidelines published in 'General Specifications for Acquiring Aerial Photography (April 2015)'. The 2016 aerial imagery was flown to cover the amended 'Highwood anticipated study area', which was received by Golder on July 27, 2015. A flight index map is presented in Appendix A.

On May 6th, 2016, the aerial photography survey was completed using a Cessna TU206D aircraft outfitted with a gyro-stabilized Vexcel UltraCam LP digital camera, a differential Global Navigation Satellite System (GNSS) and an Inertial Measurement Unit (IMU) system. Ground and meteorological conditions were favourable for image collection. The ground was free of snow and fog, while skies were free of haze, smoke, and clouds / cloud shadows. Twelve flight lines were flown at an average height of 4600 m above sea level at a speed of 225 knots. Colour imagery was acquired in red, green, blue, near-infrared wavelengths with a bit depth of 8 bits per band, as specified in the TOR.

Images were acquired between 10:41 and 12:07 MDT ensuring that the variation in the angle of solar illumination is low (42.2 to 52.2 degrees) and within the specified range; thus eliminating long shadows and large reflections on water. The flight design was planned so that the flight lines are oriented in a manner to best capture the irregular shape of the target area with 60% forward overlap and 30% sidelap (between adjacent flight lines which are approximately 2400 m apart). The images acquired were flown at an approximate scale of 1:15,500 with a focal length of 70.7 mm. The camera and navigation systems were calibrated within the past 1.5 years and dates of calibration are listed in the metadata.

After the aerial survey was completed, GeodesyGroup post-processed the GNSS and IMU data to calculate the parameters required by AEP. These values are visible within the attributes of the spatial metadata layers (see photo centres, flight lines and footprints). The accuracy of the roll, pitch and yaw were found to be 0.008, 0.008 and 0.016 degrees respectively. The accuracy of vertical elevation measurements captured in flight was found to be 3.5 m prior to post-processing. Digital image processing was carried out using Vexcel UltraMap® and Trimble Inpho® post-processing software packages. These software were used for aerial triangulation, the creation of stereo models as well as for orthophoto production. The process of aerial triangulation generated over 58,000 tie points for 231 photos yielding an RMS error of 0.9 µ (RMS is 0.8 µ for x axis and 0.9 µ for y axis). After aerial triangulation was done, the RMS error of the vertical GNSS measurements was found to be 0.056 m. Please refer to the aerial triangulation report for more information. Using the parameters determined during aerial triangulation, stereomodels were made so that the stereo imagery could be viewed in 3D using softcopy photogrammetry software.

Each raw image was orthorectified using 50 cm resolution bare earth LiDAR from 2015 and the calculated aerial triangulation data. After orthorectification, each image was colour balanced and mosaiced to create a seamless product which was then tiled into quarter townships. Throughout the data processing workflow, GeodesyGroup undertook random spot checks to ensure consistency and quality of the deliverables. An index map of the orthophotography tiles is presented in Appendix B.

3.0 RESULTS

After receipt of the data from GeodesyGroup, Golder undertook a completeness check and a quality assurance check. These were done to ensure that all requested deliverables were received and that the quality of the deliverables would meet the needs of the project and conform to the AEP general specifications.

The quality of the deliverables was assessed in several ways. First, a visual check of the raw stereo imagery was done using ENVI® (v 5.3) to ensure that the images were free of blurs, clouds, shadows and other visual defects. This included checking the size of bright saturated areas (pixel values of 255), highlights and dark shadows to ensure that the pixel values were within the permissible range. The bit depth, number of bands and ‘no data’ values were also confirmed to meet the TOR requirements. Next the orthorectified imagery was reviewed in ArcGIS® (v 10.2) to check that the geopositioning of the data matched the 2015 LiDAR (Light detection and ranging) and the 20 cm resolution 2013 post-flood aerial imagery provided by AEP. Additional base data and online image services were used to spot check the geopositioning of the imagery beyond the limits of the provided data, as needed. The spatial reference of the data was also checked to ensure that all data is projected in the 3-degree Transverse Mercator (3TM) projection using the NAD83 Canadian Spatial Reference System (CSRS) datum and Canadian Geodetic Vertical Datum of 1928 (CGVD28).

In order to ensure that the aerial survey was conducted as specified, the geospatial metadata files were used for random spot checks to verify that the flight design resulted in the correct amount of forward overlap and sidelap, and that any changes in elevation or heading were within the specified amount. The attributes of the data were checked to ensure that they contained the correct information and that the file naming and tiling schemas used matched the AEP guidelines. The metadata files for each image were also checked for completeness in ArcCatalog® (v 10.2). Additional checks of the image processing undertaken by GeodesyGroup included the review of the Aerial Triangulation Report.

On November 10, 2016, AEP provided their review comments on the digital files submitted by Golder in mid-September 2016. To address these comments, GeodesyGroup was asked to reprocess and deliver the affected files. The re-processed files were checked for completeness and adherence to the projects imagery specifications; these are included as an amendment to our previous data deliverable.

4.0 DELIVERABLES

The following revised files and deliverables are included with this memorandum:

- updated aerial triangulation (external orientation) data in plain text format and DATEM compatible file formats;
- renamed Colour (RGBI) digital orthophotos in 8-bit GeoTIF format with associated world (.tfw) files for the study area; tiled as quarter townships;
- updated metadata for the orthophotos and stereo images provided as shapefiles and FGDC.xml files;
- updated aerial triangulation image adjustment report;
- flight report (Aerial Photography Report);
- index map of aerial imagery as shapefile; and
- updated memorandum documenting the methodology and results of aerial imagery acquisition, along with digital copies of this memorandum in Word and unsecured PDF formats.

Two digital copies of the above deliverables are being provided on the accompanying USB drives. Please note that the stereoimagery and camera calibration reports remain unchanged; these have been excluded from the revised deliverables.

5.0 CLOSURE

We trust that the enclosed data meets your present requirements. If you have any questions or require additional details, please contact Hua Zhang at (403) 216-8962.

Yours truly,

GOLDER ASSOCIATES LTD.

Prepared by:

Vanessa Vallis, M.Sc.
Remote Sensing / GIS Analyst

Reviewed by:

Hua Zhang, Ph.D., P.Eng.
Associate, Sr. Water Resources Engineer

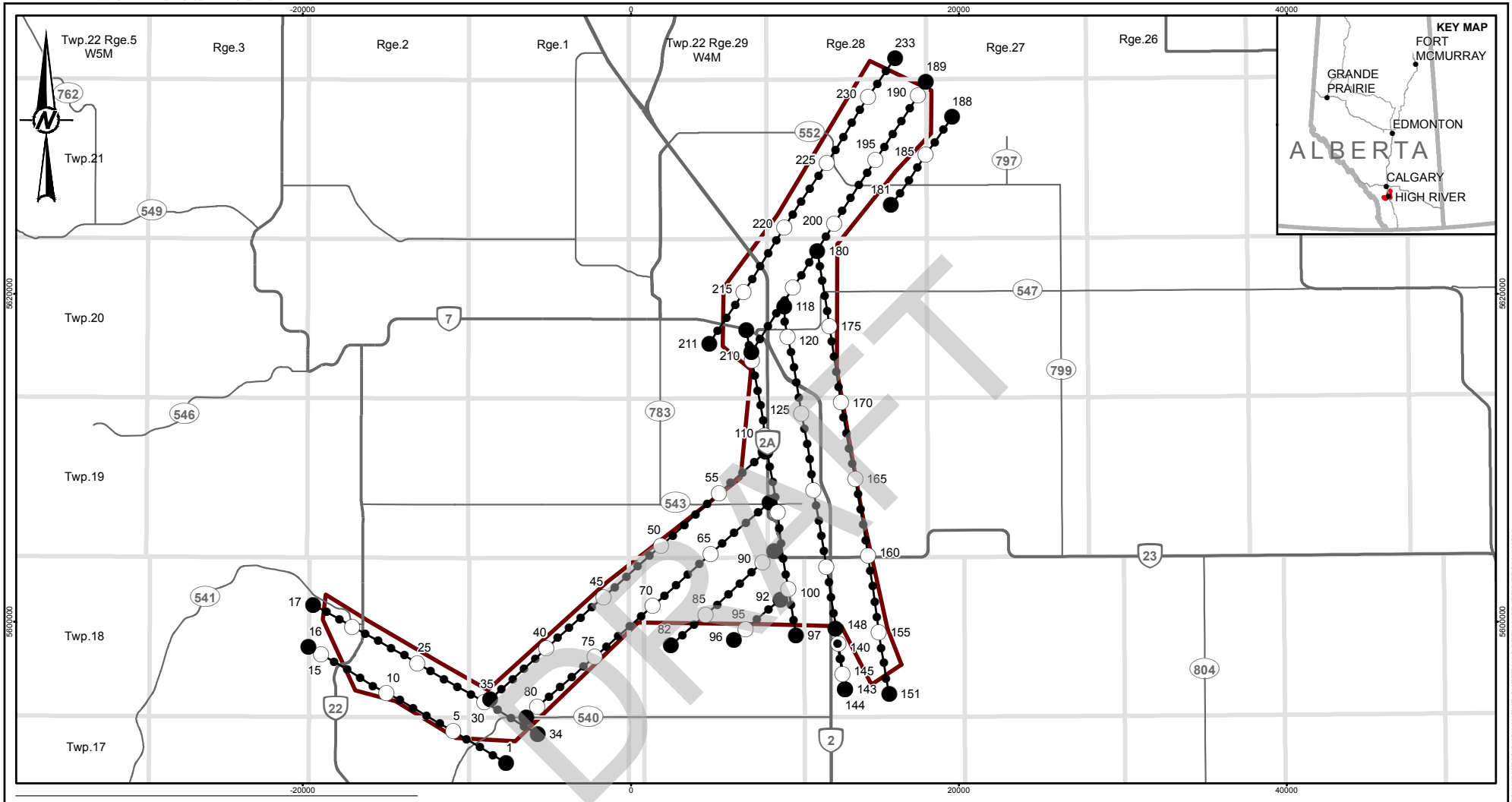
VV/HZ/rp

\\golder.gds\calim\gisactive\2015\1536669\outbox\toclient\aep\20161124\4_memorandum\aerial_imagery_memo_updated\1536669_2016aerial_imagery_collection_memo_24nov2016.docx

APPENDIX A

Flight Index Map

PATH: I:\2015\1536669\Mapping\MXD\Aerial_Imagery_memo\Flight_Path_20160823_Rev0.mxd PRINTED ON: 2016-08-23 AT: 11:32:52 AM



LEGEND

- BEGINNING / END FLIGHT PATH PHOTO
- 5th PHOTO
- PHOTO
- FLIGHT LINE
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- PROJECT STUDY AREA
- PROJECT LOCATION

0 5,000 10,000

1:350,000 METRES

REFERENCE(S)

1. TRANSPORTATION FEATURES OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. TOWNSHIP DATA OBTAINED FROM © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
3. COORDINATE SYSTEM: CSRS 3TM 114 DATUM: NAD 83

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-23
DESIGNED	V. VALLIS
PREPARED	J. EMERSON
REVIEWED	H. ZHANG
APPROVED	R. ATKINS

TITLE
FLIGHT DESIGN

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		0	A

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

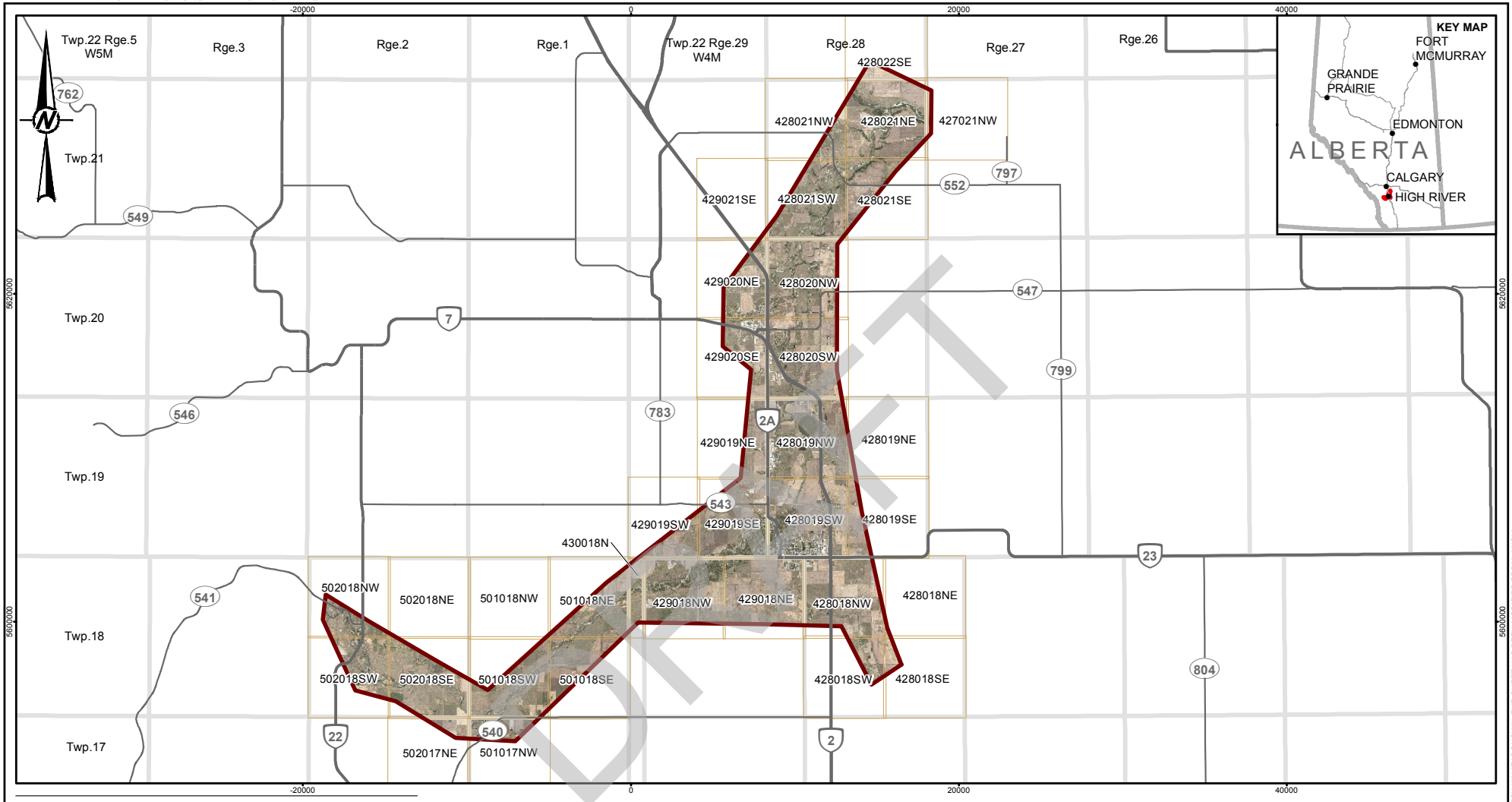
25mm

0

APPENDIX B

Orthophotography Index Map

PATH: I:\2015\1536669\Mapping\MXD\Aerial_Imagery_memo\Ortho_Index_20160823_Rev1.mxd PRINTED ON: 2016-11-24 AT: 3:36:51 PM



LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- ORTHOPHOTO TILE
- PROJECT STUDY AREA
- PROJECT LOCATION

NOTE: ORTHOPHOTO TILE NAMES ARE SHOWN WITH ABBREVIATED FILE NAMES FOR MAPPING PURPOSES.

0 5,000 10,000

1:350,000 METRES

REFERENCE(S)

1. TRANSPORTATION FEATURES OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. TOWNSHIP DATA OBTAINED FROM © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
3. 30 cm ORTHOPHOTOGRAPHY FLOWN BY GEODESY GROUP ON MAY 6, 2016.
4. COORDINATE SYSTEM: CSRS 3TM 114 DATUM: NAD 83

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-11-24
DESIGNED	V. VALLIS
PREPARED	J. EMERSON
REVIEWED	H. ZHANG
APPROVED	R. ATKINS

TITLE
ORTHOPHOTOGRAPHY INDEX MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1536669		1	B

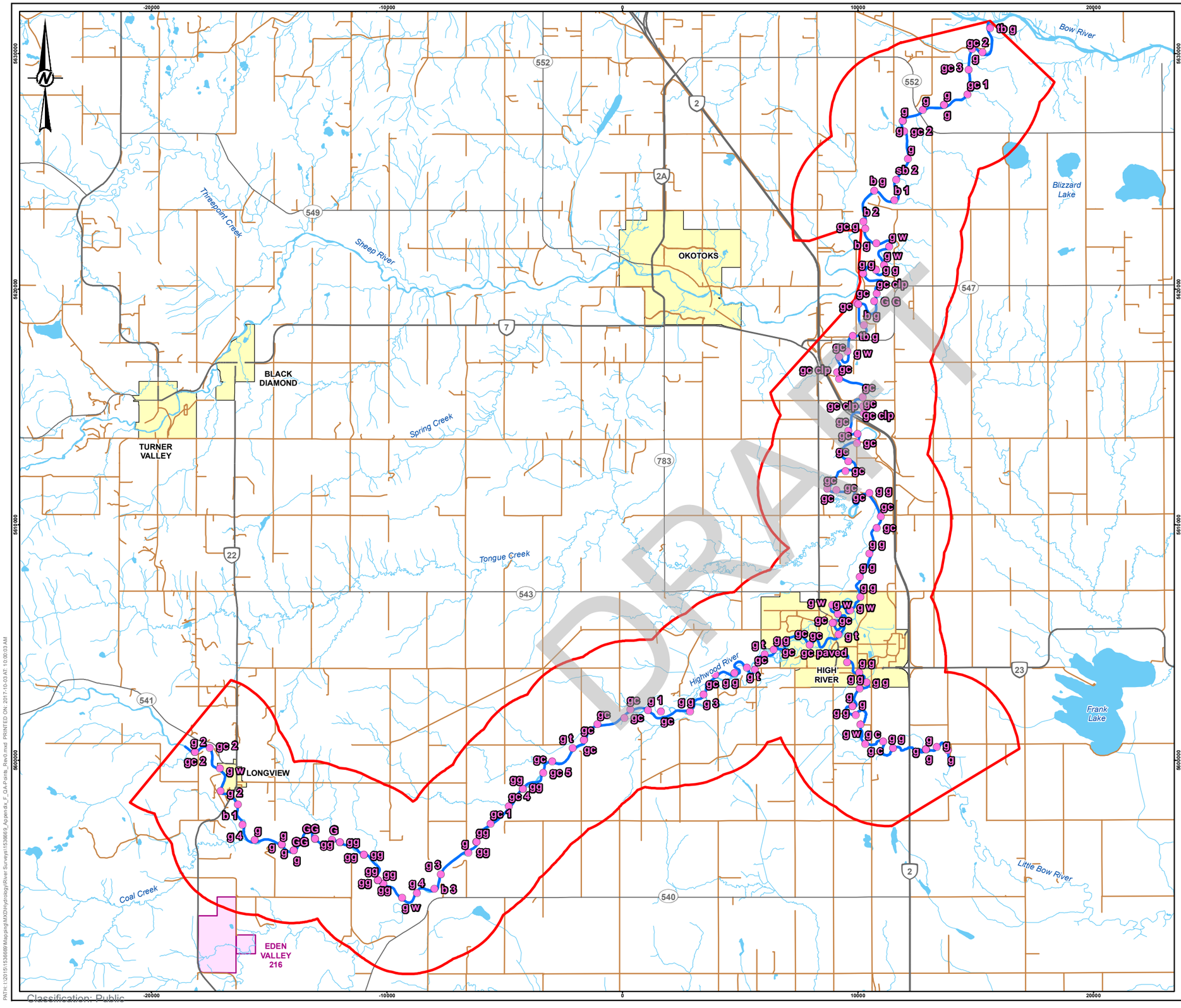
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

25mm

0

APPENDIX F

Surveyed Ground Control Points



LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- INDIAN RESERVE
- POPULATED PLACE
- LIDAR GROUND CONTROL POINT
- SURVEY REACH
- RIVER HAZARD STUDY AREA

CODE DESCRIPTION

b	BANK
clp	CENTRE LINE OF PATH
g	GROUND
sb	STREAM BOTTOM
1	MUD/SILT
2	GRAVEL
3	COBBLE
4	BOULDER
5	BEDROCK
c	CONCRETE
gg	GROUND-GRASS
t	TREES
w	WILLOWS

0 4 8

1:160,000 KILOMETRES

REFERENCE(S)

POPULATED PLACES AND HYDROGRAPHY OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
ROADS OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
HIGHWOOD RIVER HAZARD STUDY

TITLE
LOCATIONS OF SURVEYED GROUND CONTROL POINTS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-03
DESIGNED	BJ
PREPARED	PT
REVIEWED	HZ
APPROVED	DL

PROJECT NO. 1536669 | CONTROL | REV. 0 | FIGURE F-1

PATH: I:\2015\1536669\Mapping\MXD\Hydrology\River Surveys\1536669_Appendix_F_QA-Points_Rev0.mxd PRINTED ON: 2017-10-03 AT: 10:00:03 AM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

TABLE F-1: ELEVATION COMPARISON BETWEEN SURVEYED GROUND CONTROL POINTS AND LiDAR DTM

Northing (m)	Easting (m)	Elevation (m)	Code	Elevation Different Between Surveyed Ground Control Points and LiDAR DTM (m)	Reach
5603858.34	5627.40	1048.19	gc	0.13	Pekiski Creek to High River
5603729.89	10049.09	1037.34	g g	-0.08	Little Bow Lower Reach
5603310.45	10360.95	1031.40	g g	0.00	Little Bow Upper Reach
5603056.55	10070.57	1032.42	g g	-0.01	Little Bow Upper Reach
5604694.51	6430.17	1046.25	g g	-0.02	High River
5604983.35	6786.95	1045.86	gc	0.00	High River
5601525.74	10106.39	1027.79	g w	-0.04	Little Bow Upper Reach
5601924.04	9911.85	1030.49	g g	0.02	Little Bow Upper Reach
5600692.18	10313.40	1025.66	g c	0.01	Little Bow Upper Reach
5600522.63	11485.74	1022.50	g g	-0.02	Little Bow Upper Reach
5600800.55	11067.62	1024.62	g c	0.07	Little Bow Upper Reach
5604889.77	7954.73	1040.07	gc	0.02	High River
5605272.95	8132.86	1039.67	gc	0.05	High River
5607785.55	10081.97	1033.97	g g	-0.06	High River to Tongue Creek
5608766.22	10485.51	1034.05	g g	0.08	High River to Tongue Creek
5605346.37	9177.67	1036.38	g t	0.01	High River
5610357.51	10980.92	1033.73	gc	-0.02	High River to Tongue Creek
5609872.23	10801.48	1030.95	gc	-0.01	High River to Tongue Creek
5611339.38	10490.53	1033.13	g g	-0.02	High River to Tongue Creek
5606205.37	9148.24	1034.19	g w	-0.02	High River
5605850.29	8967.14	1036.21	gc	-0.08	High River
5605837.01	8925.55	1036.49	gc	-0.01	High River
5606375.99	9673.97	1032.12	g w	-0.04	High River
5606594.35	8907.26	1033.11	g w	0.01	High River
5611163.06	9950.95	1031.20	gc	-0.03	High River to Tongue Creek
5606922.16	10115.47	1036.05	g g	-0.09	High River
5611467.17	9074.95	1032.48	gc	-0.11	High River to Tongue Creek
5611549.71	9784.78	1032.62	gc	-0.10	High River to Tongue Creek
5611520.82	8696.37	1032.35	gc	-0.11	Tongue Creek to Sheep River
5612282.61	9477.89	1029.30	gc	-0.11	Tongue Creek to Sheep River
5612685.74	9598.78	1028.82	gc	-0.09	Tongue Creek to Sheep River
5604492.84	6044.55	1047.52	g t	-0.06	Pekiski Creek to High River
5603938.98	5289.69	1052.16	g t	-0.08	Pekiski Creek to High River
5603697.94	4763.25	1055.72	g g	0.04	Pekiski Creek to High River
5613454.58	9959.97	1033.68	gc	0.03	Tongue Creek to Sheep River
5613852.25	9988.79	1025.54	gc	-0.01	Tongue Creek to Sheep River
5613976.01	9594.05	1031.81	gc	-0.07	Tongue Creek to Sheep River
5614727.30	10248.49	1027.82	gc	-0.03	Tongue Creek to Sheep River
5614942.09	10281.72	1027.50	gc clp	0.02	Tongue Creek to Sheep River
5615026.63	10222.91	1030.96	gc clp	0.07	Tongue Creek to Sheep River
5602784.81	3439.49	1061.05	g 3	-0.05	Pekiski Creek to High River
5603635.90	3941.13	1060.21	gc	0.03	Pekiski Creek to High River
5602066.25	2874.92	1064.71	g g	0.08	Pekiski Creek to High River
5615408.33	10197.53	1026.01	gc	-0.02	Tongue Creek to Sheep River
5616185.89	9206.39	1023.17	gc	-0.02	Tongue Creek to Sheep River
5616463.06	9116.37	1025.76	gc clp	0.03	Tongue Creek to Sheep River
5602124.34	1082.46	1074.17	g 1	-0.03	Pekiski Creek to High River
5602059.74	1645.27	1071.03	gc	0.10	Pekiski Creek to High River
5602140.23	335.87	1093.40	gc	0.00	Pekiski Creek to High River
5601789.33	80.58	1080.02	gc	0.07	Pekiski Creek to High River
5600510.94	-2111.85	1088.45	g t	0.07	Pekiski Creek to High River
5600874.68	-1620.65	1086.25	gc	0.10	Pekiski Creek to High River
5601527.58	-1053.33	1085.54	gc	0.00	Pekiski Creek to High River
5600842.95	-1636.86	1086.14	gc	0.13	Pekiski Creek to High River
5599952.15	-2972.32	1092.62	gc	0.09	Pekiski Creek to High River
5618454.95	10262.19	1014.21	b g	0.06	Tongue Creek to Sheep River
5617113.92	9203.36	1022.25	gc	-0.03	Tongue Creek to Sheep River
5617349.16	9557.71	1018.51	g w	-0.08	Tongue Creek to Sheep River
5619402.71	9948.65	1020.12	gc	-0.02	Tongue Creek to Sheep River
5619352.17	10019.22	1021.95	gc	-1.12	Tongue Creek to Sheep River
5618011.48	9778.76	1033.05	tb g	0.03	Tongue Creek to Sheep River
5619798.92	10794.75	1009.32	gc clp	0.00	Tongue Creek to Sheep River
5619472.80	10687.89	1023.35	G G	0.08	Tongue Creek to Sheep River
5620646.91	10212.05	1031.26	g g	-0.09	Tongue Creek to Sheep River
5620807.56	10778.94	1032.26	g g	-0.07	Tongue Creek to Sheep River
5621002.74	11114.50	999.93	g w	0.02	Tongue Creek to Sheep River
5621794.50	11327.00	997.83	g w	0.00	Tongue Creek to Sheep River
5626685.23	11963.97	966.34	gc 2	0.00	Sheep River to Bow River Confluence
5625516.30	12122.91	969.72	g	0.01	Sheep River to Bow River Confluence
5628260.99	14653.56	957.95	gc 1	-0.09	Sheep River to Bow River Confluence
5631077.15	15606.41	948.82	tb g	-0.01	Sheep River to Bow River Confluence
5630040.79	15290.89	955.37	gc 2	0.56	Sheep River to Bow River Confluence
5630182.78	14855.20	956.17	g	-0.06	Sheep River to Bow River Confluence
5629290.97	14708.55	954.44	gc 3	-0.05	Sheep River to Bow River Confluence
5624627.76	11621.18	971.74	sb 2	0.05	Sheep River to Bow River Confluence
5623762.40	11538.88	975.67	b 1	0.09	Sheep River to Bow River Confluence

5624164.17	10691.31	980.95	b g	0.01	Sheep River to Bow River Confluence
5622850.46	10234.14	984.56	b 2	0.00	Sheep River to Bow River Confluence
5621928.50	10793.40	987.49	b g	0.03	Tongue Creek to Sheep River
5622548.84	10309.86	988.94	gc g	-0.07	Tongue Creek to Sheep River
5598036.08	-4815.24	1105.93	gc 4	0.07	Pekiski Creek to High River
5599454.77	-3352.50	1095.70	gc 5	-0.01	Pekiski Creek to High River
5598769.22	-4227.15	1100.38	gg	-0.02	Pekiski Creek to High River
5598770.73	-4228.58	1100.32	gg	-0.04	Pekiski Creek to High River
5596522.11	-6198.28	1114.08	gg	-0.06	Pekiski Creek to High River
5596521.59	-6195.28	1114.19	gg	-0.02	Pekiski Creek to High River
5597291.79	-5589.07	1106.92	gc 1	0.06	Pekiski Creek to High River
5594538.12	-7980.04	1123.93	b 3	0.03	Pekiski Creek to High River
5596056.96	-6544.99	1116.10	g	0.00	Pekiski Creek to High River
5594746.38	-10148.21	1135.42	gg	-0.06	Upstream Boundary to Pekiski Creek
5594899.53	-10376.61	1137.90	gg	-0.02	Upstream Boundary to Pekiski Creek
5594897.60	-10378.38	1137.54	gg	0.05	Upstream Boundary to Pekiski Creek
5594894.95	-10380.64	1137.00	gg	0.03	Upstream Boundary to Pekiski Creek
5595985.68	-10971.16	1145.54	gg	0.04	Upstream Boundary to Pekiski Creek
5595982.94	-10972.04	1145.54	gg	0.06	Upstream Boundary to Pekiski Creek
5596516.24	-11991.75	1149.00	gg	0.06	Upstream Boundary to Pekiski Creek
5596509.82	-11994.70	1148.98	gg	-0.17	Upstream Boundary to Pekiski Creek
5596649.12	-13049.91	1157.23	GG	0.06	Upstream Boundary to Pekiski Creek
5596653.60	-13047.00	1157.15	GG	-0.01	Upstream Boundary to Pekiski Creek
5596599.52	-12333.89	1151.14	G	-0.07	Upstream Boundary to Pekiski Creek
5595134.43	-7707.58	1119.11	g 3	-0.05	Pekiski Creek to High River
5594356.88	-8727.33	1127.01	g 4	0.05	Pekiski Creek to High River
5594145.88	-9344.69	1133.48	g w	0.00	Upstream Boundary to Pekiski Creek
5600340.62	-18154.03	1199.91	g 2	0.18	Upstream Boundary to Pekiski Creek
5600337.76	-18141.26	1199.75	gc 2	0.10	Upstream Boundary to Pekiski Creek
5600512.28	-17520.66	1194.25	gc 2	0.14	Upstream Boundary to Pekiski Creek
5600547.81	13342.02	1017.73	g	0.06	Little Bow Upper Reach
5600460.82	12881.90	1020.04	g	-0.03	Little Bow Upper Reach
5600457.82	12881.30	1020.40	g	0.05	Little Bow Upper Reach
5600454.22	12880.93	1019.97	g	-0.02	Little Bow Upper Reach
5600414.75	13827.05	1017.26	g	-0.09	Little Bow Upper Reach
5602282.37	9769.89	1030.43	g	-0.04	Little Bow Upper Reach
5602278.73	9769.65	1030.17	g	-0.06	Little Bow Upper Reach
5604138.98	9540.11	1033.77	gc paved	0.05	Little Bow Lower Reach
5599635.09	-17082.98	1191.80	g w	0.01	Upstream Boundary to Pekiski Creek
5598678.10	-17054.92	1185.93	g 2	0.03	Upstream Boundary to Pekiski Creek
5597253.11	-16123.90	1177.54	g 4	0.06	Upstream Boundary to Pekiski Creek
5598113.84	-16317.73	1181.72	b 1	-0.01	Upstream Boundary to Pekiski Creek
5596159.66	-13947.86	1166.09	g	-0.02	Upstream Boundary to Pekiski Creek
5596605.97	-15612.15	1177.43	g	-0.07	Upstream Boundary to Pekiski Creek
5596159.00	-13946.71	1166.08	g	0.02	Upstream Boundary to Pekiski Creek
5596405.59	-14455.68	1168.90	g	0.02	Upstream Boundary to Pekiski Creek
5596408.64	-14452.98	1169.90	g	-0.05	Upstream Boundary to Pekiski Creek
5627135.35	11907.59	972.04	g	0.03	Sheep River to Bow River Confluence
5627806.60	13660.13	962.72	g	-0.14	Sheep River to Bow River Confluence
5627800.36	13661.16	962.65	g	-0.03	Sheep River to Bow River Confluence
5627110.72	11899.68	972.21	g	0.02	Sheep River to Bow River Confluence
5627587.62	12745.10	966.09	g	-0.07	Sheep River to Bow River Confluence

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
102, 2535 - 3rd Avenue S.E.
Calgary, Alberta, T2A 7W5
Canada
T: +1 (403) 299 5600

Golder Associates