REPORT

Survey and Base Data Collection Report

Upper Red Deer River Hazard Study

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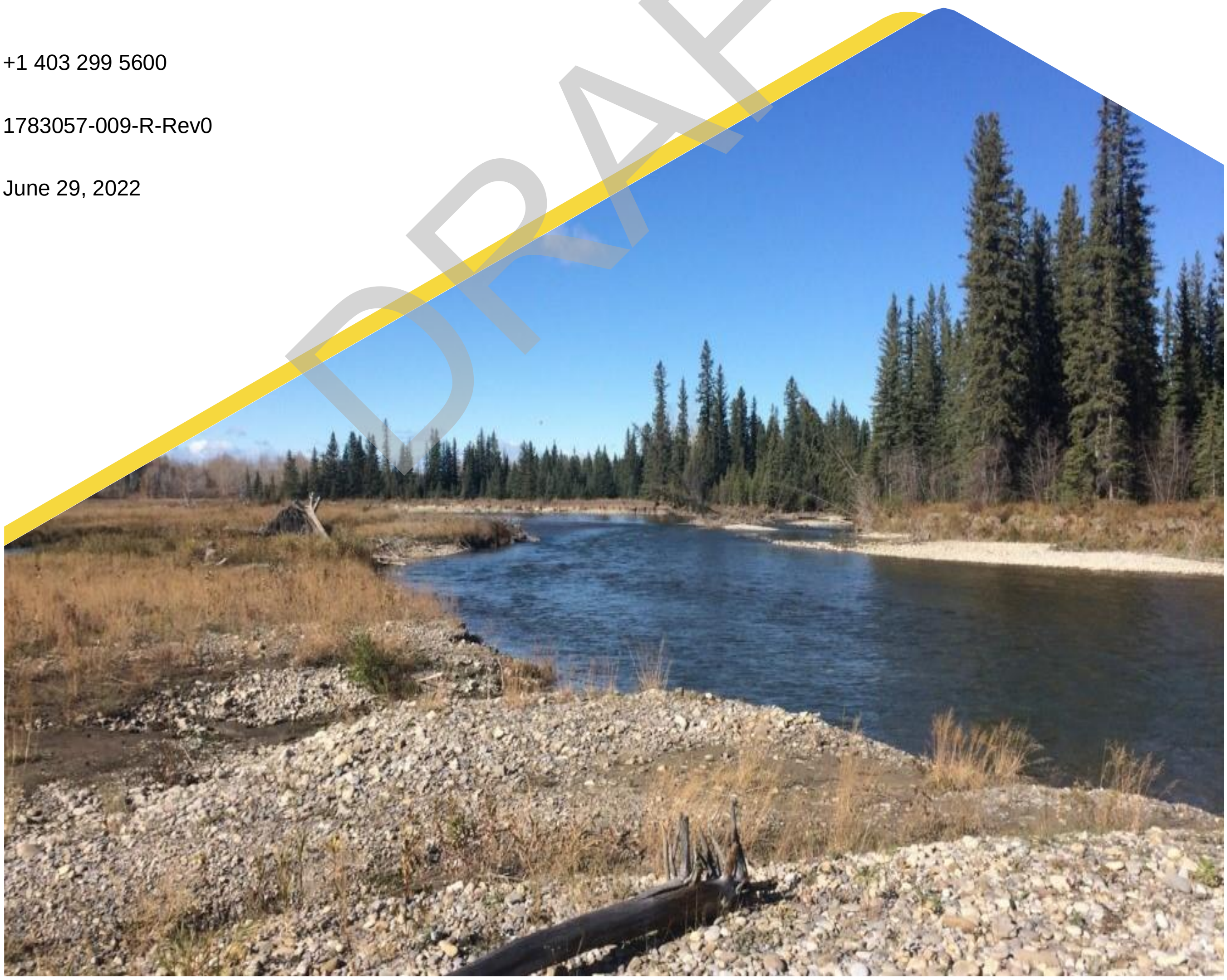

Executive Summary

Alberta Environment and Parks (AEP) commissioned Golder Associates Ltd. (Golder) in September 2017 to conduct the Upper Red Deer River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Red Deer River reach from Coal Camp to Gleniffer Lake and the Bearberry Creek reach from Range Road 62 to its confluence with the Red Deer River in Sundre.

The study is conducted under the provincial Flood Hazard Identification Program (FHIP), the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. Project stakeholders include the Government of Alberta, the Town of Sundre, and the Counties of Mountain View, Clearwater and Red Deer, and the public.

The Upper Red Deer River Hazard Study includes multiple components and deliverables. This report documents the methodology and results of the survey and base data collection component, which supports the hydraulic modelling, flood mapping, flood risk assessment, and channel stability investigation components. The tasks associated with this component include cross section surveys as well as hydraulic and flood control structure data collection. Additional base data collected in this study includes administrative, cadastral, and transportation data, structural design drawings, benchmark surveys, and other relevant data.

Topographic, control point, and shallow-water surveys were performed using Real-time Kinematic (RTK) GPS units. In the areas along the Red Deer River where water was too deep to wade, an echo sounder mounted on a Remotely Operated Vehicle (ROV) was used to collect stream bed elevations. The Gleniffer Lake survey was conducted using an Acoustic Doppler Profiler (ADP), in combination with a boat-mounted RTK unit, where flow depths were too deep to wade. Bridge survey data was collected using RTK.

The total length of the Red Deer River study reach is approximately 80 km. The total length of the Bearberry Creek study reach is approximately 18 km. The study area includes an approximately 13 km reach of the Red Deer River upstream of Sundre that was previously surveyed as part of the McDougal Flats Flood Hazard study (Golder, 2015). The features surveyed in this study are summarized in Table i.

Table i: Summary of Survey Features

Feature	Red Deer River	Gleniffer Lake	Bearberry Creek	Totals
Cross Sections	125 + 49(1)	12	130	**267** + 49(1)
Bridges	2	-	4	**6**
Culverts	-	-	2	**2**
Flood Control Structures	3	-	2	**5**
Other Features	19(2)	-	-	**18**

Notes:

1) 49 cross sections were surveyed in 2013 as part of the McDougal Flats Flood Hazard Study (Golder, 2015)

2) There are 12 culverts through Range Roads and the Sundre Airstrip within the McDougal Flats floodplain, one culvert with flaps through the Sundre West Dike, four culverts with flaps through the Sundre East Dike, one culvert with flaps through the Bearberry Creek North Dike, and one berm in McDougal Flats that is not considered a flood control structure

Water levels were measured at individual channel cross sections and discharge measurements were completed at suitable locations. These data will be used in the study to calibrate the hydraulic model for low-flow conditions.

Acknowledgements

This component of the Upper Red Deer River Hazard Study was managed by Dr. Wolf Ploeger. Overall direction and senior review was provided by Dr. Dejiang Long. The field survey was conducted by Kevin Whitten, Paul Wyntjes, Anna-Maria Viaud, Michael De Coste, Hossein Kheirkhah, Gaven Tang, and Nancy Guo.

The authors thank Ryan Morrison from Mountain View County, and Kevin Heerema and Ian James from the Town of Sundre for leading a site reconnaissance on September 14, 2017 and providing available information and comments on the flood control structures in the study area. We also thank Carlin Soehn from Alberta Environment and Parks (AEP) for providing additional information on the flood control structures in the study area.

The authors express their special thanks to Jane Eaket, project manager for Alberta Environment and Parks (AEP), who provided overall study management, background data, and technical guidance.

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1.0 INTRODUCTION

1.1 Study Background

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The study is conducted under the provincial Flood Hazard Identification Program (FHIP), the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. Project stakeholders include the Government of Alberta, the Town of Sundre, and the Counties of Mountain View, Clearwater and Red Deer, and the public.

The Upper Red Deer River Hazard Study includes multiple components and deliverables. This report documents the methodology and results of the survey and base data collection component, which supports the hydraulic modelling, flood mapping, flood risk assessment, and channel stability investigation components. The tasks associated with this component include channel cross section surveys as well as hydraulic and flood control structure data collection. Additional base data collected by Golder includes administrative, cadastral, and transportation data, structural design drawings, benchmark surveys, and other relevant data.

1.2 Study Objectives

The primary purpose of the study is to assess and identify river and flood hazards along the Red Deer River from Coal Camp to Gleniffer Lake and Bearberry Creek from Range Road 62 to its confluence with the Red Deer River in Sundre.

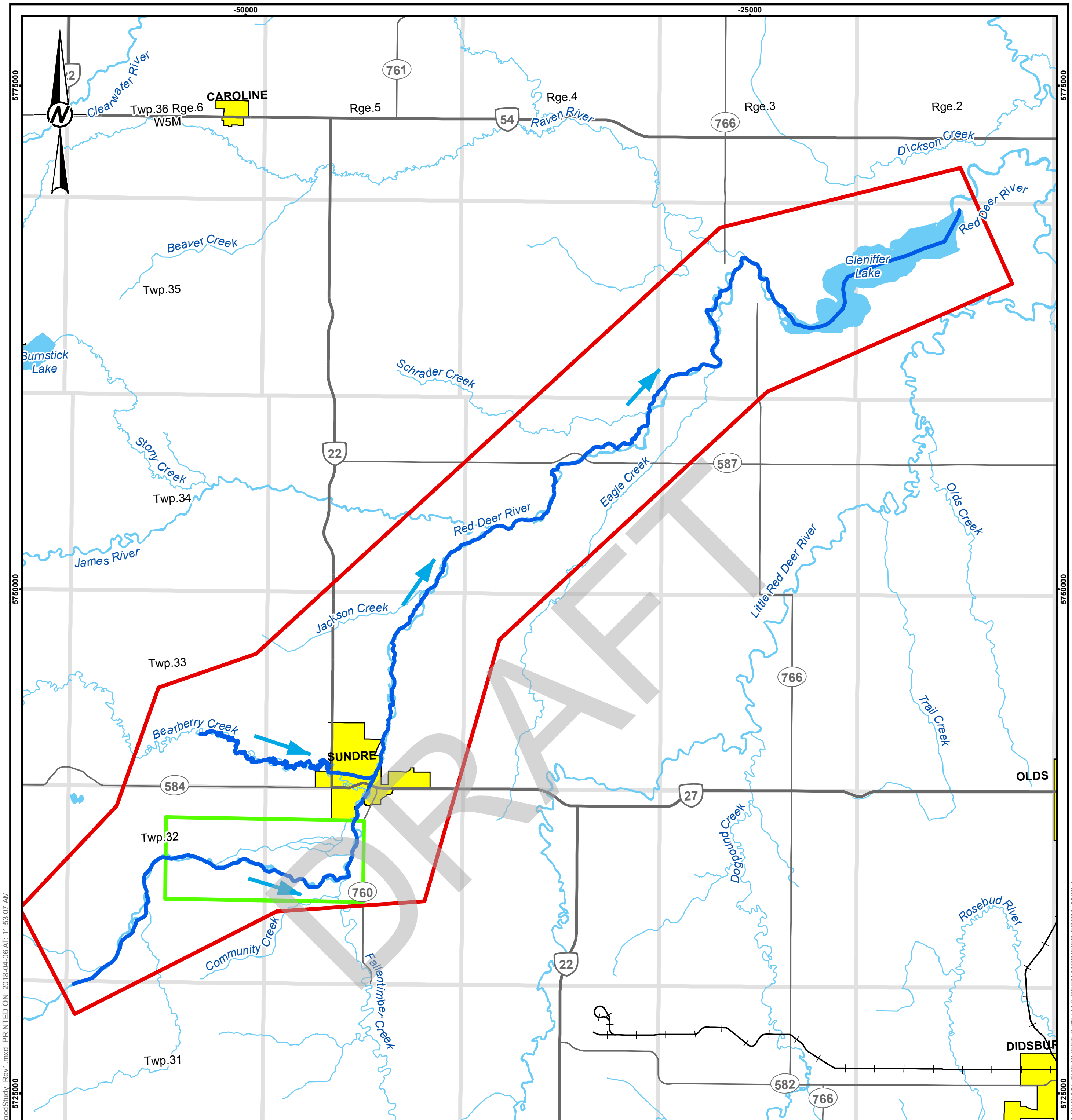
1.3 Study Area and Reaches

The study area includes approximately 80 km of the Red Deer River and approximately 18 km of Bearberry Creek. An approximately 13 km reach of the Red Deer River upstream of Sundre was previously surveyed as part of the McDougal Flats Flood Hazard study (Golder, 2015). The study area is shown in Figure 1.

1.4 Scope of Work

The river survey program includes the survey of channel cross sections, hydraulic structures, flood control structures, and other features.

The base data collection includes administrative information, cadastral, and transportation data, structural design drawings, benchmark surveys, and other relevant data.



LEGEND

- FLOW DIRECTION
- STUDY REACH
- STUDY AREA
- McDOUGAL FLATS STUDY AREA
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- RAILROAD
- WATERCOURSE
- POPULATED PLACE
- WATERBODY

0 5 10

1:275,000 KILOMETRES

REFERENCE(S)
ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2014. ALL RIGHTS RESERVED, CANVEC, GEOGRATIS, IHS ENERGY INC.
PROJECTION: 3TM 114 DATUM: NAD 83 CSRS

CLIENT

Alberta Government

PROJECT
UPPER RED DEER RIVER FLOOD STUDY

TITLE
STUDY AREA

CONSULTANT

GOLDER

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2.0 SURVEY PROGRAM AND COLLECTED DATA

2.1 General

The survey of the stream cross sections, hydraulic structures, and flood control structures within the study area was conducted between September 27, and October 18, 2017. In addition, several temporary benchmarks associated with highwater marks along Bearberry Creek and the Red Deer River, surveyed by AEP in 2005 (Bearberry Creek) and 2013 (Red Deer River), were surveyed as part of this study. Both water levels measured at individual cross sections and discharge measurements at suitable locations were used to assist with the calibration of the hydraulic model in subsequent study components.

2.2 Procedures and Methodology

2.2.1 Topographic, Bathymetric and Structure Surveys

The following survey equipment was used to collect the topographic, bathymetric, and structure data for this study:

- **Real-time Kinematic (RTK) GPS** – Trimble R8® and R10® RTK units were used to survey ground features and river bed levels in areas where hydraulic conditions allowed the surveyors to wade the channel. The RTK units were also used to survey in the control points and benchmarks found within the study area.
- **Acoustic Doppler Profiler (ADP)** – A SonTek RiverSurveyor M9® was used in combination with a boat-mounted RTK unit to survey Gleniffer Lake.
- **Remotely Operated Vehicle (ROV) with SonarMite Echo Sounder** – A Seafloor SonarMite echo sounder was used on a Seafloor Hydrone remotely operated vehicle in combination with an RTK unit to survey the river bed in areas where water was too deep or too fast flowing to wade.
- **Total Station** – A Nikon Nivo total station was used to collect cross section data on Bearberry Creek where vegetation was too dense to receive sufficient satellite reception for the RTK GPS.

All of the survey data collected in this study were referenced to the Alberta Survey Control Network using Alberta Survey Control Markers (ASCMs). For some of the study area at Sundre, the Can-Net Virtual Reference System (VRS) Network (Can-Net, 2016) was used to provide network-corrected data via a cellular network to define horizontal and vertical positions to within ±0.02 m. When Can-net was used, each RTK rover was calibrated daily to an ASCM or a Golder-established temporary benchmark that had been tied to an ASCM.

For all remaining areas, a RTK base station was set up over temporary benchmarks at various locations and calibrated to an ASCM that was close to each study reach or a Golder-established temporary benchmark that had been tied to an ASCM.

The survey data was acquired by RTK rover units with pre-loaded geoid files. The RTK data output for this study provides an orthometric elevation with correct northing and easting coordinates. All survey data was collected in the 3TM coordinate system with the Meridian at 114° W and referenced to NAD83 (CSRS) horizontal and CGVD28 vertical datum. Ellipsoidal heights are transformed to CGVD28 orthometric heights using the HTv2.0 geoid model. Survey data collected on Gleniffer Lake using the ADP/RTK combination was collected in UTM coordinates and projected into the 3TM 114° coordinate system.

Each survey point collected using either the RTK or total station was attributed a specific code. A schematic of survey point codes and corresponding locations is shown in Figure 2, which also includes a complete list of survey codes for the RTK and total station.

The quality and accuracy of all survey data was checked by using a Trimble data extraction and processing tool. All survey data was imported into Global Mapper to allow for validation and further processing. Data with horizontal or vertical accuracies of less than ±0.05 m was rejected. Daily quality and accuracy checks were conducted in the office. In cases where multiple points with low accuracy were detected at a cross section, the survey crew repeated that survey the next day.

In addition to the quality assurance and quality control (QA/QC) procedures for field data collection, the survey data was checked in Esri ArcGIS® for outliers and through visual inspection of triangulated irregular network (TIN) surfaces developed from the survey data. Similar procedures were applied to ensure concurrence among all datasets collected on different dates and using different types of survey equipment.

Figure 2: Schematic of Survey Point Locations and Code Descriptions

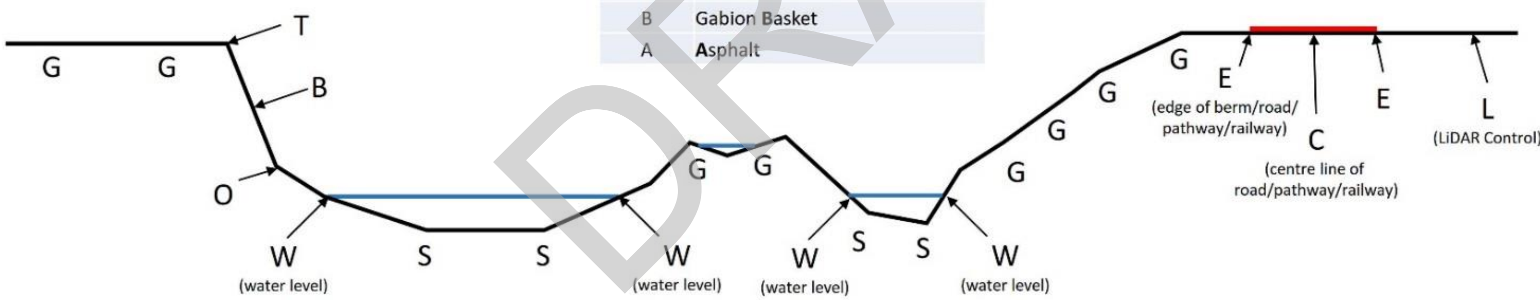
Survey Codes for RTK GPS River Surveys (No Structures)

Purpose: - Create common definitions for survey points collected in the field for easier data processing in the office
- Reduce confusion or uncertainty for field staff regarding coding of points

Location Code	
G	**G**round
T	**T**op of Bank
B	**B**ank
O	T**o**e of Bank
W	**W**ater Level
S	**S**tream Bottom (under water)
E	**E**dge of Road/Berm/Pathway/Railway
C	**C**entre Line of Road/Berm/Pathway/Railway
L	**L**iDAR control point

Material Code	
1	Mud/Silt (<0.063 mm)
2	Sand (0.063 mm - 2 mm)
3	Gravel (2 mm - 6.4 cm)
4	Cobble (6.4 cm - 25 cm)
5	Boulder (> 25 cm)
6	Bedrock
C	**C**oncrete
G	**G**rass
R	**R**iprap
T	**T**rees (large, trunk > 10 cm)
W	**W**illows and Shrubs
B	Gabion **B**asket
A	**A**sphalt

Examples	
G2	Ground, Sand
G4	Ground, Cobble
W3	Water Level, Gravel
GG	Ground, Grass
GT	Ground, Trees
CA	Centre Line, Asphalt
BR	Bank, Riprap
LC	LiDAR control, Concrete



Version 0, August 25, 2017 Golder Associates Ltd. Wolf Ploeger

Channel Cross Section Surveys

The field data was collected by surveying channel cross sections approximately perpendicular to the direction of the flow. The study reach within Gleniffer Lake was surveyed by boat. Most of the cross sections on the Red Deer River and Bearberry Creek were surveyed by wading. For some cross sections on the Red Deer River that were too deep to wade, a remotely operated vehicle (ROV) was used.

The following procedures were applied when carrying out a bathymetric survey by wading:

- Set up the RTK-GPS base station if Can-net coverage was not available or didn't provide sufficient accuracy.
- RTK rover units were used to collect cross-sectional information from a location approximately 2 to 5 m beyond the top of bank on one side of the channel to a location approximately 2 to 5 m beyond the top of bank on the other side. A minimum of 20 points were established across the channel and care was taken to reference points where the transverse bed slope changed significantly.
- In areas with dense vegetation, a total station was used to collect the cross section information. The total station survey was completed by establishing at least two independent temporary benchmarks using RTK-GPS in open areas and by calibrating the total station against these temporary benchmarks.
- In areas along the Red Deer River where no clear top of the bank was present, the survey was collected approximately 10 m beyond the edge of water on both sides of the river. In braided sections, this applies to all identified braided channels.
- Special attention was paid to surveying topographic slope breaks along the banks.
- All surveyed data points were attributed with field codes that described substrate and vegetation types.
- The water surface elevation was surveyed at all points where the water made contact with both banks. In case of the braided channels, water surface points were surveyed for each channel.

The following procedure was applied when the ROV was used for deeper sections of the Red Deer River:

- Set up the RTK-GPS base station if Can-net coverage was not available or didn't provide sufficient accuracy.
- Mount the Sonarmite onto frame on the Hydrone ROV.
- Place the RTK-GPS unit on top of the Sonarmite mount and measure the offset to the water surface.
- Connect both Sonarmite and RTK-GPS units to a data collector with Bluetooth transmission capability and use a field laptop or Trimble data collector for data collection.
- For each day the ROV was used, a calibration was performed to correct the water depth measurements. This was conducted by placing the ROV over a relatively flat river bed, measuring the depth and surveying the same point with the RTK unit. The elevation correction was then applied in the office.
- Survey deep portions of the Red Deer River main channel(s) by remotely controlling the Hydrone with the onboard motors or by pulling the Hydrone across with ropes if the flow velocities were too high.

The boat survey method for Gleniffer Lake involved the following:

- The ADP was mounted onto a frame, which was fastened to the side of the river boat. Once the ADP was securely mounted on the boat, it was deployed in the water and the distance from the middle sensor to the water surface was measured using a standard tape measure.

- The RTK unit was attached to the top of the ADP mount at a measured offset from the water surface. This offset was measured and recorded on a daily basis.
- The ADP and RTK units were connected to a laptop data acquisition system that provided data storage and a real-time display of the position and data being collected. The RiverSurveyor software installed on the computer used on the boat was checked to make sure that both units were communicating properly and data was being stored.
- A short calibration profile was run at the beginning of each day to verify that both the ADP offset and the level of the sounding head below the water surface remained consistent while the boat was in motion. Furthermore, the sounding depths were verified by direct measurements during the calibration process.
- The bathymetric data was collected using the ADP and RTK units at a frequency of one Hertz along the prescribed cross sections (i.e., a data point was collected every second). At a nominal boat speed of 0.75 m/s, this would correspond to a measured depth at intervals of about 0.75 m.
- Bank topographic data was obtained using RTK rover units, as described above.
- Water surface elevations were surveyed at all points where the water made contact with the bank.

Processing of the data collected using an ADP and RTK included the following steps:

- Data was sorted using the UTM easting values and any points with UTM coordinates of zero were removed.
- Data was sorted by altitude, which corresponds to the elevation value supplied to the ADP from the RTK unit (instrument offsets were applied to the data during post-processing).
- Data was sorted by combined depth and those points with a zero depth or depths outside of the possible range were discarded.
- Data were sorted by difference between the vertical beam (VB) depth and the averaged bottom track (BT) depth. If the VB returned an inaccurate value (i.e., shallow areas), the BT depth was used.
- Data was sorted by mean velocity. The ADP returns a value of zero when it cannot compute a flow velocity and vector. These values were removed, and the rest of the values within the data set were retained.

Processing the data collected using the ROV included the following steps:

- A calibration was performed to correct the water depths measurements. This was conducted by comparing the RTK-GPS calibration shot with the ROV measurement at the same location and applying a constant vertical offset to the ROV data collected. This was done each day the ROV was used.
- For some ROV measurements, the Sonarmite echo sounder did not record a depth. This could be the case in fast flowing water with high turbulence or because of the movement of the ROV due to waves in the stream. These points were filtered and deleted.

In total, less than five percent of the collected survey data points were removed during the above-mentioned process.

Hydraulic Structures

Hydraulic structures within the study area that could affect channel conveyance and subsequent water levels include two highway bridges on the Red Deer River, four road bridges over Bearberry Creek, and one pedestrian bridge over Bearberry Creek in Sundre. The features of the bridges that were surveyed include the following:

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

There are several culverts through Range Roads in the McDougal Flats area and underneath the Sundre Airstrip. For all culverts the following details were obtained:

- culvert type
- culvert shape
- entrance conditions
- culvert dimensions
- upstream and downstream inverts

The hydraulic structures were surveyed using RTK-GPS and measuring tape. Geo-located photos of each structure were taken during the survey.

Flood Control Structures

Flood control structures located along the Red Deer River and Bearberry Creek were surveyed using an RTK-GPS to verify as-built elevations and to characterize their typical cross-sectional geometry. Survey data was collected along the crest(s) of each flood control structure at regular intervals of approximately 20 m. In addition, a number of cross sections were surveyed along the structure lengths. Geo-located photos of all flood control structures were taken.

2.2.2 Flow and Water Level Measurements

Water levels along the various study reaches were measured to support the low-flow hydraulic model calibration. Appendix A contains plots of the surveyed main channel thalweg of each river reach and the water levels measured during the cross section survey (see Section 2.4).

River flows along the various study reaches were measured to provide a check on the provisional data obtained from the online database provided by Water Survey of Canada (WSC). Figures B-1, B-3, B-4, B-6, and B-8 of Appendix B show the locations where flows were measured on the Red Deer River and Bearberry Creek. The Red Deer River is mostly braided throughout the study area and fast flowing with relatively shallow water depths during the survey in October 2017. Therefore, only a limited number of flow measurements were conducted at suitable locations identified in the field.

Bearberry Creek flows were relatively small. The flow measurements were made at suitable locations with sufficient water depths.

All flow measurements were performed by wading the channel with a handheld Acoustic Doppler Velocimeter (*SonTek FlowTracker2® ADV*) and top-set wading rod in accordance with standard WSC protocols. This includes: (i) selecting a suitable measurement location; (ii) choosing an even number of transects with equal left bank to right transects and right bank to left transects; and (iii) ensuring that the data set of each transect is within a maximum standard deviation of five percent. The measurement procedure included the following:

- Survey points were selected to result in a minimum of 20 panels (flow segments across the stream thus requiring a minimum of 21 velocity measurement points).
- Velocity readings were taken at 0.6 of the total depth at measurement locations since flow depth was less than 1.0 m in all cases.
- Survey points were selected such that no panel discharge exceeded 10 percent of the total discharge, six panels were within the 5 to 10 percent range and the remaining 17 panels were all less than five percent.

The measured discharges are reported in Section 2.7.

2.3 Cross Sections

The total length of the Red Deer River study reach is approximately 80 km. The total length of the Bearberry Creek study reach is approximately 18 km. The study area includes an approximately 13 km reach of the Red Deer River upstream of Sundre that was previously surveyed as part of the McDougal Flats Flood Hazard study (Golder, 2015). Two cross sections were surveyed in the McDougal Flats Red Deer River reach to understand if the 2013 survey of that reach is still representative of the overall cross section characteristics. A summary of the surveyed channel cross sections is provided in Table 1.

Table 1: Surveyed Channel Cross Sections within the Study Area

Waterbody	Reach Description	Cross Section ID	Total Number of Cross Sections	Average Cross Section Spacing (m)	Year of Survey
Red Deer River	Above McDougal Flats	R1 to R30	30	300	2017
	Through McDougal Flats	X1, X2	2	Not Applicable(1)	2017
	Through McDougal Flats	M1 to M49	49	270	2013(2)
	Below McDougal Flats to Bearberry Creek confluence	R31 to R36	6	300	2017
	Below Bearberry Creek confluence to Gleniffer Lake	R37 to R125	88	500	2017
Gleniffer Lake	Gleniffer Lake	R126 to R137	12	1,000	2017

Table 1: Surveyed Channel Cross Sections within the Study Area

Waterbody	Reach Description	Cross Section ID	Total Number of Cross Sections	Average Cross Section Spacing (m)	Year of Survey
Bearberry Creek	Above Highway 22	B1 to B96	96	150	2017
	Below Highway 22	B97 to B123	26	100	2017
Fishway at Bearberry Creek Weir	Fishway	F1 to F7	7	50	2017

Notes:

1) These two cross sections are for comparison to the 2013 survey completed as part of the McDougal Flats Flood Hazard Study (Golder, 2015)

2) see McDougal Flats Flood Hazard Study (Golder, 2015) for details.

2.3.1 Cross Section Comparison

Two cross section collected in 2013 as part of the McDougal Flats Flood Hazard Study (Golder, 2015) were compared to two cross sections collected in 2017 as part of the current study; both the 2013 survey and LiDAR and the 2017 survey and LiDAR were used in the comparison. Comparison plots for M42 (X2) and M36 (X1) are provided in Figures 3 and 4. There is some elevation variation at the main channel river which is expected for a highly mobile river like the Red Deer River. However, the overall the cross section characteristics are very similar between the 2013 and 2017 data at these two cross sections. Therefore, it was concluded that the survey data from the McDougal Flats Flood Hazard Study is still valid and can be used for this river hazard study.

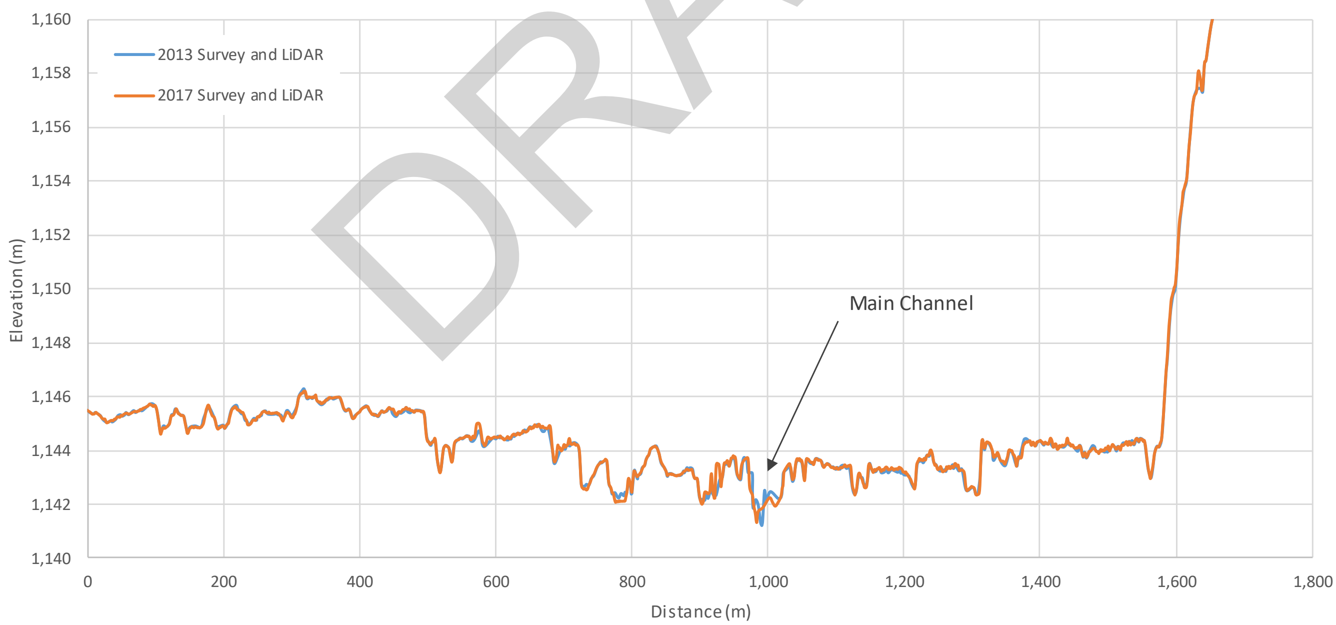


Figure 3: Comparison of 2013 and 2017 survey and LiDAR data at cross section M42 (X2)

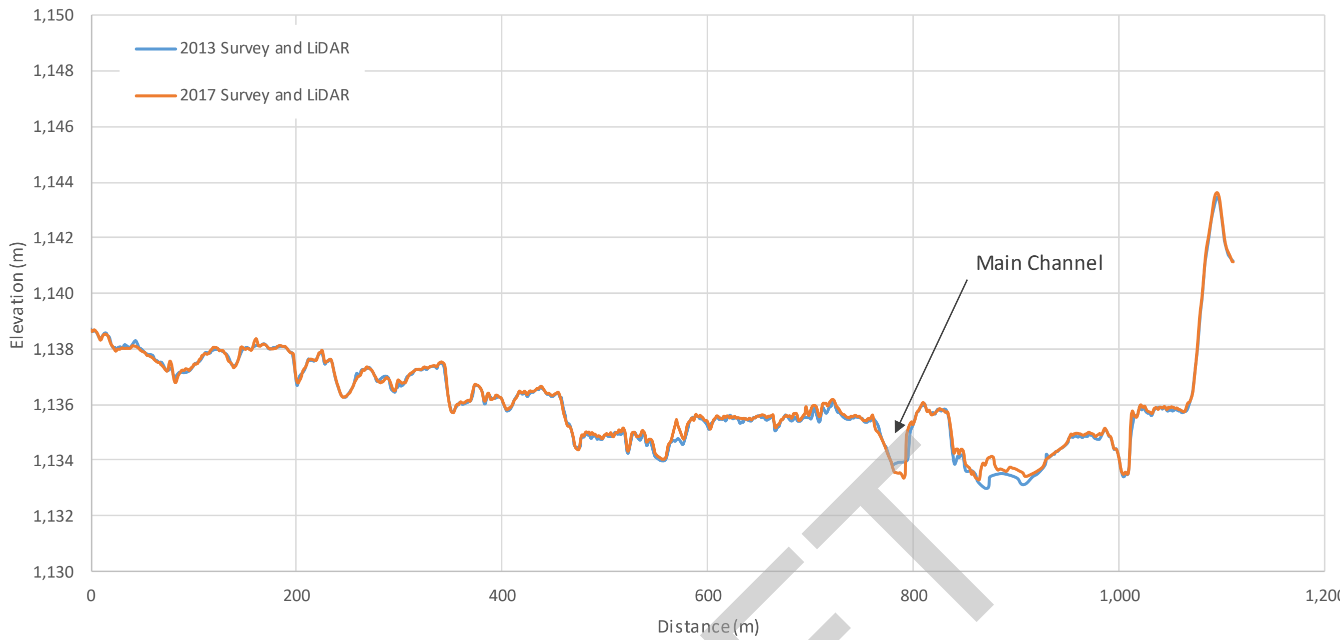


Figure 4: Comparison of 2013 and 2017 survey and LiDAR data at cross section M36 (X1)

2.4 Longitudinal Profiles

Appendix A contains plots of the surveyed main channel thalweg of each river reach and the water levels measured during the cross section survey. An overview of the surveyed cross sections is provided in Appendix B.

2.5 Hydraulic Structures

2.5.1 Bridges

There are six bridge crossings within the study area, including two bridges on the Red Deer River and four bridges on Bearberry Creek. One of the bridges along Bearberry Creek is designated for pedestrian use only; all others are road bridges. There is a bridge at the upstream end of the study reach (Range Road 62), but this structure was not included in this study. The bridge spans the full width of the channel with one pier and the potential local effect on downstream water levels is considered negligible. A summary of the bridges within the study area is provided in Table 2.

Bridge locations are shown in the map sheets provided in Figures B-3, B-5, and B-8 of Appendix B. Summary datasheets that include site photos, survey data point locations, and detailed information with regard to the bridge deck and piers are provided in Figures C-1 to C-6 of Appendix C.

Bridge file data (detailed design and/or as-built survey drawings) for road bridges was obtained from AEP through Alberta Transportation, but is not included in this report.

Table 2: Bridges within the Study Area

Waterbody	Description	Name / Identifier	Preliminary River Station[(1)] (m)	Bridge Type	No. of Spans	Corresponding Figure No.
Red Deer River	Highway 27	Main Avenue E Bridge (Sundre)	24,340	Traffic	4	C-1
	Highway 587	Bridge at Garrington	47,500	Traffic	4	C-2
Bearberry Creek	Range Road 60	Range Road 60 Bridge and Culvert	7,175	Traffic	3	C-3
	Highway 22	Cowboy Trail Bridge and Culvert	15,405	Traffic	1 (clear)	C-4
	Above Centre Street North	Sundre Footbridge	16,710	Pedestrian	1 (clear)	C-5
	Centre Street North	Centre Street Bridge	17,070	Traffic	3	C-6

Note: 1) River stations will be finalized during the hydraulic model setup.

2.5.2 Culverts

There are two culverts on Bearberry Creek as part of the Highway 22 and Range Road 60 crossings (see Table 3).

Table 3: Culverts within the Study Area

Waterbody/Area	Location	Description	Culvert Shape	Dimension
Bearberry Creek	Range Road 60	Culvert on remnant Bearberry Creek channel 60 m north of the bridge	Circular	2.0 m Diameter
	Highway 22	Cattle culvert through road embankment with gate at upstream end (140 m north of bridge)	Circular	2.0 m Diameter

2.5.3 Weirs

There is one weir on Bearberry Creek within the study area (see Table 4). The weir is located on Bearberry Creek approximately 930 m upstream of the Centre Street Bridge at the west end of Sundre. The bottom width is 20.0 m. There is an approximately 300 m long fishway around the weir on the north (left) side. The location of the weir is included in the map sheets in Appendix B.

Table 4: Weirs within the Study Area

Stream	Preliminary River Station (m)	Description	Weir Crest Height (m)
Bearberry Creek	16,100	Trapezoidal concrete weir with multiple steps with fishway on north (left) side.	1,100.13

2.5.4 Other Features

There are several culverts through Range Roads in the McDougal Flats area and underneath the Sundre Airstrip relatively far away from the Red Deer River that do not convey any Red Deer River flow during normal flow conditions. However, they frequently convey overland flows generated by the Red Deer River and are part of the floodplain overall conveyance system of remnant channels in the area.

There are three culverts equipped with flap gates through the Sundre East Dike south of Highway 27 and one on the north side of Highway 27. There is one culvert equipped with flap gates through the Sundre West Dike south of Highway 27 and there is one culvert equipped with flap gates through the Bearberry Creek North Dike upstream of fishway. These culverts are not considered part of the Red Deer River as they function to drain local runoff from the area behind the dike. Table 5 includes details of these culverts within the study area.

Additionally, there is a berm structure in the McDougal Flats floodplain located approximately 120 m north of the Red Deer River between Range Road 60 and 61. The above-mentioned features are summarized in Table 5.

Table 5: Other Features within the Study Area

Waterbody/Area	Location and Description	Material and Shape	Dimension
McDougal Flats	Culvert through Range Road 54 (1.2 km south of Hwy 27)	Corrugated Steel, Circular	0.5 m Diameter
	Culvert through Range Road 54 (1.45 km south of Hwy 27)	Corrugated Steel, Circular	2 x 0.4 m Diameter
	Two culverts through Sundre Airstrip (150 north of south end of airstrip)	Corrugated Steel, Circular	2 x 0.6 m Diameter
	Two culverts through Range Road 55 (2,720 m south of Highway 27)	Corrugated Steel, Circular	2 x 0.8 m Diameter
	Two culverts through Range Road 55 (2,790 m south of Highway 27)	Corrugated Steel, Circular	2 x 0.8 m Diameter
	Culvert through Range Road 55 (40 m north of Coyote Creek RV Resort entrance)	Corrugated Steel, Circular	0.6 m Diameter
	Culvert through Range Road 60 (2,780 m south of Highway 27)	Corrugated Steel, Circular	0.4 m Diameter
	Three culverts through Range Road 60 (160 m north of end of road)	Corrugated Steel, Circular	3 x 0.8 m Diameter
	Culvert through Range Road 61 (520 m south of Township Road 325)	Corrugated Steel, Circular	0.6 m Diameter
	Culvert through Range Road 61 (1,410 m south of Township Road 325)	Corrugated Steel, Circular	0.4 m Diameter
	Culvert through Range Road 62 (210 m south of Township Road 325)	Corrugated Steel, Circular	0.8 m Diameter
	Culvert through Range Road 62 (770 m south of Township Road 325), bottom partly filled with gravel	Corrugated Steel, Circular	0.6 m Diameter
Red Deer River Sundre East Dike	Culvert through Sundre East Dike equipped with a steel flap on Red Deer River side (60 m south of Highway 27)	Corrugated Steel, Circular	1.0 m Diameter
	Culvert through Sundre East Dike equipped with a steel flap on Red Deer River side (near Highway 760 and 1st Avenue intersection)	Corrugated Steel, Circular	1.0 m Diameter
	Culvert through Sundre East Dike equipped with a steel flap on Red Deer River side (near Highway 760 and 4th Avenue intersection)	Corrugated Steel, Circular	1.0 m Diameter
	Culvert through Sundre East Dike equipped with a steel flap on Red Deer River side (near Highway 27 and 5th Street SE intersection)	Corrugated Steel, Circular	1.0 m Diameter
Red Deer River Sundre West Dike	Culvert through Sundre West Dike equipped with a steel flap on Red Deer River side (near Centre Street S and 1st Avenue SW intersection)	Corrugated Steel, Circular	0.6 m Diameter
Bearberry Creek North Dike	Culvert through Bearberry Creek North Dike (350 m upstream of Bearberry Creek Weir)	Unknow	Unknown
McDougal Flats	Berm on floodplain between Range Road 60 and 61 approximately 120 m north of Red Deer River channel-	Earth fill with some rock protection on south side	300 m long

2.6 Flood Control Structures

A summary of flood control structures within the study area is provided in Table 6. The locations of the flood control structures are shown in Figures B-3 and B-8 of Appendix B. Summary datasheets for the various flood control structures are provided in Appendix D.

Table 6: Flood Control Structures within Study Area

Stream	Name	Approximate Length	Survey Spacing	Corresponding Figure No.
Red Deer River	Sundre West Dike (upstream of Highway 27)	0.3 km	Points along the top of the dike every 20 m, dike cross section at representative locations or at least every 100 m.	D-1
Red Deer River	Sundre East Dike (upstream of Highway 27)	2.5 km	Points along the top of the dike every 20 m, dike cross section at representative locations or at least every 250 m.	D-2
Red Deer River	Sundre East Dike (downstream of Highway 27)	1.0 km	Points along the top of the dike every 20 m, dike cross section every at representative locations or at least every 250 m.	D-3
Bearberry Creek	Bearberry Creek North Dike	1.8 km	Points along the top of the dike every 25 m, At least 3 representative dike cross sections.	D-4
Bearberry Creek	Bearberry Creek South Dike	1.4 km	Points along the top of the dike every 25 m, At least 3 representative dike cross sections.	D-5

2.7 Discharge Measurements

Stream flows were measured, as described in Section 2.2.2, to provide additional data to support the low-flow hydraulic model calibration. The flow data also provides a check on the provisional data obtained from the online database provided by WSC for the following gauges:

- Red Deer River below Burnt Timer Creek (05CA009);
- Fallentimber Creek near Sundre (05CA012);
- Bearberry Creek near Sundre (05CA011); and
- James River near Sundre (05CA002).

A total of four flow measurements were performed on the Red Deer River and two on Bearberry Creek. The measured flows are compared to the preliminary published flows from WSC (see Table 7).

Table 7: Comparison between Measured and WSC Flow Data

Stream	Date	Location	Flow (m³/s)		Difference between Measured and WSC Flows		Contributing WSC Gauges
			Measured during Survey	WSC Gauge(1)	(m³/s)	(%)	
Red Deer River	17-Oct-2017	R109	12.7	13.2	-0.5	-4%	Red Deer River below Burnt Timber Creek, Fallentimber Creek near Sundre, Bearberry Creek at Sundre, James River near Sundre
	9-Oct-2017	R72	12.5	13.8	-1.3	-11%	Red Deer River below Burnt Timber Creek, Fallentimber Creek near Sundre, Bearberry Creek at Sundre, James River near Sundre
	5-Oct-2017	R37	11.9	12.5	-0.6	-5%	Red Deer River below Burnt Timber Creek, Fallentimber Creek near Sundre, Bearberry Creek at Sundre
	5-Oct-2017	R27	11.1	11.5	-0.4	-4%	Red Deer River below Burnt Timber Creek
Bearberry Creek	30-Sep-2017	B41	0.11	0.22	-0.1	-93%	Bearberry Creek at Sundre
	28-Sep-2017	B115	0.24	0.25	0.0	-4%	Bearberry Creek at Sundre

Note:
1) WSC gauge flows are preliminary and subject to changes.

The flow measurements along the Red Deer River are 4% to 11% lower than the preliminary sum of flows at the gauge stations for the contributing streams. Sources of the differences may include the following:

- Throughout the study reach there were very few locations that were suitable for flow measurements. Even at the locations where flow measurements were made, conditions were not ideal because there were relatively large portions of the channel cross sections that were too shallow to measure any flow.
- The river bed consists of relatively large alluvial material (mostly cobbles) with a high porosity. A portion of the total flow entering the study area could be conveyed within the river bed.
- The preliminary flows posted by WSC are provisional at this time and may be subject to change when manually reviewed and corrected by WSC.

The flow measurement on Bearberry Creek at cross section B115 (near the Footbridge in Sundre) is within the measurement accuracy.

The flow measured further upstream on Bearberry Creek at cross section B41 (upstream of the Range Road 60 bridge) is much smaller than the provisional data posted by WSC at that day. Possible explanations for this discrepancy are provided below:

- There is a small tributary entering Bearberry Creek upstream of the Highway 22 bridge (upstream of the WSC gauge) that was conveying some flow at the time of the survey. The flow in Bearberry Creek upstream of this tributary would be smaller than the flow posted by WSC.

- The subsurface in the McDougal Flats and Bearberry Plains area west and southwest of Sundre is known for containing permeable and deep gravel deposits. It is possible that during low flow conditions a relatively large portion of the flow in Bearberry Creek upstream of Highway 22 is fed by groundwater from the Red Deer River because the Red Deer River to the south is approximately 10 m higher than Bearberry Creek. This would result in a reduction of surface flow in upstream direction within the influence zone of the Red Deer River aquifer.
- The flow value reported by WSC was not directly measured but estimated using the flow rating curve. Such estimation may introduce large error particularly during low flow condition.

2.8 Accuracy

The accuracy of the points collected using the RTK system is considered to be within ±0.02 m in both horizontal and vertical directions. The spatial position and elevation of each RTK rover unit was calibrated daily to an Alberta Survey Control Marker (ASCM) benchmark or a temporary benchmark tied to an ASCM. Furthermore, the daily survey protocol required that the field crews calibrate to and then open and close at an ASCM benchmark or a temporary benchmark to maintain a ±0.02 m level of accuracy.

The RTK data collectors were set to provide a warning when calculated maximum error exceeded 0.05 m for a manually-recorded point. When notified, the survey crew would either adjust their location, wait longer to measure the point, or use a longer rod before surveying that point. All RTK collected survey data was analyzed in the office using a Trimble tool to check the accuracy of each point. The relatively small number of points with less than 0.05 m horizontal or vertical accuracy were deleted. In the rare case that multiple survey points for one cross section didn't fulfill the accuracy requirement, this cross section was then re-surveyed.

Some of the Bearberry Creek cross sections were surveyed using a total station that was set up over temporary benchmarks established using the RTK. The temporary benchmark setup and total station accuracy are considered to have a combined total accuracy level of ±0.05 m or less. The exact accuracy for each point varies in proportion to the distance between the target and the survey instrument.

The bathymetric surveys conducted from the river boat using the RTK-ADP combination have a slightly reduced accuracy relative to the ground-based surveys, because the constant movement of the boat on the water surface creates pitch, roll, and yaw that influence the angle of the ADP beams. Depending on the water depth and the angle of deviation from vertical, the ±0.02 m accuracy from the RTK can be reduced by a few centimetres. Overall, the bathymetric surveys conducted using the RTK-ADP combination are considered to have an accuracy of ±0.10 m in both the horizontal and vertical directions.

3.0 ADDITIONAL BASE DATA

Additional base data collected in this study includes the following:

- Highwater marks for the Red Deer River, (Alberta Environment and Parks, 1965), (Alberta Environment and Parks, 1981), (Alberta Environment and Parks, 1986), (Alberta Environment and Parks, 1990), (Alberta Environment and Parks, 2005) and (Alberta Environment and Parks, 2013) and for Bearberry Creek (Alberta Environment and Parks, 1992) and (Alberta Environment and Parks, 2005), all provided by Alberta Environment and Parks.
- Survey data and as-built drawings of road bridges located within the study area. These bridge file datasets were provided by Alberta Transportation.
- Engineering design drawings and reports for the Bearberry Creek weir and fish way (Sameng, 2008).

- Engineering design drawings for the Sundre East and West flood control dikes (Alberta Environment and Parks, 1980) and (Alberta Environment and Parks, 1981).
- Engineering design drawings for the Sundre groynes (Alberta Environment, 1979).
- Contract specifications for the Bearberry Creek dikes (Alberta Environment, 1979) and As Constructed Report (Alberta Environment, 1981).
- Provisional streamflow data from the following WSC gauging on the Red Deer River, Bearberry Creek and other tributaries within or near the study area:
  - Red Deer River below Burnt Timber (WSC Station 05CA009),
  - Bearberry Creek near Sundre (WSC Station 05CA011),
  - Fallentimber Creek near Sundre (WSC Station 05CA012), and
  - James River near Sundre (WSC Station 05CA002).
- McDougal Flats Flood Hazard Study (Golder, 2015).
- Sundre Flood Risk Mapping Study (AEP, 1997).

4.0 CONCLUSIONS

Topographic, bathymetric, and supporting base data required for subsequent components of the Upper Red Deer River Hazard Study were collected in accordance with AEP's requirements. The following conclusions are made:

- *River Cross Section Surveys* – Cross section survey data collected for this study in September/October 2017 meet the current study requirements with regard to cross section spacing and alignment, extents of cross sections on the floodplains, labeling of survey points, and data accuracy.
- *Hydraulic and Flood Control Structure Surveys* – Hydraulic and flood control structure survey data collected in September/October 2017 meet the study requirements and include the necessary details for the hydraulic modelling.
- The survey was conducted according to the Red Deer River and Bearberry Creek Survey Plan, dated October 3, 2017 without any substantial deviations with potential to impact project deliverables.

Signature Page

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Associate, Project Manager

Reviewed by:

Original Signed by

Dejiang Long, Ph.D., P.Eng.
Principal, Senior River Engineer

WP/DL/rd

https://golderassociates.sharepoint.com/sites/140764/project files/5 technical work/06_upper red deer/05_update reports/survey report/1783057-009-r-rev0 survey and base data report_20220629.docx

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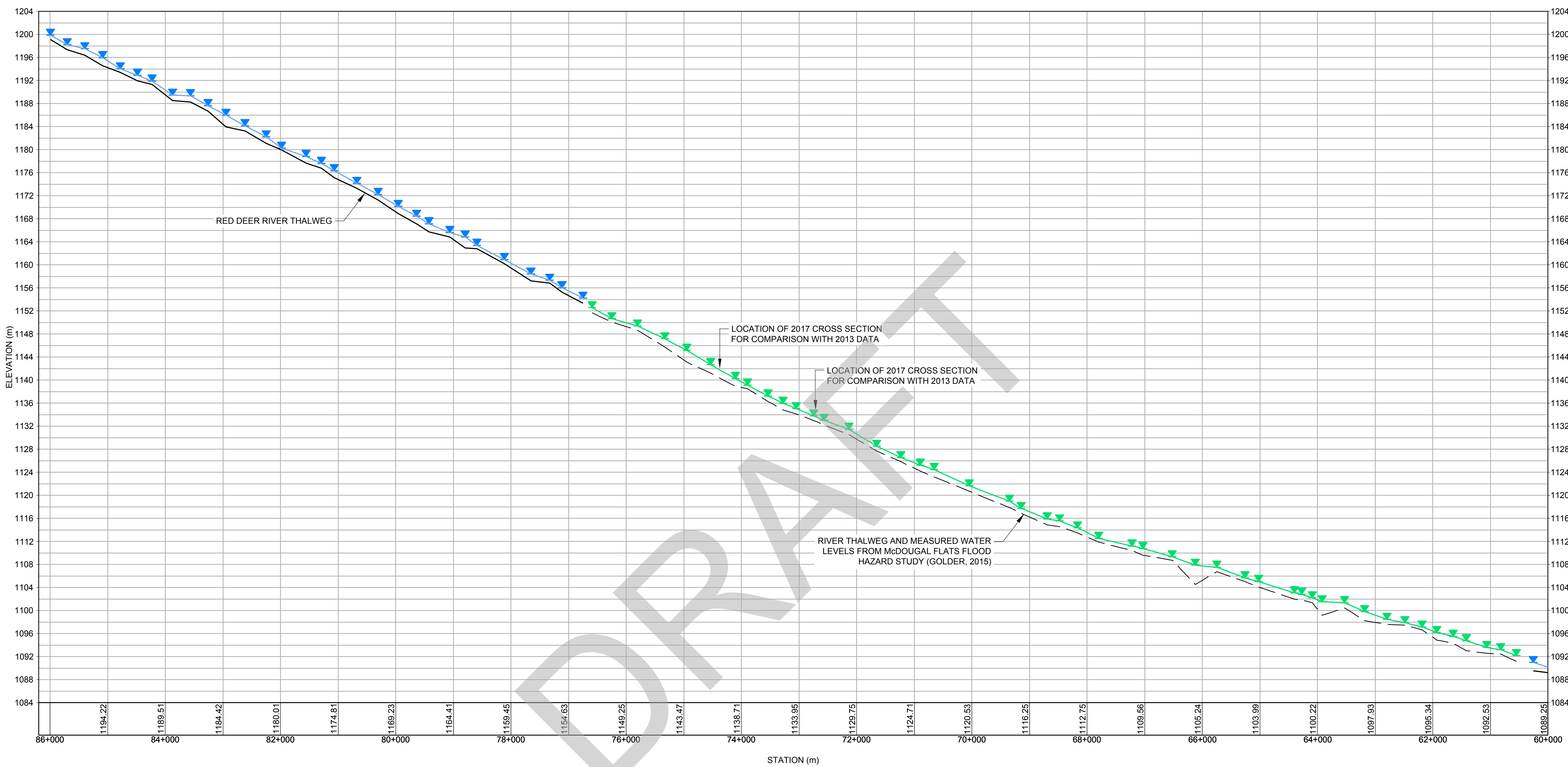
APPENDIX A

Surveyed Thalweg and Water Surface Profiles



LEGEND

- MEASURED WATER LEVELS DURING CROSS SECTION SURVEY
- MEASURED WATER LEVELS DURING CROSS SECTION SURVEY (2013)

REFERENCE

SURVEY DATA COLLECTED BY GOLDER FROM SEPTEMBER 27 TO OCTOBER 17, 2017 AND FROM SEPTEMBER 25 TO OCTOBER 9, 2013 AS PART OF THE McDOUGAL FLATS FLOOD HAZARD STUDY (GOLDER, 2015)

0 1,250 2,500
HORIZONTAL SCALE 1:75,000 METRES
VERTICAL EXAGGERATION = 100X

CLIENT
ALBERTA ENVIRONMENT AND PARKS

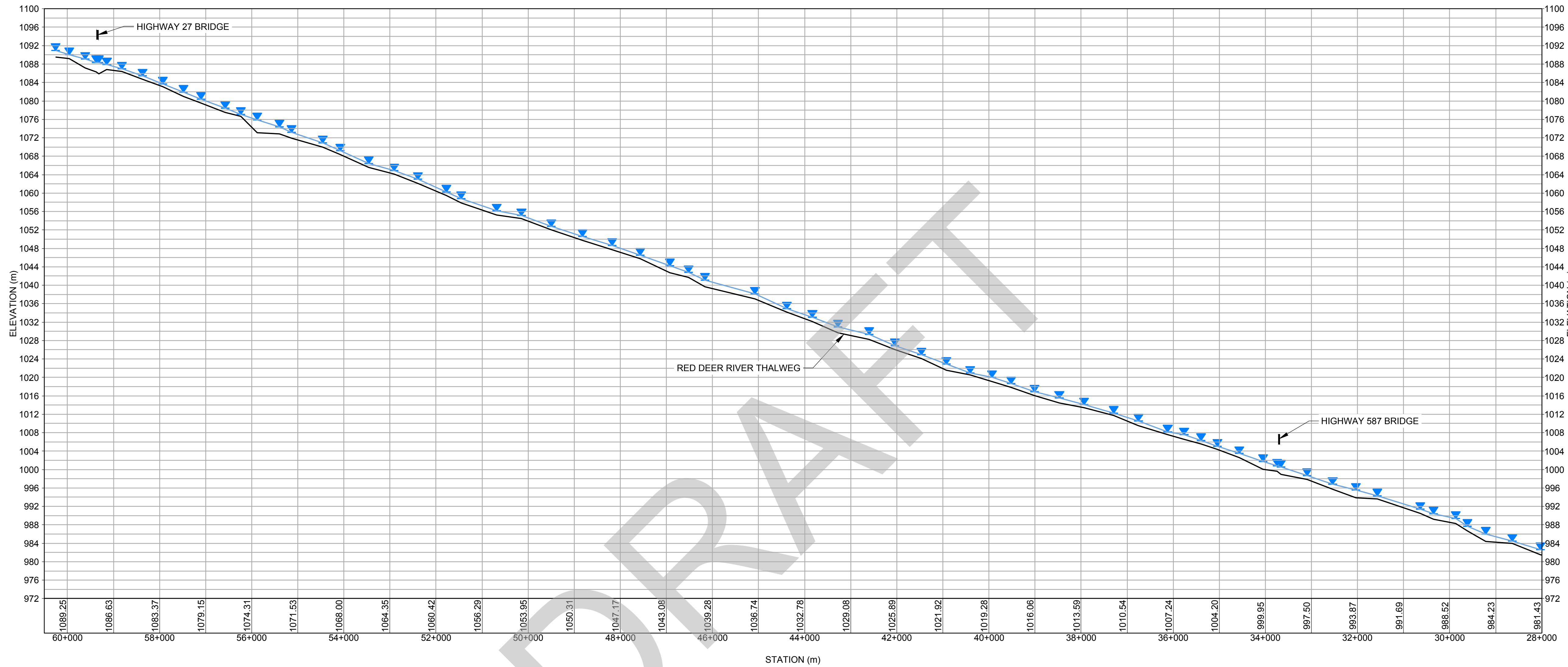
PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE
RED DEER RIVER

CONSULTANT
GOLDER

YYYY-MM-DD	2018-04-24
PREPARED	JDS
DESIGN	MD
REVIEW	WP
APPROVED	WP

PROJECT No. 1783057 | Rev. 0 | FIGURE A-1



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MEASURED WATER LEVELS DURING CROSS SECTION SURVEY

REFERENCE

SURVEY DATA COLLECTED BY GOLDER FROM SEPTEMBER 27 TO OCTOBER 17, 2017

0 2,500 5,000

HORIZONTAL SCALE 1:100,000 METRES

VERTICAL EXAGGERATION = 100X

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

UPPER RED DEER RIVER HAZARD STUDY

TITLE

SURVEYED THALWEG AND WATER SURFACE PROFILE
RED DEER RIVER

CONSULTANT

GOLDER

YYYY-MM-DD	2018-04-24
PREPARED	JDS
DESIGN	MD
REVIEW	WP
APPROVED	WP

PROJECT No.	Rev.	FIGURE
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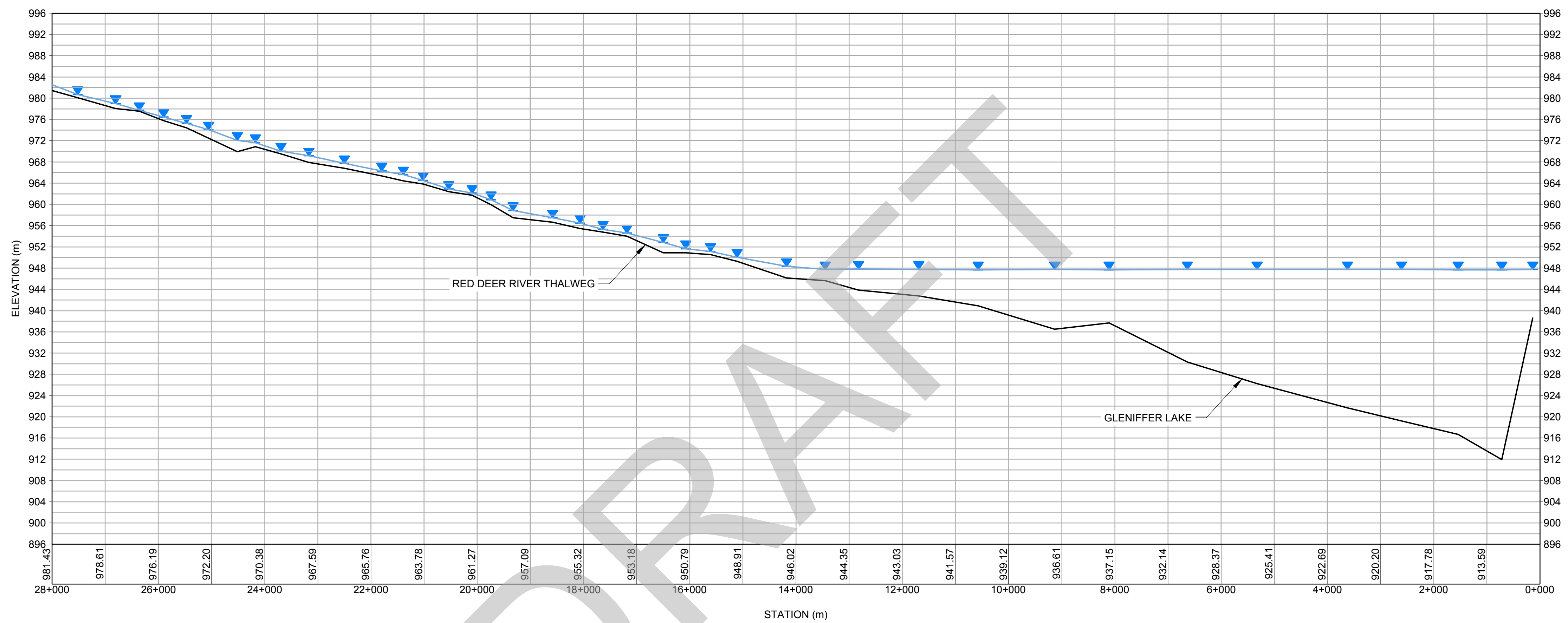

LEGEND

▼ MEASURED WATER LEVELS DURING CROSS SECTION SURVEY

REFERENCE

SURVEY DATA COLLECTED BY GOLDER FROM SEPTEMBER 27 TO OCTOBER 17, 2017

0 2,500 5,000

HORIZONTAL SCALE 1:100,000 METRES
VERTICAL EXAGGERATION = 100X

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE
RED DEER RIVER

CONSULTANT

GOLDER

YYYY-MM-DD	2018-04-24
PREPARED	JDS
DESIGN	MD
REVIEW	WP
APPROVED	WP

PROJECT No.	Rev.	FIGURE
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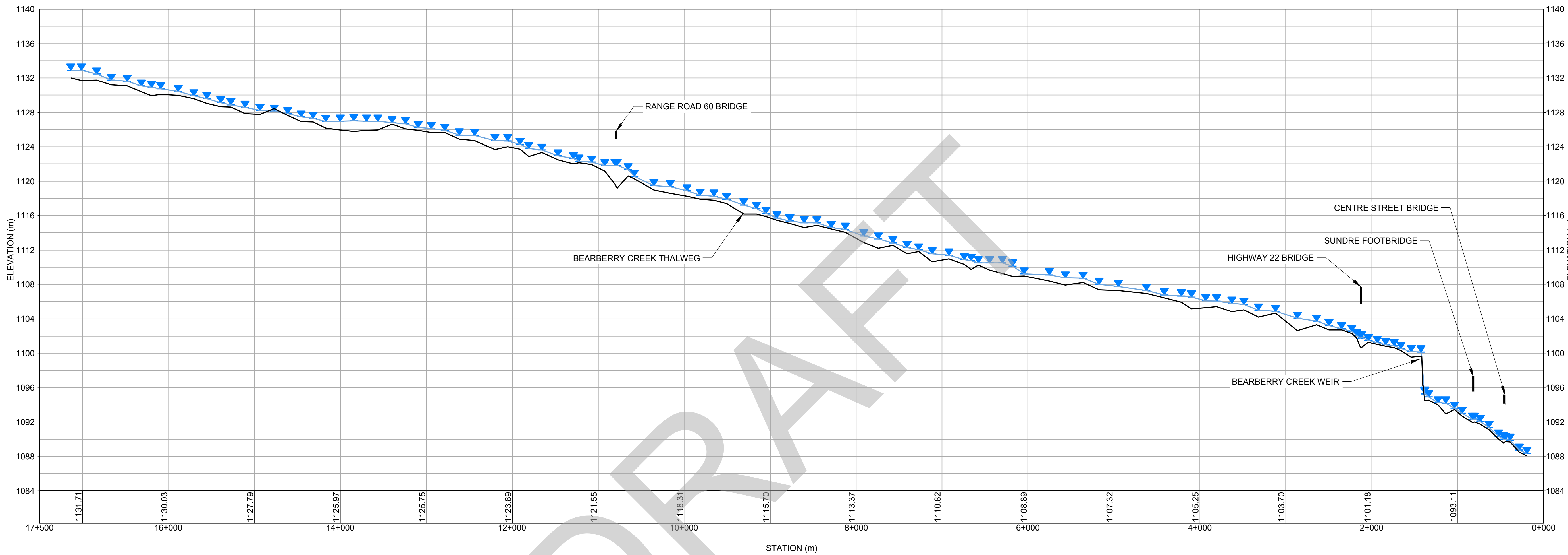

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MEASURED WATER LEVELS DURING CROSS SECTION SURVEY

REFERENCE

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HORIZONTAL SCALE 1:50,000 (0 – 1,000 – 2,000 METRES)
VERTICAL EXAGGERATION = 100X

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PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE
BEARBERRY CREEK

CONSULTANT

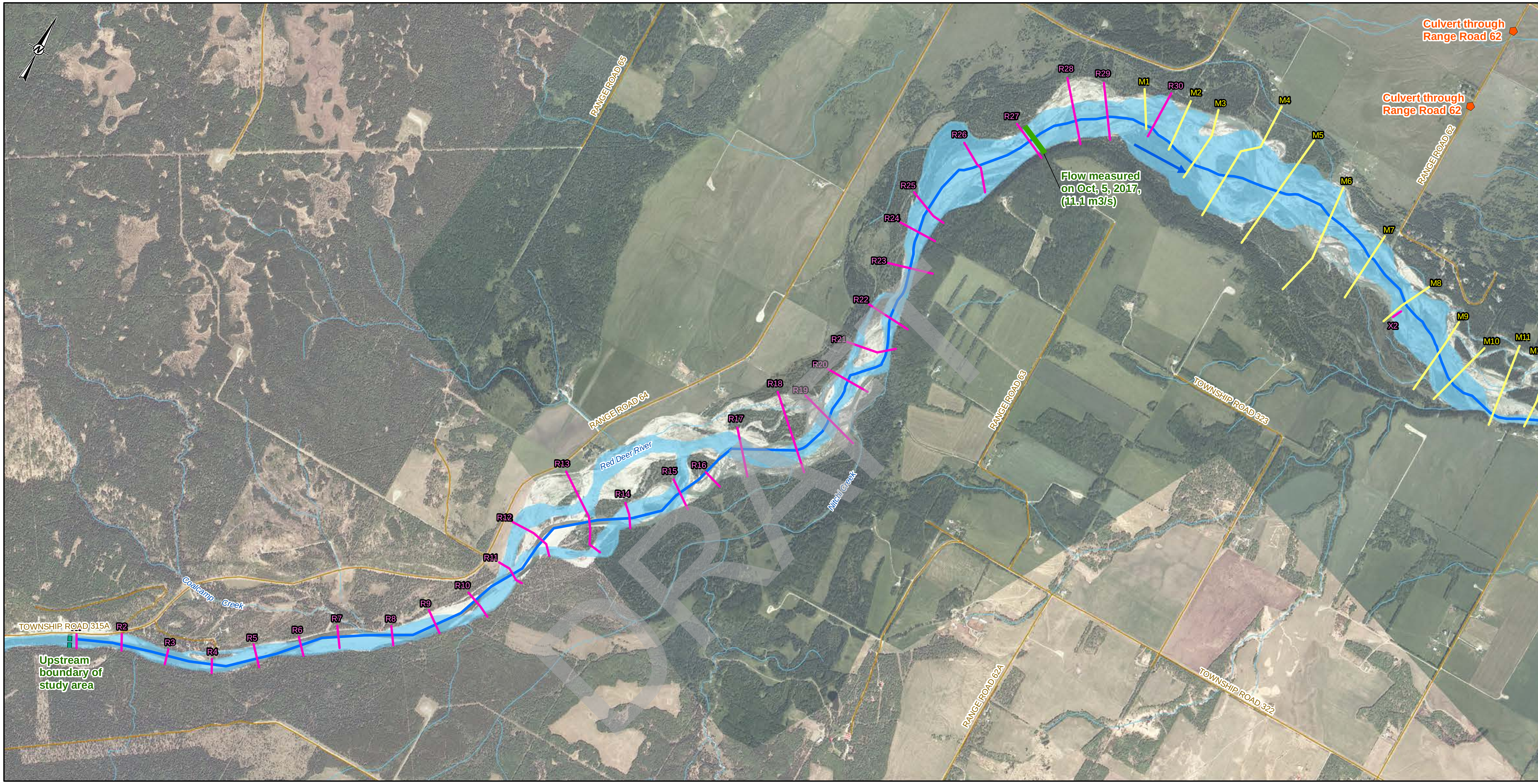
GOLDER

YYYY-MM-DD	2018-04-24
PREPARED	JDS
DESIGN	MD
REVIEW	WP
APPROVED	WP

PROJECT No. 1783057 | Rev. 0 | FIGURE A-4

APPENDIX B

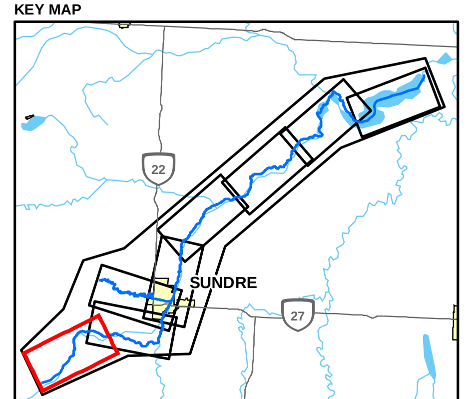
Cross Section, Hydraulic Structure, and Flood Control Structure Locations



LEGEND

- FLOW DIRECTION
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- POPULATED AREA
- BERM
- BRIDGE
- CULVERT
- DAM
- WEIR
- FLOOD CONTROL STRUCTURE
- FLOW MEASUREMENT
- SURVEY REACH
- SURVEYED CROSS SECTION (2013)
- SURVEYED CROSS SECTION (2017)
- STUDY BOUNDARY

KEY MAP



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NOTE(S)

CROSS SECTION, HYDRAULIC STRUCTURE AND FLOOD CONTROL STRUCTURE SURVEY PERFORMED BY GOLDER ASSOCIATES LTD. IN SEPTEMBER AND OCTOBER 2017 AND 2013.
SURVEY REACH LINE BASED ON ALTALIS HYDROLOGY LAYER AND MAY NOT REPRESENT ACTUAL CHANNEL CENTRE LINE.

REFERENCE(S)

2016 SPOT6 IMAGERY PROVIDED BY AEP, OTHER IMAGERY CAPTURED JULY 2018 BY ORTHOSHOP GEOMATICS LTD. FOR THE GOVERNMENT OF ALBERTA. 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

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CONSULTANT

YYYY-MM-DD	2019-06-04
DESIGNED	S. KURASH
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES ON THE RED DEER RIVER AND BEARBERRY CREEK

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	B-1

Classification: Public

LEGEND

- FLOW DIRECTION
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
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- WATERCOURSE
- WATERBODY
- POPULATED AREA
- BERM
- BRIDGE
- CULVERT
- DAM
- WEIR
- FLOOD CONTROL STRUCTURE
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- STUDY BOUNDARY

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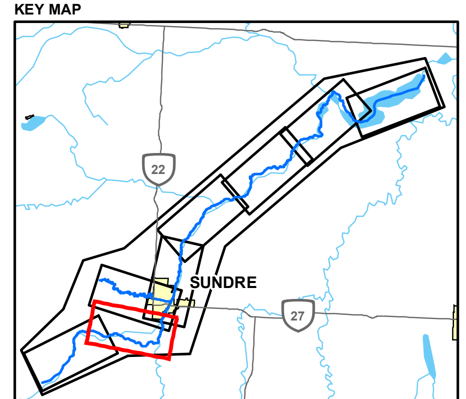

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1:25,000 KILOMETRES

CLIENT
ALBERTA ENVIRONMENT AND PARKS

Alberta Government

CONSULTANT

GOLDER

YYYY-MM-DD	2022-06-29
DESIGNED	S. KURASH
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

NOTE(S)
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PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES ON THE RED DEER RIVER AND BEARBERRY CREEK

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	**B-2**

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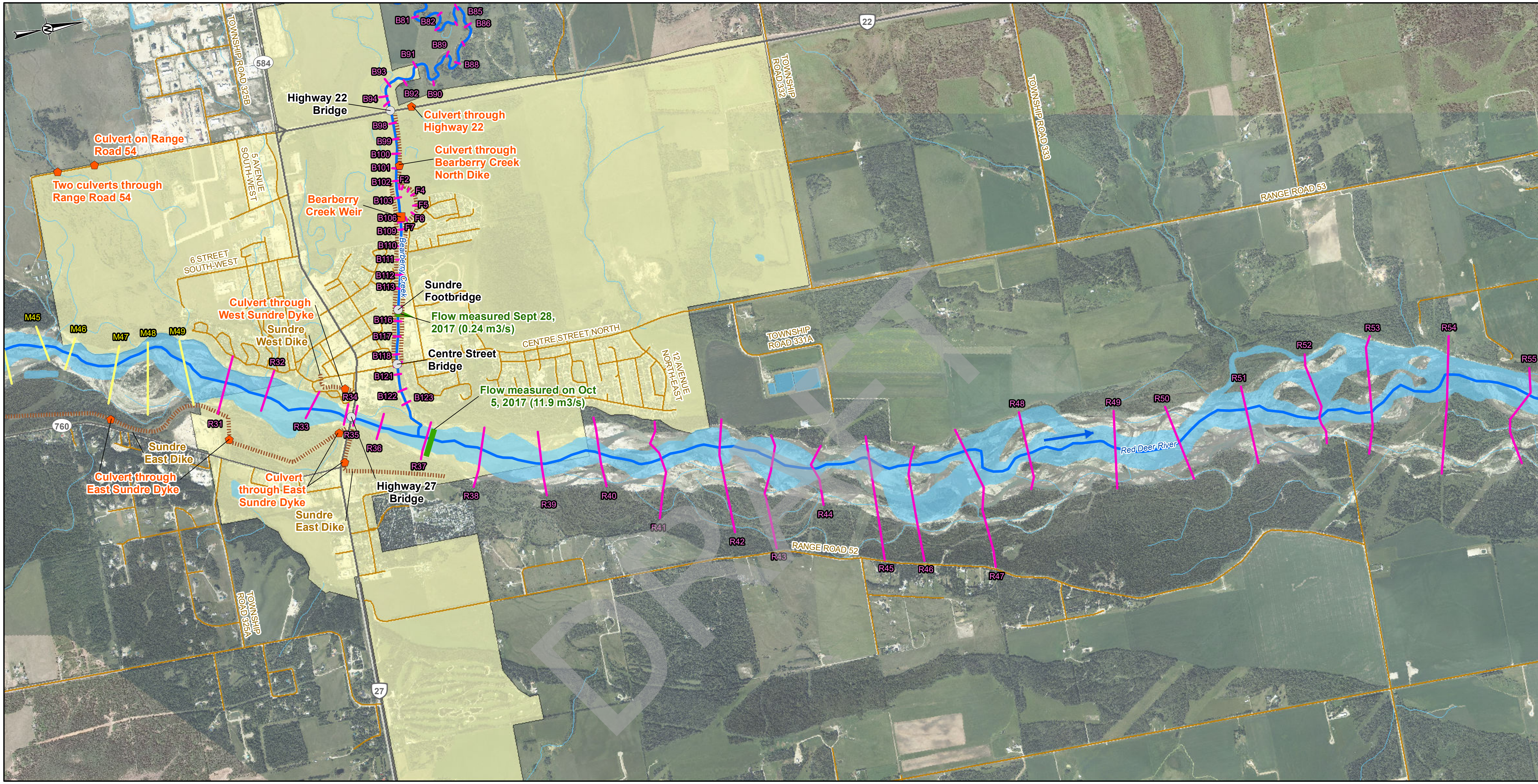

LEGEND

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- SECONDARY HIGHWAY
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- POPULATED AREA
- BERM
- BRIDGE
- CULVERT
- DAM
- WEIR
- FLOOD CONTROL STRUCTURE
- FLOW MEASUREMENT
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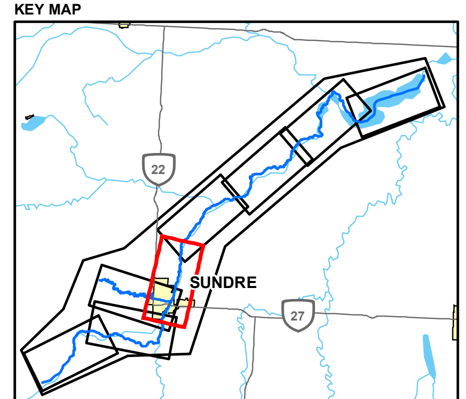
- SURVEYED CROSS SECTION (2013)
- SURVEYED CROSS SECTION (2017)
- STUDY BOUNDARY

KEY MAP



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1:25,000 KILOMETRES

CLIENT
ALBERTA ENVIRONMENT AND PARKS

Alberta Government

CONSULTANT

GOLDER

YYYY-MM-DD	2022-06-29
DESIGNED	S. KURASH
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

NOTE(S)
CROSS SECTION, HYDRAULIC STRUCTURE AND FLOOD CONTROL STRUCTURE SURVEY PERFORMED BY GOLDER ASSOCIATES LTD. IN SEPTEMBER AND OCTOBER 2017 AND 2013. SURVEY REACH LINE BASED ON ALTALIS HYDROLOGY LAYER AND MAY NOT REPRESENT ACTUAL CHANNEL CENTRE LINE.

REFERENCE(S)
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PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES ON THE RED DEER RIVER AND BEARBERRY CREEK

PROJECT NO.	CONTROL	REV.	FIGURE
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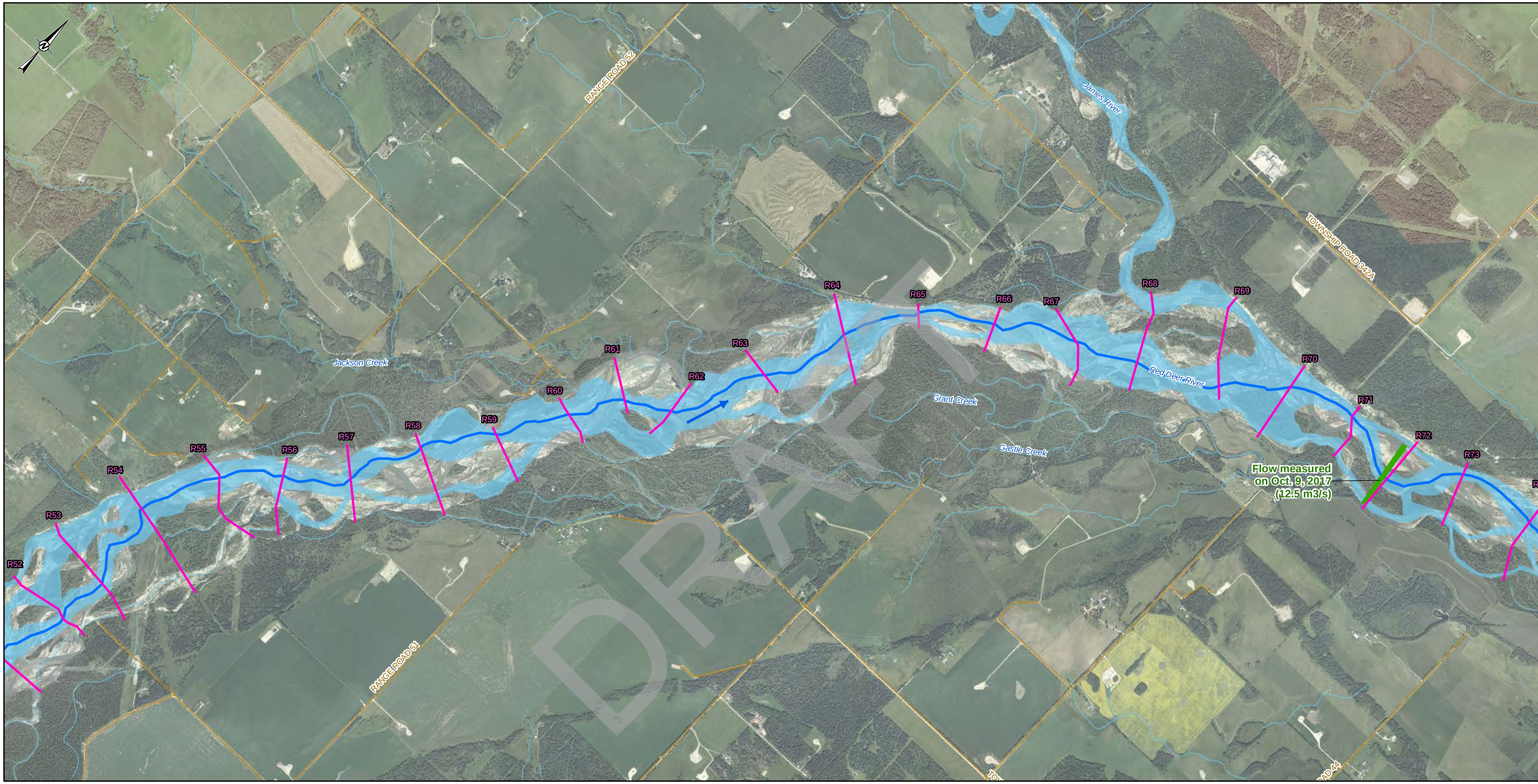

LEGEND

- FLOW DIRECTION
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
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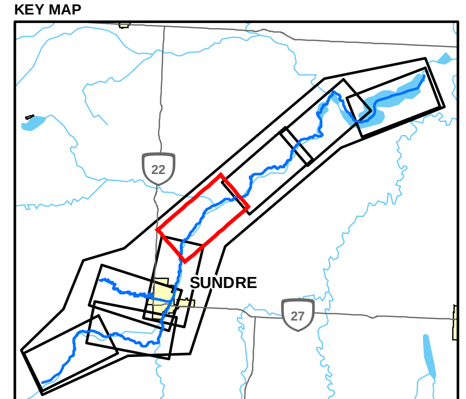
- WATERBODY
- POPULATED AREA
- BERM
- BRIDGE
- CULVERT
- DAM
- WEIR
- FLOOD CONTROL STRUCTURE
- FLOW MEASUREMENT
- SURVEY REACH
- SURVEYED CROSS SECTION (2013)
- SURVEYED CROSS SECTION (2017)
- STUDY BOUNDARY

KEY MAP



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NOTE(S)

CROSS SECTION, HYDRAULIC STRUCTURE AND FLOOD CONTROL STRUCTURE SURVEY PERFORMED BY GOLDER ASSOCIATES LTD. IN SEPTEMBER AND OCTOBER 2017 AND 2013. SURVEY REACH LINE BASED ON ALTALIS HYDROLOGY LAYER AND MAY NOT REPRESENT ACTUAL CHANNEL CENTRE LINE.

REFERENCE(S)

2016 SPOT6 IMAGERY PROVIDED BY AEP, OTHER IMAGERY CAPTURED JULY 2018 BY ORTHOSHOP GEOMATICS LTD. FOR THE GOVERNMENT OF ALBERTA. 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

Alberta Government

CONSULTANT

GOLDER

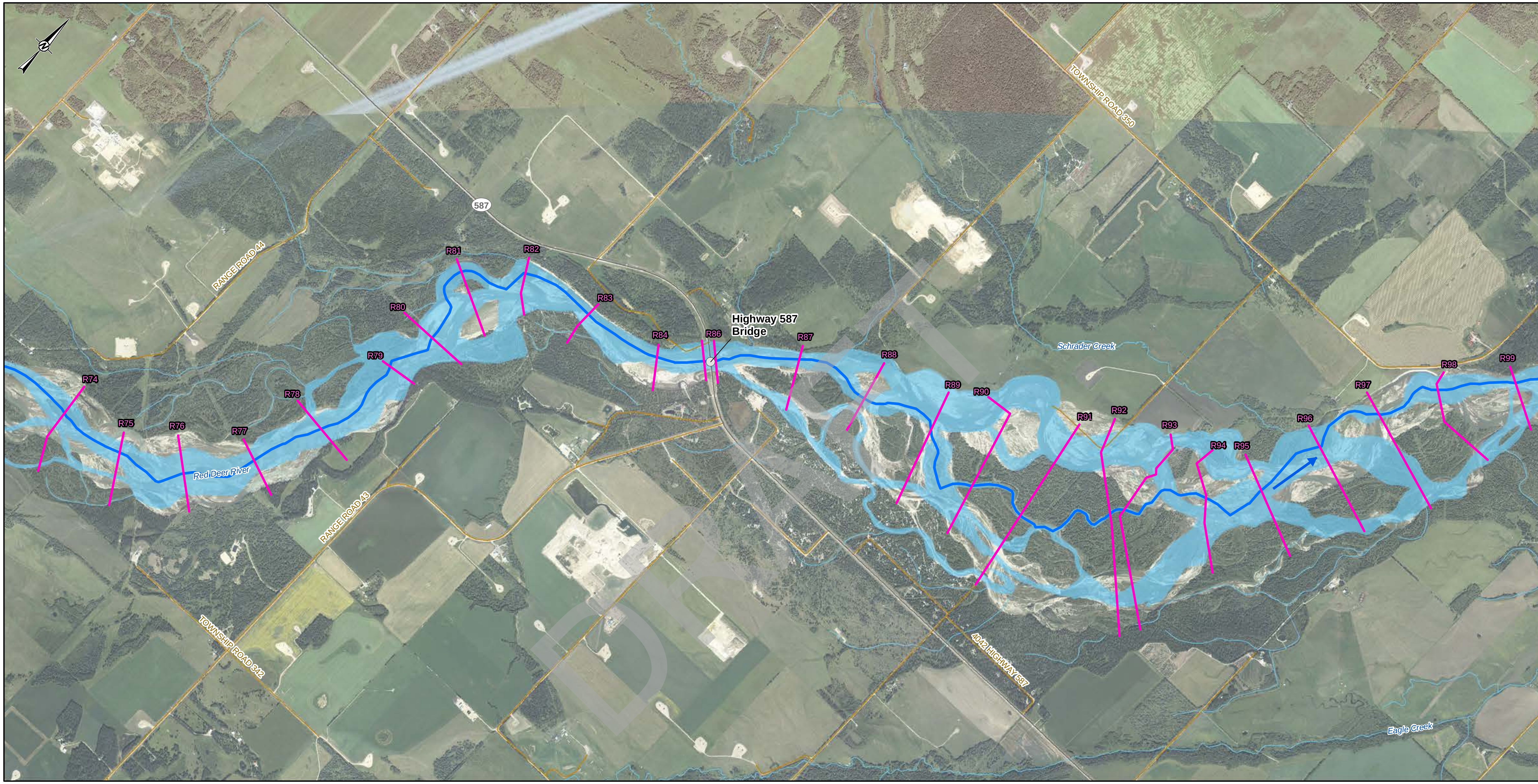
YYYY-MM-DD	2019-06-04
DESIGNED	S. KURASH
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES ON THE RED DEER RIVER AND BEARBERRY CREEK

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	B-4

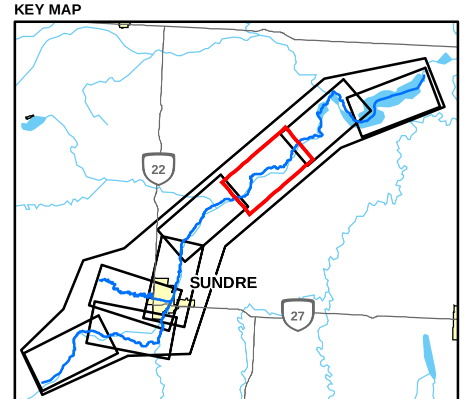
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm



LEGEND

- FLOW DIRECTION
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- POPULATED AREA
- BERM
- BRIDGE
- CULVERT
- DAM
- WEIR
- FLOOD CONTROL STRUCTURE
- FLOW MEASUREMENT
- SURVEY REACH
- SURVEYED CROSS SECTION (2013)
- SURVEYED CROSS SECTION (2017)
- STUDY BOUNDARY

KEY MAP



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PROJECT
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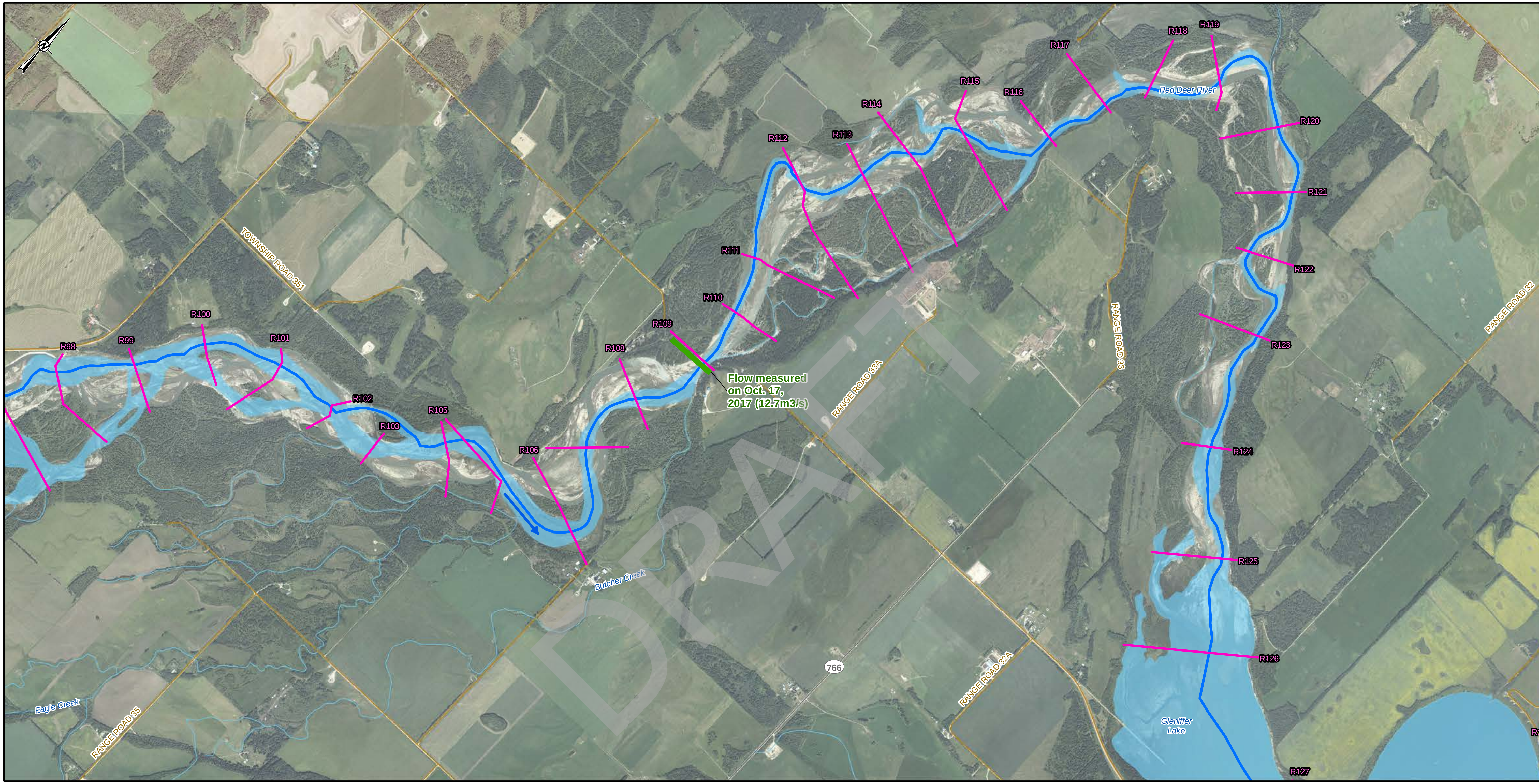
TITLE
CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES ON THE RED DEER RIVER AND BEARBERRY CREEK

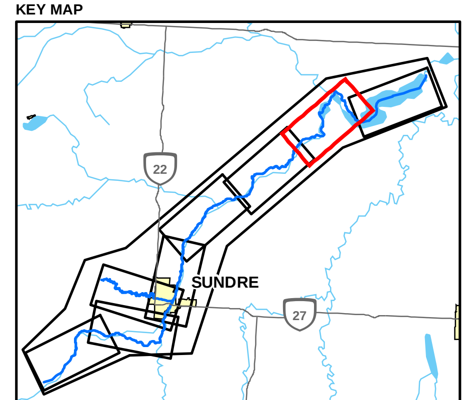
PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	**B-5**



LEGEND

- FLOW DIRECTION
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- POPULATED AREA
- BERM
- BRIDGE
- CULVERT
- DAM
- WEIR
- FLOOD CONTROL STRUCTURE
- FLOW MEASUREMENT
- SURVEY REACH
- SURVEYED CROSS SECTION (2013)
- SURVEYED CROSS SECTION (2017)
- STUDY BOUNDARY

KEY MAP



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1:25,000 KILOMETRES

CLIENT
ALBERTA ENVIRONMENT AND PARKS

Alberta Government

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GOLDER

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DATUM: NAD 83 CSRS PROJECTION: 3TM 114

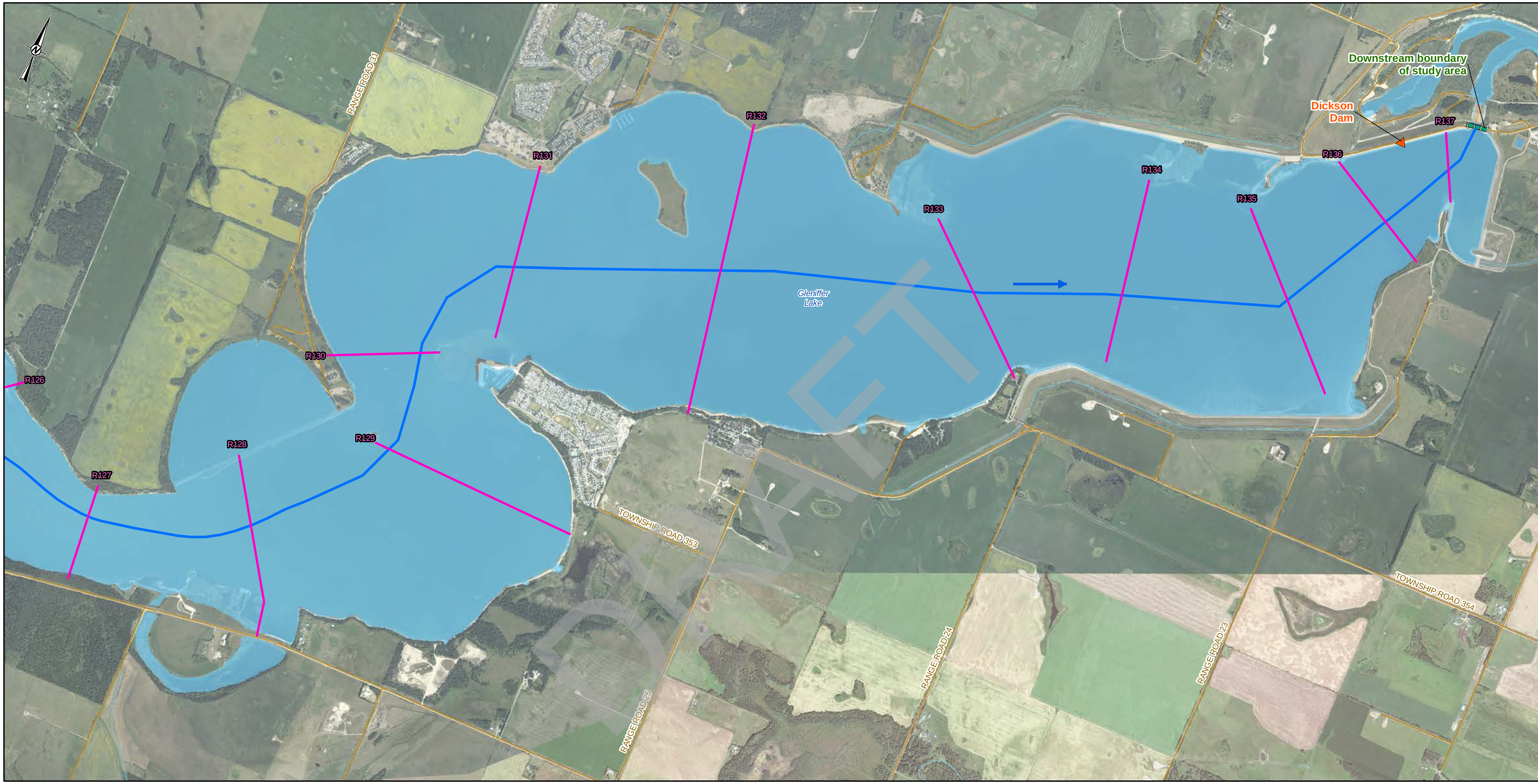
PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES ON THE RED DEER RIVER AND BEARBERRY CREEK

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	**B-6**

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

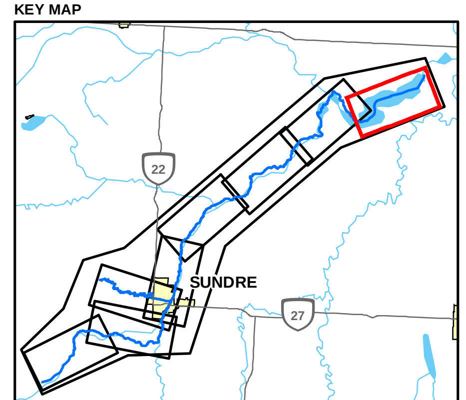
25mm



LEGEND

FLOW DIRECTION	BERM
PRIMARY HIGHWAY	BRIDGE
SECONDARY HIGHWAY	CULVERT
LOCAL ROAD	DAM
WATERCOURSE	WEIR
WATERBODY	FLOOD CONTROL STRUCTURE
POPULATED AREA	FLOW MEASUREMENT
	SURVEY REACH
	SURVEYED CROSS SECTION (2013)
	SURVEYED CROSS SECTION (2017)
	STUDY BOUNDARY

KEY MAP



0 1 2

1:25,000 KILOMETRES

NOTE(S)

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DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

Alberta Government

CONSULTANT

GOLDER

YYYY-MM-DD	2019-06-04
DESIGNED	S. KURASH
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES ON THE RED DEER RIVER AND BEARBERRY CREEK

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	B-7

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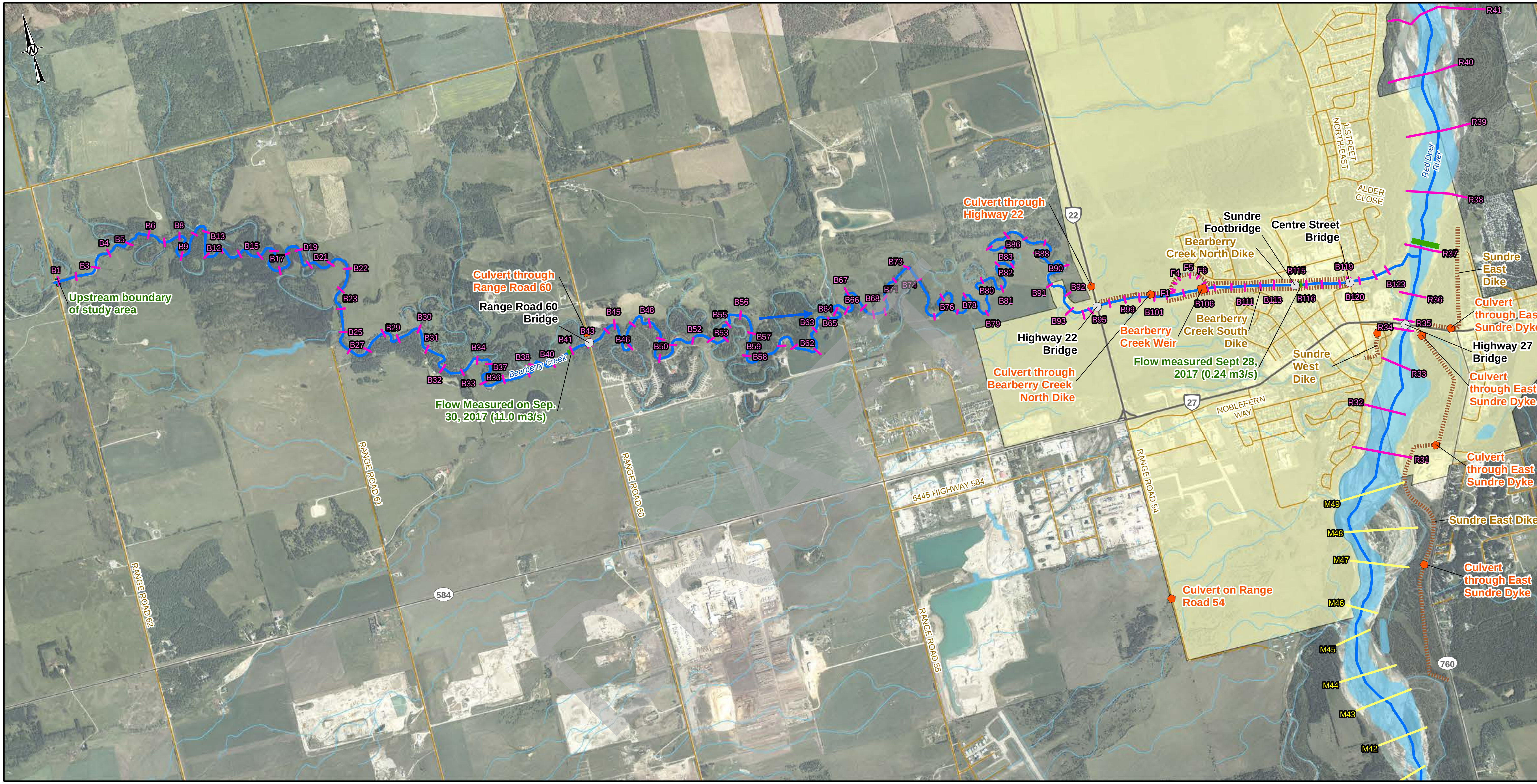
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

Classification: Public



LEGEND

- FLOW DIRECTION
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- WATERCOURSE
- WATERBODY
- POPULATED AREA
- BERM
- BRIDGE
- CULVERT
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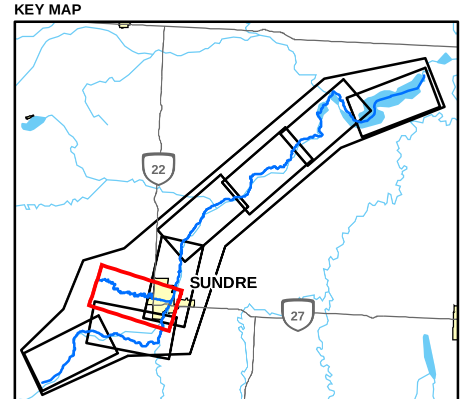
- FLOW MEASUREMENT
- SURVEY REACH
- SURVEYED CROSS SECTION (2013)
- SURVEYED CROSS SECTION (2017)
- STUDY BOUNDARY

KEY MAP



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1:25,000 KILOMETRES

CLIENT
ALBERTA ENVIRONMENT AND PARKS

Alberta Government

CONSULTANT

GOLDER

YYYY-MM-DD	2019-06-04
DESIGNED	S. KURASH
PREPARED	B. PENDERGAST
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APPROVED	D. LONG

NOTE(S)
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DATUM: NAD 83 CSRS PROJECTION: 3TM 114

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

TITLE
CROSS SECTIONS, HYDRAULIC STRUCTURES AND FLOOD CONTROL STRUCTURES ON THE RED DEER RIVER AND BEARBERRY CREEK

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	B-8

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

APPENDIX C

Hydraulic Structure Datasheets

0 100 200

1:3,000 METRES

TITLE
HIGHWAY 27 BRIDGE

LOCATION	RED DEER RIVER
DESCRIPTION	MAIN AVENUE E BRIDGE (SUNDRE)
ALBERTA TRANSPORTATION BRIDGE FILE NUMBER	1980
YEAR BUILT	1962
TOTAL LENGTH OF SPAN (m)	130.92
DECK WIDTH OF BRIDGE (m)	12.04
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1095.31
AVERAGE LOW CHORD ELEVATION (m)	1093.33
AVERAGE DECK HEIGHT (m)	1.98
NUMBER OF PIERS	3

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	34.94	2.24	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
2	65.46	2.24	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
3	95.98	2.24	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL

LEGEND

- BRIDGE SURVEY POINT
- ROAD

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

SEE REPORT SECTION 2.5 AND HYDRAULIC MODEL FOR MORE INFORMATION.

REFERENCE(S)
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IMAGERY CAPTURED JULY 2018 BY ORTHOSHOP GEOMATICS LTD. FOR THE GOVERNMENT OF ALBERTA.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

PHOTO 1 UPSTREAM

PHOTO 2 DOWNSTREAM

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-08
DESIGNED	W.PLOEGER
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	**C-1**

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1:3,000 METRES

TITLE

HIGHWAY 587 BRIDGE

LOCATION	RED DEER RIVER
DESCRIPTION	BRIDGE AT GARRINGTON
ALBERTA TRANSPORTATION BRIDGE FILE NUMBER	8800
YEAR BUILT	1962
TOTAL LENGTH OF SPAN (m)	137.21
DECK WIDTH OF BRIDGE (m)	9.45
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1007.65
AVERAGE LOW CHORD ELEVATION (m)	1005.47
AVERAGE DECK HEIGHT (m)	2.18
NUMBER OF PIERS	3

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	34.18	2.18	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
2	68.61	2.18	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL
3	103.04	2.18	CONCRETE	SEMI-CIRCULAR NOSE AND TAIL

LEGEND

- BRIDGE SURVEY POINT
- ROAD

NOTE(S)

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DATUM: NAD 83 CSRS PROJECTION: 3TM 114

PHOTO 1 UPSTREAM

PHOTO 2 DOWNSTREAM

DRAFT

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-08
DESIGNED	W.PLOEGER
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	**C-2**

PATH: I:\CLIENTS\AEP\1783057\Mapping\MXD\Hydrology\01_Survey & Base Data Collection\Rev0\1783057_Appendix_C_Bridges_Datasheets_Rev0.mxd PRINTED ON: 2019-05-08 AT: 9:41:50 AM

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1:3,000 METRES

PHOTO 1 LOOKING UPSTREAM

PHOTO 2 DOWNSTREAM

TITLE

RANGE ROAD 60 BRIDGE

LOCATION	BEARBERRY CREEK
DESCRIPTION	RANGE ROAD 60 BRIDGE
ALBERTA TRANSPORTATION BRIDGE FILE NUMBER	8758
YEAR BUILT	1984
TOTAL LENGTH OF SPAN (m)	31
DECK WIDTH OF BRIDGE (m)	9.82
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1125.76
AVERAGE LOW CHORD ELEVATION (m)	1124.92
AVERAGE DECK HEIGHT (m)	0.84
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	10.01	0.9	WOOD	TRIANGULAR NOSE
2	21.03	0.9	WOOD	TRIANGULAR NOSE
3	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD

NOTE(S)

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PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	C-3

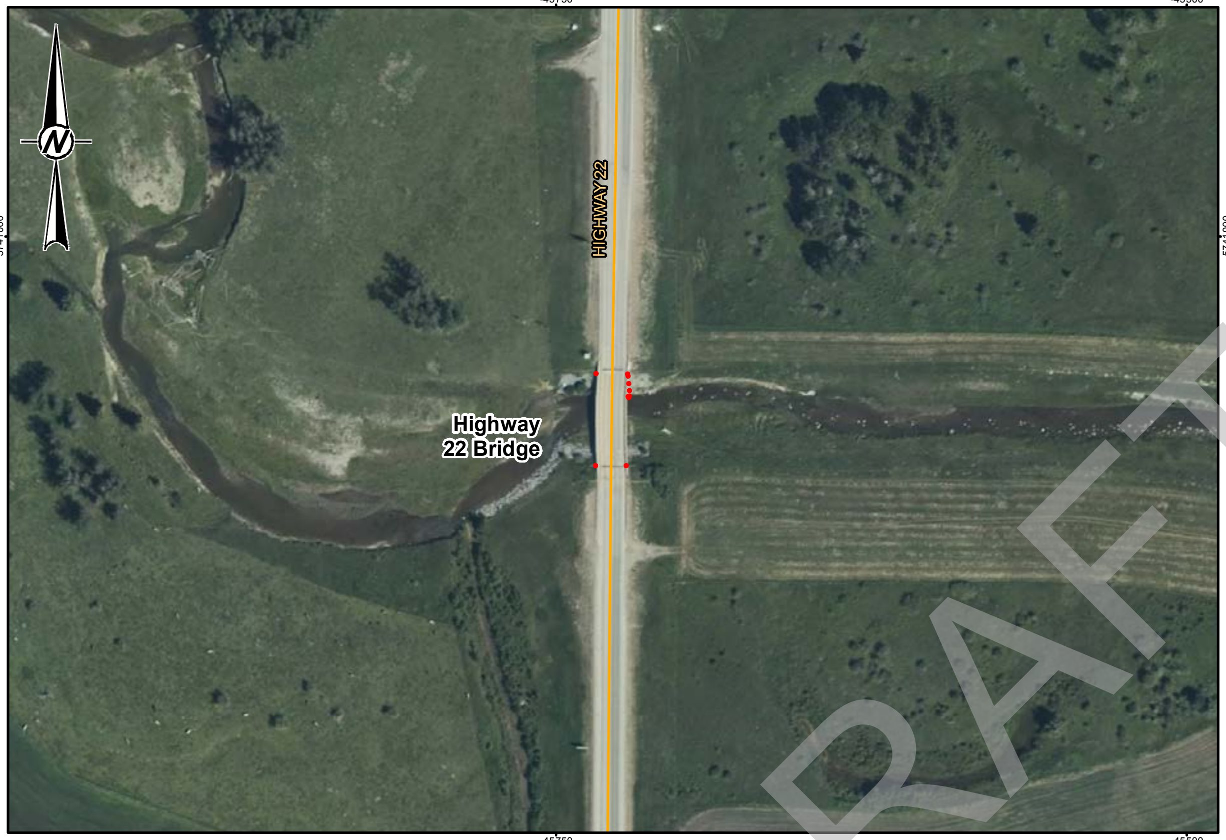
DRAFT

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

25mm

Classification: Public

PATH: I:\CLIENTS\AEP\1783057\Mapping\MXD\Hydrology\01_Survey & Base Data Collection\Rev0\1783057_Appendix_C_Bridges_Datasheets_Rev0.mxd PRINTED ON: 2019-05-08 AT: 9:41:53 AM



0 100 200
1:3,000 METRES

PHOTO 1 UPSTREAM

PHOTO 2 LOOKING UPSTREAM

TITLE

HIGHWAY 22 BRIDGE

LOCATION	BEARBERRY CREEK
DESCRIPTION	COWBOY TRAIL BRIDGE
ALBERTA TRANSPORTATION BRIDGE FILE NUMBER	78518
YEAR BUILT	1982
TOTAL LENGTH OF SPAN (m)	38
DECK WIDTH OF BRIDGE (m)	12.22
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1126.9
AVERAGE LOW CHORD ELEVATION (m)	1124.92
AVERAGE DECK HEIGHT (m)	1.98
NUMBER OF PIERS	0

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

LEGEND

- BRIDGE SURVEY POINT
- ROAD

NOTE(S)

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UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-08
DESIGNED	W.PLOEGER
PREPARED	B. PENDERGAST
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APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	C-4

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

0 100 200

1:3,000 METRES

TITLE

SUNDRE FOOTBRIDGE

LOCATION	BEARBERRY CREEK
DESCRIPTION	FOOTBRIDGE ABOVE CENTRE STREET NORTH
ALBERTA TRANSPORTATION BRIDGE FILE NUMBER	-
YEAR BUILT	-
TOTAL LENGTH OF SPAN (m)	35.3
DECK WIDTH OF BRIDGE (m)	2.6
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1097.32
AVERAGE LOW CHORD ELEVATION (m)	1095.55
AVERAGE DECK HEIGHT (m)	1.77
NUMBER OF PIERS	0

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

LEGEND

- • BRIDGE SURVEY POINT
- — ROAD

NOTE(S)

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PHOTO 1 UPSTREAM

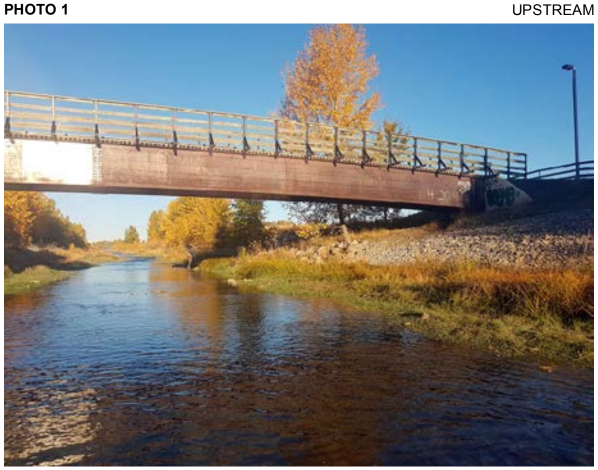

PHOTO 2 DOWNSTREAM

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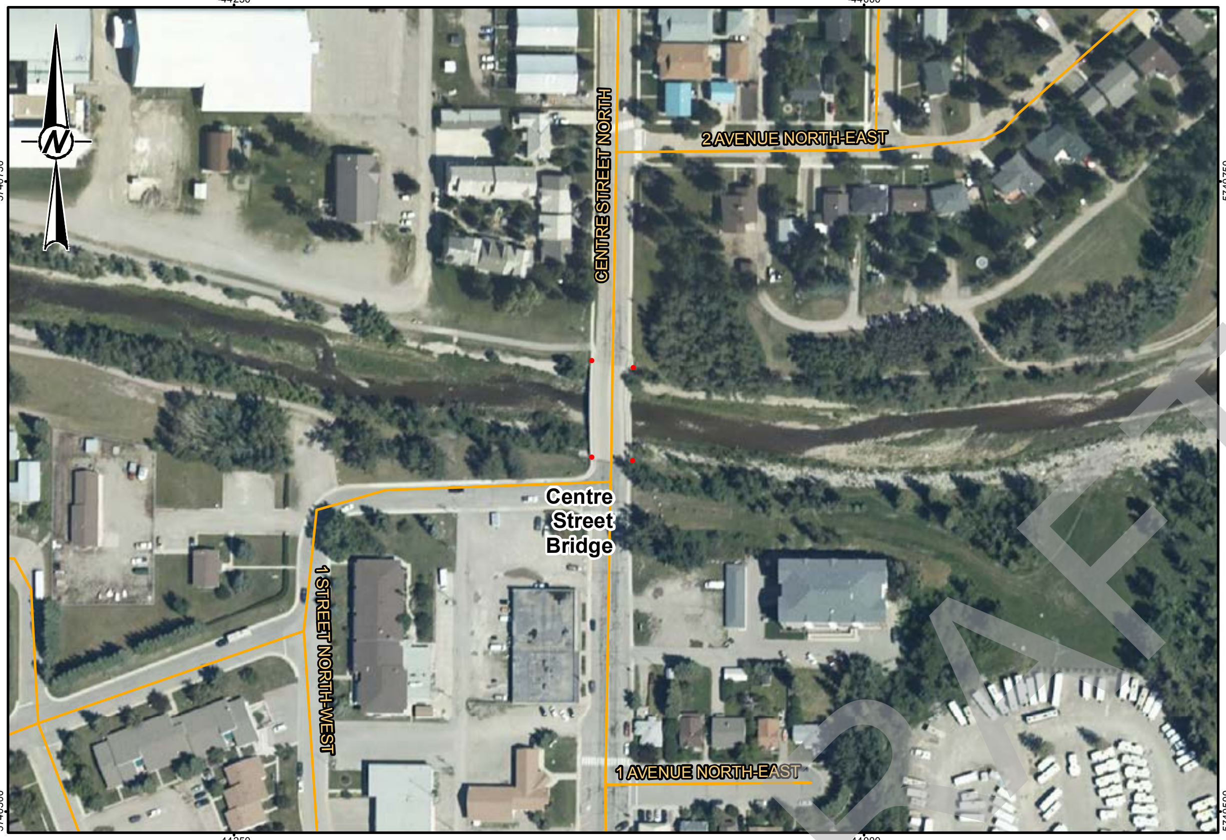
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	C-5



0 100 200

1:3,000 METRES

TITLE
CENTRE STREET BRIDGE

LOCATION	BEARBERRY CREEK
DESCRIPTION	CENTRE STREET NORTH
ALBERTA TRANSPORTATION BRIDGE FILE NUMBER	1886
YEAR BUILT	1981
TOTAL LENGTH OF SPAN (m)	38.3
DECK WIDTH OF BRIDGE (m)	16.4
AVERAGE TOP OF CURB OR SOLID GUARD RAIL ELEVATION (m)	1095.15
AVERAGE LOW CHORD ELEVATION (m)	1094.15
AVERAGE DECK HEIGHT (m)	1
NUMBER OF PIERS	2

PIER	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
1	12.15	0.51	CONCRETE	CYLINDER
2	26.45	0.51	CONCRETE	CYLINDER
3	-	-	-	-

LEGEND

- BRIDGE SURVEY POINT
- ROAD

NOTE(S)

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

SEE REPORT SECTION 2.5 AND HYDRAULIC MODEL FOR MORE INFORMATION.

REFERENCE(S)

BRIDGE SURVEY AND BRIDGE PHOTOS BY GOLDER ASSOCIATES LTD.
ROADS OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2017. ALL RIGHTS RESERVED.
IMAGERY CAPTURED JULY 2018 BY ORTHOSHOP GEOMATICS LTD. FOR THE GOVERNMENT OF ALBERTA.
DATUM: NAD 83 CSRS PROJECTION: 3TM 114

PHOTO 1 UPSTREAM

PHOTO 2 DOWNSTREAM

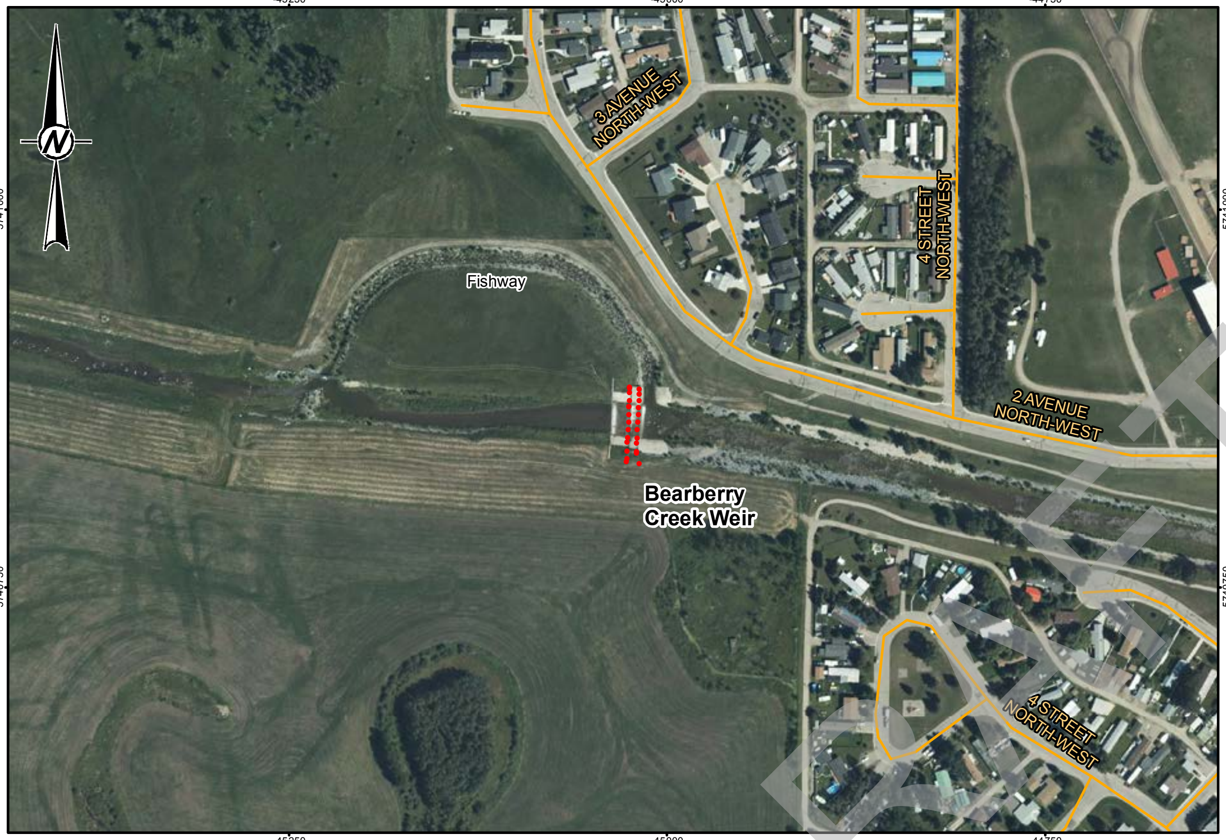
CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-08
DESIGNED	W.PLOEGER
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	C-6



0 100 200

1:5,000 METRES

DRAFT

PHOTO 1 DOWNSTREAM LOOKING UPSTREAM

PHOTO 2 FISHWAY LOOKING UPSTREAM

TITLE

BEARBERRY CREEK WEIR

DESCRIPTION	WEIR AND FISHWAY
NUMBER OF WEIRS	1
WIDTH OF WEIRS (m)	20.0
WEIR TYPE	CONCRETE TRAPEZOIDAL
WEIR CREST ELEVATION - FULLY OPEN (m)	1100.13

LEGEND

- • WEIR SURVEY POINT
- — ROAD

NOTE(S)

HYDRAULIC STRUCTURE SURVEY PERFORMED BY GOLDER ASSOCIATES LTD. IN SEPTEMBER AND OCTOBER 2017

SEE REPORT SECTION 2.5 AND HYDRAULIC MODEL FOR MORE INFORMATION

REFERENCE(S)

WEIR SURVEY AND WEIR PHOTOS BY GOLDER ASSOCIATES LTD. ROADS OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2017. ALL RIGHTS RESERVED. IMAGERY CAPTURED JULY 2018 BY ORTHOSHOP GEOMATICS LTD. FOR THE GOVERNMENT OF ALBERTA. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT

ALBERTA ENVIRONMENT AND PARKS

PROJECT

UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT

GOLDER

YYYY-MM-DD	2019-05-08
DESIGNED	W.PLOEGER
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	C-7

APPENDIX D

Flood Control Structure Datasheets

PATH: I:\CLIENTS\AEP\1783057\Mapping\MXD\Hydrology\01_Survey & Base Data Collection\Rev0\1783057_Appendix_D_FloodControl_Datasheets_Rev0.mxd PRINTED ON: 2019-05-08 AT: 9:45:48 AM

LEGEND

- CULVERT
- FLOW DIRECTION
- FLOOD CONTROL STRUCTURE
- ROAD
- SECONDARY HIGHWAY
- PRIMARY HIGHWAY

NOTE(S)

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

FOR MORE DETAILS SEE SECTION 2.6.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY BY GOLDER ASSOCIATES LTD. OCTOBER 2017. ROADS OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2017. ALL RIGHTS RESERVED. IMAGERY CAPTURED JULY 2018 BY ORTHOSHOP GEOMATICS LTD. FOR THE GOVERNMENT OF ALBERTA. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

LOCATION	RED DEER RIVER
APPROX. LENGTH OF STRUCTURE (m)	326
TYPE OF STRUCTURE	EARTH FILL BARRIER

0 200 400

1:5,000 METRES

TITLE
SUNDRE WEST DIKE

DESCRIPTION
UPSTREAM OF HIGHWAY 27

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT

GOLDER

YYYY-MM-DD	2017-11-29
DESIGNED	G.TANG
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	**D-1**

PATH: I:\CLIENTS\AEP\1783057\Mapping\MXD\Hydrology\01_Survey & Base Data Collection\Rev0\1783057_Appendix_D_FloodControl_Datasheets_Rev0.mxd PRINTED ON: 2019-05-08 AT: 9:45:55 AM

LEGEND

- CULVERT
- FLOW DIRECTION
- FLOOD CONTROL STRUCTURE
- ROAD
- SECONDARY HIGHWAY
- PRIMARY HIGHWAY

NOTE(S)

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

FOR MORE DETAILS SEE SECTION 2.6.

REFERENCE(S)

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LOCATION	RED DEER RIVER
APPROX. LENGTH OF STRUCTURE (m)	2725
TYPE OF STRUCTURE	EARTH FILL BARRIER

0 200 400
1:10,000 METRES

TITLE
SUNDRE EAST DIKE

DESCRIPTION
UPSTREAM OF HIGHWAY 27

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT
GOLDER

YYYY-MM-DD	2017-11-29
DESIGNED	G.TANG
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	**D-2**

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

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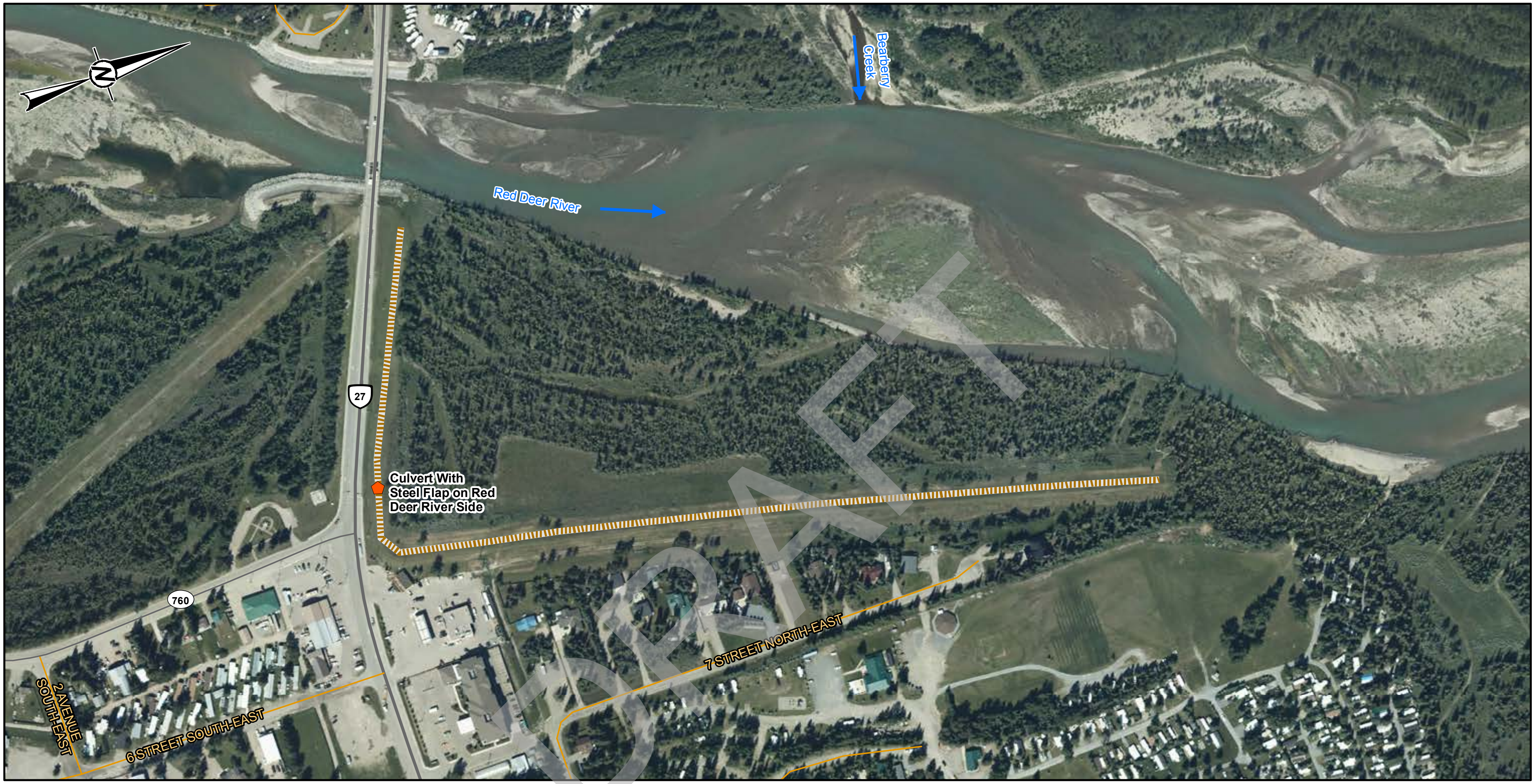

LEGEND

- CULVERT
- FLOW DIRECTION
- FLOOD CONTROL STRUCTURE
- ROAD
- SECONDARY HIGHWAY
- PRIMARY HIGHWAY

NOTE(S)

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

FOR MORE DETAILS SEE SECTION 2.6.

REFERENCE(S)

FLOOD CONTROL STRUCTURE SURVEY BY GOLDER ASSOCIATES LTD. OCTOBER 2017. ROADS OBTAINED FROM ALTALIS, © GOVERNMENT OF ALBERTA 2017. ALL RIGHTS RESERVED. IMAGERY CAPTURED JULY 2018 BY ORTHOSHOP GEOMATICS LTD. FOR THE GOVERNMENT OF ALBERTA. DATUM: NAD 83 CSRS PROJECTION: 3TM 114

LOCATION	RED DEER RIVER
APPROX. LENGTH OF STRUCTURE (m)	925
TYPE OF STRUCTURE	EARTH FILL BARRIER

0 200 400
1:5,000 METRES

TITLE
SUNDRE EAST DIKE

DESCRIPTION
DOWNSTREAM OF HIGHWAY 27

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT
GOLDER

YYYY-MM-DD	2017-11-29
DESIGNED	G.TANG
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	D-3

LEGEND

- CULVERT
- FLOW DIRECTION
- FLOOD CONTROL STRUCTURE
- ROAD
- SECONDARY HIGHWAY
- PRIMARY HIGHWAY

NOTE(S)

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

FOR MORE DETAILS SEE SECTION 2.6.

REFERENCE(S)

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LOCATION	BEARBERRY CREEK
APPROX. LENGTH OF STRUCTURE (m)	1705
TYPE OF STRUCTURE	EARTH FILL BARRIER

0 200 400

1:7,500 METRES

TITLE
BEARBERRY CREEK NORTH DIKE

DESCRIPTION
ALONG NORTH SIDE OF CREEK

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT

GOLDER

YYYY-MM-DD	2017-11-29
DESIGNED	G.TANG
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	D-4

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

25mm

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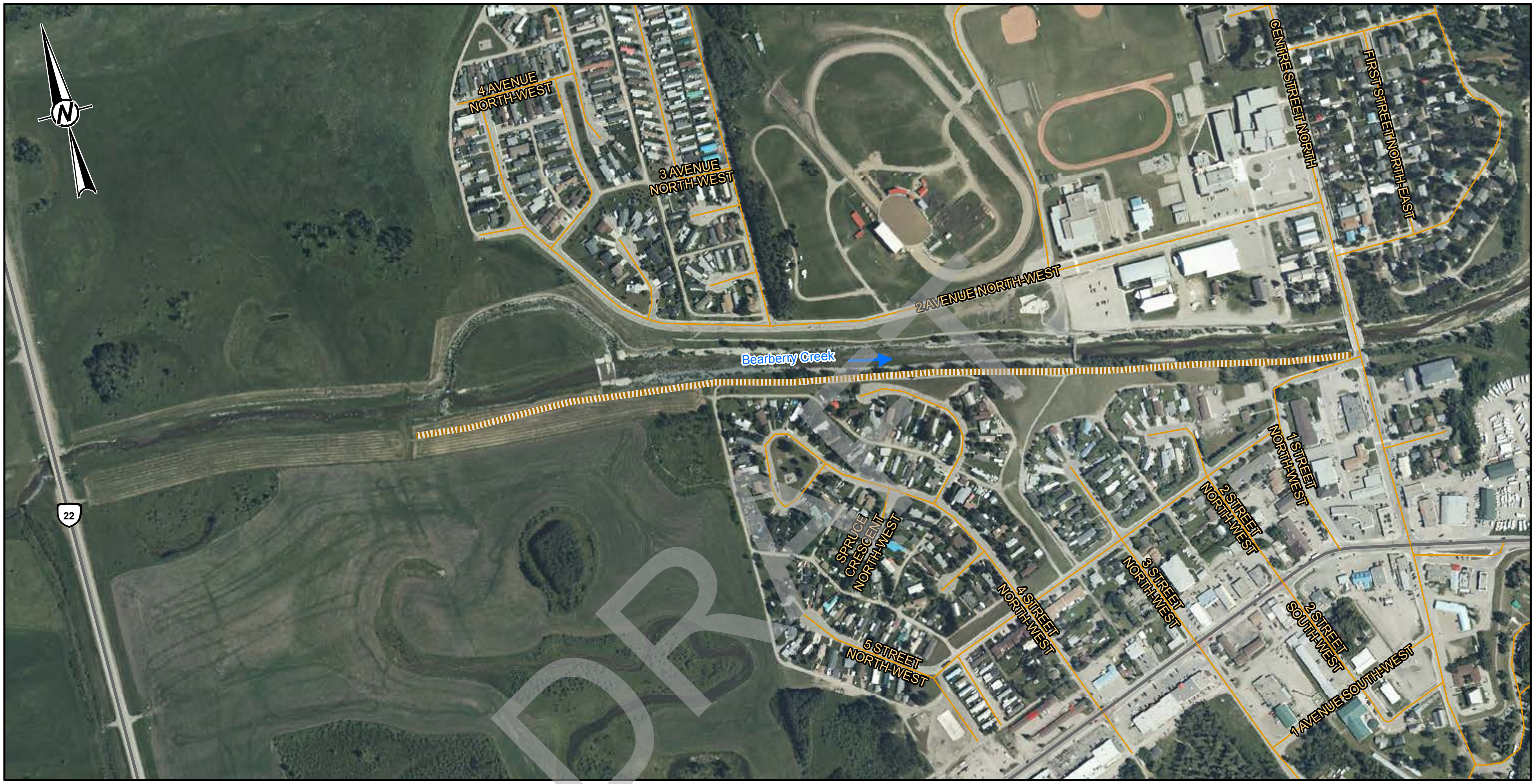
Classification: Public



LEGEND

- CULVERT
- FLOW DIRECTION
- FLOOD CONTROL STRUCTURE
- ROAD
- SECONDARY HIGHWAY
- PRIMARY HIGHWAY

NOTE(S)

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

FOR MORE DETAILS SEE SECTION 2.6.

REFERENCE(S)

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LOCATION	BEARBERRY CREEK
APPROX. LENGTH OF STRUCTURE (m)	1189
TYPE OF STRUCTURE	EARTH FILL BARRIER

0 200 400

1:7,500 METRES

TITLE
BEARBERRY CREEK SOUTH DIKE

DESCRIPTION
ALONG SOUTH SIDE OF CREEK

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
UPPER RED DEER RIVER HAZARD STUDY

CONSULTANT
GOLDER

YYYY-MM-DD	2017-11-29
DESIGNED	G.TANG
PREPARED	B. PENDERGAST
REVIEWED	W. PLOEGER
APPROVED	D. LONG

PROJECT NO.	CONTROL	REV.	FIGURE
1783057	1000	0	**D-5**

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