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Edson Flood Study

Final Report – Revision 1
April 27, 2026
KWL Project No. 3052.029

Prepared for:
Alberta Environment and Protected Areas

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Executive Summary

The Edson Flood Study was initiated by Alberta Environment and Protected Areas (EPA) under the provincial Flood Hazard Identification Program (FHIP). Kerr Wood Leidal Associates Ltd. (KWL) was retained by EPA to identify and assess riverine flood hazards along Bench, Wase, and Poplar creeks within the Town of Edson and the surrounding Yellowhead County.

The Edson Flood Study comprises five major components: Survey and Base Data Collection, Open Water Hydrology Assessment, Open Water Hydraulic Modelling, Open Water Flood Inundation Mapping, and Design Flood Hazard Mapping. The work associated with all five components are summarized in this report and its appendices.

The primary purpose of collecting survey and base data is to facilitate the hydraulic modelling and flood mapping. Cross sections, totalling 357, were surveyed along the study reaches for each creek and used to augment a digital terrain model (DTM) based on 2024 LiDAR data. Survey data was also collected for 27 bridges and 29 culverts in the study area, a summary of which is presented in Appendix A (Selected Survey & Base Data).

The estimation of peak flow rates for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year flood frequencies for Bench, Wase, and Poplar creeks is described in the Open Water Hydrology Assessment (Appendix B). No streamflow gauges are present within the flood mapping study area, so the flood frequencies were estimated through a combination of regional flood frequency analysis (RFFA) and deterministic modelling using the U.S. Army Corps of Engineers' (USACE) Hydrologic Engineering Centre – Hydrologic Modelling System (HEC-HMS) software.

A two-dimensional (2D) hydraulic model was developed using the USACE Hydrologic Engineering Centre – River Analysis System (HEC-RAS) software to assess flooding in the study area associated with each of the above flood scenarios. A composite digital terrain model (DTM) was created using the surveyed creek bathymetry and 2024 LiDAR terrain data. Surveyed bridge and culvert measurements were used to incorporate these hydraulic structures into the model. The model was calibrated using highwater marks (HWM) from the June 2023 flood event.

Modelled water surface elevations (WSE) are provided graphically and in tabular format in Appendix C (Open Water Flood Frequency Profiles) and Appendix D (Open Water Flood Frequency WSE Tables), respectively. The sensitivity of the hydraulic model to changes in channel and floodplain roughness as well as downstream boundary conditions was assessed, with results presented in the report and supporting tables in Appendix E (Hydraulic Model Sensitivity Analysis Inundation Width Tables). Flood inundation maps were produced for each of the above noted flood scenarios and are presented together in a single Open Water Flood Inundation Map Library which is provided in Appendix F. Within the study area, flooding is expected to begin impacting properties and infrastructure at levels above the 10-year flood. Widespread overtopping of roads due to Wase Creek flooding begins at the 20-year flood. Overall, significant flooding impacts due to flooding from all three creeks are expected by the 50- to 75-year flood level, with the overtopping of Highway 16 in multiple locations at levels above the 100-year flood.

The Open Water Design Flood Profile in Appendix G shows the 100-year water levels along each of the creeks. The flood hazard identification criteria used to determine floodway boundaries are presented in tabular format and graphically in Appendix H (Floodway Determination Criteria Tables) and Appendix I (Floodway Criteria Maps). These tables and maps document the rationale behind the Flood Hazard Maps (Appendix J), which identify the area flooded for the 100-year open water design flood, divided into floodway and flood fringe zones. The floodway typically represents the area of highest hazard where flows are deepest, fastest, and most destructive during the 100-year design flood. Areas of deeper or faster moving water outside of the floodway, but within the flood fringe, are identified as high hazard flood fringe areas.

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Credits & Acknowledgements

The Edson Flood Study was prepared by Kerr Wood Leidal Associates Ltd. for the Government of Alberta under the provincial Flood Hazard Identification Program, the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. The study was co-funded by the Government of Canada through the federal Flood Hazard Identification and Mapping Program.

Project management was provided by Ms. Deighen Blakely. Hydrological tasks were led by Mr. David Roche, with support from Mr. Bill Zhao and Mr. Jack Dietze. Hydraulic modeling was led by Dr. Hua Zhang with support from Ms. Caitlin Cain, Mr. Graham Waugh, and Mr. Jack Dietze. GIS tasks were led by Mr. Ryan Taylor with support from Mr. Tyler Romans. Field studies were completed by Mr. Andrew Hill with support from Mr. Jack Dietze, Mr. Alexander Lyford, Mr. Evan Perdue, and Mr. Tom Claxton. Mr. Mark Chiarandini reviewed the Survey & Base Data Collection component.

The authors express their special thanks to Ms. Jane Eaket, project manager for Alberta Environment and Protected Areas, who provided overall study management, background data, and technical guidance.

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Contents

Executive Summary i
Credits & Acknowledgements ii
1. Introduction 1-1
1.1 Study Background 1-1
1.2 Study Objectives 1-1
1.3 Study Area & Reach 1-2
2. Survey & Base Data Collection 2-1
2.1 Digital Terrain Model 2-1
2.2 Aerial Imagery 2-1
2.3 Survey Procedures & Methods 2-1
2.4 Cross Sections & Bathymetry 2-2
2.5 Hydraulic Structures 2-3
2.6 Flood Control Structures 2-6
2.7 Other Features 2-7
3. Flood Hydrology 3-1
3.1 Flooding History 3-1
3.2 Open Water Flood Frequency Analysis 3-3
4. Open Water Hydraulic Modelling 4-1
4.1 Available Data 4-1
4.2 River & Valley Features 4-2
4.3 Model Construction 4-4
5. Open Water Flood Inundation Maps 5-1
5.1 Methodology 5-1
5.2 Manual Flood Extent Modifications 5-1
5.3 Flood Inundation Areas 5-2
6. Floodway Determination 6-1
6.1 Floodway & Flood Fringe Terminology 6-1
6.2 Flood Hazard Identification 6-1
6.3 Design Flood Hazard Maps 6-2
7. Potential Climate Change Impacts 7-1
8. Conclusions 8-1
Report Submission
References

DRAFT

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Figures

Figure 1-1: Study Area 1-3
Figure 4-1. Shrub and forest conditions typical of overbank and floodplain areas along Bench Creek .. 4-3
Figure 4-2: Simulated and Observed WSEs on Bench Creek – June 2023 Flood Event 4-8
Figure 4-3: Simulated and Observed WSEs on Wase Creek – June 2023 Flood Event 4-9
Figure 4-4: Bench Creek at 4th Avenue 4-10
Figure 4-5: Bench Creek at the Galloway Station Museum footbridge (7:24 PM) 4-10
Figure 4-6: Bench Creek at 2nd Avenue and CN Rail (7:24 PM) 4-11
Figure 4-7: Bench Creek at Edson Golf Club (time unknown) 4-11
Figure 4-8: Wase Creek at 6th Avenue (2:09 PM) 4-12
Figure 4-9: Wase Creek at 2nd Avenue (time unknown) 4-12
Figure 4-10: Bench Creek downstream of Poplar Creek confluence 4-12
Figure 4-11: Simulated and Observed WSEs on Bench Creek – Low Flow Conditions 4-13

Tables

Table 2-1: Creek Reach Details 2-3
Table 2-2: Cross Section Survey Details 2-3
Table 2-3: Bridge Survey Details 2-4
Table 2-4: Culvert Survey Details 2-5
Table 2-5: Bench Creek Streamflow Measurements 2-7
Table 3-1: Open Water Flood History 3-2
Table 3-2: Recommended flood frequency estimates 3-3
Table 3-3: Bench Creek design flows reported in previous bridge hydrotechnical reports 3-4
Table 3-4: Comparison of 1965 peak flow rate estimates 3-4
Table 4-1: Summary of June 2023 HWMs 4-1
Table 4-2: Peak Flow Estimates for the June 2023 Event 4-6
Table 4-3: Comparison of June 2023 HWMs to Simulated WSEs 4-7
Table 4-4: Low Flow Validation Results 4-12
Table 4-5: Simulation Time Summary 4-14
Table 4-6: Final Manning's Roughness Values 4-15
Table 4-7: Bridge Contraction and Expansion Loss Coefficients 4-15
Table 4-7: Sensitivity Analysis Parameters 4-16
Table 4-8: Sensitivity of water levels to variation in Downstream Boundary Condition Slope 4-17
Table 4-9: Sensitivity of water levels to variation in channel roughness 4-17
Table 4-10: Sensitivity of water levels to variation in overbank roughness 4-18
Table 4-11: Modelled flows 4-18
Table 5-1: Flood Inundation Areas – Bench Creek 5-2
Table 5-2: Flood Inundation Areas – Wase Creek 5-3
Table 5-3: Flood Inundation Areas – Poplar Creek 5-4
Table 6-1: Design Flood Flow Estimates 6-1
Table 7-1: Potential Climate Change Impacts to the 100-Year Design Flood 7-1

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Appendices

Appendix A: Selected Survey & Base Data
Appendix B: Open Water Hydrology Assessment
Appendix C: Open Water Flood Frequency Profiles
Appendix D: Open Water Flood Frequency WSE Tables
Appendix E: Hydraulic Model Sensitivity Analysis Inundation Width Tables
Appendix F: Open Water Flood Inundation Map Library
Appendix G: Open Water Design Flood Profile
Appendix H: Floodway Determination Criteria Tables
Appendix I: Floodway Criteria Maps
Appendix J: Flood Hazard Maps

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1. Introduction

1.1 Study Background

In September 2024, Alberta Environment and Protected Areas (EPA) retained Kerr Wood Leidal and Associates Ltd. (KWL) to identify and assess riverine flood hazards along Bench, Wase, and Poplar creeks within the Town of Edson and the surrounding Yellowhead County. The Edson Flood Study was initiated under the provincial Flood Hazard Identification Program (FHIP). The results from this study are intended to support emergency response planning, inform local infrastructure design, and support long-term development planning and regulation.

1.2 Study Objectives

The primary objectives of this study are to provide the necessary flood maps to assist all levels of government and the public in forming effective flood mitigation strategies, planning flood mitigation infrastructure, and informing local development decisions.

This study was completed in accordance with the FHIP Technical Guidelines (EPA, 2022). This report presents the methodology and results of the flood study that includes the following major tasks:

- Field work and survey data collection, including procedures and methodology, equipment used, and details on what was surveyed (Section 2).
- Open water hydrological analysis (Section 3) that includes the estimation of flow frequencies for the 2-year to the 1,000-year floods. This is outlined in greater detail in the Open Water Hydrology Memorandum (Appendix B).
- Hydraulic analysis, including the setup, calibration, validation, and sensitivity analysis of the 2D hydraulic model (Section 0).
- Flood mapping, including flood inundation mapping (Section 5), as well as flood hazard identification and mapping (Section 6).
- Discussion of potential impacts of climate change on flood hazards in the study basin (Section 7).

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1.3 Study Area & Reach

The Town of Edson is located about 200 kilometers west of Edmonton, situated in the southwestern part of the Athabasca Basin. The Canadian National Railway (CN Rail) mainline and Highway 16 both pass through the community. Bench Creek and Poplar Creek cross under both the CN Rail and Highway 16, while Wase Creek crosses under Highway 16. The general domain for hydraulic modeling and flood mapping is presented in Figure 1-1.

The study reaches for flood mapping includes approximately 25 km of Bench Creek, 4 km of Wase Creek, and 3 km of Poplar Creek, as described below:

- Bench Creek as it flows eastward from Range Road 180 (NW 19-53-17-W5M) through the Town of Edson and past Township Road 534 to SE 25-53-17-W5M.
- Wase Creek as it flows southward from Township Road 534 (NE 21-53-17-W5M) to the CN Rail where the channel has been realigned eastward to Poplar Creek.
- Poplar Creek as it flows southward from Highway 748 (NW 22-53-17-W5M) past Highway 16 to the confluence with Bench Creek.

The headwaters of Bench, Wase, and Poplar creeks have elevations in the range of 970 m, 950 m, and 955 m, respectively, with the lowest downstream elevation along Bench Creek being 872 m. Within the study area, Bench Creek has an average channel slope of approximately 0.3%, while Wase and Poplar creeks are noticeably steeper with average channel slopes of 0.9% and 1.1%, respectively.

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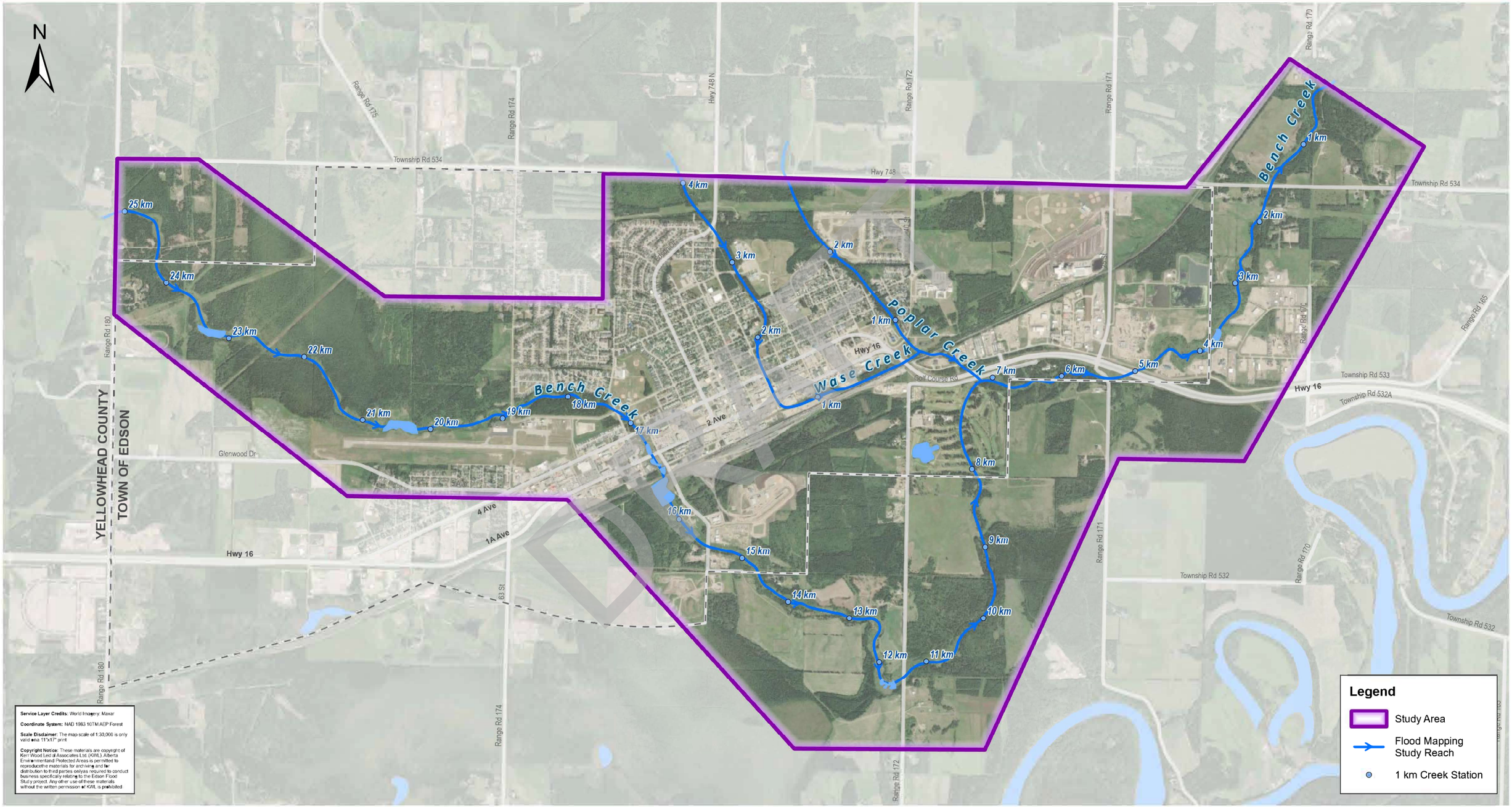
Edson Flood Study

KERR WOOD LEIDAL consulting engineers



Project No. 3052.029

Date April 2026

Scale 1:30,000

0 250 500 1,000 Metres

Study Area

Figure 1-1

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2. Survey & Base Data Collection

Accurate geospatial and hydrometric data forms the basis of high-quality hydraulic models and flood maps. For the Edson Flood Study, this data was obtained from the following sources:

- a detailed field program (survey data, hydraulic structure measurements, and flow measurements);
- EPA (digital terrain model (DTM) based on light detection and ranging (LiDAR) as well as highwater marks [HWM] from the June 2023 flood event); and
- publicly available databases (administrative, DTM, land cover, and transportation geographic information system (GIS) layers).

A map showing the surveyed cross-sections, flow measurement locations, June 2023 HWMs, and hydraulic structures is presented in Appendix A.

2.1 Digital Terrain Model

The following DTMs supported modeling and mapping for the study:

- LiDAR-derived DTM of the study area procured by EPA in spring 2024; and
- Canadian Digital Elevation Model (CDEM) covering the upper Bench Creek basin (NRCan, 2011).

2.2 Aerial Imagery

Satellite imagery of the study area at 0.31 m resolution was sourced through ArcGIS and used for all maps (ESRI, 2025).

2.3 Survey Procedures & Methods

The survey program was completed by KWL staff between 19 September and 2 October 2024 and included:

- the survey of channel cross sections along all three creeks;
- the survey and measurement of hydraulic structures (bridges and culverts);
- the survey of non-dedicated flood control structures (defined in Section 2.6);
- the survey of Alberta Survey Control Monuments (ASCM) within the study area; and
- streamflow measurements at two locations on Bench Creek.

2.3.1 Alberta Survey Control Monuments

Five Alberta Survey Control Monuments (ASCMs) specified by EPA were used to verify the project reference frame and verify the project LiDAR data: 82578, 127720, 192492, 198481, and 200089. Three additional ASCMs were also surveyed for project quality control (151035, 138859, and 260505). At minimum, one ASCM was tied into at the beginning and end of every survey day to ensure consistency and reliability.

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2.3.2 Survey Datums

Survey data was collected in the Alberta-specific 3-Degree Transverse Mercator Projection with the Central Meridian of 111° (3TM 111) using the horizontal North American Datum of 1983, Epoch 2002 (NAD83 (CSRS, Epoch 2002)) and the Canadian Geodetic Vertical Datum of 1928 (CGVD28). Orthometric elevations were calculated using the HTv2.0 (2002) hybrid geoid model.

2.3.3 Survey Equipment

The following survey equipment was used for the project.

Real-Time Kinematic Global Navigation Satellite System

Trimble R8 Model 3 and R12i Real-Time Kinematic (RTK) rover units were used to conduct most of the survey. Both units operated on the Can-Net Virtual Reference Station Network 3.0. Can-Net, owned by Cansel Group, operates a base station located in the centre of the Town of Edson.

The minimum reported accuracy of Can-Net is within 24 mm horizontally and 50 mm vertically. Accuracy improves with proximity to a base station, with reported horizontal and vertical accuracy being ±10 mm at the base station and decreasing to ±20 mm at a distance of 10 km from the base station. The entire study reach was within 10 km of the Edson Can-Net base station and thus the expected horizontal and vertical accuracy of the survey is between ±10 mm and ±20 mm. The R8 Model 3 and R12i rover units were paired to TSC3 and TSC5 survey controllers, both operating on Trimble Access software. Trimble Access monitors the integrity of the Global Navigation Satellite System (GNSS) solution throughout the survey to ensure accuracy is maintained.

Total Station

A Trimble S6 2” DR Plus total station was used to survey cross sections and portions of bridges and culverts where the RTK Rover units had weak GPS satellite reception due to dense tree cover and overhead structures. The accuracy of the total station survey is comparable to those listed for the RTK equipment, as it relies on the same base station connection.

2.4 Cross Sections & Bathymetry

Cross section locations were selected to efficiently represent the varied channel characteristics of Bench, Wase, and Poplar creeks throughout the study reaches. Factors influencing cross section placement include changes to channel pattern, width, and slope, as well as the presence of confluences, bridges, culverts, or other irregularities.

Prior to the field program, a shapefile containing proposed cross section locations, including cross sections upstream and downstream of hydraulic structures, was produced as a guide for the survey crew. Table 2-1 and Table 2-2 summarize the cross sections surveyed on each of the creek reaches in the study area. Reaches are bounded by study area boundaries and confluences.

The primary objective of surveying the creek cross sections was to define the channel bed and bank geometry. Care was taken to ensure that survey points were taken at the top and bottom of both banks, the edge of water, and key inflection points along the cross section. A small portion of overbank floodplain at each cross section was also surveyed to provide overlap with the LiDAR DTM supplied by EPA. Quality assurance checks confirmed agreement between ground survey points and the corresponding DTM.

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Each recorded survey data point includes Northing and Easting coordinate positions, ground (or channel bed) elevation, and water surface elevation (WSE) where present. Each survey point was assigned a description code, and where necessary, additional information as such as height of vegetation or sediment type. Channel cross sections were surveyed perpendicular to the channel.

Table 2-1: Creek Reach Details

Reach	Upstream Extent	Downstream Extent	Reach Length (km)
Upper Bench Creek	Range Road 180	Confluence with Poplar Creek	18
Lower Bench Creek	Confluence with Poplar Creek	Downstream of Highway 748	7.1
Wase Creek	Township Road 534	Confluence with Poplar Creek	4.4
Upper Poplar Creek	Highway 748	Confluence with Wase Creek	2.6
Lower Poplar Creek	Confluence with Wase Creek	Confluence with Bench Creek	0.63

Table 2-2: Cross Section Survey Details

Reach	# Cross Sections	Average Spacing (m)	Minimum Spacing (m)	Maximum Spacing (m)
Upper Bench Creek	191	95	2.5	250
Lower Bench Creek	78	91	5.8	230
Wase Creek	56	78	27	160
Upper Poplar Creek	27	96	17	150
Lower Poplar Creek	5	130	20	240

2.5 Hydraulic Structures

All hydraulic structures on Bench, Wase, and Poplar creeks within the study area were surveyed during the field program. This includes traffic, rail, and pedestrian bridges and culverts. Critical structural elements such as road crowns, as well as culvert and bridge dimensions, were subject to a rigorous survey process, including duplicate measurements.

Hydraulic structures were surveyed via total station, GPS rover, or a combination of the two. The GPS unit was used to collect structural data where satellite reception was available. Photographs of each bridge and culvert, with geolocation and other relevant metadata, were obtained during the field program. A cross section was surveyed immediately upstream and downstream of each bridge or culvert. Where bank armoring or other unique features existed at bridges or culverts; additional data points were obtained to capture key elevations and dimensions. Photographs and geometry details for each structure are presented in Appendix A.

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2.5.1 Bridges

The following data was collected for each bridge:

- 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 distance of each pier from the abutment;
- type of piers (i.e. concrete, steel pile, wood, etc.);
- shape of pier (i.e. round nose, wedge shape, etc.); and
- top of roadway profile.

Table 2-3 provides an overview of all relevant bridges in the study area.

Table 2-3: Bridge Survey Details

No.	Creek	Description	Crossing Type	No. of Spans	Bridge File No. (if applicable)
1	Bench	63rd Street	Public Road	1	75766
2	Bench	4th Avenue (Highway 16)	Public Road	1	72123
3	Bench	Galloway Station Museum Trail	Pedestrian	1	N/A
4[1]	Bench	CN Rail	Railway	3	N/A
5	Bench	Private access west of 54th Street	Private	1	N/A
6	Bench	54th Street	Public Road	1	74695
7	Bench	Private access east of 54th Street	Private	1	N/A
8	Bench	Private access east of landfill	Private	1	N/A
9	Bench	Private access west of Range Road 172	Private	1	N/A
10	Bench	Farm access road	Private	1	N/A
11	Bench	Golf course path	Private	1	N/A
12	Bench	Golf course path	Private	1	N/A
13	Bench	Golf course path	Private	1	N/A
14	Bench	Golf course path	Private	1	N/A
15	Bench	Golf course path	Private	1	N/A
16	Bench	Golf course path	Private	1	N/A
17	Bench	Golf course path	Private	1	N/A
18	Bench	Golf course path	Private	1	N/A
19	Bench	Golf course path	Private	1	N/A
20	Bench	Golf course path	Private	1	N/A
21	Wase	Trail north of 10th Avenue cul-de-sac	Pedestrian	1	N/A
22	Wase	Parkland Lodge	Private	1	N/A
23[2]	Poplar	Trail northwest of 43rd Street & 10th Avenue	Pedestrian	1	N/A

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No.	Creek	Description	Crossing Type	No. of Spans	Bridge File No. (if applicable)
24	Poplar	Trail north of 8th Avenue cul-de-sac	Pedestrian	1	N/A
25	Poplar	Trail west of 8th Avenue cul-de-sac	Pedestrian	1	N/A
26	Poplar	Trail north of 6th Avenue	Pedestrian	1	N/A
27	Poplar	Trail northwest of 4th Avenue cul-de-sac	Pedestrian	1	N/A

Notes:
1. The structural components of the active CN Rail bridge on Bench Creek were not surveyed due to access restriction. Geometry was estimated using measurements from the DEM, satellite imagery, and photographs of the bridge.
2. The foot bridge on Poplar Creek northwest of 43rd Street & 10th Avenue was not identified during the field program. Information provided by the Town of Edson confirmed that this structure has the same construction as the downstream foot bridge, which was surveyed. Bridge geometry was based on this downstream bridge, site specific photographs, and DTM.

2.5.1 Culverts

The following data was collected for each culvert:

- culvert type (i.e. concrete, CMP, etc.);
- culvert shape (i.e. round, arch, rectangular, etc.);
- entrance condition (i.e. projecting from fill, mitered to conform to slope, head wall with square or bevel end, etc.);
- culvert dimensions and barrel length;
- upstream and downstream inverts; and
- top of roadway profile.

Table 2-4 provides an overview of all the relevant culverts in the study area.

Table 2-4: Culvert Survey Details

No.	Creek	Description	Crossing Type	No. of Barrels	Bridge File No. (if applicable)
1	Bench	Range Road 180	Public Road	1	73399
2	Bench	Range Road 180 crossroad	Public Road	1	N/A
3	Bench	56th Street & 6th Avenue	Public Road	1	78954
4	Bench	2nd Avenue (Highway 16)	Public Road	1	78680
5	Bench	1st Avenue	Pedestrian	1	N/A
6	Bench	Range Road 172	Public Road	1	73050
7	Bench	25th Street (Range Road 171)	Public Road	1	70506
8	Bench	Highway 16	Public Road	1	13598
9	Bench	Township Road 534	Public Road	1	9883
10	Wase	Highway 748 (Township Road 534)	Public Road	1	79694
11	Wase	Edson Drive	Public Road	1	N/A
12	Wase	12th Avenue	Public Road	1	N/A

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No.	Creek	Description	Crossing Type	No. of Barrels	Bridge File No. (if applicable)
13	Wase	9th Avenue	Public Road	3	N/A
14	Wase	7th Avenue alley	Public Road	2	N/A
15	Wase	6th Avenue	Public Road	2	N/A
16	Wase	5th Avenue	Public Road	2	N/A
17	Wase	4th Avenue (Highway 16)	Public Road	1	N/A
18	Wase	3rd Avenue	Public Road	1	N/A
19	Wase	2nd Avenue (Highway 16)	Public Road	1	N/A
20	Wase	Private Access off 48th Street	Private	1	N/A
21	Wase	Private Access adjacent to CN Rail	Private	1	N/A
22	Wase	Highway 16	Public Road	1	77315
23	Poplar	Highway 748 (Township Road 534)	Public Road	1	N/A
24	Poplar	ATCO pipeline	Private	1	N/A
25	Poplar	6th Avenue	Public Road	1	N/A
26	Poplar	2nd Avenue/ 40th Street	Public Road	1	9920
27	Poplar	CN Rail	Railway	1	N/A
28	Poplar	1st Avenue	Public Road	1	73784
29	Poplar	Highway 16	Public Road	1	511

2.6 Flood Control Structures

Flood control structures (e.g. berms, dikes, or flood walls) are defined as “permanent barriers or engineered systems that keep water from entering and flooding an area” (EPA, 2022). Some infrastructure, like road and rail embankments, have the potential to affect stream hydraulics and block water from parts of the floodplain; however, they are not typically considered dedicated flood control structures. Railway embankments running parallel to a stream along the edge of a valley wall are typically assumed to be permeable and not considered to perform as flood control structures.

Based on the information provided by EPA and local authorities, no dedicated flood control structures exist in the study area.

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2.7 Other Features

2.7.1 Streamflow Measurements

Streamflow data coupled with surveyed WSEs are valuable for calibration of hydraulic models. Ideally, the data is from a flood event, or at least moderately high flow. During the field program, Bench Creek was flowing at low flow (i.e. baseflow) conditions with no recent rainfall. Nonetheless, two open channel flow measurements were taken along Bench Creek to support hydraulic model calibration.

Flow measurements were performed with a Sontek Flowtracker Model 2 acoustic Doppler velocimeter (ADV) unit using the mid-section method. In line with best practices, a minimum of 20 measurement panels were made along each transect, ensuring that no panel contained more than 10 percent of the total flow. Transect locations were chosen to ensure consistent flow across the channel, with no eddies or debris causing disturbances.

The measurements were taken upstream and downstream of the Town of Edson. The upper measurement location was just downstream of the 63rd Street bridge, while the lower measurement location was just downstream of the Edson Golf Club, before the confluence with Poplar Creek. Table 2-5 summarizes the flow measurements. The measured flow rates of 0.012 and 0.022 m^3/s were significantly below the 1:2 flood of 5.22 m^3/s. At this low flow rate, the conditions are not representative of the channel roughness that would be experienced during flood conditions. This significantly limits the usefulness of the streamflow data for hydraulic model calibration (see Section 4.3.2 for further discussion).

Table 2-5: Bench Creek Streamflow Measurements

Approximate Location	Date & Time (MDT)	Measured Flow (m^3/s)
Edson Golf Club	26 September 2024 07:13	0.022
63rd Street bridge	27 September 2024 07:30	0.012

2.7.2 Highwater Mark Data

EPA provided HWM information gathered after the June 2023 flood. This included survey points and photographs of flood debris at three locations in the study area: (1) Bench Creek near the 4th Avenue bridge, (2) Bench Creek near the 2nd Avenue culvert, and (3) Wase Creek near 1st Avenue.

2.7.3 Base Mapping Features

The following data sets were acquired or developed to facilitate hydraulic modelling and flood mapping for the study:

- Administrative – municipal boundaries from Altalis Base Features;
- Land Cover – land-use and land-cover (LULC) classification of Alberta dataset (Chowdhury, 2021);
- Transportation – road and rail alignments from National Road Network and National Railway Network, respectively; and
- Hydrography – manually digitized creek alignments based on Google satellite imagery and the LiDAR-derived DTM.

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3. Flood Hydrology

3.1 Flooding History

3.1.1 General Information

Historical flood data and previous studies provide important context for flood mapping projects. There have been numerous open water floods documented in and around the Town of Edson, going back to 1954 and as recently as 2024. No ice jam floods are recorded in the study area. Available details on past major floods are presented below.

3.1.2 Open Water Floods

Open water flooding in the study area is summarized in Table 3-1 and described in further detail in Appendix B.

3.1.3 Ice Jam Floods

No ice jam floods have been recorded in the study area.

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Table 3-1: Open Water Flood History

Date	72-hour Rainfall Depth (mm)	24-hour Rainfall Depth (mm)	Peak Flow Rate (m^3/s)	Comments
4-6 June 1954	>85	-	Bench Creek at Highway 16, downstream of Edson: 14.2 m^3/s (reported estimate)	The hydrotechnical file history for Bridge File (BF) 13598 (Highway 16 over Bench Creek) includes a photo printed in a local newspaper showing the road surface overtopped in 1954. The hydrotechnical file history for BF 70506 (Range Road 171 over Bench Creek) notes that several structures on Bench Creek washed out during the 1954 event.
7-9 July 1965	125.8	68.6	Bench Creek at Highway 16, downstream of Edson: 20.4 m^3/s (reported estimate)	The road surface of Range Road 171, which is located immediately upstream of Highway 16, was reportedly overtopped by Bench Creek during the 1965 flood event (BF 70506).
11 July 1974	-	59.4	Bench Creek at Highway 16, downstream of Edson: 22.7 m^3/s (reported estimate)	Flow rate reported in hydrotechnical file history for BF 13598 (Highway 16 over Bench Creek).
17 July 1986	-	72.7	unknown	Precipitation described as “very heavy” (Public Safety Canada, 2013) occurred between 13 and 24 July 1986, with the highest concentration falling about 60 km southwest of Edson. A rapid rise in water levels and extensive damage in floodplain areas were experienced along the McLeod (of which Bench Creek is a primary tributary), Pembina, Athabasca, and North Saskatchewan Rivers. No flood damage was reported in Edson, but the event remains hydrologically relevant.
29 August 2002	-	20	unknown	As reported by the Athabasca River Basins Feasibility Study (IBI, 2014), a 29 August 2002 flood event inundated several road intersections along Bench and Wase creeks, as well as basements adjacent to Bench, Wase, and Poplar creeks. The study describes the storm as being driven by “heavy” rainfall. Debris blockages at structures and beaver damming on each of the three creeks may have contributed to increased flooding despite the relatively moderate rainfall depth.
18-20 June 2023	>125	88.8	Bench Creek at Highway 16, downstream of Edson: 25.6 m^3/s (modelled estimate) Wase Creek upstream of Poplar Creek confluence: 3.53 m^3/s (modelled estimate)	A local state of emergency was declared on 19 June 2023 following a significant rainfall event. Based on published rainfall data for the ECCC Edson Climate station, the event was in the realm of a 100-year storm. High flows were experienced on Bench, Wase, and Poplar creeks, inundating large areas of Edson, including basements and roadways. Multiple hydraulic structures are reported to have been blocked by debris, which exacerbated flood levels. Compared to the 1986 rainfall event, this event had relatively low antecedent soil moisture conditions (Government of Alberta, 2023). Following the flood event, EPA surveyed highwater marks (HWM) along Bench and Wase creeks. Peak flow rates have been estimated using the hydrologic model created as part of the current study, with recorded rainfall data and antecedent moisture conditions.
4 August 2024	-	43.3	unknown	Just over a year after the 2023 flood, another flood occurred, including flooding and bank erosion at several locations on Wase and Poplar creeks, although not to the extent of the 2023 flood. Culvert and stormwater blockages caused by fallen branches and leaves knocked down by heavy winds during the storm were primary contributors to flooding. Bench Creek also experienced high flows, but no flooding was reported along its banks.

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Classification: Public

3.2 Open Water Flood Frequency Analysis

The objective of the open water hydrology assessment was to estimate thirteen flood frequencies for the three creeks in the study area. The full details of the hydrologic analysis are presented in the Open Water Hydrology Memorandum (Appendix B).

3.2.1 Flood Frequency Estimates

Estimated peak flow rates across a range flood frequencies for each of the three creeks are provided in Table 3-2. These flow rates are intended for use as steady flow inputs at the upstream boundary of each creek within the 2D hydraulic model.

Table 3-2: Recommended flood frequency estimates

Return Period (Years)	Instantaneous Maximum Flow (m^3/s)		
	Bench Creek	Wase Creek	Poplar Creek
2	5.22	1.14	1.08
5	10.8	2.54	2.37
10	16.4	4.09	3.77
20	23.5	6.15	5.45
35	28.3	7.44	6.54
50	34.1	9.18	8.03
75	38.3	10.3	9.04
100	43.2	11.8	10.5
200	57.1	15.5	13.7
350	76.3	20.6	17.9
500	81.8	22.0	19.2
750	95.1	25.4	22.1
1,000	105	27.9	24.2

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3.2.1 Comparison to Previous Studies

While no previous flood studies have been completed in the study area, several hydrotechnical reports were available for crossings along Bench Creek and Wase Creek. Table 3-3 summarizes the reported 100-year design flows from these reports along with the calculated unit peak flow rates based on drainage area. The 100-year unit peak flow from these hydrotechnical reports ranged from 0.23 to 0.43 $m^3/s/km^2$ along Bench Creek and 0.79 $m^3/s/km^2$ for the one location on Wase Creek. The present study found higher unit peak flow rates along both Bench and Wase creeks of 0.57 and 1.51 $m^3/s/km^2$, respectively.

The differences in the unit peak flow rates are expected, as the various studies include differing flood record periods and methodologies. Two key differences that are expected to have contributed to the higher values from the present study are that:

- Previous hydrotechnical reports utilized an RFFA that included data from the WSC hydrometric station ‘Sundance Creek Near Bickerdike’ which has among the lowest unit runoff of hydrometric stations in the region. The present study did not use data from this hydrometric station.
- Previous hydrotechnical reports were completed prior to the June 2023 flood which was among the largest flood event in the past 50 years across the region.

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Further discussion on these previous hydrotechnical studies is provided in the Open Water Hydrology Assessment in Appendix B.

Table 3-3: Bench Creek design flows reported in previous bridge hydrotechnical reports

File #	Crossing Location	Hydrotechnical Report Author	Report Year	Drainage Area (km^2)	100-year Design Peak Flow (m^3/s)	100-year Unit Peak Flow (m^3/s per km^2)
13589	Bench Creek, Highway 16	Unknown	Unknown	79	18	0.23
70506	Bench Creek, Range Road 171	Unknown	Unknown	79	18	0.23
09883	Bench Creek, Township Road 534	Assenheimer Consulting Ltd.	Unknown	78	21	0.27
72123	Bench Creek, 4th Avenue	MPA Engineering Ltd.	Unknown	59	23	0.39
74695	Bench Creek, 54th Street	AECOM	2009	59	25	0.42
75766	Bench Creek, 63rd Street	AECOM	2009	54	23	0.43
85041	Wase Creek, Pipeline West of Edson Drive	AECOM	2009	7.6	6.0	0.79

The hydrotechnical report from BF 70506 provides a peak flow estimate of 20.4 m^3/s for the 1965 flood along with a recorded daily rainfall total of 68.6 mm (Table 3-4). This total daily rainfall was converted to a Chicago-type design storm and simulated using the HEC-HMS hydrological model. This produced a simulated peak flow rate of 21.5 m^3/s, which closely matches the observed estimate for the event, supporting the recommended flow rates from this study.

Table 3-4: Comparison of 1965 peak flow rate estimates

Year	Location	24-hour Rainfall Estimate (mm)	Estimated Peak Flow from BF 70506 (m^3/s)	Modelled Peak Flow using HEC-HMS (m^3/s)
1965	Bench Creek at Range Road 171, just upstream of Highway 16	68.6	20.4	21.5

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4. Open Water Hydraulic Modelling

4.1 Available Data

4.1.1 Survey & Base Data

The following data form the basis of the HEC-RAS 2D model:

- the LiDAR-derived DTM;
- survey data, including channel cross sections and bathymetry, and on-stream hydraulic structures;
- aerial imagery, which informed the creek channel delineation; and
- streamflow measurements, which were used for low flow model validation.

4.1.2 Existing Models

No previous flood studies have been completed for the study area; there are no existing models.

4.1.3 Highwater Marks

A HWM survey records the highest water levels experienced by a stream during a flood event. EPA surveyed HWMs at two locations on Bench Creek and one location on Wase Creek following the June 2023 flood. Table 4-1 lists the June 2023 HWMs, which were used for the hydraulic model calibration (Section 4.3.2).

Table 4-1: Summary of June 2023 HWMs

EPA HWM Point #	Site	Surveyed HWM (m)
26[1]	Bench Creek, upstream of 4th Avenue	907.91
28	Bench Creek, upstream of 2nd Avenue	908.10
29	Bench Creek, upstream of 2nd Avenue	908.17
30	Bench Creek, upstream of 2nd Avenue	908.19
35	Wase Creek near 1st Avenue	909.17
36	Wase Creek near 1st Avenue	909.12
37[2]	Wase Creek near 1st Avenue	909.06
38[2]	Wase Creek near 1st Avenue	909.02
40[2]	Wase Creek near 1st Avenue	909.15
41[2]	Wase Creek near 1st Avenue	909.10
43[2]	Wase Creek near 1st Avenue	909.22
44	Wase Creek near 1st Avenue	909.16

Notes:
1. It is suspected that Point 26 may not have captured the true HWM. Photos show that the grass was mowed between the flood and the survey, which may have disturbed the flood debris. Photos taken during the flood show higher WSEs - in the range of 908.00 to 908.30.
2. Points 37-38 and 40-43 are not documented with photos.

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4.1.4 Gauge Data and Rating Curves

There are no active or discontinued hydrometric monitoring stations on Bench, Wase, or Poplar creeks. No other streamflow measurement data or rating curves were available for this study.

4.1.5 Flood Photography

Photographs taken during flood events were provided by the Town of Edson and obtained from news archives and social media. This includes oblique photographs of the June 1954, June 2023, and August 2024 flood events.

Flood photographs must be used with caution and consider the unique conditions leading to the flooding, as well as the timing of the photograph relative to the peak flow. For instance, debris jamming and culvert blockages occurred during the August 2024 flood. Meaning that photographed water levels may not represent open water flood conditions. Photographs from the June 2023 flood were deemed to be representative of open water flooding and were therefore useful for the calibration of the hydraulic model (Section 4.3.2).

4.2 River & Valley Features

4.2.1 General Description

The study reaches of Bench, Wase, and Poplar creeks have well defined channels flowing through predominately forested floodplains, with some developed floodplain areas. Bench Creek meanders through a broad valley while Wase and Poplar creeks are situated in steeper, incised valleys.

4.2.2 Channel Characteristics

The channels of each of the three creeks are generally well defined, with channel bottom material varying from silt to large gravel and small boulders. Each is described in more detail below.

Bench Creek meanders through forested areas from the upstream study area boundary to the 56th Street & 6th Avenue culvert. Downstream of 4th Avenue, it flows through a series of constructed ponds and manicured lawns before entering a wetland downstream of the CN Rail bridge. This wetland and other reaches of Bench Creek are periodically affected by beaver damming. The creek continues south and east through a mix of forest and agricultural lands, and then turns back to the north where it flows through the Edson Golf Club. It is then joined by Poplar Creek and crosses under Highway 16. From here to the downstream end of the study area, it flows through heavily vegetated forest and wetland. After the large culvert crossing at Township Road 534, the valley becomes narrower to the downstream end of the study reach.

Wase Creek follows a natural, meandering path from the upstream study area boundary to Kinsmen Park, near 7th Avenue. Downstream of 7th Avenue, the channel has been straightened into a ditch generally following 48th Street. Presently, it flows to the CN Rail line where it turns east and follows a ditch to Poplar Creek. Topography in this area suggests that prior to the construction of the CN Rail, Wase Creek would have flowed south directly into Bench Creek near the Edson Golf Club.

Poplar Creek flows through a narrow valley from the upstream study area boundary to the Edson Lions Park Campground near 2nd Avenue. The channel was straightened briefly at the campground but returns to a natural alignment downstream of 2nd Avenue where it is joined by Wase Creek. From there, it crosses under the CN Rail embankment via a 186 m long pipe that includes two 90-degree bends and changes from a diameter of 1.1 m at its entrance to 2.0 m at its outlet. Immediately downstream, it crosses under Highway 16 and then joins Bench Creek.

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4.2.3 Floodplain Characteristics

The floodplain along Bench Creek is typically composed of coniferous forest and riparian shrubs, such as willow and alder (Figure 4-1). The exceptions are the developed areas in the Town of Edson, grassed areas at the Edson Golf Club, and a couple isolated agricultural fields along the middle reach of Bench Creek. The floodplain along Wase Creek is also predominately forested areas but includes residential and commercial properties south of 6th Avenue. The floodplain of Poplar Creek is exclusively coniferous forest, although spill areas along the CN Rail at the east end of the Town of Edson includes some industrial properties.



Figure 4-1. Shrub and forest conditions typical of overbank and floodplain areas along Bench Creek

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4.2.4 Anthropogenic Features

Anthropogenic changes relevant to flooding in the study area include:

- 27 bridge crossings and 29 culvert crossings (listed in Table 2-3 and Table 2-4)
- Channel re-alignment of Wase Creek
- Land use changes and fill within the floodplain
- Town of Edson residential, commercial, and industrial areas
- Edson Golf Club
- Rural development outside the Town of Edson limits
- CN Rail line
- Town of Edson Wastewater Treatment Plant

Classification: Public

4.3 Model Construction

A hydraulic model was created using the US Army Corps of Engineers' Hydraulic Engineering Centre – River Analysis System (HEC-RAS) computer software (version 6.6, September 2024). The program can operate on a one-dimensional (1D), two-dimensional (2D), or combined 1D and 2D basis; the required inputs differ slightly depending on the model type. For this study, a full 2D modelling approach was used.

Below are a number of considerations that were taken into account when selecting a 2D model.

- The complexity of flow at confluences, in the floodplain, and at flow splitting locations due to roadway overtopping is better handled by 2D computations, rather than trying to anticipate which way flows will travel and setting up 1D routes in those directions.
- The latest versions of HEC-RAS 2D can model bridges and culverts directly inside the 2D flow areas using 1D calculations and equations.
- The flow directions can change with increasing flows and therefore a single 1D model setup likely would not work for the entire range of flows to be simulated.
- The 2D modelling approach allows for direct detailed inundation mapping without interpolating WSEs between cross sections. The delineated floodway will be based on depth and velocity information, which is more accurate with a 2D model, as it calculates the results at each cell location.
- The ineffective flow areas and levees do not need to be predefined, as the computations will show 'dead zones' and will find low spots for overtopping of high ground features.
- Floodplain roughness is much more accurately represented by a 2D layout than with 1D cross sections, given the potential variability of ground cover types.

4.3.1 Methodology

For the 2D model, the basic inputs include:

- a high-resolution DTM, including detailed channel terrain;
- geometry consisting of a 2D mesh and hydraulic structures; and
- boundary conditions comprised of inflow at the upstream boundary and a normal depth slope at the downstream boundary.

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Digital Terrain Model

The terrain component of the hydraulic model is a composite surface comprised of a LiDAR-derived DTM of the study area (acquired by EPA in spring 2024), an interpolated channel surface based on surveyed cross sections, and minor localized modifications to ensure seamless integration of hydraulic structures.

The interpolated channel surface was created using terrain tools in HEC-RAS RasMapper that allows for the interpolation of cross sections along a curvilinear (i.e. meandering) path. Due to the extremely meandering path of Bench Creek, and to a lesser extent Wase and Poplar creeks, an approach that allowed for smooth interpolation along a non-linear path was essential. The process is described in the following steps:

- Channel reach centerlines and bank lines were delineated based on the LiDAR DTM, aerial imagery, and surveyed thalweg points.
- Surveyed cross sections were linearly interpolated following the channel centreline and bounded by the bank lines. This step is essential for retaining the natural shape of the meandering watercourse.
- The resulting interpolated channel terrain was checked and adjustments were made to the centreline and banklines as needed to ensure correct alignment with the adjacent LiDAR DTM.
- ArcGIS was used to combine the channel raster surface with the LiDAR raster surface using a built-in algorithm. This helped the edges of the surfaces align, thereby creating a realistic surface.

Due to the channel cross section spacing and variations in the thalweg slope, occasionally the interpolated channel bed was above the surveyed culvert invert elevations (detailed in Section 2.5.1). In the absence of a documented culvert blockage, the built-in terrain modification tools in HEC-RAS were used to locally lower the channel bed elevation to match that of the culvert. In these cases, the channel bed was locally lowered in the order of a few centimetres.

2D Computational Mesh

The computational mesh in HEC-RAS defines the area and resolution at which hydraulic calculations are performed. A polygon was drawn to represent the boundary of the mesh and iteratively modified to ensure that the inundation boundaries for all flood events did not touch the boundary of the mesh. The initial cell size was defined at 30 m x 30 m and then refined through multiple steps. Break lines, which force the mesh to align the computational cell faces along control flow features, were enforced along the channel centreline on all reaches, all hydraulic structures, and major roads inundated by the 1,000-year flood.

The mesh was refined using refinement regions to a resolution of 3 m x 3 m within the bank lines of Bench, Wase, and Poplar creeks, 10 m x 10 m in urban areas, and between 3 m x 3 m and 10 m x 10 m along hydraulic structures and major roads outside urban areas. A large undeveloped area south of Edson that remains dry in all flood scenarios, was assigned a mesh size of 200 m x 200 m to improve model run times. Since Bench, Wase, and Poplar creeks are small, meandering creeks, the near repeat function was used to help transition the fine mesh of the refinement regions outward into the coarser mesh.

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Hydraulic Structures

The model includes 27 bridges and 29 culverts, as summarized in Table 2-3 and Table 2-4, respectively. As outlined in Section 2.5, detailed data on bridge and culvert location, alignment, elevation, and other characteristics was collected as part of the survey program. Computation of overtopping flow at hydraulic structures was performed using the standard weir method. Weir lengths were set based on site specific terrain and roadway and bridge deck profiles.

4.3.2 Model Calibration

Hydraulic model calibration involves adjusting model parameters to reproduce recorded WSEs for a known flow rate. Calibration should prioritize the parameters of greatest importance that can be represented using the available observed flood events.

Methodology

The most common parameters considered for calibration include channel and overbank roughness, expansion and contraction coefficients for 1D elements, and entrance and exit losses for culverts. The number of parameters that can reasonably be calibrated is a function of the number of separate calibration events.

The open water flow and WSE data recorded during the September 2024 field program was considered for calibration of channel parameters such as roughness. However, the flow conditions were far too low to be representative of normal conditions, let alone the smallest of the floods of interest (the 2-year event).

Of the historical open water flood events described in Section 3.1, only the June 2023 event included sufficient data for hydraulic model calibration. Other past flood events were missing critical information such as peak flow rates, recorded WSE data (i.e. HWM data), or involved confounding factors such as debris jams (e.g. the 2024 event). The magnitude of the June 2023 event was in the range of bankfull to just beyond bankfull, making it suitable as the primary means for calibrating channel roughness. Following calibration, the September 2024 data could be used to provide a general validation of the calibrated channel roughness values.

June 2023 Flood Event

Peak flow rates for the June 2023 event were estimated using the using the hydrologic model created as part of the current study that is based on recorded rainfall and antecedent soil moisture conditions from the time of the event. Further details are presented in the Open Water Hydrology Assessment included in Appendix B and peak flow estimates are provided in Table 4-2.

Table 4-2: Peak Flow Estimates for the June 2023 Event

Instantaneous Maximum Flow (m^3/s)						
Bench Creek				Wase Creek	Poplar Creek	
Range Road 180	Railway West of 54th Street	Upstream of Poplar Creek	Downstream End of Study Area	Upstream of Poplar Creek	Upstream of Wase Creek	Upstream of Bench Creek
14.1	18.3	18.5	25.6	3.53	2.81	6.41

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The June 2023 HWM data consists of 12 surveyed elevations, along with photographs, collected at three locations: two nearby sites on Bench Creek and one on Wase Creek, all within the Town of Edson. The surveyed HWM locations are provided in Appendix A. Although the HWMs are clustered in just three areas, channel characteristics are consistent throughout the study area, meaning that calibrated roughness values can reasonably be applied throughout.

Channel roughness values were applied to the 2D mesh as an override region defined as the area within the bank lines of the creeks. The channel roughness values were initially set to 0.045 to align with the recommendation provided by Chow (1959) for winding streams with some “weeds and rocks”. Calibration to the 2023 HWMs brought this value down slightly to 0.035, which is still in the expected range for this type of channel.

At this roughness value, the simulated WSEs for the June 2023 event are within acceptable tolerances of surveyed HWMs at all three locations. The average difference between simulated WSEs and surveyed HWMs is +0.02 m and ranges from -0.11 m to +0.31 m. A comparison between simulated WSEs and surveyed HWMs is provided in Figure 4-2 and Figure 4-3 for both Bench and Wase creeks. Further discussion of the highwater conditions along with accompanying photographs follows.

Table 4-3: Comparison of June 2023 HWMs to Simulated WSEs

EPA HWM Point #	Site	Water Surface Elevation (m)		
		Surveyed	Simulated	Difference
26[1]	Bench 4th Avenue	907.91	908.22	0.31[1]
28	Bench 2nd Avenue	908.10	908.11	0.01
29	Bench 2nd Avenue	908.17	908.11	-0.06
30	Bench 2nd Avenue	908.19	908.11	-0.08
35	Wase 1st Avenue	909.17	909.07	-0.10
36	Wase 1st Avenue	909.12	909.06	-0.06
37	Wase 1st Avenue	909.06	909.06	-0.00
38	Wase 1st Avenue	909.02	909.06	0.04
40	Wase 1st Avenue	909.15	909.12	-0.03
41	Wase 1st Avenue	909.10	909.13	0.03
43	Wase 1st Avenue	909.22	909.11	-0.11
44	Wase 1st Avenue	909.16	909.07	-0.09

Notes:
1. It is suspected that Point 26 may not have captured the true HWM. Photos show that the grass was mowed between flood and survey, which may have disturbed the flood debris. Photos taken during the flood show higher WSEs - in the range of 908.00 to 908.30

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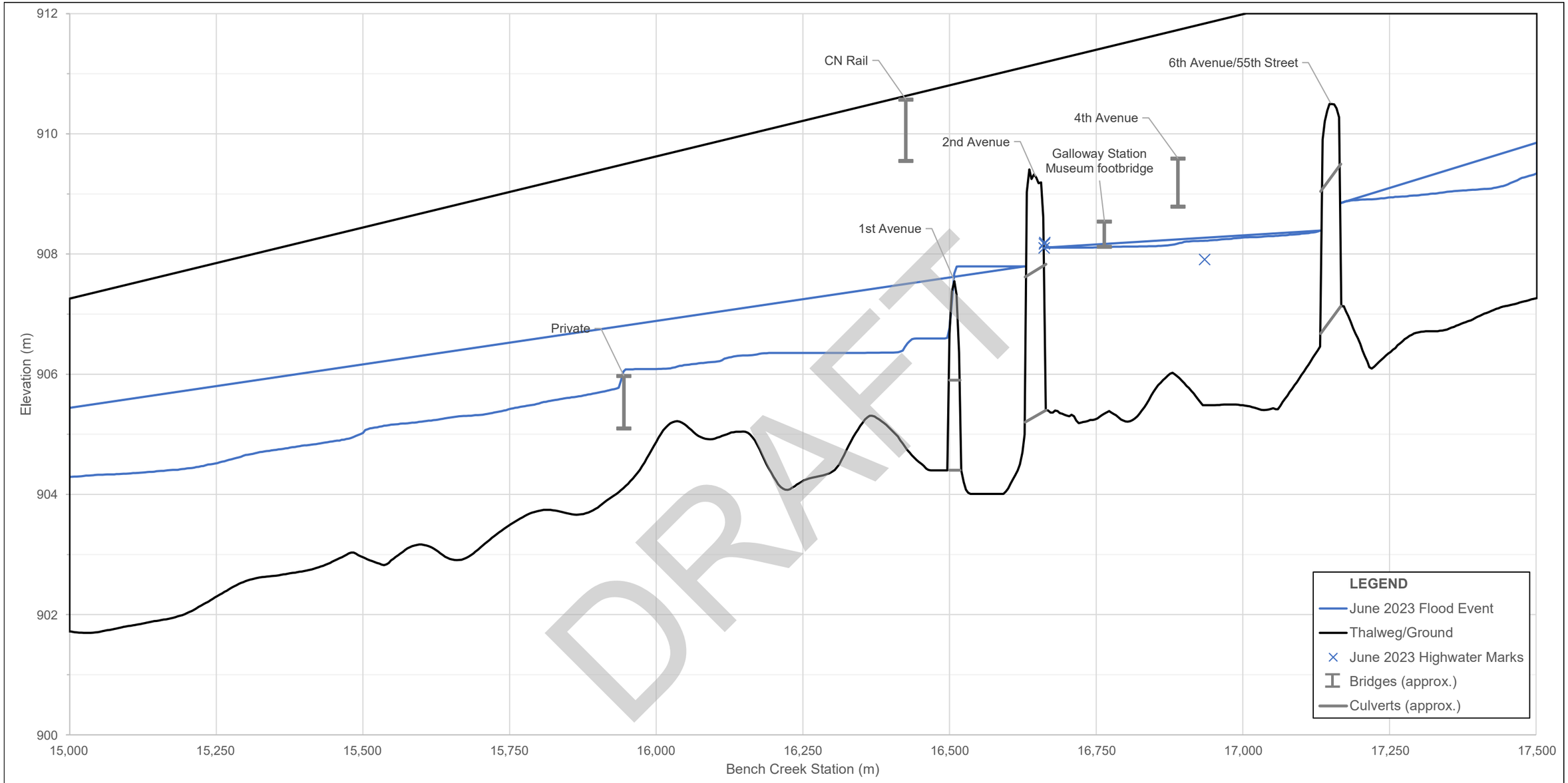

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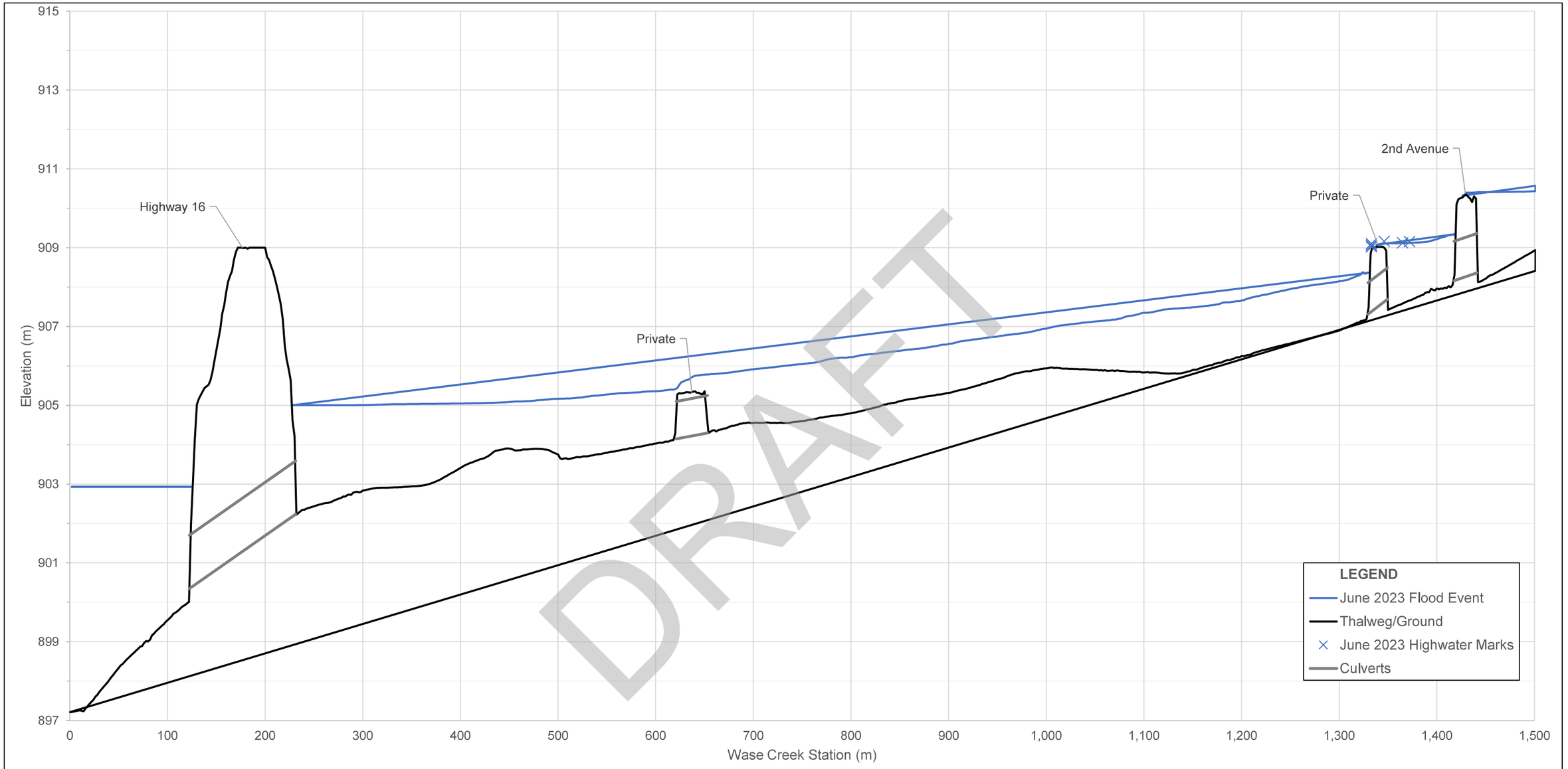
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure 4-2
SIMULATED AND OBSERVED WSEs ON BENCH CREEK — JUNE 2023 FLOOD EVENT

Classification: Public



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Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure 4-3
SIMULATED AND OBSERVED WSEs ON WASE CREEK — JUNE 2023 FLOOD EVENT

Classification: Public

Photographs from the event provide additional information on peak water levels. A critical aspect of using flood photographs is to know the timing of the photograph relative to the timing of the peak water levels. Based on a review of available photographs, peak water levels are estimated to have occurred on Bench Creek sometime between 7:00 PM and 10:00 PM on 19 June 2023. This timeline is consistent with the timing of peak flow from the hydrologic model.

The timing of peak water levels on Wase Creek and Poplar Creek is less clear. There are few photographs taken of Wase Creek that were not impacted by blocked culverts and none available of Poplar Creek. However, it is a reasonable assumption that due to the smaller drainage area for these watercourses, their peak occurred earlier in the day. The photographs presented below represent the best available evidence of peak flood conditions.

Figure 4-4, *Bench Creek at 4th Avenue,* shows the downstream face of the 4th Avenue bridge, where the water surface is approximately 0.6 m below the low chord, as estimated using the known height and dimensions of the bridge. This corresponds to a WSE of approximately 908.19 m, which is 0.28 m higher than HWM Point 26, which was surveyed on the upstream side of the bridge (907.91 m). This discrepancy may have been caused by the HWM being obscured due to lawn mowing that occurred at this location between the flood and the survey. Fortunately, the simulated WSE closely approximates the photographed WSE (within 0.03 m), and therefore it is assumed that HWM Point 26 is erroneous and does not provide grounds for model parameter alteration. Furthermore, if this surveyed HWM was assumed to be correct, the difference between this HWM and the simulated WSE is insufficient to justify adjusting channel roughness well below its typical range to the detriment of other HWM calibration points. Additionally, the extent of flooding shown in the photograph closely matches the simulated flood extent from the calibrated hydraulic model.

Figure 4-5, *Bench Creek at the Galloway Station Museum footbridge,* shows the WSE roughly at the foot bridge deck elevation (approximately 908.10 m), with the sidewalk between the bridge and the light pole being inundated. The simulated WSE at the bridge is 908.17 m, 0.07 m higher than the bridge deck, and the simulated inundation boundary also extends approximately to the light pole. This supports the performance of the calibrated model in representing flooding through this area.

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Figure 4-4: Bench Creek at 4th Avenue (7:24 PM)

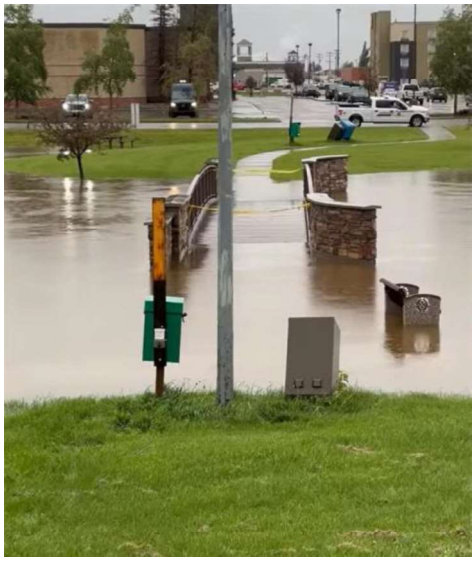

Figure 4-5: Bench Creek at the Galloway Station Museum footbridge (7:24 PM)

Classification: Public

In Figure 4-6 *Bench Creek at 2nd Avenue and CN Rail,* the crown of the 2nd Avenue culvert (907.83 m) is underwater, but the water is still well below the road elevation (909.30 m). This is in line with the surveyed HWM points 29 and 30 of 908.17 m and 908.19 m, respectively. The simulated WSE matches the observed HWM at this location (908.17 m).

Figure 4-7, *Bench Creek at Edson Golf Club* shows the second most downstream bridge at the Edson Golf Club (Structure No. 18 in Table 2-3), with the WSE just below the low chord (891.62 m). The simulated WSE at this location is 891.94 m, which is approximately 0.5 m higher than the elevation observed in the photograph; however, the timing of the photograph is unknown and may not have coincided exactly with the peak. Due to the uncertainty with the timing of this photograph and the otherwise good match between simulated and photographed WSEs, highwater information from this photograph was not used in calibration.



Figure 4-6: Bench Creek at 2nd Avenue and CN Rail (7:24 PM)



Figure 4-7: Bench Creek at Edson Golf Club (time unknown)

Along Wase Creek, significant flooding was observed in Kinsmen Park upstream of 6th Avenue. However, this was due to a culvert blockage at 6th Avenue which caused minor overtopping of the road. Figure 4-8 shows crews from the Town of Edson pumping water over the road attempting to draw down the upstream water levels. Due to the culvert blockage, these highwater conditions were not considered for calibration of the open water hydraulic model.

Further downstream on Wase Creek, the left lane of 2nd Avenue was flooded at the intersection with 48th Street (Figure 4-9). While the exact timing of this photograph is unknown, the simulated flood level generally matches the observed conditions which shows the flood contained within the street curbs.

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Figure 4-8: Wase Creek at 6th Avenue (2:09 PM)



Figure 4-9: Wase Creek at 2nd Avenue (time unknown)

September 2024 Low Flow

The performance of the calibrated hydraulic model was checked using flow rates and water levels measured during the September 2024 field program. A previously stated, the measured flow rates of 0.012 and 0.022 m^3/s were below average and significantly below the 2-year flood flow rate of 5.22 m^3/s, which is in the range of bankfull flow. The condition of the creeks at the time of the flow measurements, depicted in Figure 4-10, illustrates high roughness along the creek bed due in part to a large amount of woody debris.



Figure 4-10: Bench Creek downstream of Poplar Creek confluence

The calibrated model was used to simulate the September 2024 flow rates. As expected, the simulated WSEs are lower than the surveyed WSEs, demonstrating that the relative roughness is greater during low flow conditions. To match the surveyed WSEs for this low flow condition would require increasing the channel roughness values beyond their expected range and they would no longer be a reasonable representation during flood conditions. These results support selection of the June 2023 event for calibration of channel roughness for the purpose of flood modelling.

The comparison of simulated and surveyed WSEs for the low flow condition is provided in Table 4-4, and a profile comparing the simulated and surveyed WSEs is shown in Figure 4-11.

Table 4-4: Low Flow Validation Results

Approximate Location	Date & Time (MDT)	Measured Flow (m^3/s)	Water Surface Elevation (m)		
			Surveyed	Simulated	Difference
Edson Golf Club	26 September 2024 07:13	0.022	889.89	889.70	-0.19
63rd Street Bridge	27 September 2024 07:30	0.012	912.94	912.78	-0.16

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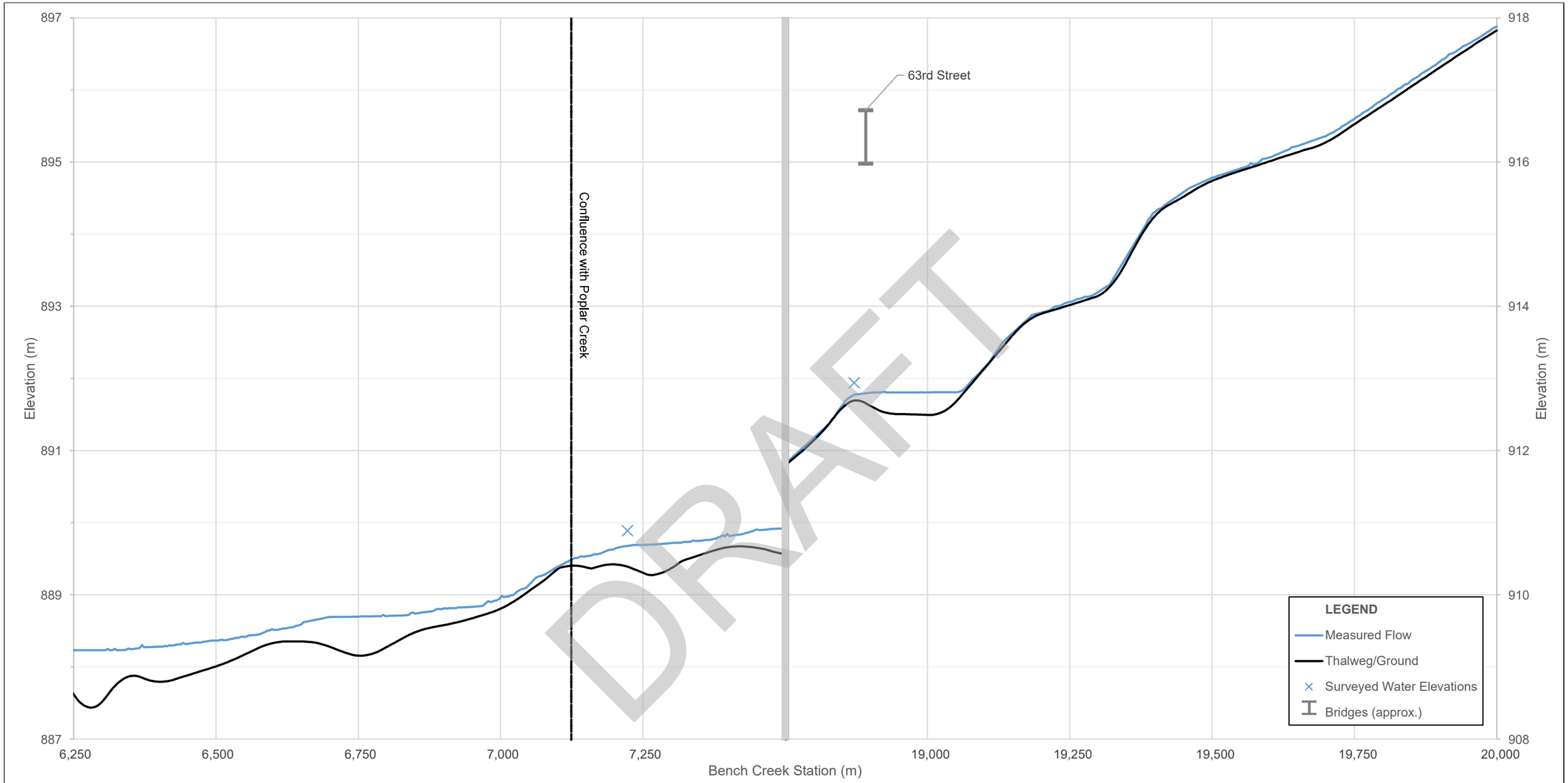

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Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.

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Figure 4-11
SIMULATED AND OBSERVED WSEs ON BENCH CREEK — LOW FLOW CONDITIONS

Classification: Public

4.3.3 Model Parameters & Options

Solver

Hydraulic calculations in a 2D model are completed using either the full Shallow Water Equations (SWE) or the simplified Diffusion Wave Equations (DWE). The SWE can better account for momentum and are necessary when modelling complex flow conditions, such as highly dynamic flood waves, flat slope rivers, or abrupt contractions or expansions. However, this comes at a cost of smaller computational time steps and longer run times. The use of steady inflow rates and the typical riverine setting, make the study area well suited for the use of the standard DWE, which was selected for the model.

Simulation Time

Each simulation was considered complete when flow at the downstream boundary was equal to the sum of the inflows. Computation interval, runtime, and computational efficiency for the final iteration of each simulation are summarized in Table 4-5.

Table 4-5: Simulation Time Summary

Return Period (Years)	Computation Interval (s)	Runtime (hr)	Computational Efficiency (Simulation Time/Runtime)
2	2	12	1.48
5	2	24	2.25
10	2	24	1.59
20	2	24	1.07
35	2	24	1.56
50	2	28	1.89
75	2	28	1.67
100	1	24	1.54
200	1	28	1.00
350	1	28	0.72
500	1	28	0.67
750	1	28	0.88
1,000	1	12	0.77

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Manning's Roughness

Manning's roughness values are used in the model to characterize the frictional energy losses of flow in the channel and overbank. Roughness values were applied spatially to the 2D mesh using land cover mapping with override regions for channel and floodplain.

Channel roughness values were applied to the 2D mesh as an override region defined as the area within the bank lines of the creeks. Calibration of the channel roughness is described in section 4.3.2. The final adopted value of 0.035 is in line with the range presented in the literature for this type of channel. Since channel conditions were generally consistent between the three creeks, this same value was assigned to all the creeks.

Throughout the study area, the majority of overbank (i.e. floodplain) areas consist of dense forest or shrubs, as illustrated in Figure 4-1. Exceptions occur near roads, within the Town of Edson, and at the Edson Golf Club. To depict the various conditions in the overbank area, roughness values were initially defined based on provincial land cover mapping (AER, 2021). The resolution of these land cover maps is coarse, leading to unexpected velocity disturbances in the overbank areas. To rectify this, aerial imagery was used to digitize land cover features within a 100 m buffer of the creeks. This allowed for a more realistic and smooth transition between land cover features, resulting in a more accurate portrayal of flow through the overbank areas. Furthermore, within the HEC-RAS cell properties editor, the spatially varied Manning's value setting was selected to ensure that individual cell faces represented the roughness values that they crossed. This was particularly useful for representing sudden changes in roughness, such as at bank lines.

Table 4-6 presents the adopted Manning's roughness values used in the model for each land cover type.

Table 4-6: Final Manning's Roughness Values

Landscape Type	Manning's n
Creek channels	0.035
Unvegetated open land including railways and roads	0.025
Grass and agricultural land	0.030
Low density developed areas, including parking lots, roads, grass, and buildings	0.030
Brush and low shrubs	0.070
Riparian areas with shrubs and trees	0.080
Coniferous and deciduous forest stands	0.100

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Expansion & Contraction Coefficients

Bridges and culverts were modelled as 1D structures within the 2D mesh using the HEC-RAS Simplified 1D/2D Approach (USACE, 2020). An advantage of using 2D modelling is that it intrinsically accounts for energy losses from contraction and expansion of flow upstream and downstream of bridges and culverts.

For bridges, contraction and expansion loss coefficients do apply to the internal bridge cross sections to account for any additional velocity head changes that are not already accounted for by the adjoining 2D mesh. Coefficients for the internal bridge cross sections were set based on the degree of flow constriction between the bridge cross sections based on the standard values provided in Table 4-7.

Table 4-7: Bridge Contraction and Expansion Loss Coefficients

Transition Type	Contraction	Expansion
Gradual transitions	0.1	0.3
Typical bridge sections	0.3	0.5
Abrupt transitions	0.6	0.8

Culvert entrance and exit loss coefficients are an additional factor applied to culvert hydraulic computations. These coefficients account for energy losses due to turbulence at the inlet and outlet of culverts and are set based on culvert shape and geometry. Inlet and exit loss coefficients were taken from the standard HEC-RAS culvert reference tables (USACE, 2020). Inlet and exit loss coefficients ranged from 0.2 to 0.9 and 0.7 to 1.0, respectively, based on the type of culvert.

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Boundary Conditions

Bench, Wase, and Poplar creeks were assigned constant inflow hydrographs at their upstream model boundaries. Use of constant inflow hydrographs ensures that the peak flow rates have time to propagate through the system and reach a steady state condition.

The only outflow boundary is at the downstream end of Bench Creek. This location was assigned a normal depth boundary condition with a friction slope of 0.0030 m/m corresponding to the average surveyed slope of the lower 2.5 km of Bench Creek.

4.3.4 Open Water Flood Frequency Profiles

The calibrated hydraulic model was used to generate longitudinal profiles of the WSE for each of the open water flood scenarios from the 2-year to the 1,000-year return period. The profile figures are presented in Appendix C with accompanying WSE tables included in Appendix D.

4.3.5 Model Sensitivity

A sensitivity analysis was carried out to quantify how key parameters influence WSEs and inundation widths. Table 4-8 outlines the three selected parameters of interest with the rationale for their respective ranges.

Table 4-8: Sensitivity Analysis Parameters

Parameter	Variation Bounds	Rationale
Normal Depth Slope (Downstream Boundary Condition)	± 20%	Due to the tortuous meanders of Bench Creek, especially in the downstream reaches, it is possible that avulsions could lead to temporarily changes to channel slope. A range of ±20% was selected as a plausible change in channel slope.
Manning's Roughness (Channel)	± 20%	Historically, flooding in Edson has often been accompanied by windstorms causing downed trees and debris accumulation in the creek channels. The extent to which this occurs in any flood event has potential to impact the channel roughness. Furthermore, the extent of beaver damming on Bench Creek, which has historically varied, can also be represented through variation in channel roughness. The chosen variation also largely contains the range of values provided in Chow (1959) for low, normal, and high roughness.
Manning's Roughness (Overbank/Floodplain)	± 20%	The vegetation in the overbank and floodplain areas will change over time as landscape succession leads to larger shrub and forest stands. Conversely, forestry, agriculture, or new development can lead to the removal of floodplain vegetation. The selected range of ± 20% is meant to capture a modest change to landscape conditions from either continued vegetative growth or due to partial clearing in the floodplain.

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Downstream Boundary Condition

Changes to normal depth slope at the downstream boundary only affected the most downstream 60 m of Bench Creek. Maximum WSE changes were limited to +/- 0.05 m (Table 4-9) while inundation width responded more strongly to an increase in slope (reducing width by 6.0 m), compared to a decrease in slope (increasing width by 0.5 m). Inundation width tables for all sensitivity analyses are provided in Appendix E.

Table 4-9: Sensitivity of water levels to variation in Downstream Boundary Condition Slope

Reach	-20% (s = 0.0024)	+20% (s = 0.0036)
	Maximum Difference in WSE (m)	Maximum Difference in WSE (m)
Lower Bench Creek	+0.05	-0.05

Channel Roughness

Variation in channel roughness had the greatest overall effect on the lower reach of Bench Creek with a maximum change in WSE of -0.17 m and +0.16 m for decreased and increased roughness values, respectively (see Table 4-10). Inundation width varied no more than +/-1.3 m along Wase and Poplar creeks, while upper Bench Creek had the greatest single maximum width increase of 8.7 m (Appendix E).

Table 4-10: Sensitivity of water levels to variation in channel roughness

Reach	-20% (n = 0.029)		+20% (n = 0.042)	
	Average Difference in WSE (m)	Maximum Difference in WSE (m)	Average Difference in WSE (m)	Maximum Difference in WSE (m)
Upper Bench Creek	-0.04	-0.10	+0.03	+0.10
Lower Bench Creek	-0.06	-0.17	+0.06	+0.16
Wase Creek	-0.01	-0.09	+0.01	+0.08
Upper Poplar Creek	-0.02	-0.12	+0.02	+0.09
Lower Poplar Creek	-0.01	-0.05	+0.01	+0.06

Overbank Roughness

Overbank areas include a mixture of land cover types with a range of roughness values. For the sensitivity analysis, all values were increased or decreased collectively by 20%. Changing the overbank roughness had the greatest overall effect on the lower reach of Poplar Creek, with a maximum change in WSE of -0.13 m and +0.16 m for decreased and increased roughness values, respectively (see Table 4-11). Inundation width was most sensitive along Bench Creek, with increases of up to 17 m and decreases of up to 13 m. Along Poplar and Wase creeks, inundation width was insensitive to increases in overbank roughness but did have a width reduction of up to 12 m when overbank roughness was decreased (Appendix E).

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Table 4-11: Sensitivity of water levels to variation in overbank roughness

Reach	-20% (n= varies)		+20% (n= varies)	
	Average Difference in WSE (m)	Maximum Difference in WSE (m)	Average Difference in WSE (m)	Maximum Difference in WSE (m)
Upper Bench Creek	-0.05	-0.11	+0.05	+0.11
Lower Bench Creek	-0.05	-0.11	+0.05	+0.12
Wase Creek	-0.02	-0.06	+0.02	+0.06
Upper Poplar Creek	-0.02	-0.08	+0.02	+0.06
Lower Poplar Creek	-0.07	-0.13	+0.07	+0.16

4.3.6 Modelled Flows

The flood magnitude estimates presented in Table 3-2 were used as inflows at the upstream boundary of each stream. The flows combine at the confluences; Table 4-12 presents the modelled flows for all reaches. Modelled flows for Lower Bench Creek are the sum of the flows from Upper Bench Creek and Lower Poplar Creek; modelled flows for Lower Poplar Creek are the sum of the flows from Upper Poplar Creek and Wase Creek.

Table 4-12: Modelled flows

Return Period (Years)	Instantaneous Maximum Flow (m^3/s)				
	Upper Bench Creek (above Poplar Creek)	Lower Bench Creek (below Poplar Creek)	Wase Creek	Upper Poplar Creek (above Wase Creek)	Lower Poplar Creek (below Wase Creek)
2	5.22	7.44	1.14	1.08	2.22
5	10.8	15.7	2.54	2.37	4.91
10	16.4	24.3	4.09	3.77	7.86
20	23.5	35.1	6.15	5.45	11.6
35	28.3	42.3	7.44	6.54	14.0
50	34.1	51.3	9.18	8.03	17.2
75	38.3	57.6	10.3	9.04	19.3
100	43.2	65.5	11.8	10.5	22.3
200	57.1	86.3	15.5	13.7	29.2
350	76.3	115	20.6	17.9	38.5
500	81.8	123	22.0	19.2	41.2
750	95.1	143	25.4	22.1	47.5
1,000	105	157	27.9	24.2	52.1

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5. Open Water Flood Inundation Maps

Open water flood inundation maps show the maximum extent of flooding for a given flood quantile. The flood inundation maps prepared as part of this study include the open water 2-, 5-, 10-, 20-, 35-, 50, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year flood frequencies. These maps are presented in Appendix F.

5.1 Methodology

All inundation maps were created in accordance with the FHIP Technical Guidelines (EPA, 2022).

Production of inundation maps requires smoothing the granular HEC-RAS 2D model outputs and removing isolated polygons to improve readability. The following steps were applied in ArcGIS ModelBuilder to each of the inundation boundary shapefiles:

- smoothing using the Polynomial Approximation with Exponential Kernel (PAEK) algorithm to reduce jagged edges and other anomalies;
- filtering to remove detached polygons with an area less than 100 m^2 unless connected via a culvert; and
- elimination of small holes within the polygons with an area less than 100 m^2.

After manual modifications, the final inundated areas were mapped using the EPA cartographic standards provided in the style guide.

5.2 Manual Flood Extent Modifications

While the automated steps carried out in ArcGIS addressed the vast majority of mapping edits, there remained several modifications to be completed manually, as follows:

- There remained several isolated polygons just larger than the 100 m^2 threshold not connected via culvert that required manual removal.
- Small gaps in the flood mapping where flow is overtopping steep embankments, such as roads or rail lines, was manually filled. The gaps are common in 2D models when there is shallow flow over a steep slope. While the model can effectively model the hydraulics, the HEC-RAS 2D mapping routine has trouble properly depicting the shallow flow on steep ground.

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5.3 Flood Inundation Areas

Within the study area, flooding generally begins to impact properties and infrastructure at levels above the 10-year flood. Wase Creek begins to experience widespread culvert overtopping by the 20-year flood. Overall, significant flood impacts across all three creeks are expected by the 50- to 75-year flood level. Specific locations for each creek are discussed below and a full list of key features and infrastructure that may be affected by open water flooding along Bench, Wase, and Poplar creeks are summarized in Table 5-1, Table 5-2, and Table 5-3, respectively. The tables are organized in order from upstream to downstream. Shaded cells denote the flood frequencies impacting each area or structure. For bridges and culverts, only those experiencing overtopping are included in the tables below; impacted bridge low chords are visible on the Appendix C profile plots.

5.3.1 Bench Creek

- A culvert on an unnamed road east of Range Road 180 is overtopped during all flood events and contributes to the inundation of a large, forested area upstream of the culvert.
- Several private bridge structures at the Edson Golf Club begin to experience flooding at the 10-year flood.
- Roads and properties near downtown Edson begin to be affected at the 75-year flood, with Highway 16 at the east end of Edson being overtopped by the 200-year flood.
- The CN Rail bridge is not overtopped by any of the modelled events, including the 1,000-year flood.

Table 5-1: Flood Inundation Areas – Bench Creek

Overtopped Structure or Impacted Area	Flood Return Period (years)												
Range Road 180 crossroad culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
6th Avenue/55th Street culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
4th Avenue bridge (Highway 16 westbound)	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Downtown properties near Highway 16 eastbound and westbound	2	5	10	20	35	50	75	100	200	350	500	750	1,000
2nd Avenue culvert (Highway 16 eastbound)	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Properties west of 54th Street	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Edson Golf Club bridges	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Range Road 171 culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Highway 16 east of Edson (divided) culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Township Road 533 culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000

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5.3.2 Wase Creek

- The 12th Avenue culvert (at the entrance to the parking lot for Parkland Composite High School and École Pinegrove Middle School) is overtopped by the 10-year flood.
- The 10-year flood impacts the 3rd Avenue culvert and properties south of westbound Highway 16.
- The 20-year flood affects properties further north and east along Wase Creek, as well as the CN Rail tracks at the Highway 16 overpass.
- Kinsmen Park is flooded during the 35-year flood, although adjacent properties remain dry until the 100-year flood.
- Multiple culverts are impacted incrementally, up to the 200-year flood, which overtops Highway 16 eastbound (2nd Avenue).

Table 5-2: Flood Inundation Areas – Wase Creek

Overtopped Structure or Impacted Area	Flood Return Period (years)												
Edson Drive	2	5	10	20	35	50	75	100	200	350	500	750	1,000
12th Avenue culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
9th Avenue culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Kinsmen Park field	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Properties adjacent to Kinsmen Park	2	5	10	20	35	50	75	100	200	350	500	750	1,000
6th Avenue culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
5th Avenue culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
East bank properties between 5th Avenue and 4th Avenue	2	5	10	20	35	50	75	100	200	350	500	750	1,000
4th Avenue culvert (Highway 16 westbound)	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Properties south of 4th Avenue	2	5	10	20	35	50	75	100	200	350	500	750	1,000
3rd Avenue culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
2nd Avenue culvert (Highway 16 eastbound)	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Properties north of Wase Creek near the Highway 16 CN Rail overpass	2	5	10	20	35	50	75	100	200	350	500	750	1,000
CN Rail tracks near Highway 16 overpass	2	5	10	20	35	50	75	100	200	350	500	750	1,000

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5.3.3 Poplar Creek

- Parts of the Edson Lions Park Campground are inundated beginning at the 10-year flood.
- Industrial properties north of 1st Avenue are affected by the 100-year and greater floods.
- Flow spilling eastward along the CN Rail tracks, overtops the tracks near the 25th Street overpass during the 200-year flood.

Table 5-3: Flood Inundation Areas – Poplar Creek

Overtopped Structure or Impacted Area	Flood Return Period (years)												
6th Avenue culvert	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Edson Lions Park Campground	2	5	10	20	35	50	75	100	200	350	500	750	1,000
East bank properties north of 1st Avenue	2	5	10	20	35	50	75	100	200	350	500	750	1,000
Golf Course Road	2	5	10	20	35	50	75	100	200	350	500	750	1,000
CN Rail tracks near 25th Street overpass	2	5	10	20	35	50	75	100	200	350	500	750	1,000

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6. Floodway Determination

6.1 Floodway & Flood Fringe Terminology

The following zones are prescribed by the FHIP Technical Guidelines (EPA, 2022) for flood hazard mapping:

- The floodway typically represents the area of highest flood hazard for the 100-year design flood, where flows are deepest, fastest, and most destructive.
- The flood fringe is the area outside of the floodway that is flooded or could be flooded by the 100-year design flood. The flood fringe typically represents areas with shallower, slower, and less destructive flooding, but it may also include high hazard flood fringe areas.
- The high hazard flood fringe identifies areas within the flood fringe with deeper or faster moving water than the rest of the flood fringe.
- The protected flood fringe identifies areas that could be flooded if dedicated flood berms fail or do not work as designed during the 100-year design flood, even if they are not overtopped. Protected flood fringe areas illustrate residual flood risk and do not differentiate between areas with deeper and faster moving water and those with shallower or slower moving water.

6.2 Flood Hazard Identification

Flood hazards are identified through delineation of floodway and flood fringe zones for a selected design flood. The design flood standard in Alberta is the 100-year design flood, which is a flood that has a 1% chance of occurring in any given year. The flow values used for flood hazard mapping correspond to the 100-year open water flood presented in Table 6-1.

Table 6-1: Design Flood Flow Estimates

Design Flood	Instantaneous Maximum Flow (m^3/s)		
	Bench Creek	Wase Creek	Poplar Creek
100-year	43.2	11.8	10.5

6.2.1 Floodway Determination Criteria

The following criteria were used to delineate the floodway in this study:

- areas in which the flood depth exceeds 1 m or flow velocities exceed 1 m/s shall be part of the floodway;
- exceptions may be made for small backwater areas, ineffective flow areas, and to support creation of a hydraulically smooth floodway;
- the floodway must always include the main channel of a stream; and
- for reaches of supercritical flow, the floodway boundary should typically correspond to the edge of inundation or the main channel, whichever is larger.

Floodway determination criteria tables for each reach in the study area are presented in Appendix H. Left bank and right bank refer to the sides of a river as determined by facing downstream.

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6.2.2 Design Flood Levels & Profile

The open water design flood profiles for Bench, Wase, and Poplar creeks were produced using the calibrated HEC-RAS 2D model and are presented in tabular and graphical format in Appendix D (as part of the Open Water Flood Frequency WSE Tables) and Appendix G, respectively.

6.2.3 Floodway Criteria Maps

Floodway criteria maps document the technical information that help define the floodway. Information illustrated on floodway criteria maps includes areas flooded or at risk of flooding for the 100-year design flood, as well as areas with flood depths greater than 1 m and areas with flow velocities greater than 1 m/s during the design flood. The full set of floodway criteria maps is presented in Appendix I.

6.3 Design Flood Hazard Maps

Flood hazard maps are specific flood maps that identify the area flooded or at risk of flooding for the 100-year design flood and divides that flood hazard area into floodway and flood fringe zones. Flood hazard maps also illustrate areas at risk from the 200-year and 500-year floods. Flood hazard maps are presented in Appendix J.

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7. Potential Climate Change Impacts

To address the potential impact of climate change on flood levels, the FHIP Technical Guidelines recommend increasing the open water design flood flow by 10% and 20% then comparing the resulting flood levels to baseline design flood levels to obtain a measure of freeboard (EPA, 2022). Table 7-1 presents the resulting increases to design flood WSEs associated with the specified flow increases for each study reach. The 10% and 20% flow increases in flow had the greatest effect on average WSE for Bench Creek followed by Poplar Creek and Wase Creek. However, at even the 20% flow increase the average increase in WSE for Bench Creek was marginal at only 0.15 m. A more in depth commentary on the potential climate change impacts to the study area is presented in the Open Water Hydrological Assessment (Appendix B).

Table 7-1: Potential Climate Change Impacts to the 100-Year Design Flood

Stream	+10% Flow	+20% Flow
	Average Increase in WSE (m)	Average Increase in WSE (m)
Bench Creek	0.08	0.15
Wase Creek	0.03	0.05
Poplar Creek	0.05	0.09

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Classification: Public

8. Conclusions

The Edson Flood Study was conducted by KWL on behalf of EPA as part of the provincial FHIP. The study aimed to identify and evaluate riverine flood hazards along Bench, Wase, and Poplar creeks in the Town of Edson and adjacent Yellowhead County. Key components included survey and base data collection, open water hydrology assessment, open water hydraulic modelling, open water flood inundation mapping, and design flood hazard mapping.

Survey and base data collection supported the modelling efforts, with 357 cross sections surveyed along the creeks to enhance a DTM derived from 2024 LiDAR data. Surveys also covered 27 bridges and 29 culverts.

The hydrology assessment estimated peak flows for thirteen return periods from 2 to 1,000-years using RFFA and deterministic modelling with HEC-HMS software due to the lack of streamflow gauges in the study area. For the 100-year design flood, peak inflows were determined to be 43.2 m³/s for Bench Creek, 11.8 m³/s for Wase Creek, and 10.5 m³/s for Poplar Creek, as documented in Appendix B.

Hydraulic modelling employed a HEC-RAS 2D model to simulate flood scenarios. Calibration relied on highwater marks from the June 2023 flood event. A sensitivity analysis indicated that modelled flooding was least sensitive to changes in the downstream boundary condition normal depth slope, with different reaches being most sensitive to channel and overbank roughness depending on local topography.

Flood inundation mapping was produced for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year flood events for Bench, Wase, and Poplar creeks. Flood mapping shows that residential and commercial properties as well as infrastructure will begin to experience flooding at the 10-year flood level, with widespread road overtopping from Wase Creek beginning at the 20-year flood level. Significant flooding to properties and infrastructure from all three creeks is expected at the 50- to 75-year flood levels. Overtopping of Highway 16 east of Edson is possible above the 100-year flood level.

Flood hazard mapping and the delineation of floodway and flood fringe zones was produced for the 100-year open water design flood to support with land use planning and emergency management.

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Report Submission

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Revision History

Revision #	Date	Status	Revision	Author
1	April 27, 2026	Final	Reissued with Updated Appendix F and J	JDD/GAW
0	October 29, 2025	Final	For Submission	JDD/GAW

APEGA Permit # P07929

Classification: Public

References

Alberta Energy Regulator, Alberta Geological Survey, & Chowdhury, S. (2021). Land-use/Land-cover Classification of Alberta, Derived from 2020 Sentinel-2 Multispectral Data (image data, TIFF format). Digital Data Series, DIG 2021-0019. Edmonton, Alberta, Canada: Alberta Geological Survey. http://ags.aer.ca/document/DIG/DIG_2021_0019.zip, retrieved in February 2025.

Alberta Environment and Protected Areas, River Engineering and Technical Services. (2022). Flood Hazard Identification Program: Flood Study Technical Guidelines. Edmonton, Alberta, Canada: Alberta Environment and Protected Areas.

Alberta Transportation. (2004). Guidelines on Extreme Flood Analysis. Prepared for Alberta Transportation, Transportation and Civil Engineering Division, Civil Projects Branch. November 2004.

Chow, V. T. (1959). *Open-Channel Hydraulics*. Ven Te Chow, PhD, Professor of Hydraulic Engineering, University of Illinois. International Student Edition, McGraw-Hill Book Company Inc.

Chowdhury, S. (2021): Land-use/Land-cover classification of Alberta, derived from 2020 sentinel-2 multispectral data (image data, TIFF format); Alberta Energy Regulator / Alberta Geological Survey.

Friend, A., & McBroom, M. (2018). *Not Your Father's Manning's n: Adjusting Manning's n values for 2D modeling*. Michael Baker International.

ESRI. (2025). Raster Basemaps 2025.R04 [Aerial Imagery Map Layer]. Retrieved from World Imagery service. Source: Maxar, Vivid. Date: 16 July 2024.

Government of Alberta. (2023, June 8). AER/AGS Digital Data 2021-0019. *Agricultural Moisture Situation Update*. Agriculture and Irrigation. https://open.alberta.ca/publications/moisture-situation-update, retrieved in February 2025.

Natural Resources Canada. (2011). Canadian Digital Elevation Model, 1945–2011 (image data, GeoTiff format). Digital Data Series. Ottawa, Ontario, Canada: Natural Resources Canada. https://www.nrcan.gc.ca/earth-sciences/geography/topographic-information/digital-elevation-data/17215, retrieved in October 2024.

Normann, J. M., Houghtalen, R. J., & Johnston, W. J. (1985). *Hydraulic Design of Highway Culverts*. Report No. FHWA-IP-85-15. Prepared by Jerome M. Normann and Associates. United States Federal Highway Administration, Office of Implementation. September 1985. https://rosap.ntl.bts.gov/view/dot/54219

Public Safety Canada. (2013). Flood event in North-central Alberta (July 13–24, 1986). Retrieved from https://cdd.publicsafety.gc.ca/dtpg-eng.aspx?cultureCode=en-Ca&eventTypes=%27FL%27%2C%27TO%27%2C%27WF%27%2C%27SW%27%2C%27EQ%27&normalizedCostYear=1&dynamic=false&eventId=568, retrieved in November 2024.

U.S. Army Corps of Engineers. 2020. HEC-RAS, River Analysis System Hydraulic Reference Manual. https://www.hec.usace.army.mil/confluence/rasdocs/ras1dtechref/latest

U.S. Army Corps of Engineers. (n.d.). *Diffusion Wave Equation Solver*. https://www.hec.usace.army.mil/confluence/rasdocs/ras1dtechref/6.4/theoretical-basis-for-one-dimensional-and-two-dimensional-hydrodynamic-calculations/2d-unsteady-flow-hydrodynamics/numerical-methods/diffusion-wave-equation-solver, retrieved in February 2025.

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Appendix A

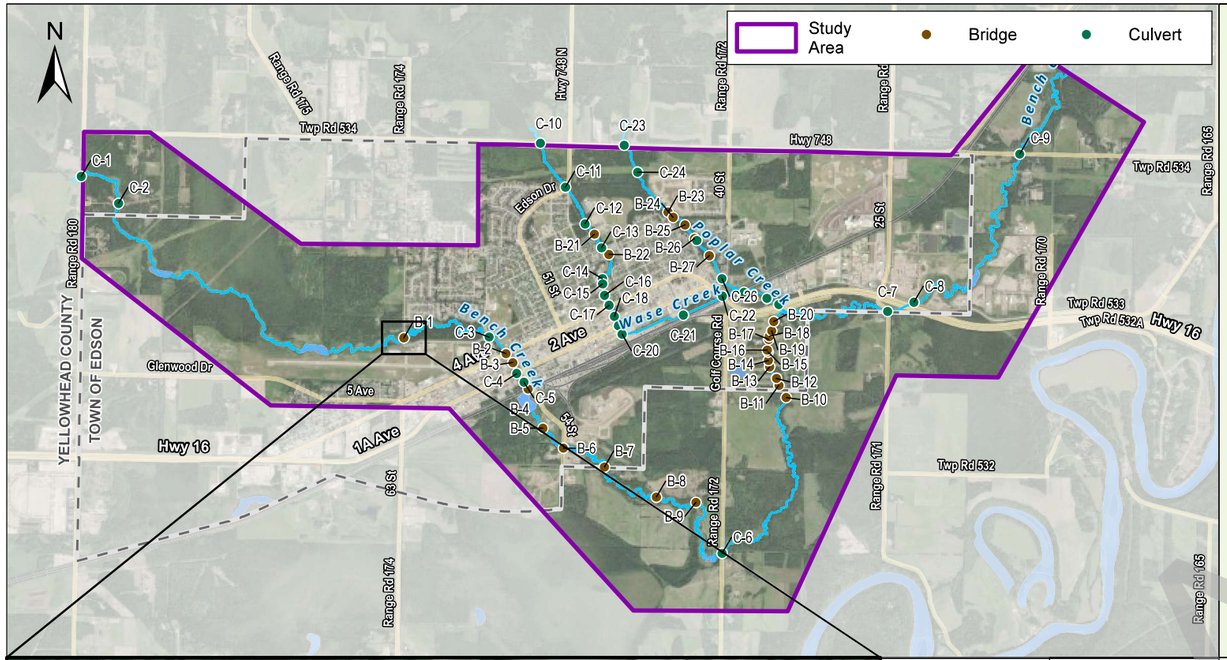
Selected Survey & Base Data

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

Scale Disclaimer: The map scale of 1:60,000 is only valid on a 11"x17" print.

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CULVERT	BRIDGE
ID: B-1	
DESCRIPTION: 63RD STREET	
FILE #: 75766	
CROSSING TYPE: TRAFFIC	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 9.60
SHAPE:	# OF PIERS: 28
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS: ROUND
LENGTH:	U/S LOW CHORD ELEV: 915.950
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 915.950
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 916.720
	D/S TOP OF CURB / GUARD RAIL ELEV: 916.720
TOP OF ROADWAY NOTES:	





Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-1

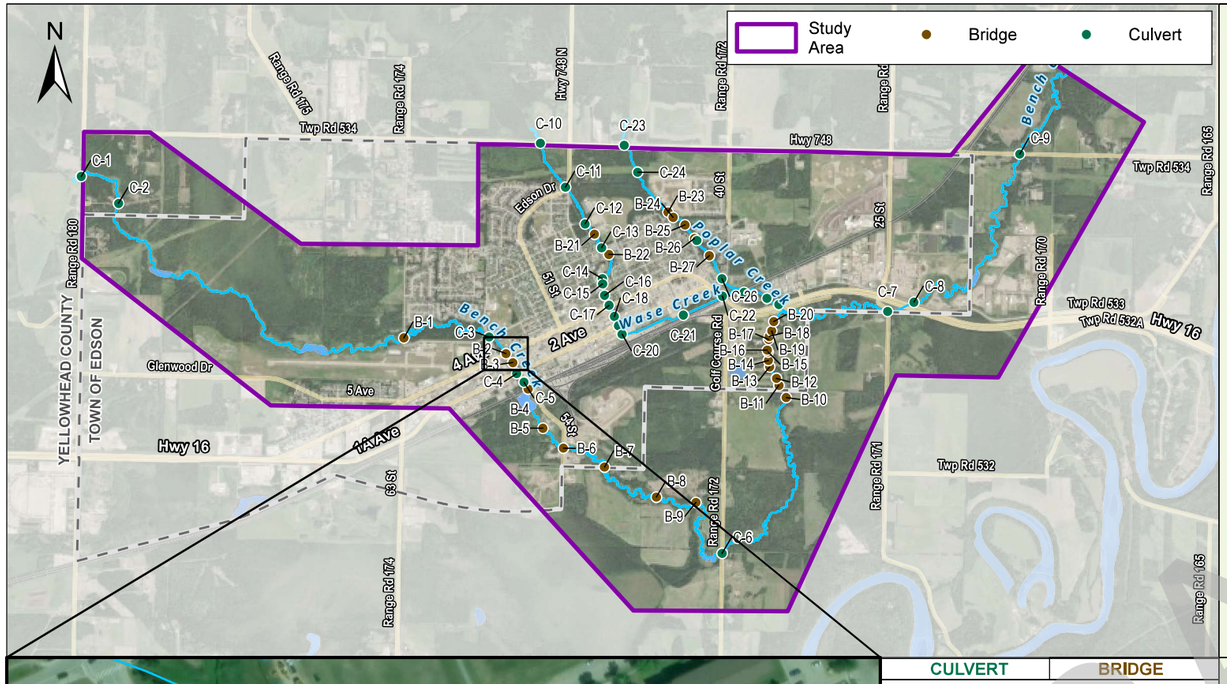
Figure A-11

Classification: Public

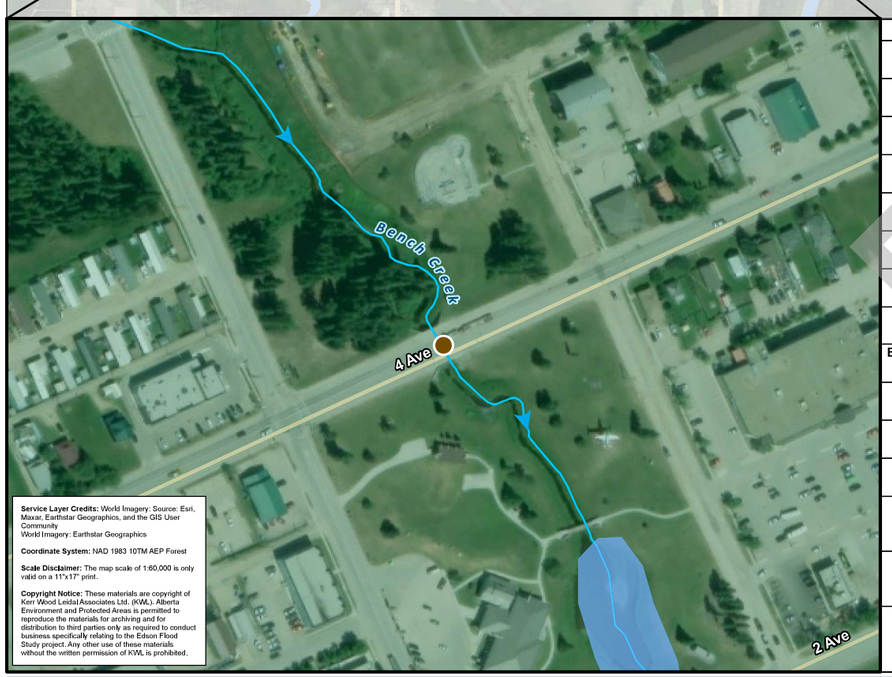
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-2	
DESCRIPTION: 4TH AVENUE (HIGHWAY 16)	
FILE #: 72123	
CROSSING TYPE: TRAFFIC	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 11.95
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 908.760
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 908.760
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 909.560
	D/S TOP OF CURB / GUARD RAIL ELEV: 909.560
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-2

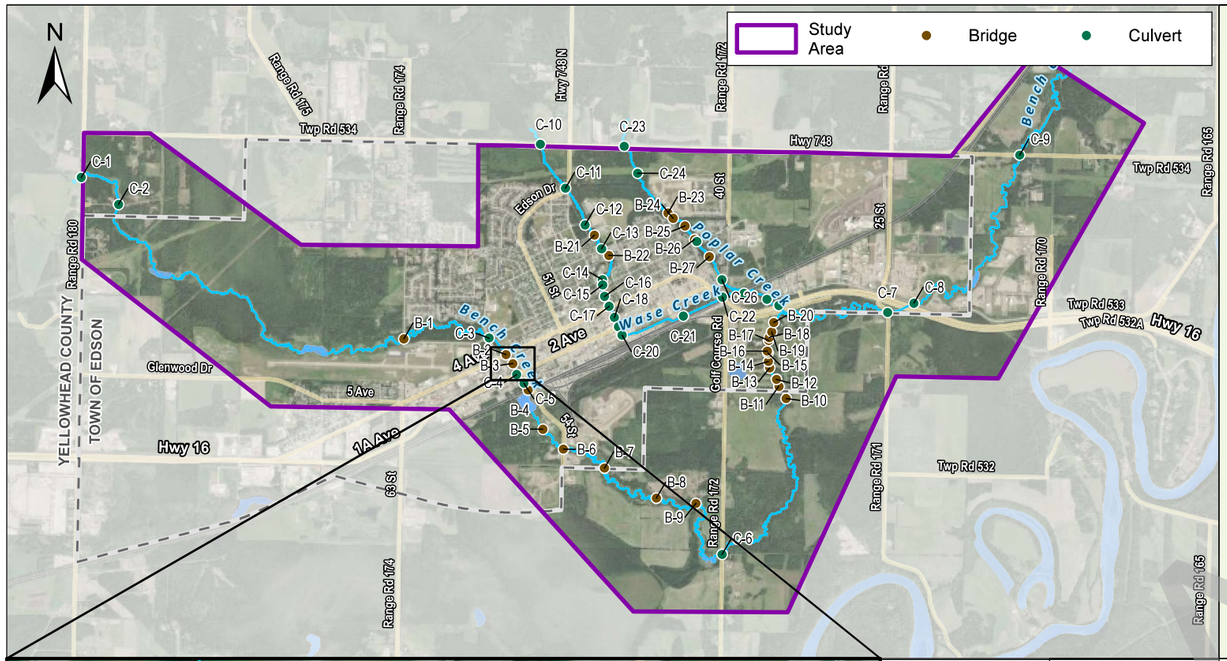
Figure A-12

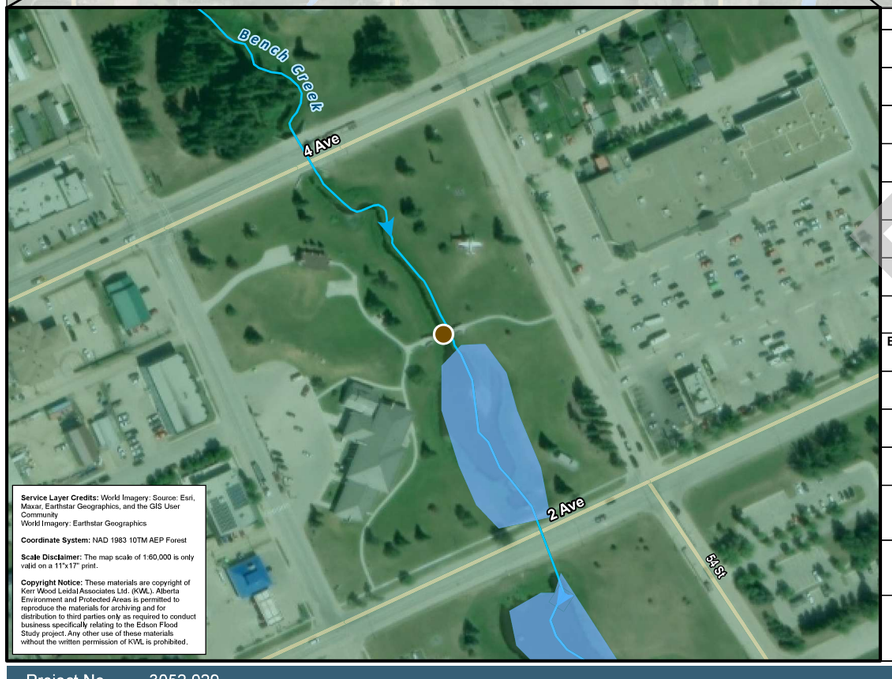
Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

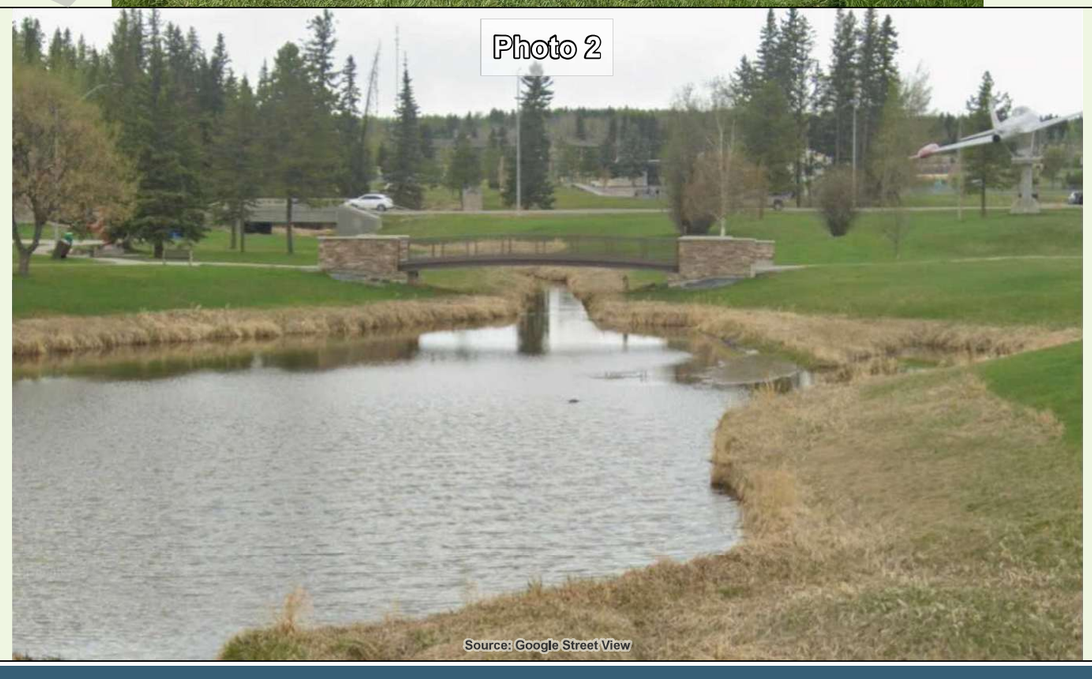
KERR WOOD LEIDAL consulting engineers





CULVERT	BRIDGE
ID: B-3	
DESCRIPTION: GALLOWAY STATION MUSEUM FOOTPATH	
FILE #: N/A	
CROSSING TYPE: PEDESTRIAN	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 20.21
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 908.120
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 908.120
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 908.520
	D/S TOP OF CURB / GUARD RAIL ELEV: 908.520
TOP OF ROADWAY NOTES:	





Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-3

Figure A-13

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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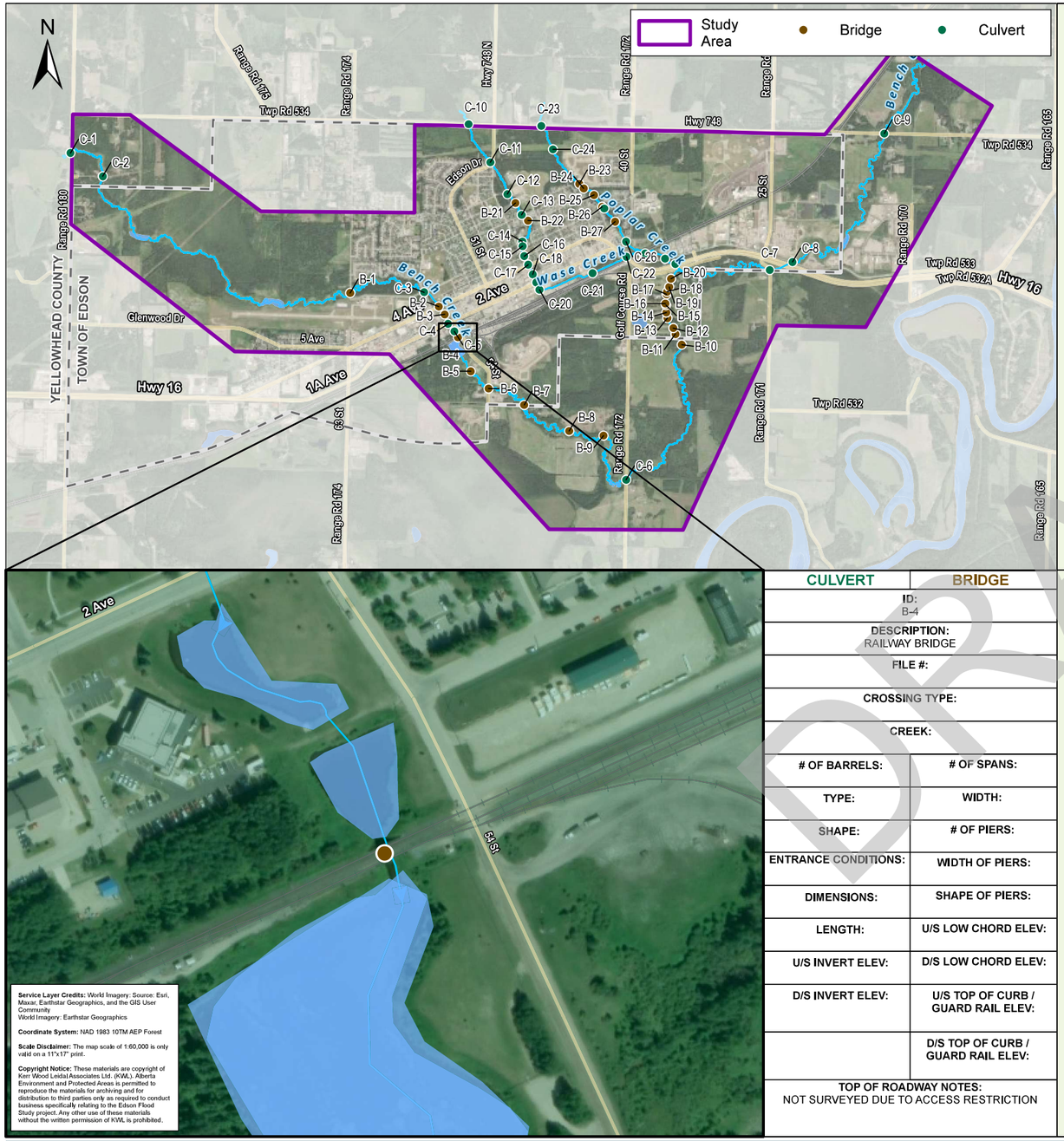
KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

Scale Disclaimer: The map scale of 1:60,000 is only valid on a 11"x17" print.

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CULVERT	BRIDGE
ID: B-4	
DESCRIPTION: RAILWAY BRIDGE	
FILE #:	
CROSSING TYPE:	
CREEK:	
# OF BARRELS:	# OF SPANS:
TYPE:	WIDTH:
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV:
U/S INVERT ELEV:	D/S LOW CHORD ELEV:
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:

TOP OF ROADWAY NOTES:
NOT SURVEYED DUE TO ACCESS RESTRICTION

Photo 1



Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-4

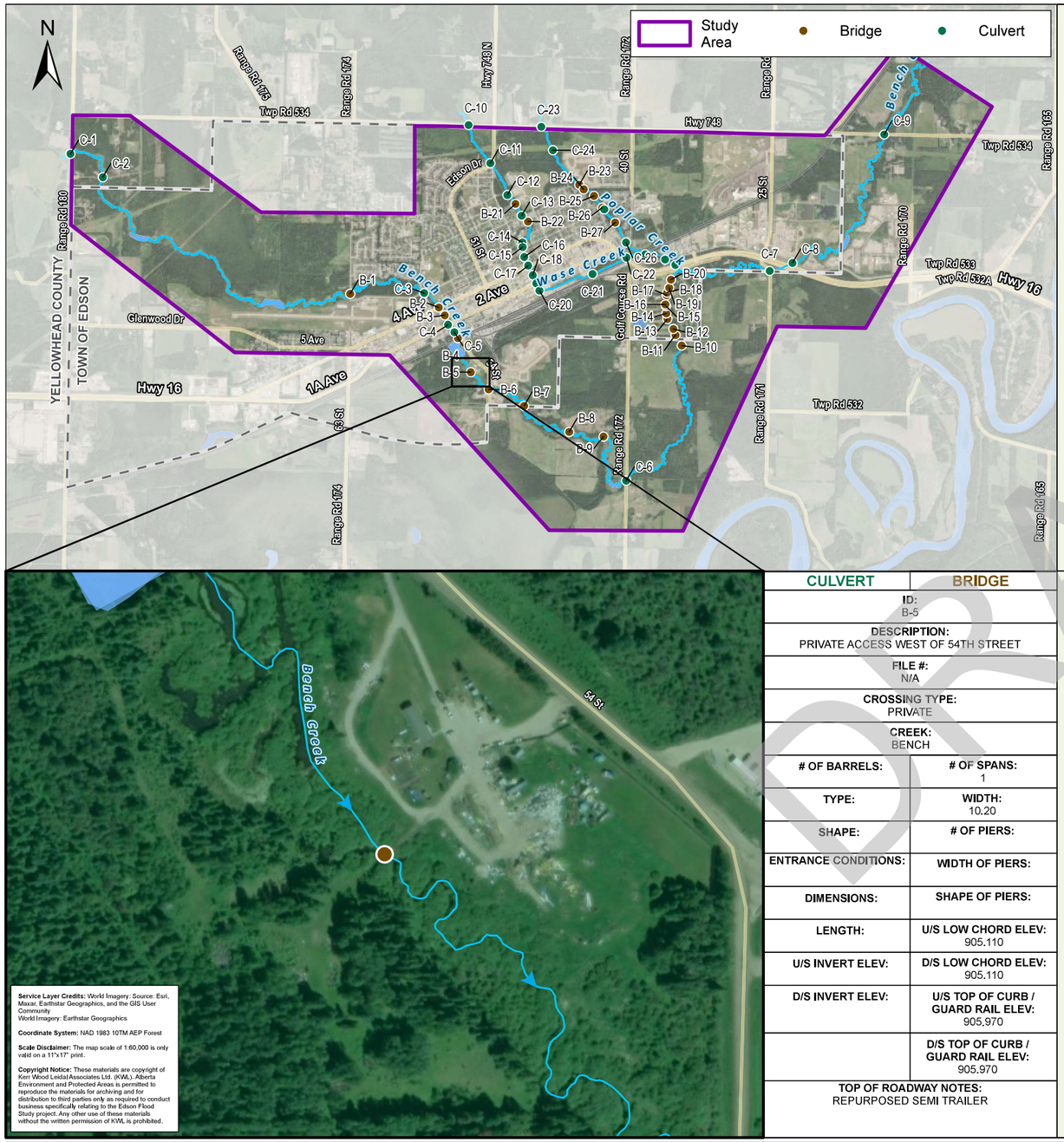
Figure A-14

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers



CULVERT	BRIDGE
ID: B-5	
DESCRIPTION: PRIVATE ACCESS WEST OF 54TH STREET	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 10.20
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 905.110
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 905.110
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 905.970
	D/S TOP OF CURB / GUARD RAIL ELEV: 905.970
TOP OF ROADWAY NOTES: REPURPOSED SEMI TRAILER	

Photo 1

NO PHOTO AVAILABLE

Photo 2

NO PHOTO AVAILABLE

Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

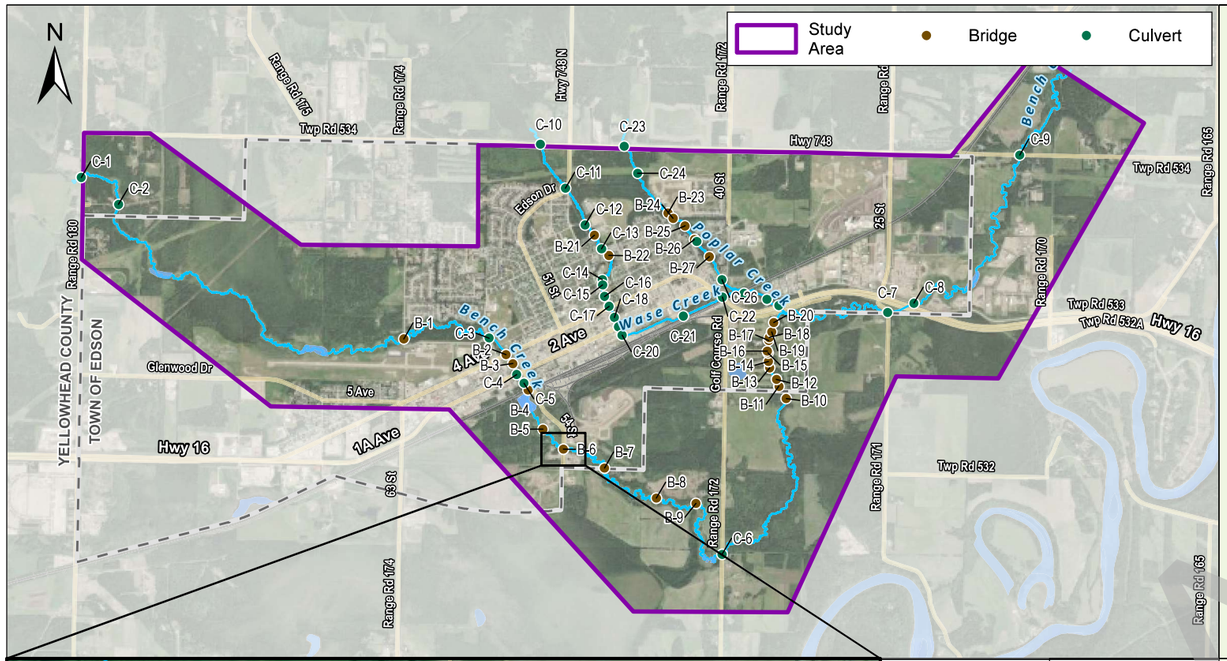
Bridge and Culvert Survey - B-5

Figure A-15

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: B-6	
DESCRIPTION: 54TH STREET	
FILE #: 74695	
CROSSING TYPE: TRAFFIC	
CREEK: BENCH	
# OF BARRELS:	**# OF SPANS:** 1
TYPE:	**WIDTH:** 6.11
SHAPE:	**# OF PIERS:** 16
ENTRANCE CONDITIONS:	**WIDTH OF PIERS:**
DIMENSIONS:	**SHAPE OF PIERS:** ROUND
LENGTH:	**U/S LOW CHORD ELEV:** 905.460
U/S INVERT ELEV:	**D/S LOW CHORD ELEV:** 905.460
D/S INVERT ELEV:	**U/S TOP OF CURB / GUARD RAIL ELEV:** 906.460
	D/S TOP OF CURB / GUARD RAIL ELEV: 906.460
TOP OF ROADWAY NOTES: GRAVEL ROAD	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-6

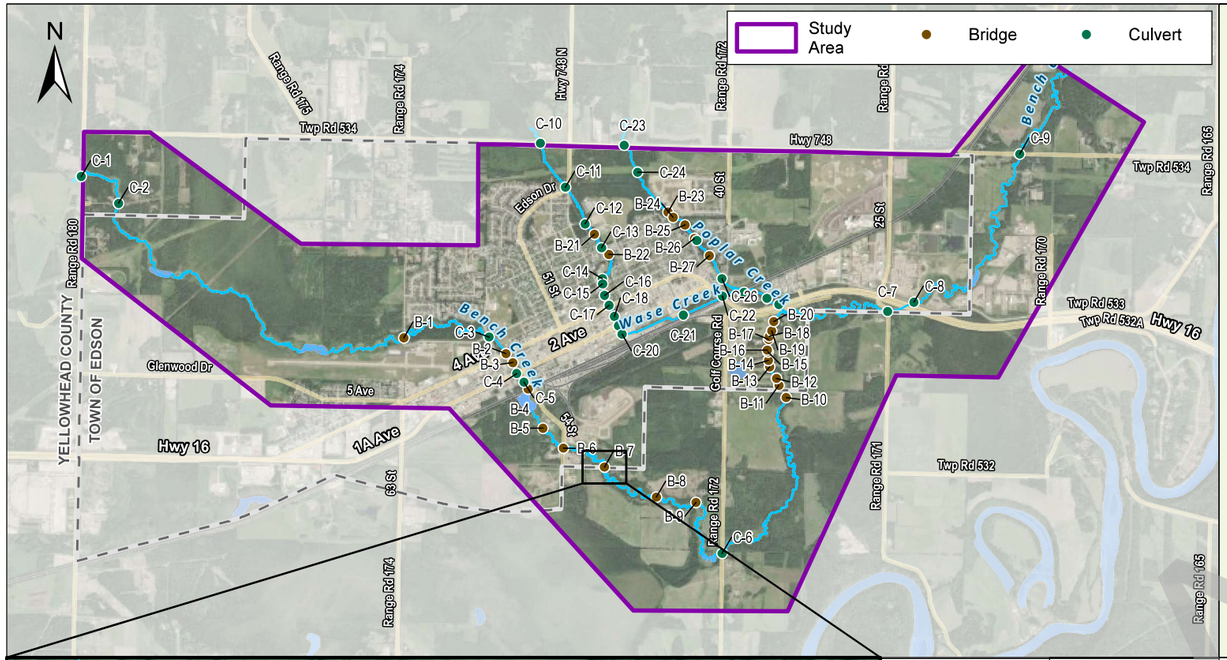
Figure A-16

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

Scale Disclaimer: The map scale of 1:60,000 is only valid on a 11"x17" print.

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CULVERT	BRIDGE
ID: B-7	
DESCRIPTION: PRIVATE ACCESS EAST OF 54TH STREET	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 9.41
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 904.070
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 904.070
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 904.590
	D/S TOP OF CURB / GUARD RAIL ELEV: 904.590
TOP OF ROADWAY NOTES:	





Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-7

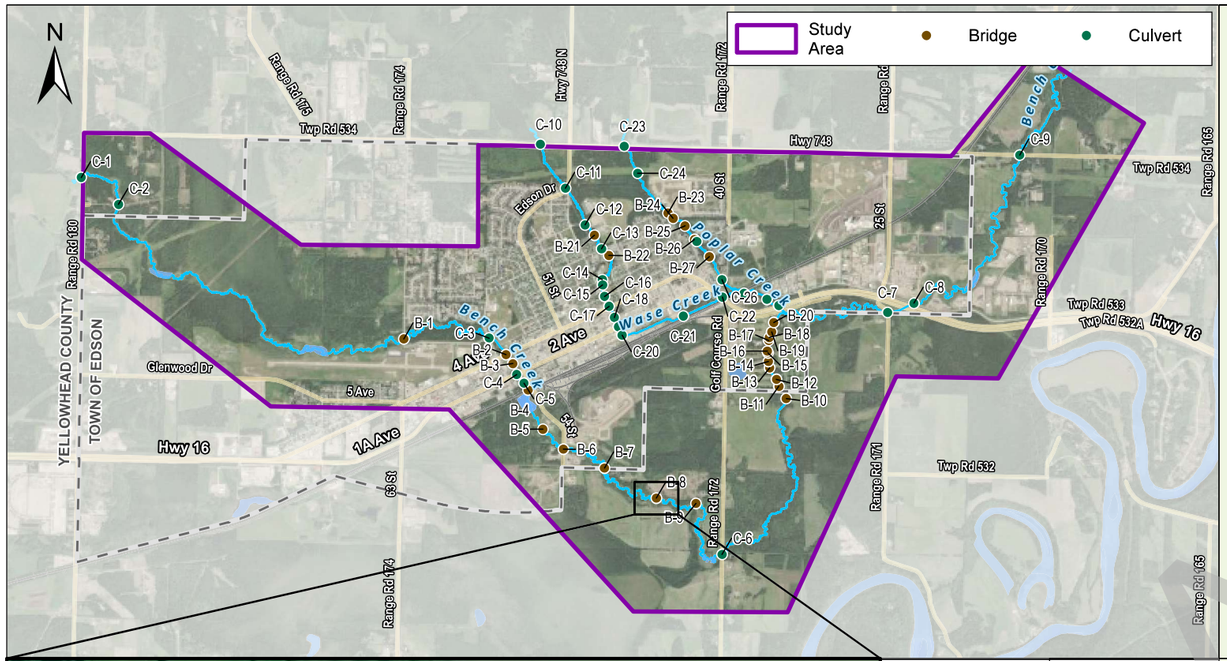
Figure A-17

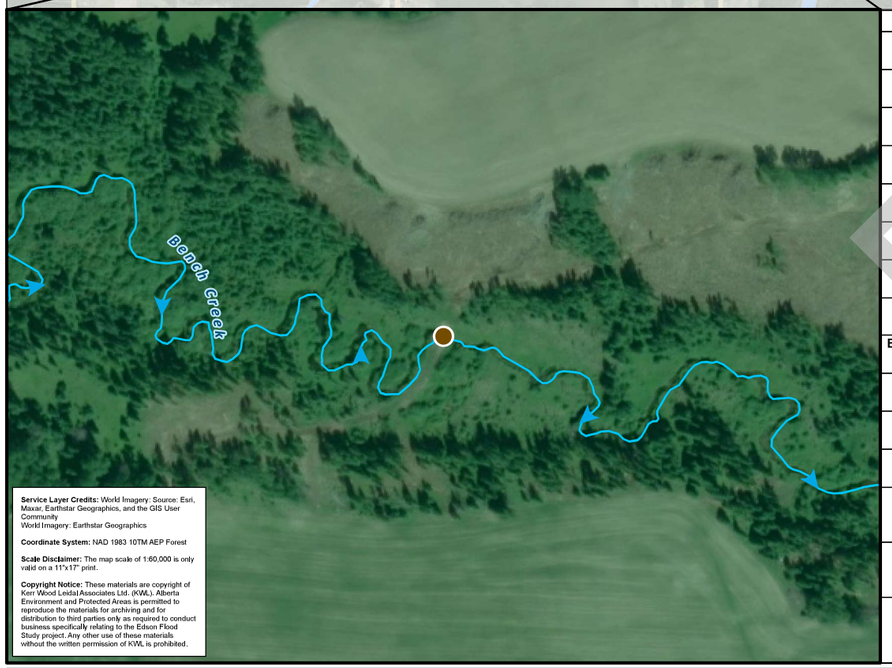
Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: B-8	
DESCRIPTION: PRIVATE ACCESS EAST OF LANDFILL	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	**# OF SPANS:** 1
TYPE:	**WIDTH:** 4.64
SHAPE:	**# OF PIERS:**
ENTRANCE CONDITIONS:	**WIDTH OF PIERS:**
DIMENSIONS:	**SHAPE OF PIERS:**
LENGTH:	**U/S LOW CHORD ELEV:** 902.160
U/S INVERT ELEV:	**D/S LOW CHORD ELEV:** 902.160
D/S INVERT ELEV:	**U/S TOP OF CURB / GUARD RAIL ELEV:** 901.650
	D/S TOP OF CURB / GUARD RAIL ELEV: 901.650
TOP OF ROADWAY NOTES:	

Photo 1

NO PHOTO AVAILABLE

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-8

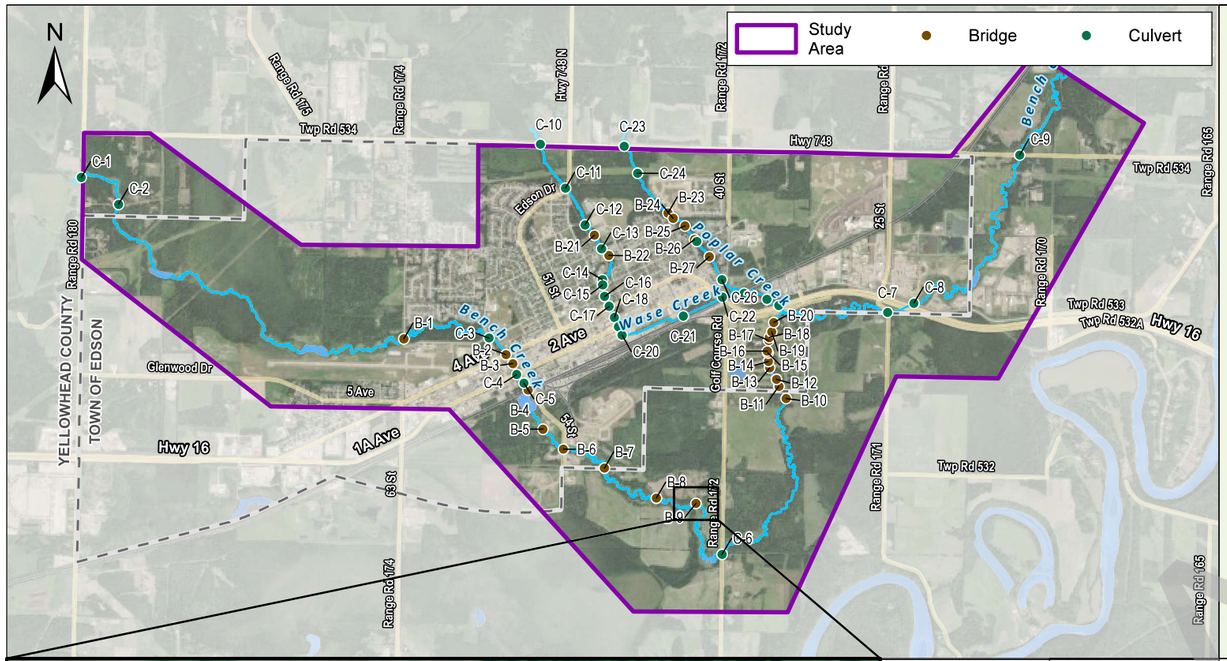
Figure A-18

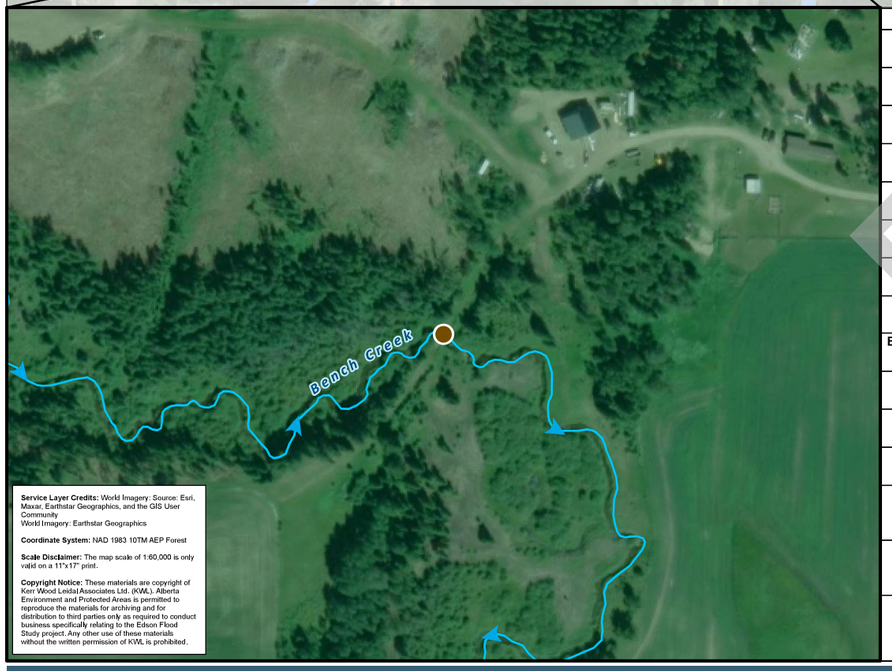
Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

Scale Disclaimer: The map scale of 1:60,000 is only valid on a 11"x17" print.

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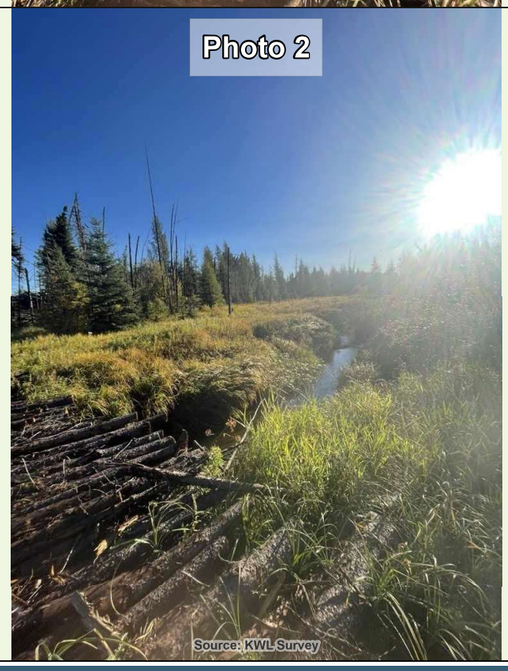
CULVERT	BRIDGE
ID: B-9	
DESCRIPTION: PRIVATE ACCESS WEST OF RANGE ROAD 172	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	**# OF SPANS:** 1
TYPE:	**WIDTH:** 8.53
SHAPE:	**# OF PIERS:**
ENTRANCE CONDITIONS:	**WIDTH OF PIERS:**
DIMENSIONS:	**SHAPE OF PIERS:**
LENGTH:	**U/S LOW CHORD ELEV:** 900.580
U/S INVERT ELEV:	**D/S LOW CHORD ELEV:** 900.580
D/S INVERT ELEV:	**U/S TOP OF CURB / GUARD RAIL ELEV:** 901.090
	D/S TOP OF CURB / GUARD RAIL ELEV: 901.090
TOP OF ROADWAY NOTES:	





Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-9

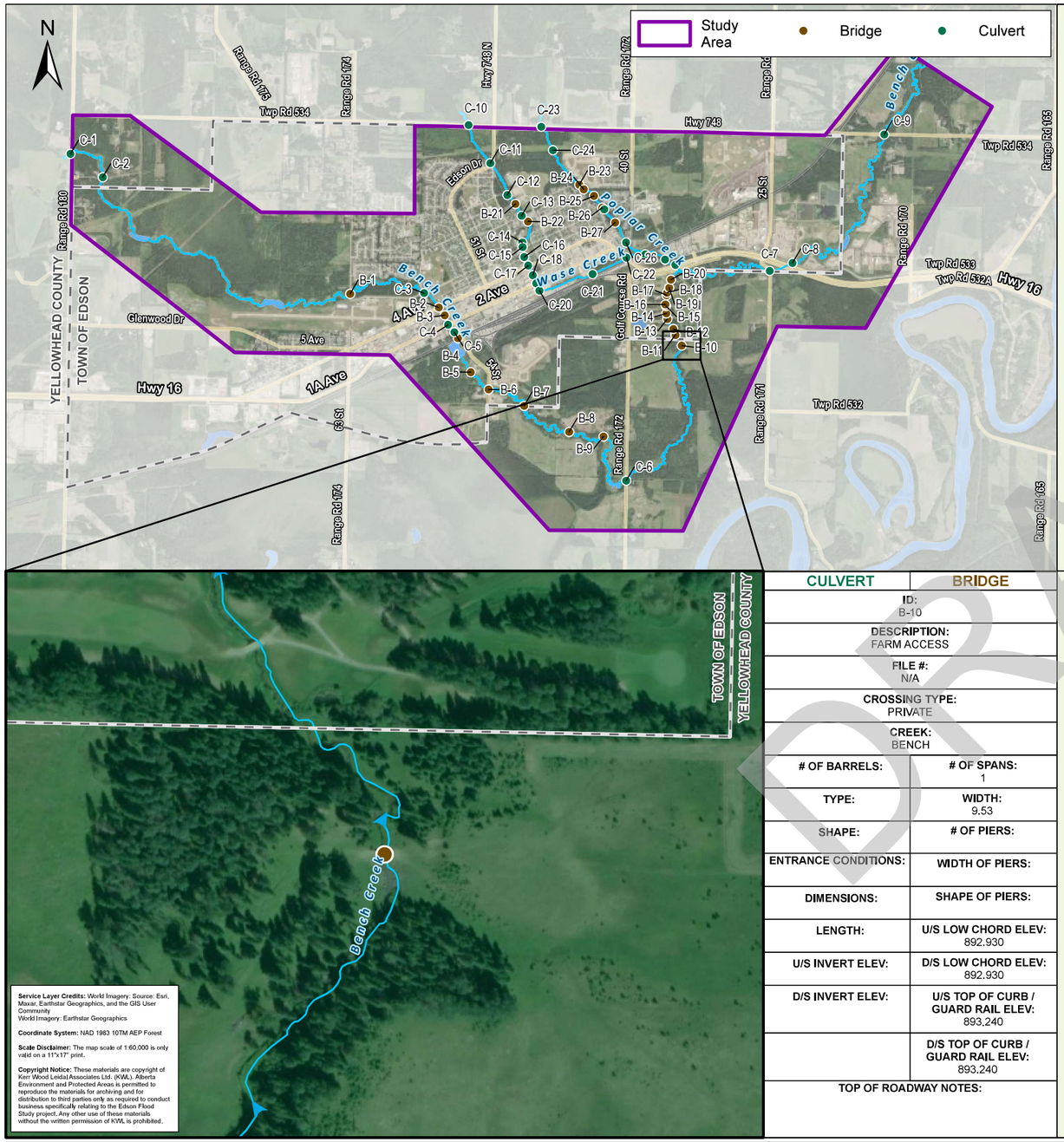
Figure A-19

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers



CULVERT	BRIDGE
ID: B-10	
DESCRIPTION: FARM ACCESS	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 9.53
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 892.930
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 892.930
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 893.240
	D/S TOP OF CURB / GUARD RAIL ELEV: 893.240
TOP OF ROADWAY NOTES:	

Photo 1

NO PHOTO AVAILABLE

Photo 2

NO PHOTO AVAILABLE

Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

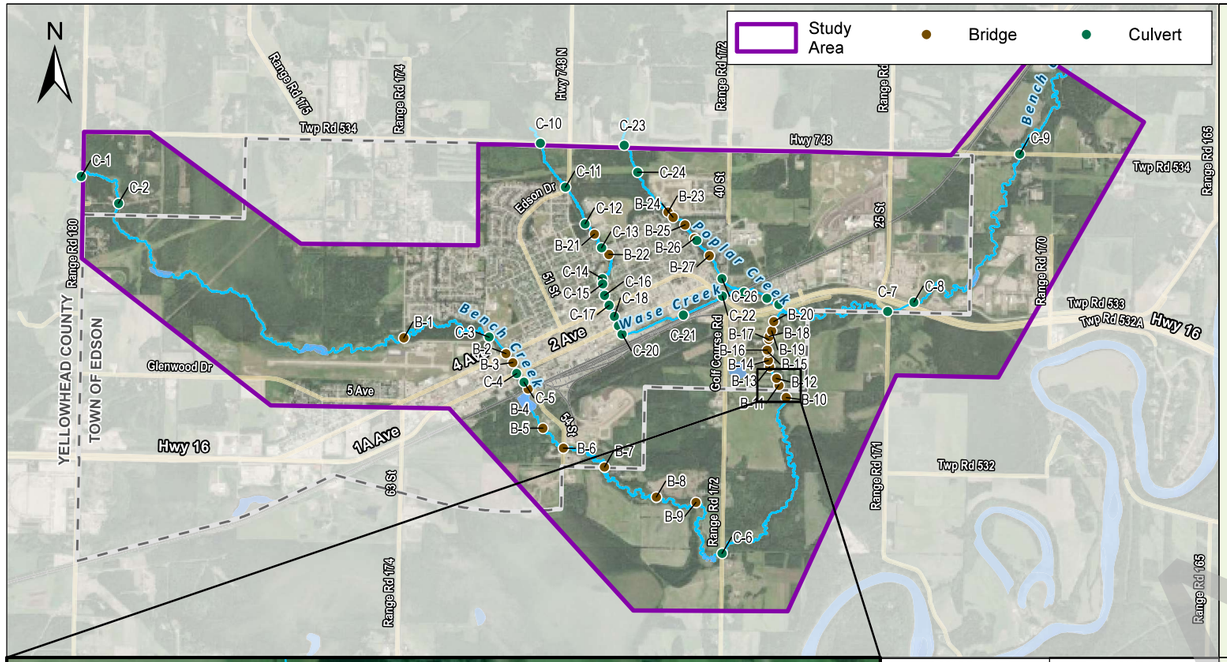
Bridge and Culvert Survey - B-10

Figure A-20

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

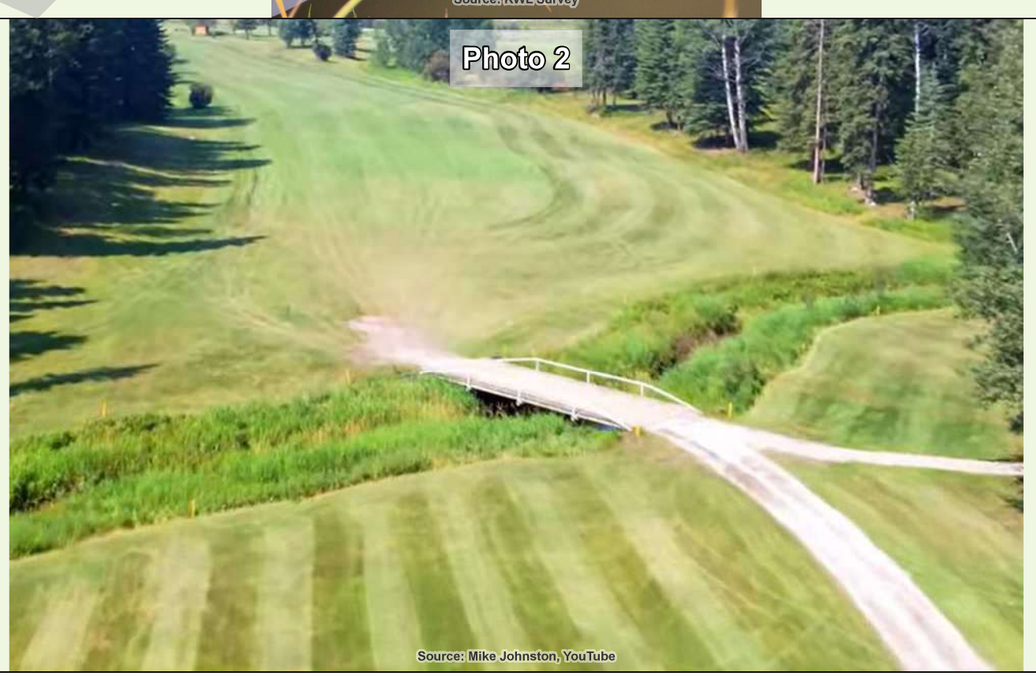
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-11	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 11.73
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 892.350
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 892.350
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 892.740
	D/S TOP OF CURB / GUARD RAIL ELEV: 892.740
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-11

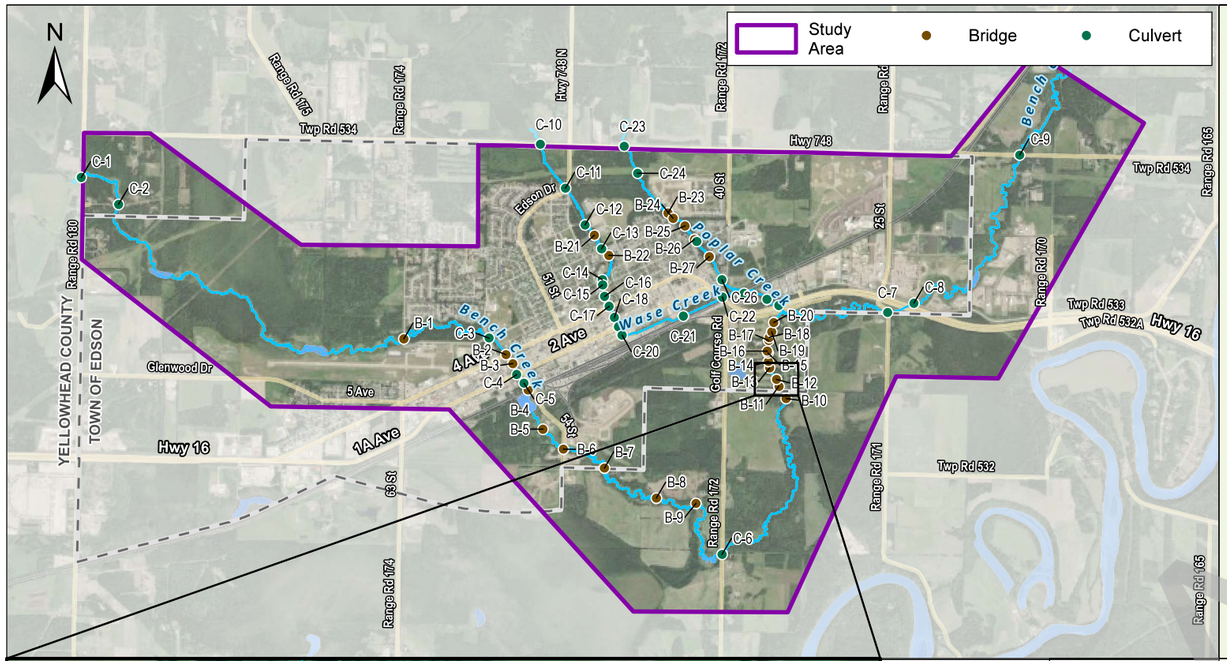
Figure A-21

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-12	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 9.59
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 892.520
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 892.520
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 892.860
	D/S TOP OF CURB / GUARD RAIL ELEV: 892.860
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-12

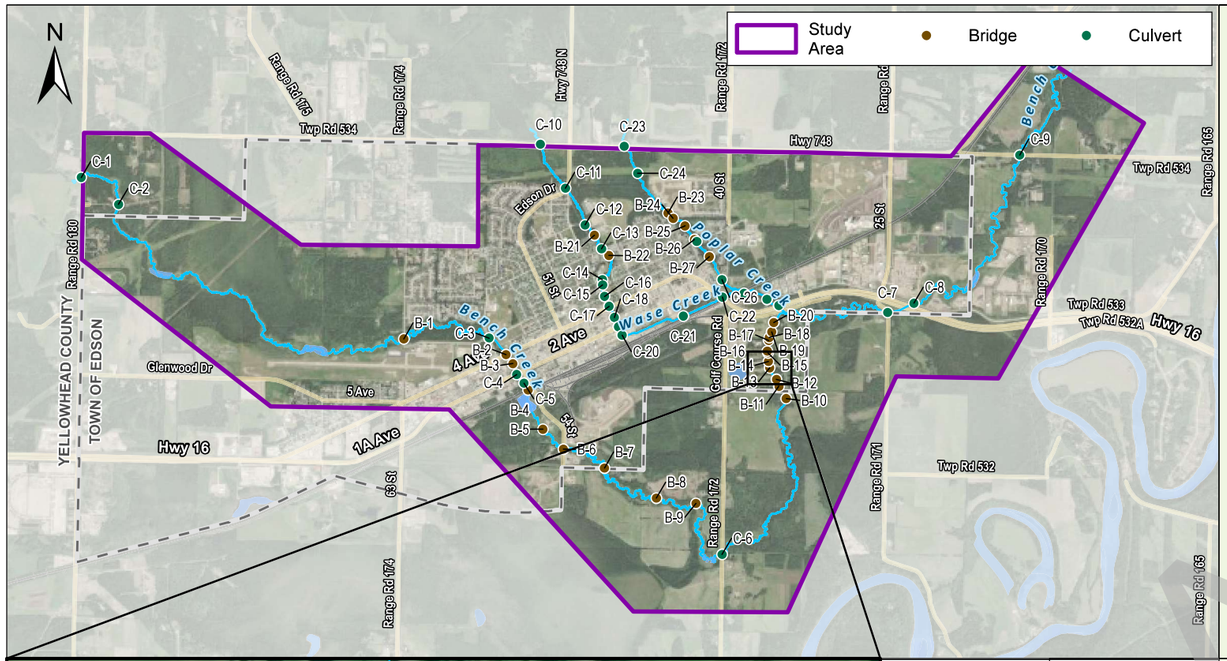
Figure A-22

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





CULVERT	BRIDGE
ID: B-13	
DESCRIPTION: GOLF COURSE PATH (SEA CAN)	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 13.75
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 892.550
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 892.550
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 895.040
	D/S TOP OF CURB / GUARD RAIL ELEV: 895.040
TOP OF ROADWAY NOTES:	

Photo 1



Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-13

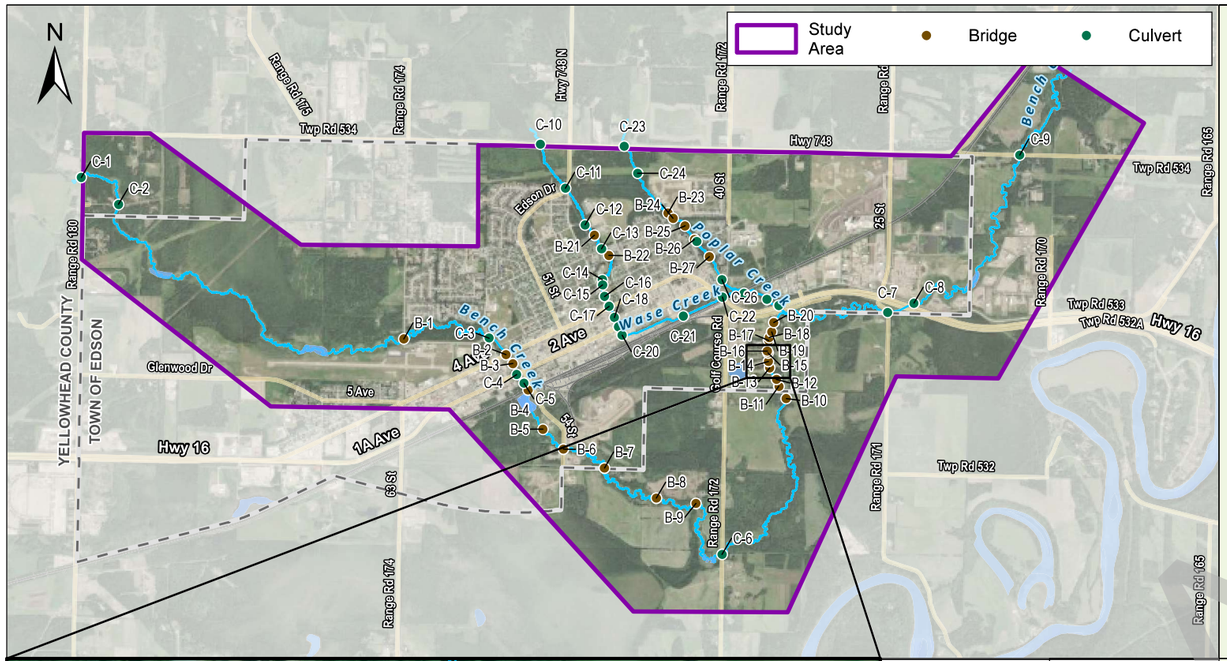
Figure A-23

Classification: Public

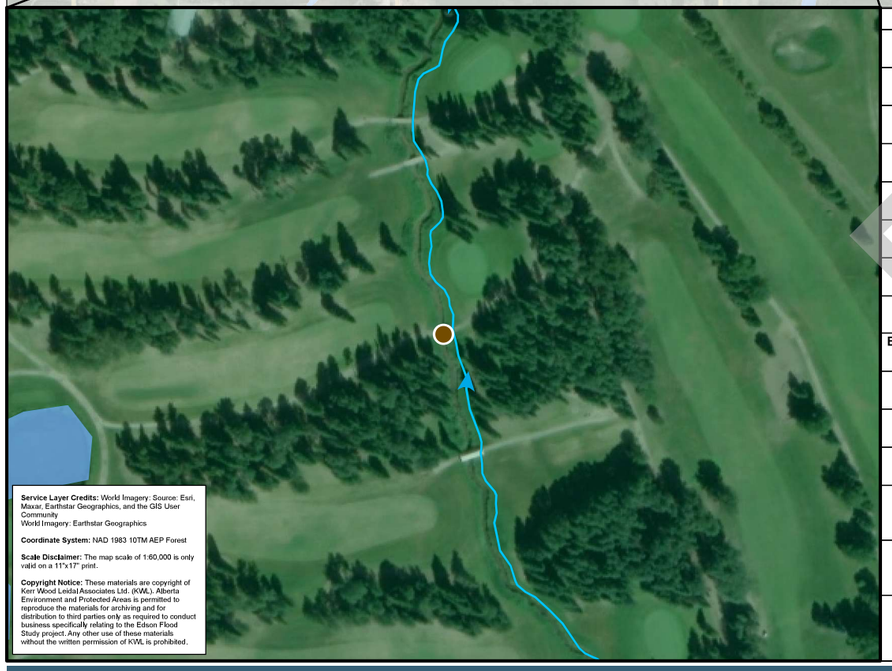
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

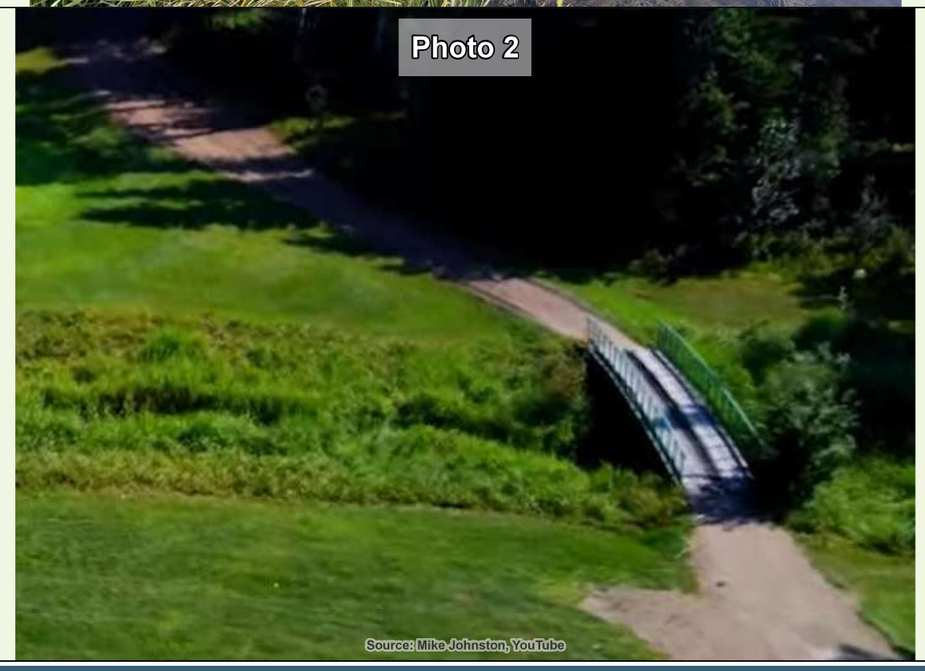
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-14	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 9.98
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 892.000
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 892.000
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 892.270
	D/S TOP OF CURB / GUARD RAIL ELEV: 892.270
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-14

Figure A-24

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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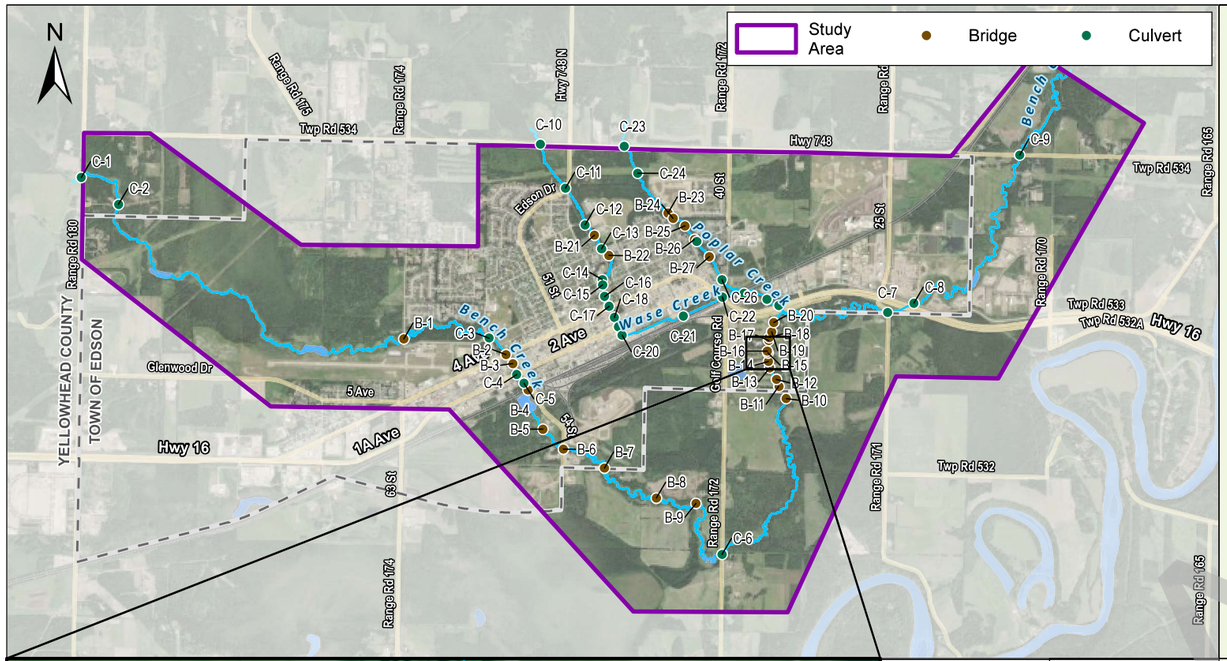
KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

Scale Disclaimer: The map scale of 1:60,000 is only valid on a 11"x17" print.

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CULVERT	BRIDGE
ID: B-15	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	**# OF SPANS:** 1
TYPE:	**WIDTH:** 10.18
SHAPE:	**# OF PIERS:**
ENTRANCE CONDITIONS:	**WIDTH OF PIERS:**
DIMENSIONS:	**SHAPE OF PIERS:**
LENGTH:	**U/S LOW CHORD ELEV:** 892.710
U/S INVERT ELEV:	**D/S LOW CHORD ELEV:** 892.710
D/S INVERT ELEV:	**U/S TOP OF CURB / GUARD RAIL ELEV:** 893.040
	D/S TOP OF CURB / GUARD RAIL ELEV: 893.040
TOP OF ROADWAY NOTES: ARCHED	

Photo 1



Source: Mike Johnston, YouTube

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-15

Figure A-25

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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KERR WOOD LEIDAL consulting engineers

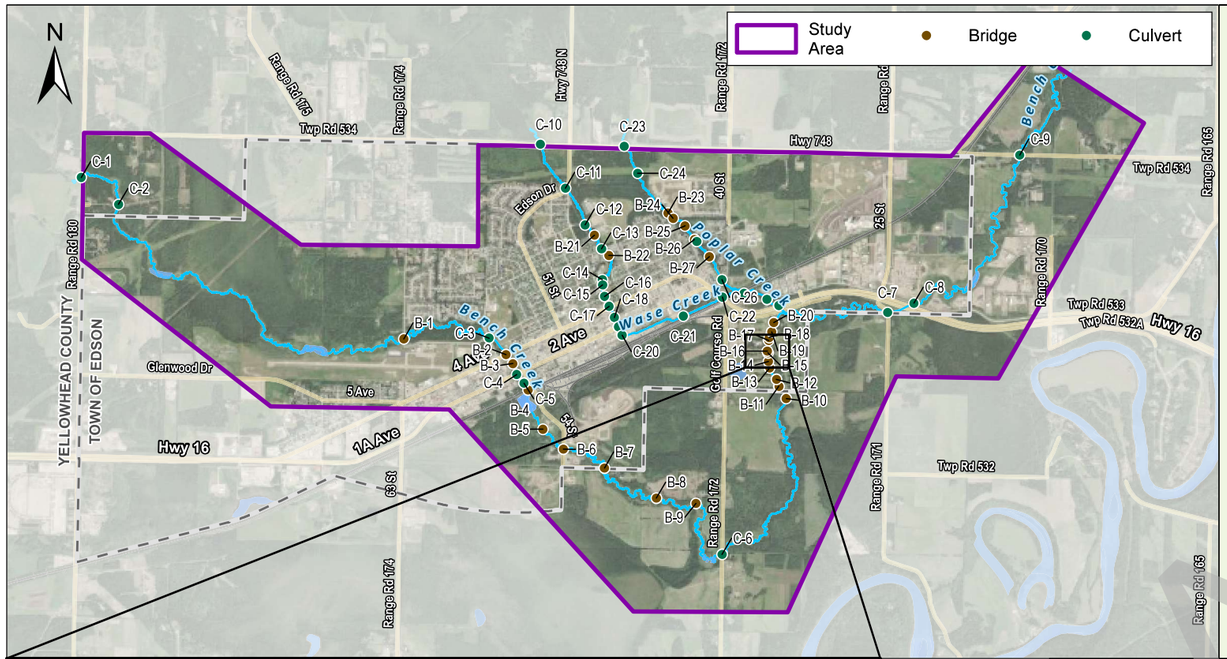

Photo 1





CULVERT	BRIDGE
ID: B-16	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 10.24
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 892.340
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 892.340
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 892.600
	D/S TOP OF CURB / GUARD RAIL ELEV: 892.600
TOP OF ROADWAY NOTES:	

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-16

Figure A-26

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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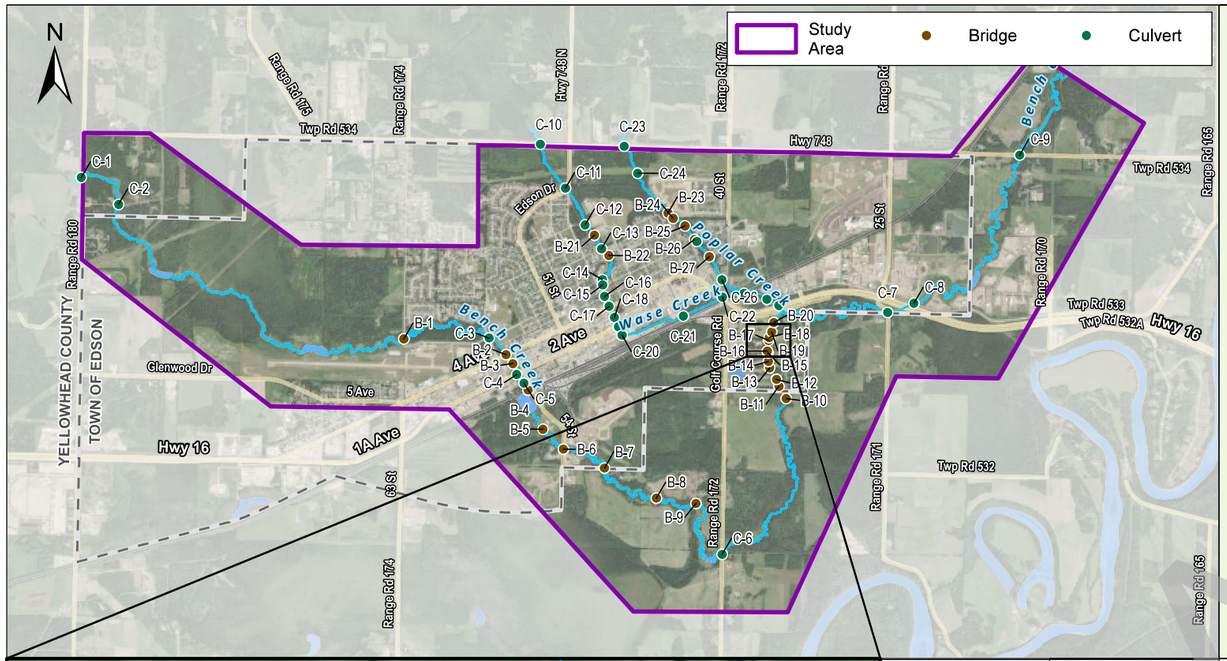
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-17	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 11.94
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 891.610
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 891.610
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 892.140
	D/S TOP OF CURB / GUARD RAIL ELEV: 892.140
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-17

Figure A-27

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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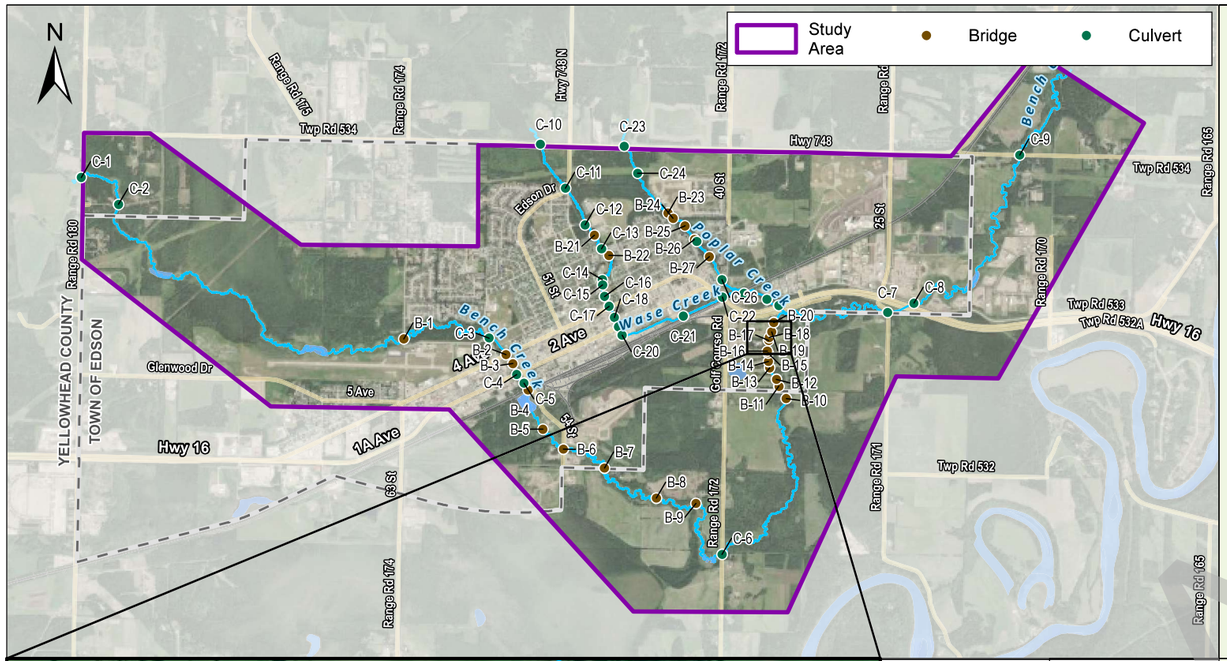
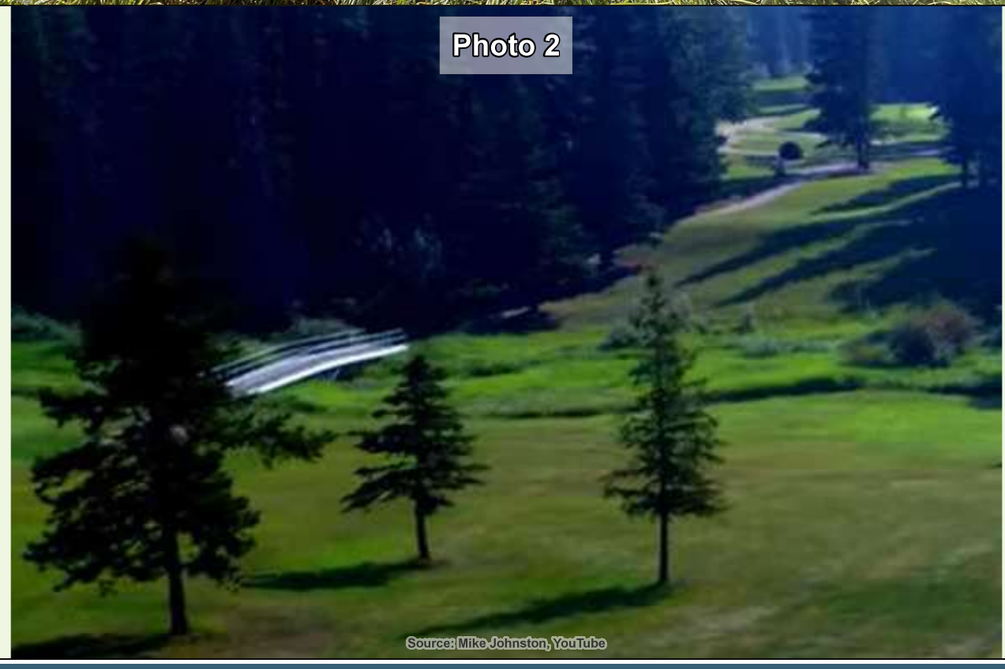
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-18	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 9.78
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 892.040
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 892.040
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 892.220
	D/S TOP OF CURB / GUARD RAIL ELEV: 892.220
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-18

Figure A-28

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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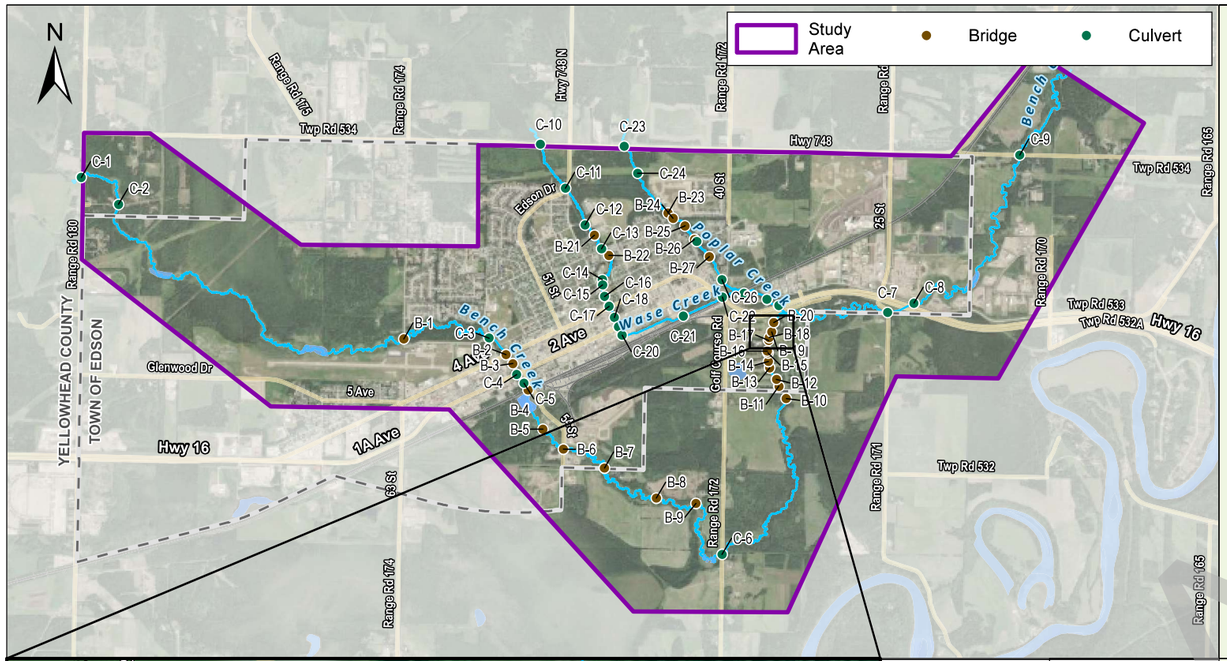
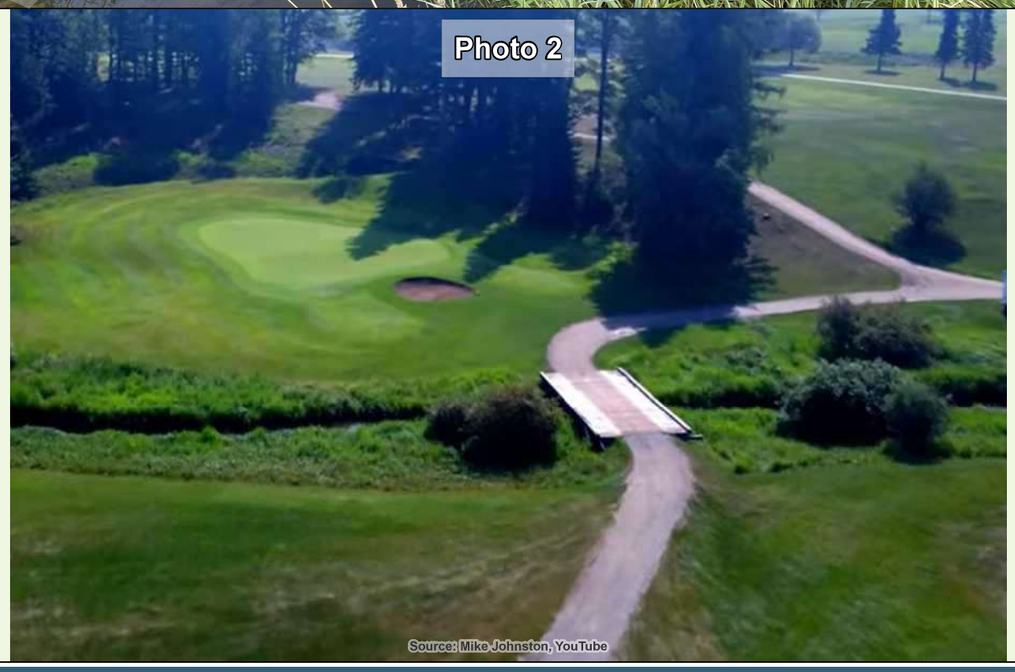
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-19	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 12.34
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 891.650
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 891.650
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 892.120
	D/S TOP OF CURB / GUARD RAIL ELEV: 892.120
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-19

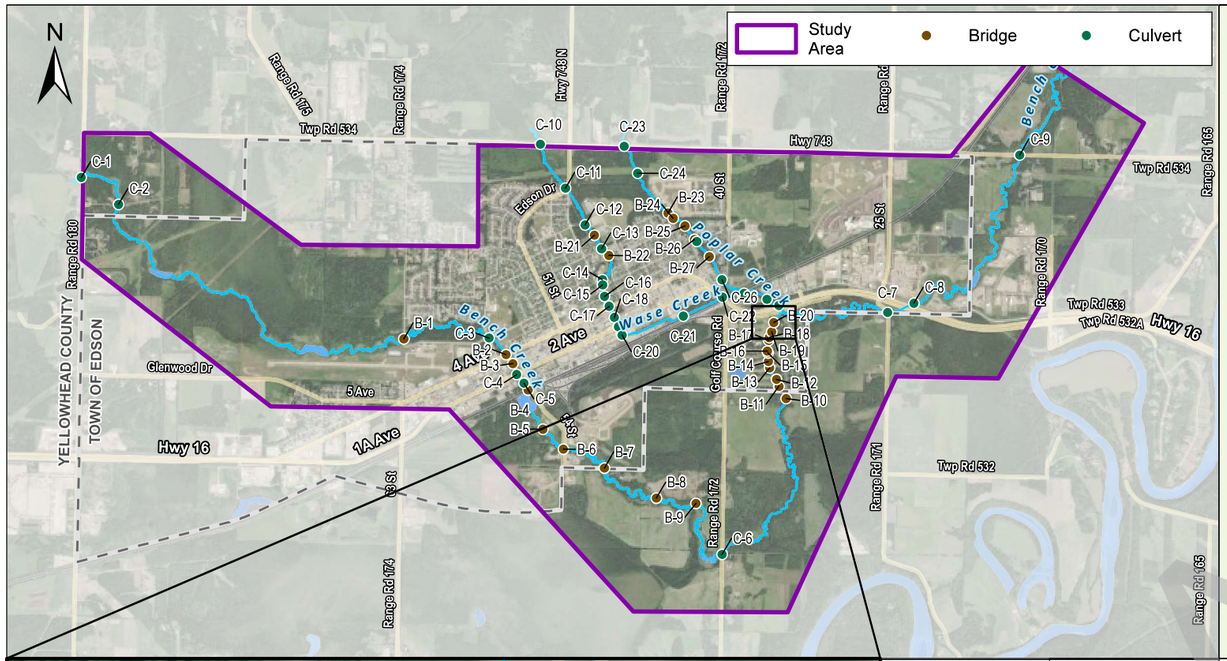
Figure A-29

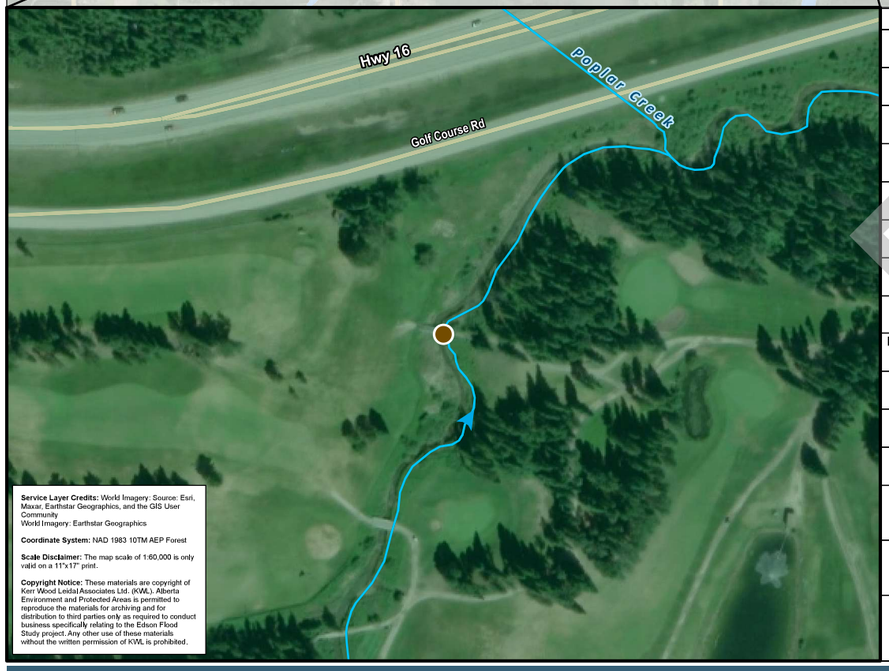
Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: B-20	
DESCRIPTION: GOLF COURSE PATH	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: BENCH	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 20.47
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 891.650
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 891.650
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 891.910
	D/S TOP OF CURB / GUARD RAIL ELEV: 891.910
TOP OF ROADWAY NOTES:	

Photo 1



Source: Mike Johnston, YouTube

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-20

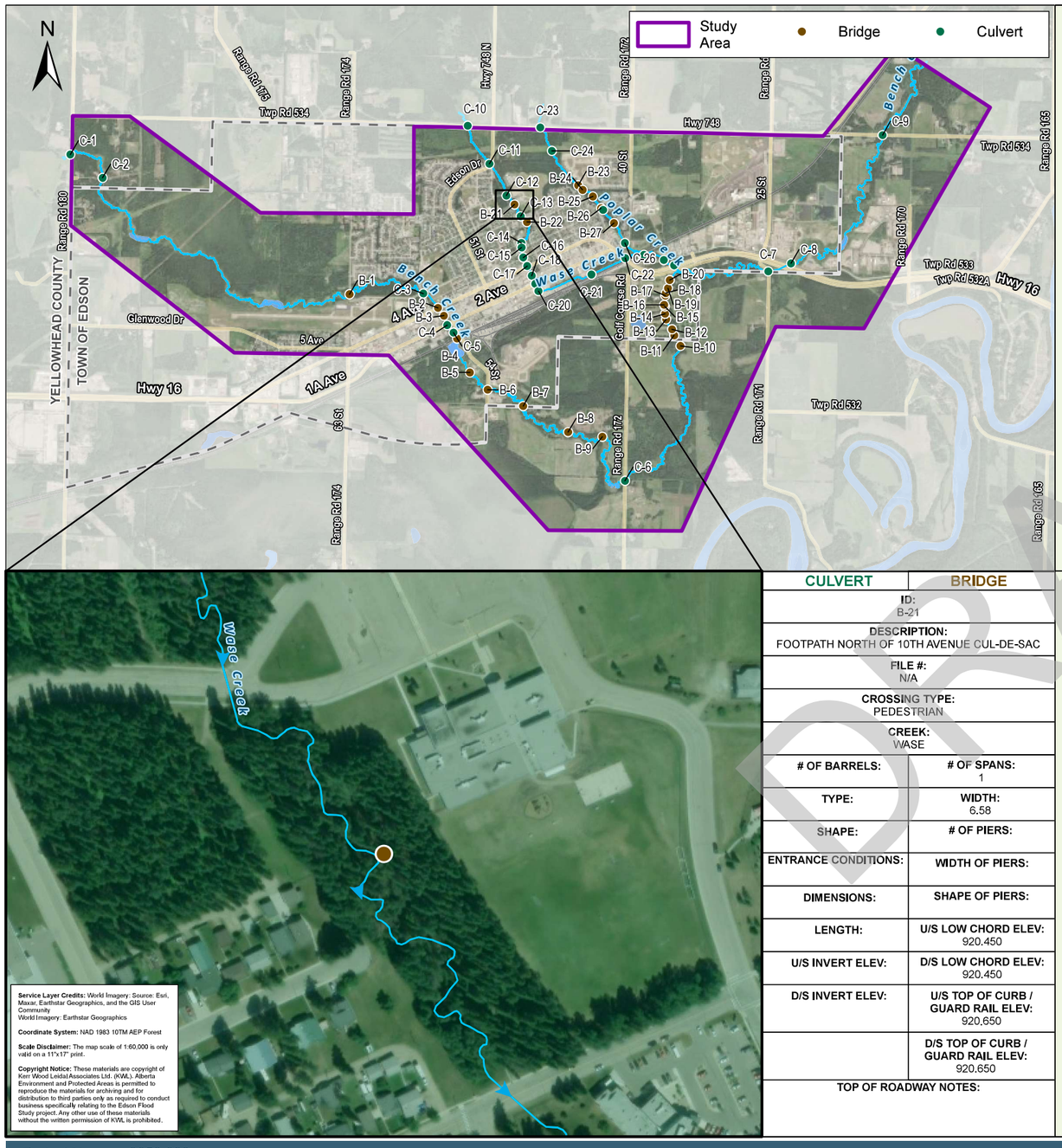
Figure A-30

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: B-21	
DESCRIPTION: FOOTPATH NORTH OF 10TH AVENUE CUL-DE-SAC	
FILE #: N/A	
CROSSING TYPE: PEDESTRIAN	
CREEK: WASE	
# OF BARRELS:	**# OF SPANS:** 1
TYPE:	**WIDTH:** 6.58
SHAPE:	**# OF PIERS:**
ENTRANCE CONDITIONS:	**WIDTH OF PIERS:**
DIMENSIONS:	**SHAPE OF PIERS:**
LENGTH:	**U/S LOW CHORD ELEV:** 920.450
U/S INVERT ELEV:	**D/S LOW CHORD ELEV:** 920.450
D/S INVERT ELEV:	**U/S TOP OF CURB / GUARD RAIL ELEV:** 920.650
	D/S TOP OF CURB / GUARD RAIL ELEV: 920.650
TOP OF ROADWAY NOTES:	

Photo 1

NO PHOTO AVAILABLE

Source: KWL Survey

Photo 2

NO PHOTO AVAILABLE

Source: KWL Survey

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-21

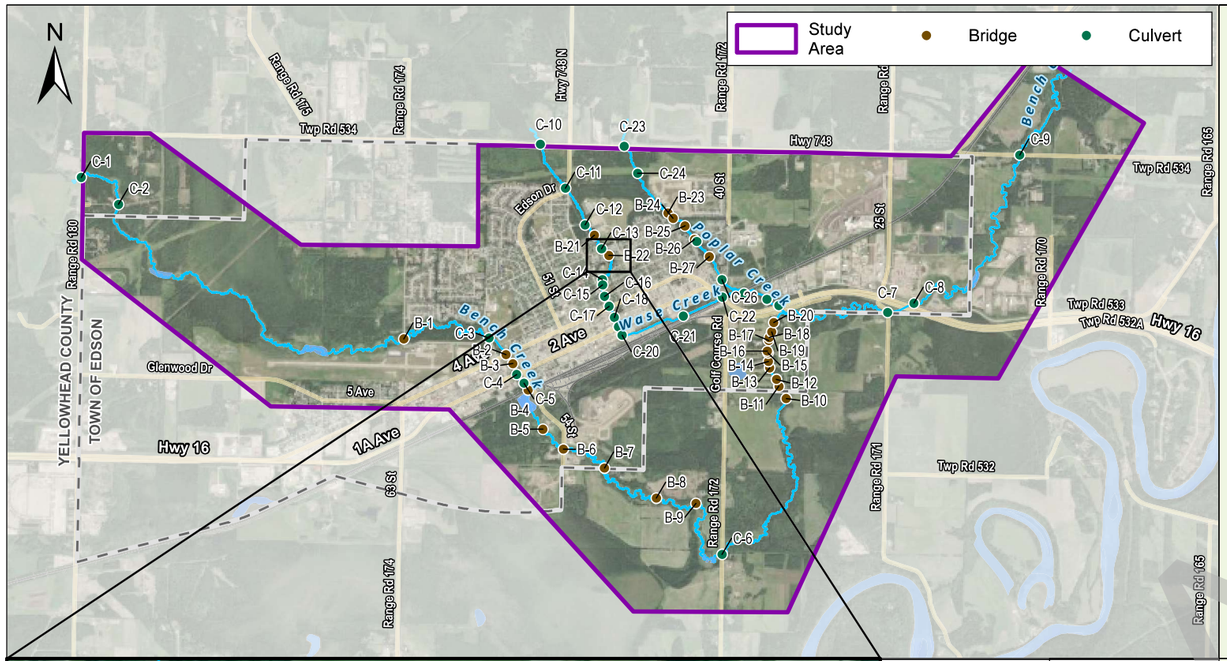
Figure A-31

Classification: Public

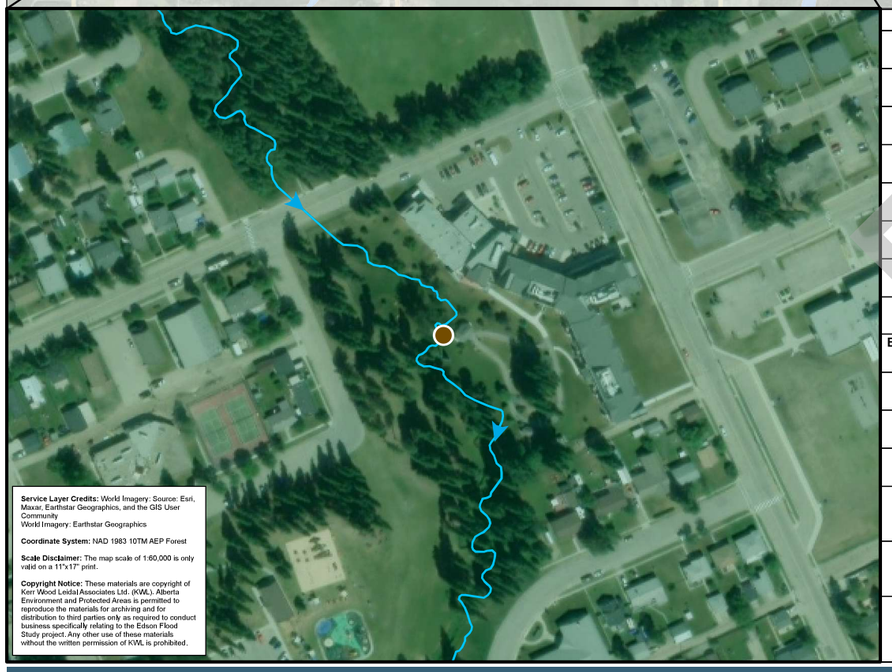
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

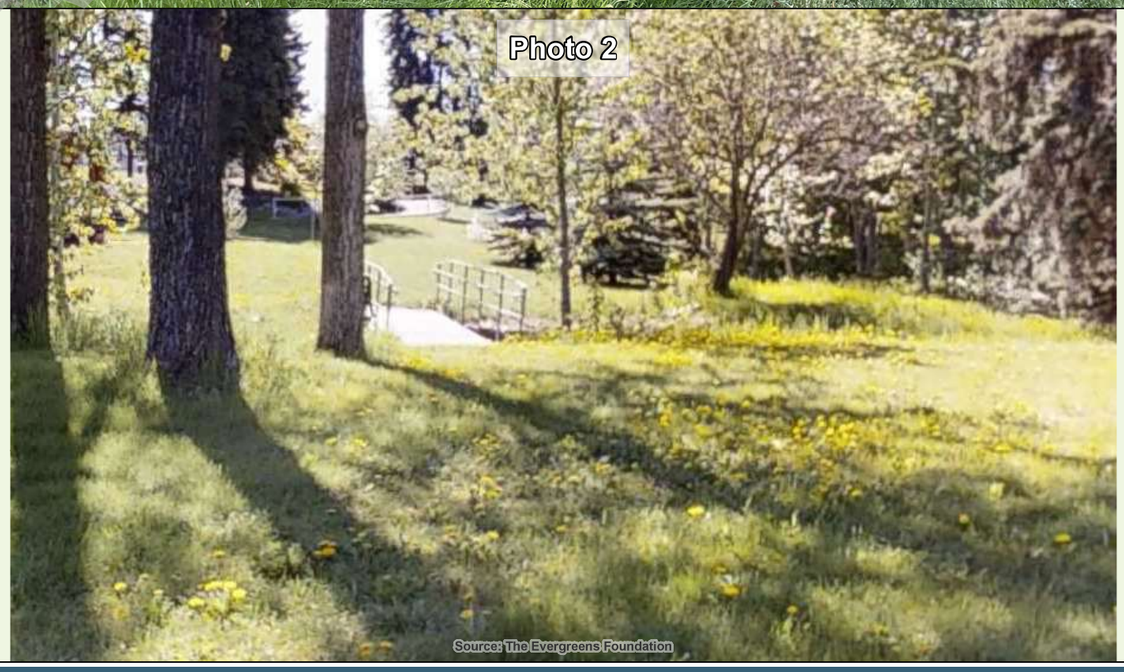
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-22	
DESCRIPTION: PARKLAND LODGE	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: WASE	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 5.39
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 918.200
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 918.000
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 918.300
	D/S TOP OF CURB / GUARD RAIL ELEV: 918.100
TOP OF ROADWAY NOTES: WOOD DECKING	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-22

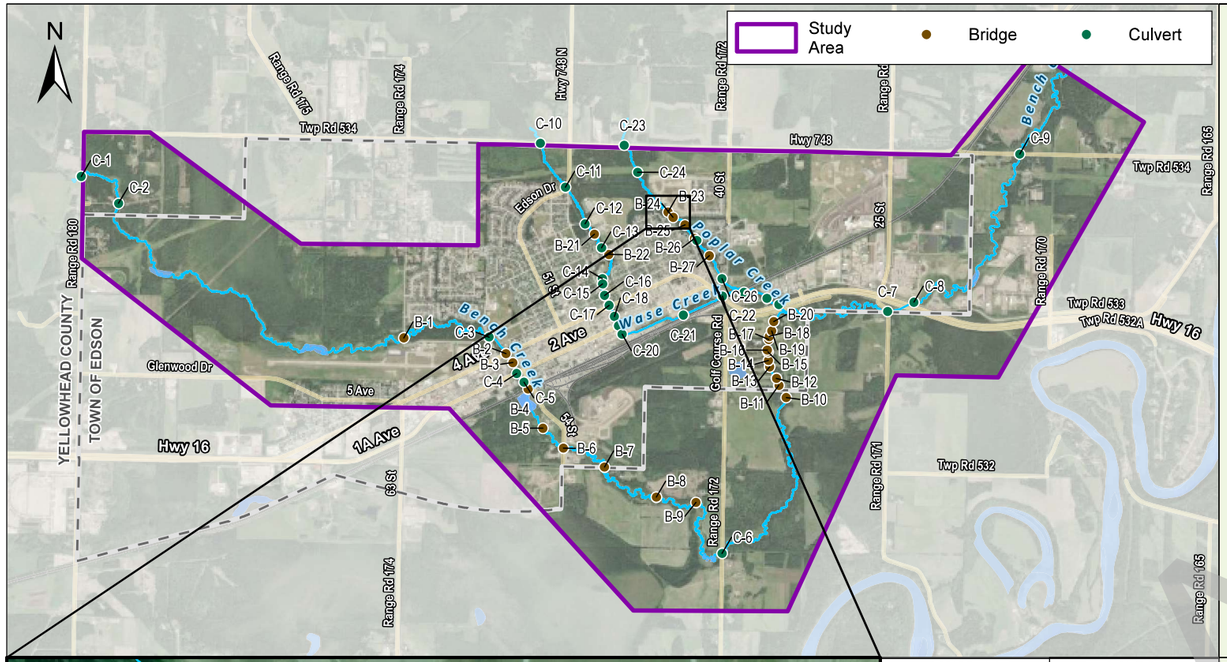
Figure A-32

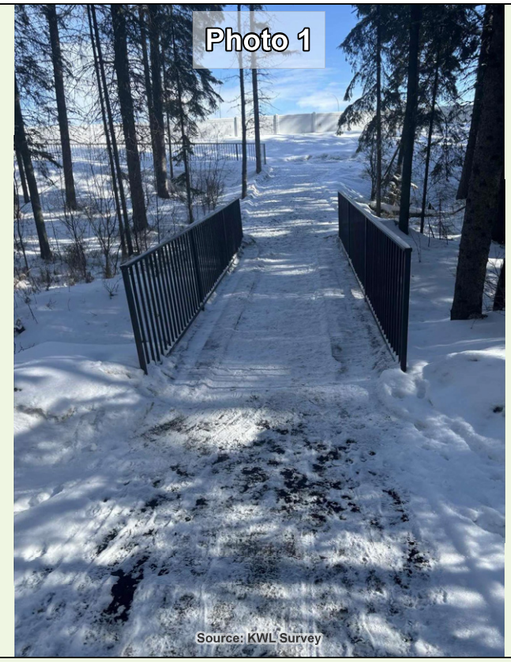
Classification: Public

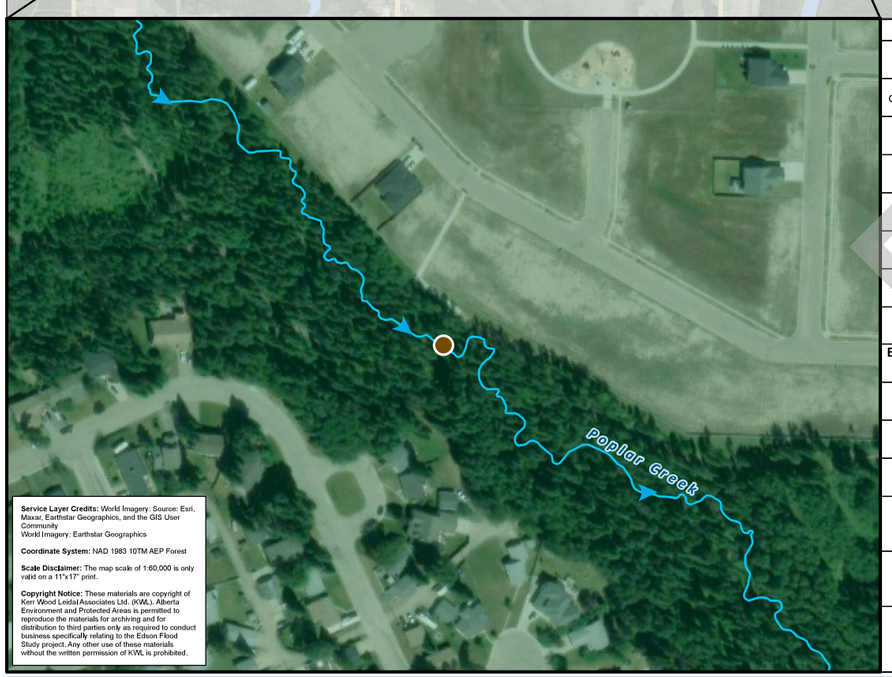
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: B-23	
<BOL>DESCRIPTION:</BOL> GREEN SPACE FOOTPATH NORTHWEST OF 43RD STREET & 10TH AVENUE	
FILE #: N/A	
CROSSING TYPE: PEDESTRIAN	
CREEK: POPLAR	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH:
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV:
U/S INVERT ELEV:	D/S LOW CHORD ELEV:
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: NOT SURVEYED	

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-23

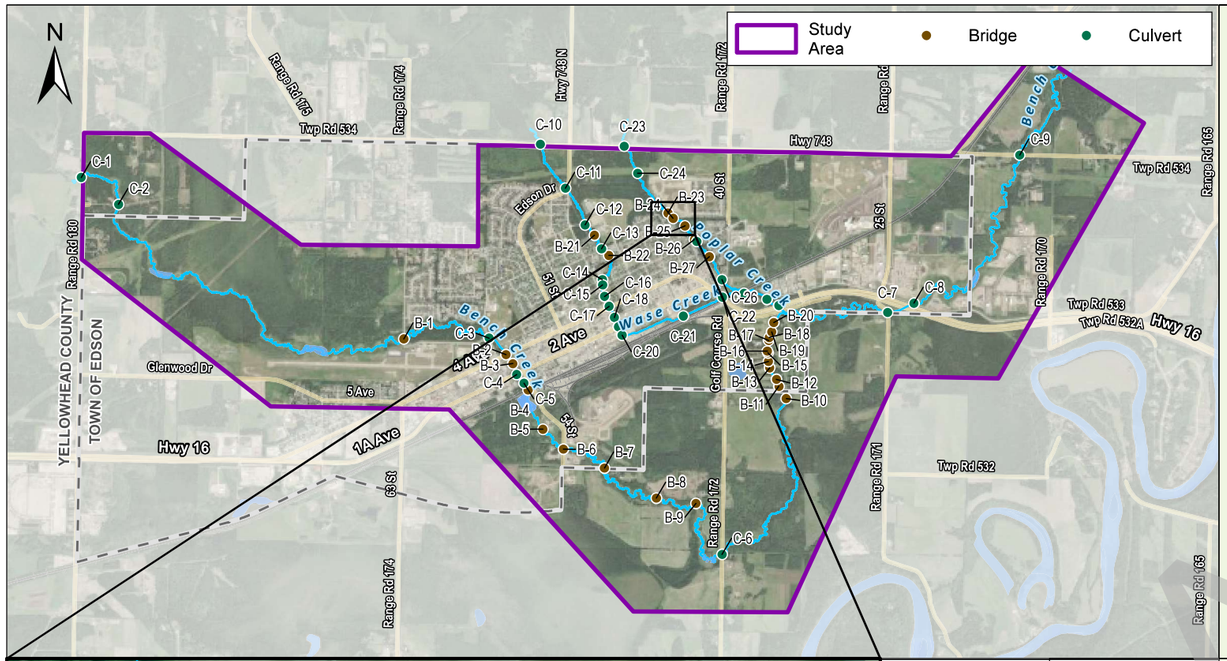
Figure A-33

Classification: Public

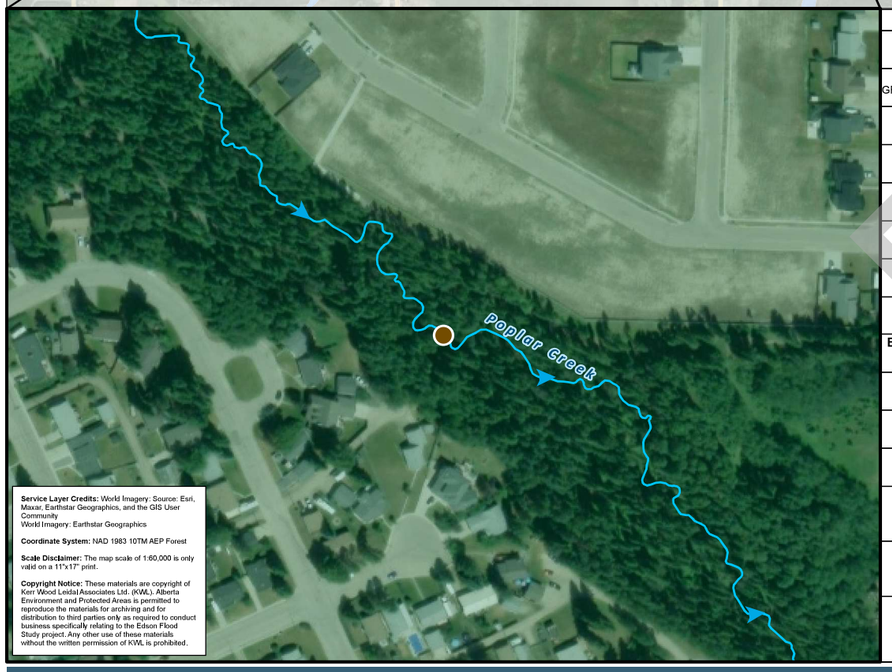
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: B-24	
DESCRIPTION: GREEN SPACE FOOTPATH NORTH OF 8TH AVENUE CUL-DE-SAC	
FILE #: N/A	
CROSSING TYPE: PEDESTRIAN	
CREEK: POPLAR	
# OF BARRELS:	**# OF SPANS:** 1
TYPE:	**WIDTH:** 6.26
SHAPE:	**# OF PIERS:**
ENTRANCE CONDITIONS:	**WIDTH OF PIERS:**
DIMENSIONS:	**SHAPE OF PIERS:**
LENGTH:	**U/S LOW CHORD ELEV:** 912.830
U/S INVERT ELEV:	**D/S LOW CHORD ELEV:** 912.830
D/S INVERT ELEV:	**U/S TOP OF CURB / GUARD RAIL ELEV:** 913.020
	D/S TOP OF CURB / GUARD RAIL ELEV: 913.020
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-24

Figure A-34

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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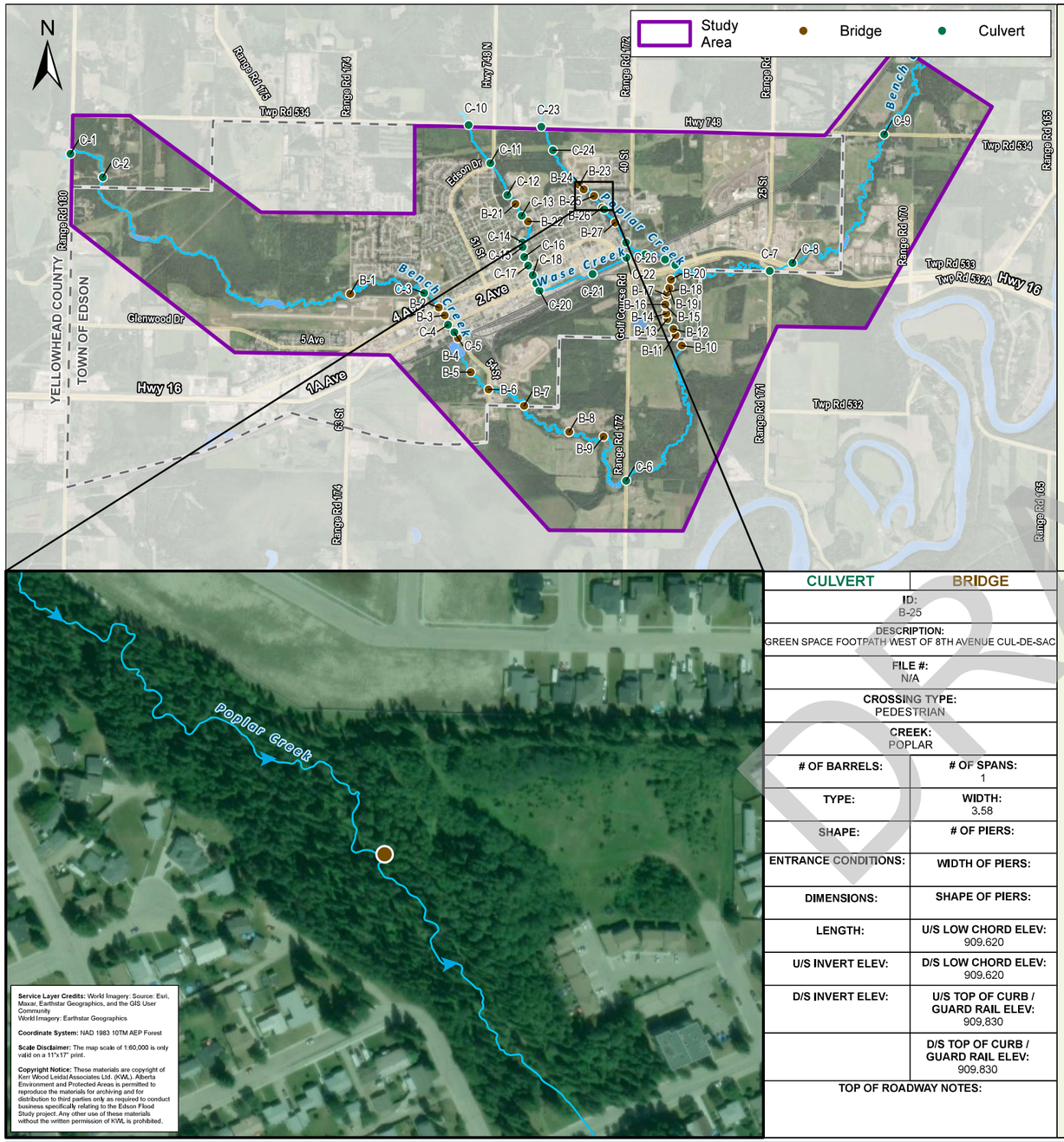
KERR WOOD LEIDAL consulting engineers



CULVERT	BRIDGE
ID: B-25	
DESCRIPTION: GREEN SPACE FOOTPATH WEST OF 8TH AVENUE CUL-DE-SAC	
FILE #: N/A	
CROSSING TYPE: PEDESTRIAN	
CREEK: POPLAR	
# OF BARRELS:	# OF SPANS: 1
TYPE:	WIDTH: 3.58
SHAPE:	# OF PIERS:
ENTRANCE CONDITIONS:	WIDTH OF PIERS:
DIMENSIONS:	SHAPE OF PIERS:
LENGTH:	U/S LOW CHORD ELEV: 909.620
U/S INVERT ELEV:	D/S LOW CHORD ELEV: 909.620
D/S INVERT ELEV:	U/S TOP OF CURB / GUARD RAIL ELEV: 909.830
	D/S TOP OF CURB / GUARD RAIL ELEV: 909.830
TOP OF ROADWAY NOTES:	

Photo 1

NO PHOTO AVAILABLE

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-25

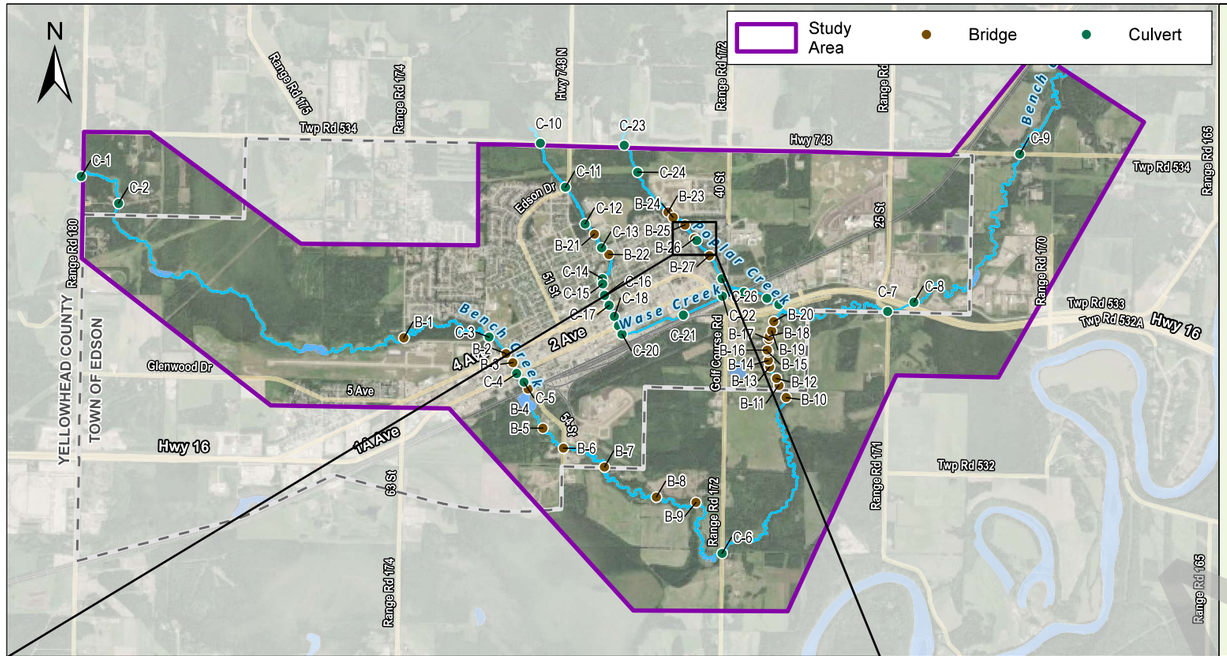
Figure A-35

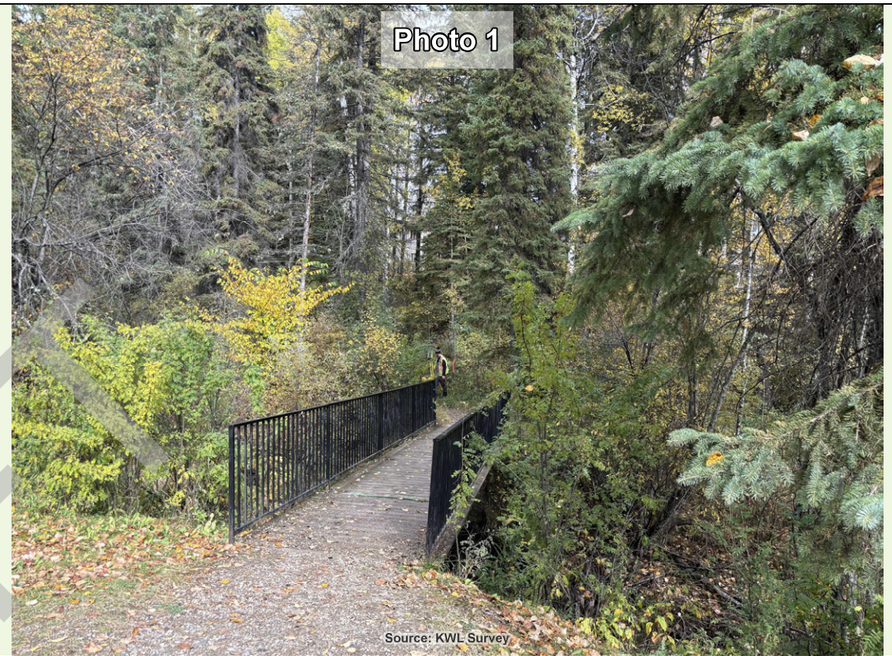
Classification: Public

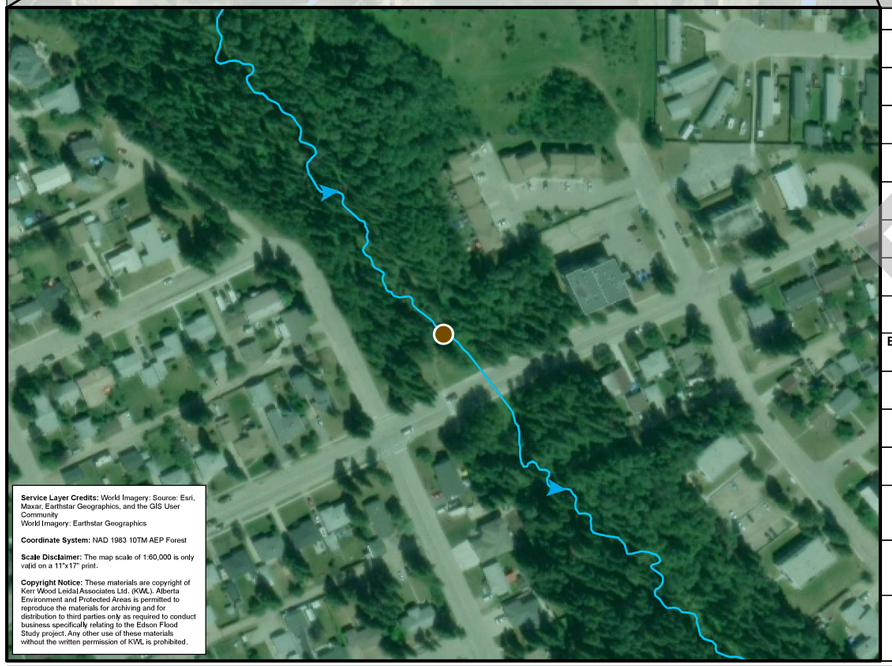
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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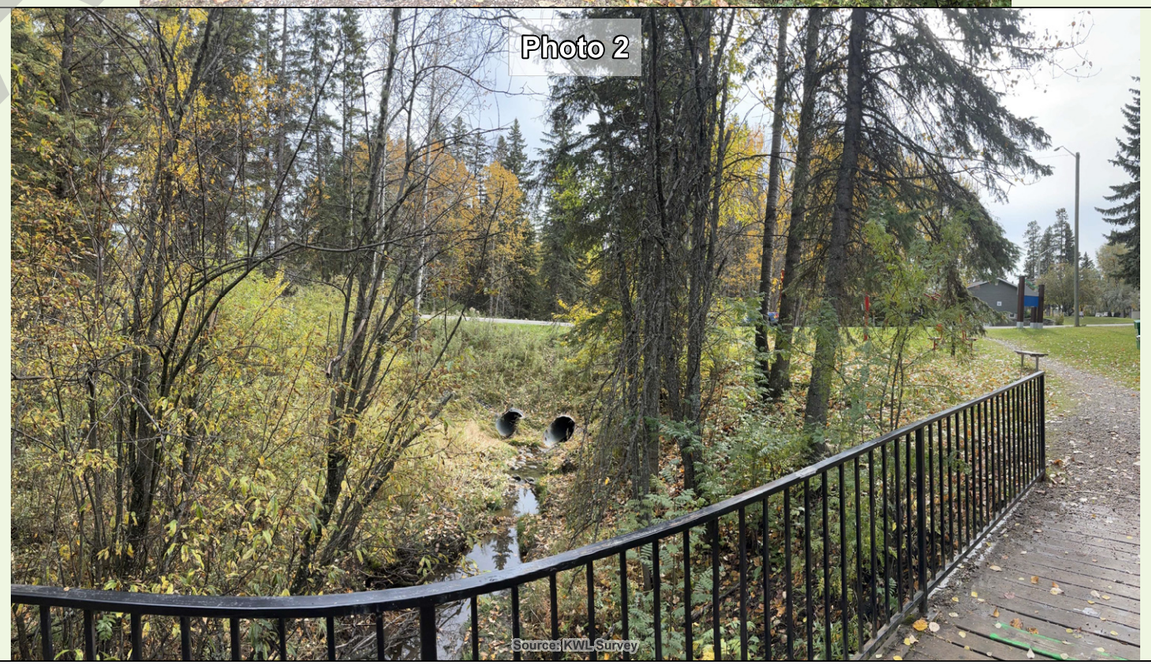
CULVERT	BRIDGE
ID: B-26	
DESCRIPTION: GREEN SPACE FOOTPATH NORTH OF 6TH AVENUE	
FILE #: N/A	
CROSSING TYPE: PEDESTRIAN	
CREEK: POPLAR	
# OF BARRELS:	**# OF SPANS:** 1
TYPE:	**WIDTH:** 7.60
SHAPE:	**# OF PIERS:**
ENTRANCE CONDITIONS:	**WIDTH OF PIERS:**
DIMENSIONS:	**SHAPE OF PIERS:**
LENGTH:	**U/S LOW CHORD ELEV:** 909.730
U/S INVERT ELEV:	**D/S LOW CHORD ELEV:** 909.730
D/S INVERT ELEV:	**U/S TOP OF CURB / GUARD RAIL ELEV:** 909.930
	D/S TOP OF CURB / GUARD RAIL ELEV: 909.930
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-26

Figure A-36

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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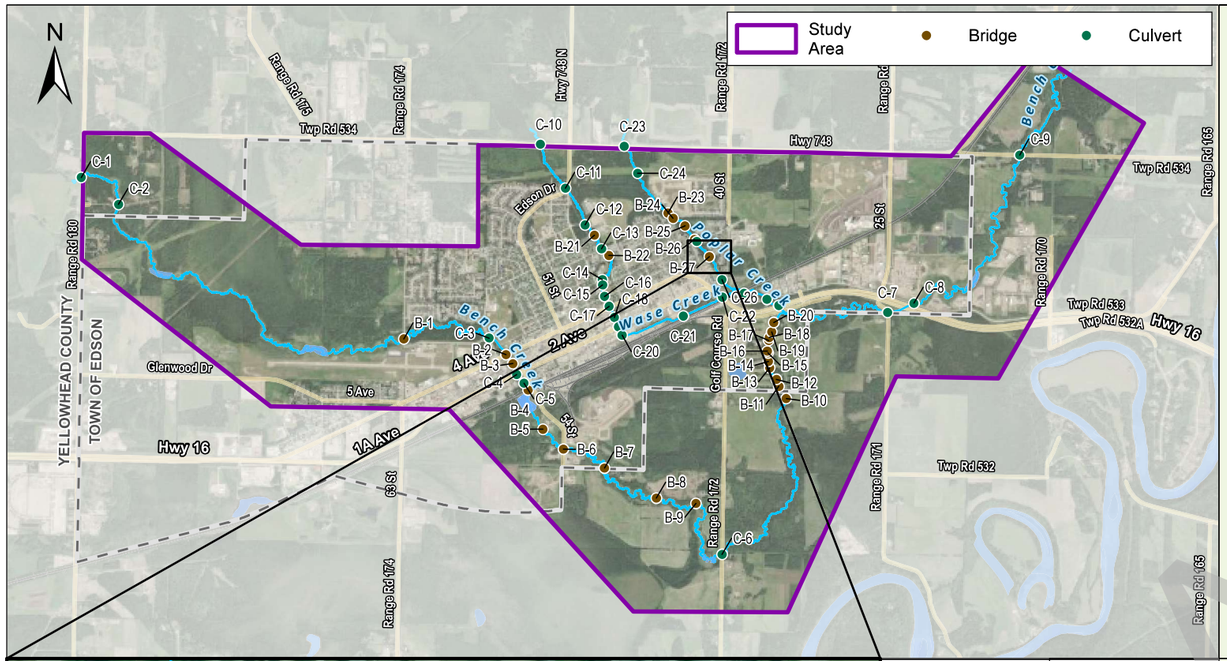
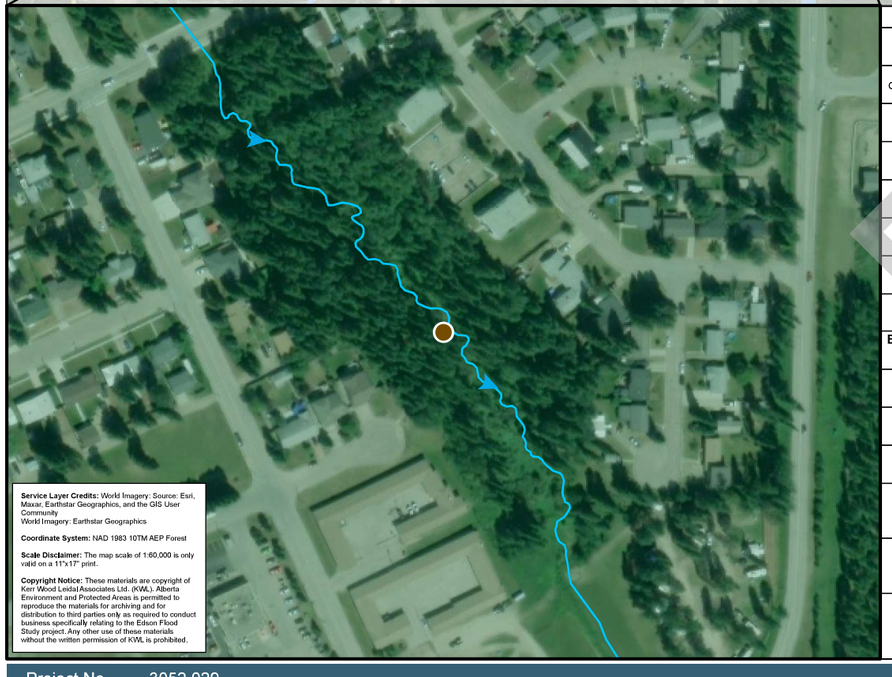
KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: B-27	
DESCRIPTION: GREEN SPACE FOOTPATH NORTHWEST OF 4TH AVENUE CUL-DE-SAC	
FILE #: N/A	
CROSSING TYPE: PEDESTRIAN	
CREEK: POPLAR	
# OF BARRELS:	**# OF SPANS:** 1
TYPE:	**WIDTH:** 5.22
SHAPE:	**# OF PIERS:**
ENTRANCE CONDITIONS:	**WIDTH OF PIERS:**
DIMENSIONS:	**SHAPE OF PIERS:**
LENGTH:	**U/S LOW CHORD ELEV:** 903.640
U/S INVERT ELEV:	**D/S LOW CHORD ELEV:** 903.640
D/S INVERT ELEV:	**U/S TOP OF CURB / GUARD RAIL ELEV:** 903.850
	D/S TOP OF CURB / GUARD RAIL ELEV: 903.850
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - B-27

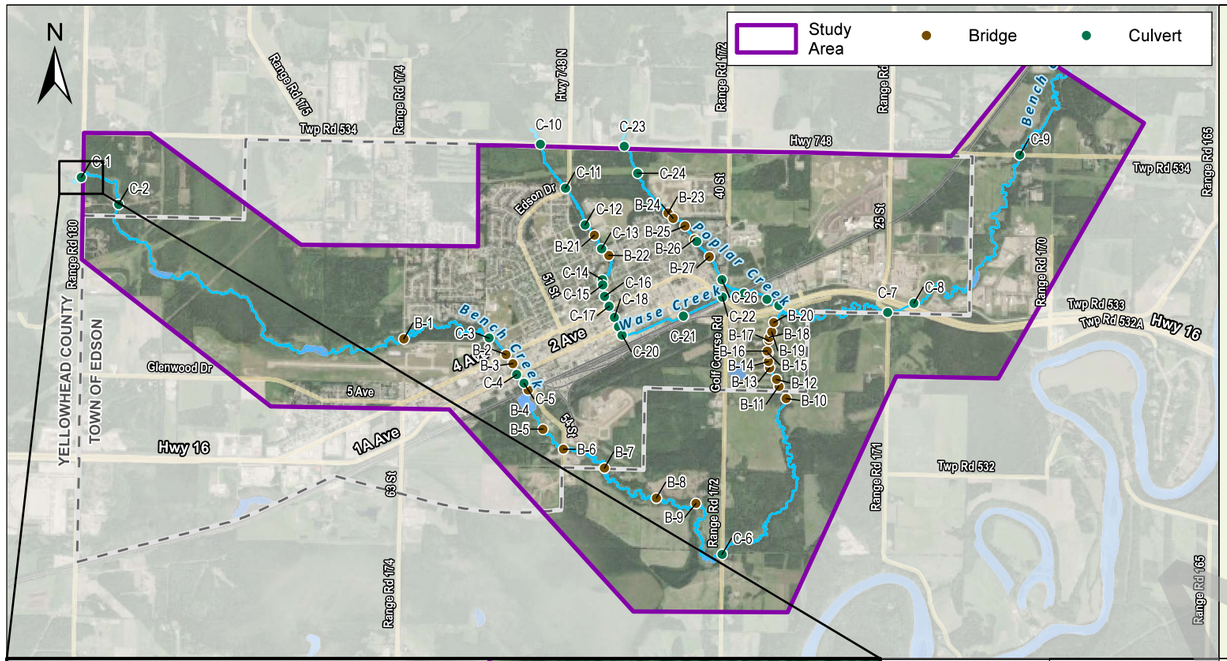
Figure A-37

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





CULVERT	BRIDGE
ID: C-1	
DESCRIPTION: RANGE ROAD 180	
FILE #:	
CROSSING TYPE: TRAFFIC	
CREEK:	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ROUND	# OF PIERS:
ENTRANCE CONDITIONS: HEADWALL	WIDTH OF PIERS:
DIMENSIONS: 3600	SHAPE OF PIERS:
LENGTH: 66,480	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 929.840	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 929.920	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: GRAVEL ROAD	

Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-1

Figure A-38

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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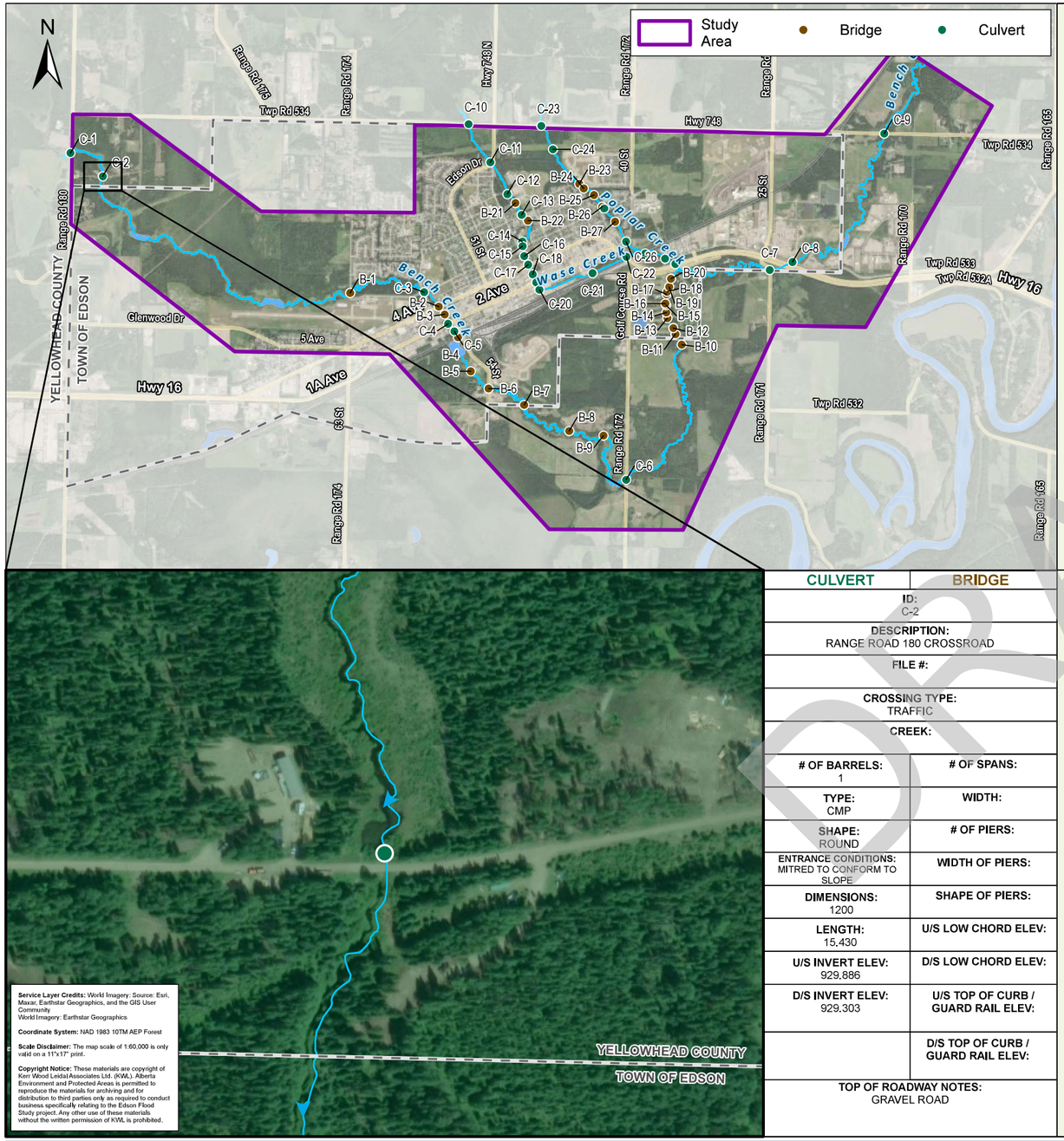
KERR WOOD LEIDAL consulting engineers



Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-2	
DESCRIPTION: RANGE ROAD 180 CROSSROAD	
FILE #:	
CROSSING TYPE: TRAFFIC	
CREEK:	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1200	**SHAPE OF PIERS:**
LENGTH: 15,430	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 929.886	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 929.303	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: GRAVEL ROAD	

Photo 1

NO PHOTO AVAILABLE

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-2

Figure A-39

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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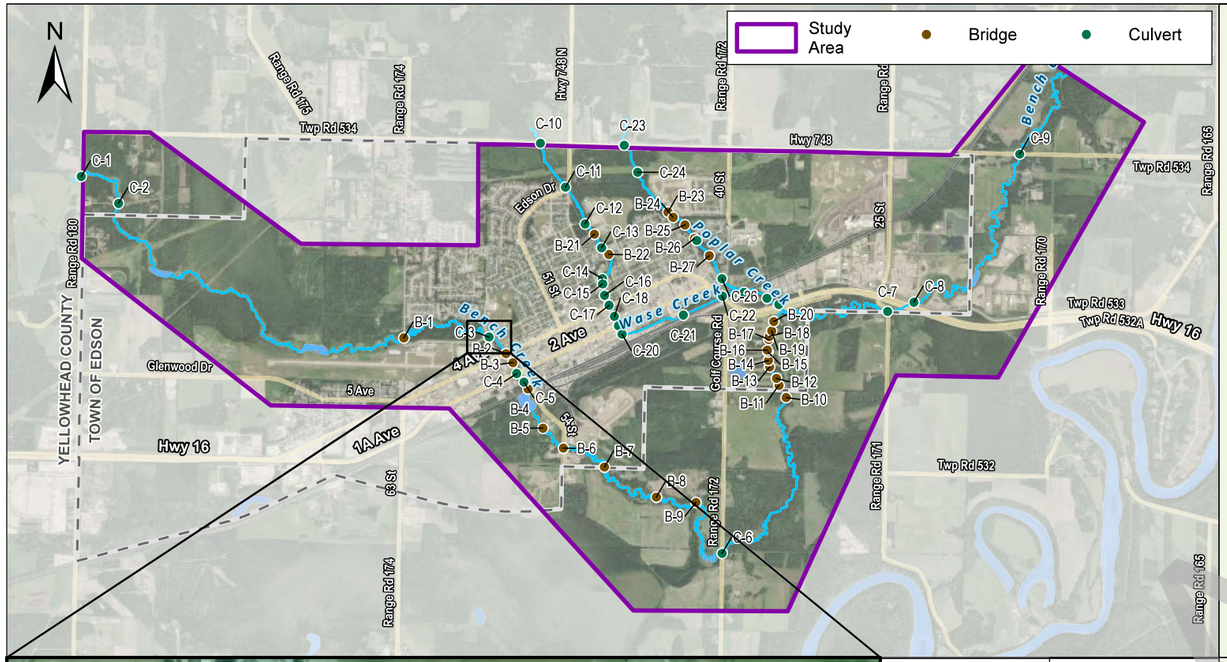
KERR WOOD LEIDAL consulting engineers



CULVERT	BRIDGE
ID: C-3	
<BOL>DESCRIPTION:</BOL> 56TH STREET & 6TH AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK:	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ROUND	# OF PIERS:
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	WIDTH OF PIERS:
DIMENSIONS: 3700	SHAPE OF PIERS:
LENGTH: 34.387	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 905.796	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 905.339	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	





Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-3

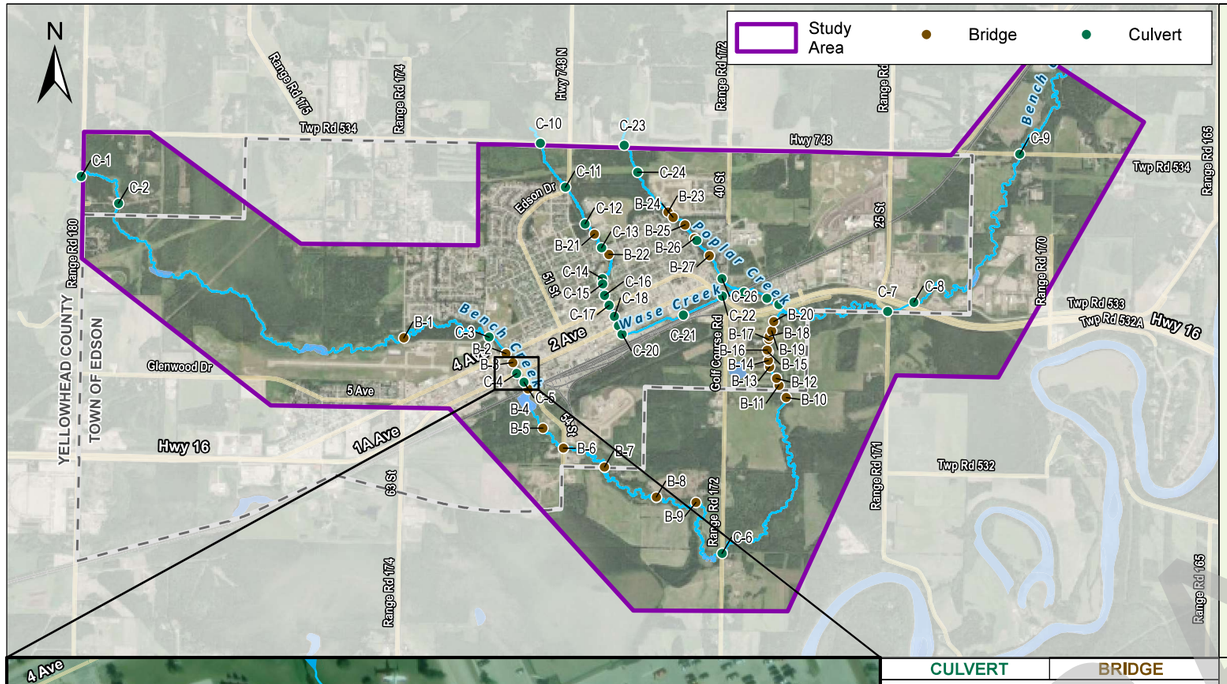
Figure A-40

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

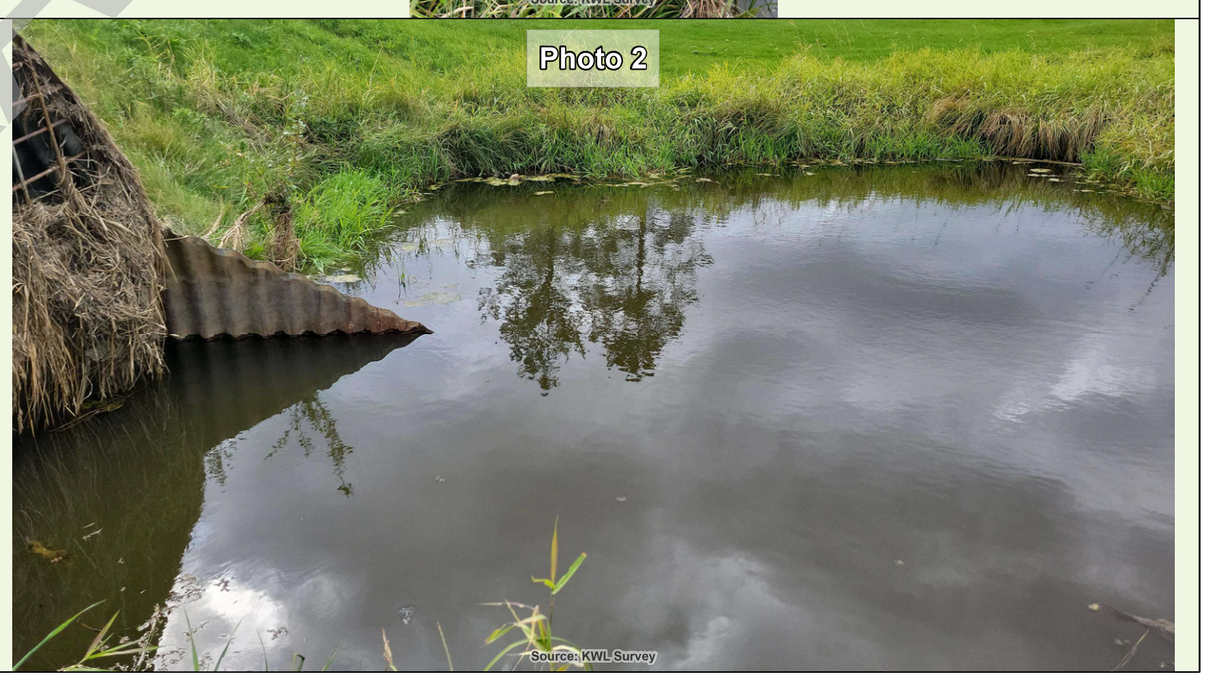
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-4	
DESCRIPTION: 2ND AVENUE (HIGHWAY 16)	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: BENCH	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ROUND	# OF PIERS:
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	WIDTH OF PIERS:
DIMENSIONS: 3600	SHAPE OF PIERS:
LENGTH: 35.500	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 904.230	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 904.016	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-4

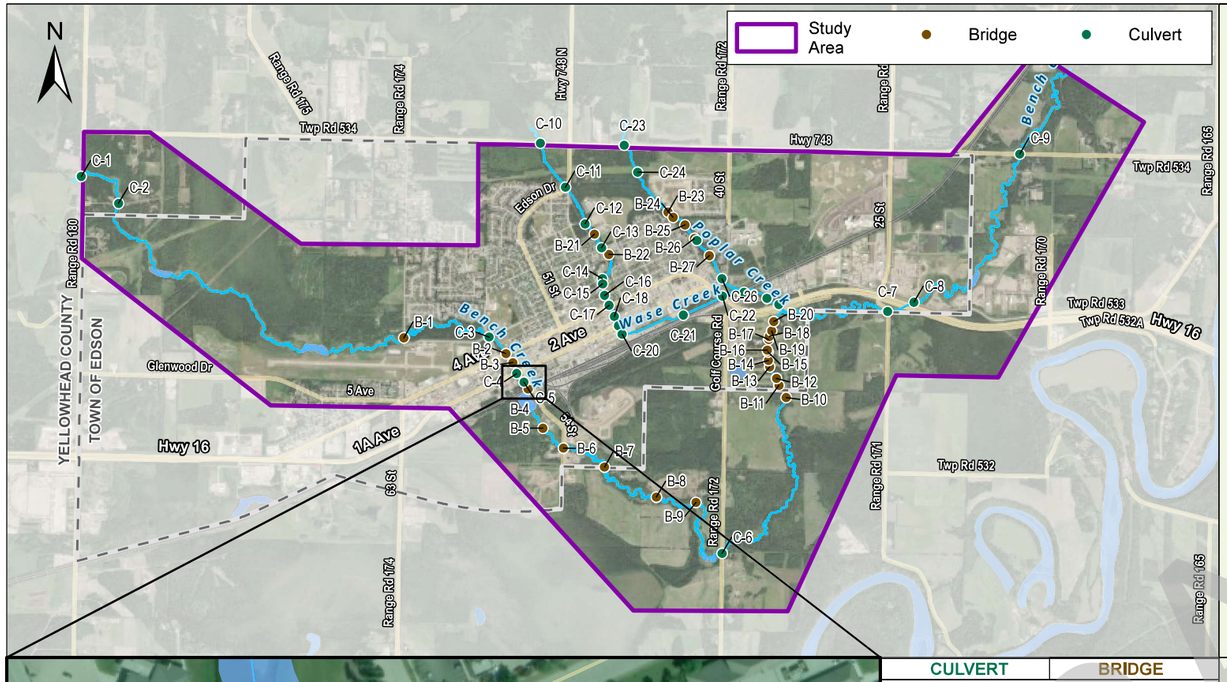
Figure A-41

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-5	
DESCRIPTION: 1ST AVENUE	
FILE #:	
CROSSING TYPE: TRAFFIC	
CREEK:	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: PROJECTING	**WIDTH OF PIERS:**
DIMENSIONS: 1500	**SHAPE OF PIERS:**
LENGTH: 20.480	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 904.400	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 904.400	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: SUBMERGED AT TIME OF SURVEY	

Photo 1

NO PHOTO AVAILABLE

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-5

Figure A-42

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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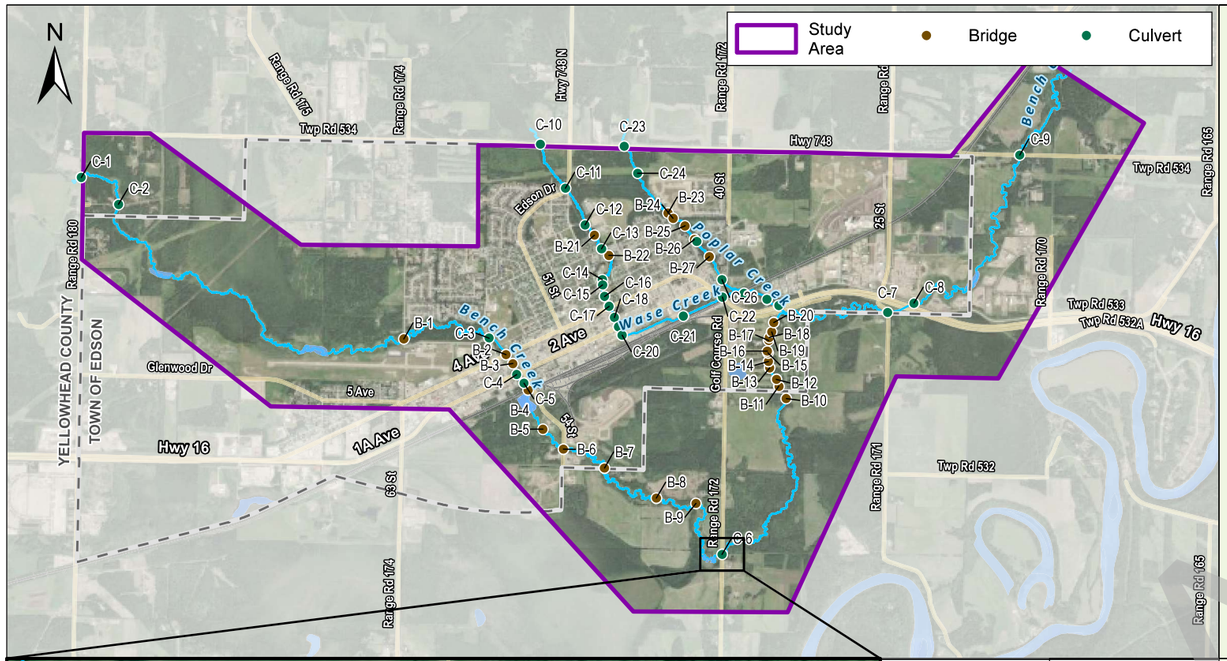
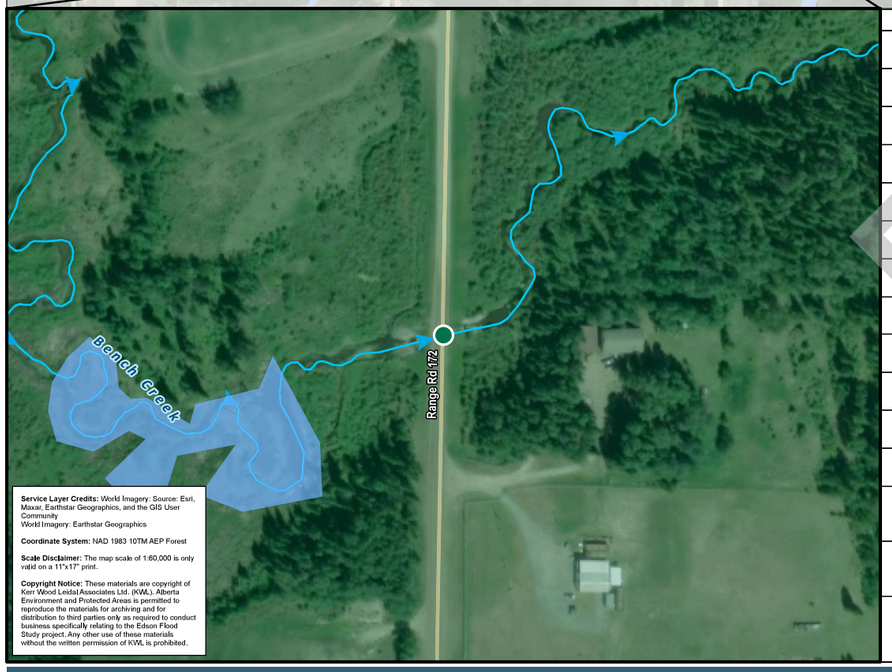
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-6	
DESCRIPTION: RANGE ROAD 172	
FILE #: 73050	
CROSSING TYPE: TRAFFIC	
CREEK: BENCH	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 2000	**SHAPE OF PIERS:**
LENGTH: 26,620	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 897.219	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 896.620	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: GRAVEL ROAD	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-6

Figure A-43

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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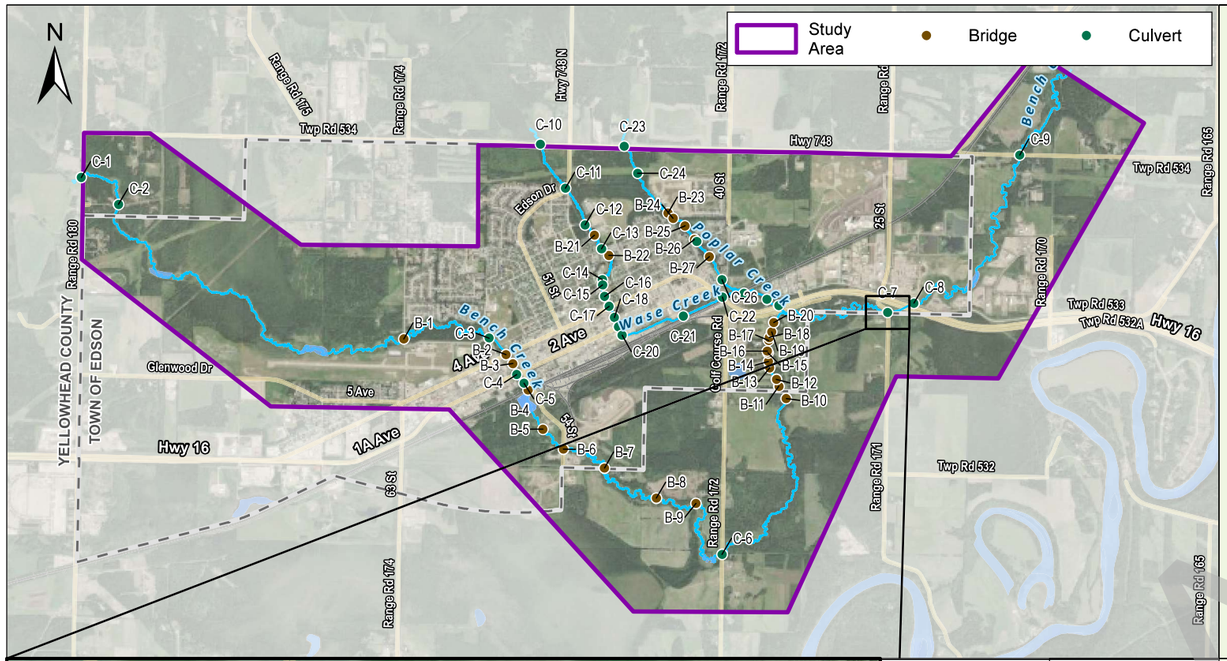
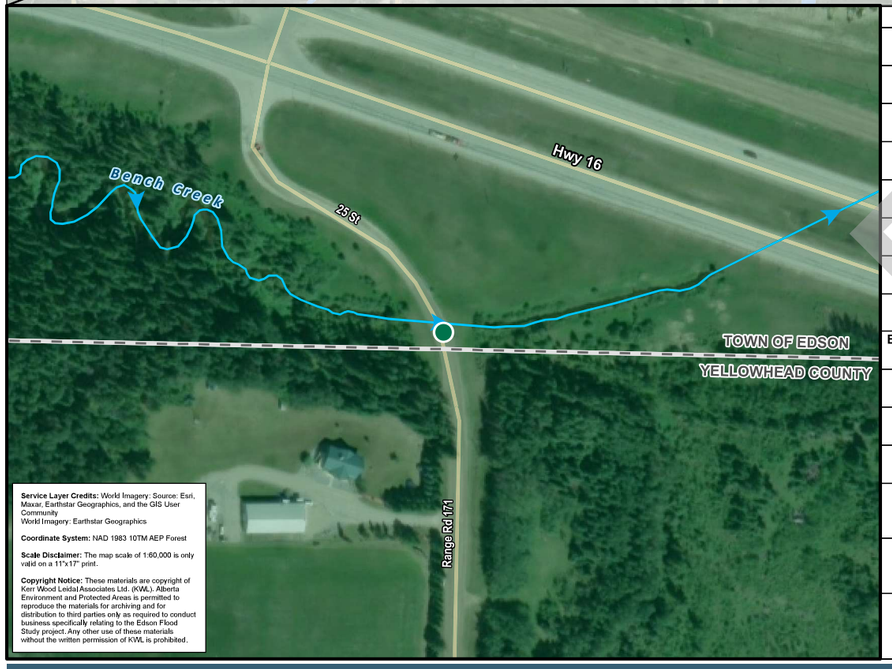
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-7	
DESCRIPTION: 25TH STREET (RANGE ROAD 171)	
FILE #: 70506	
CROSSING TYPE: TRAFFIC	
CREEK: BENCH	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ROUND	# OF PIERS:
ENTRANCE CONDITIONS: HEADWALL	WIDTH OF PIERS:
DIMENSIONS: 3500	SHAPE OF PIERS:
LENGTH: 51,450	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 885.670	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 885.150	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: GRAVEL ROAD	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-7

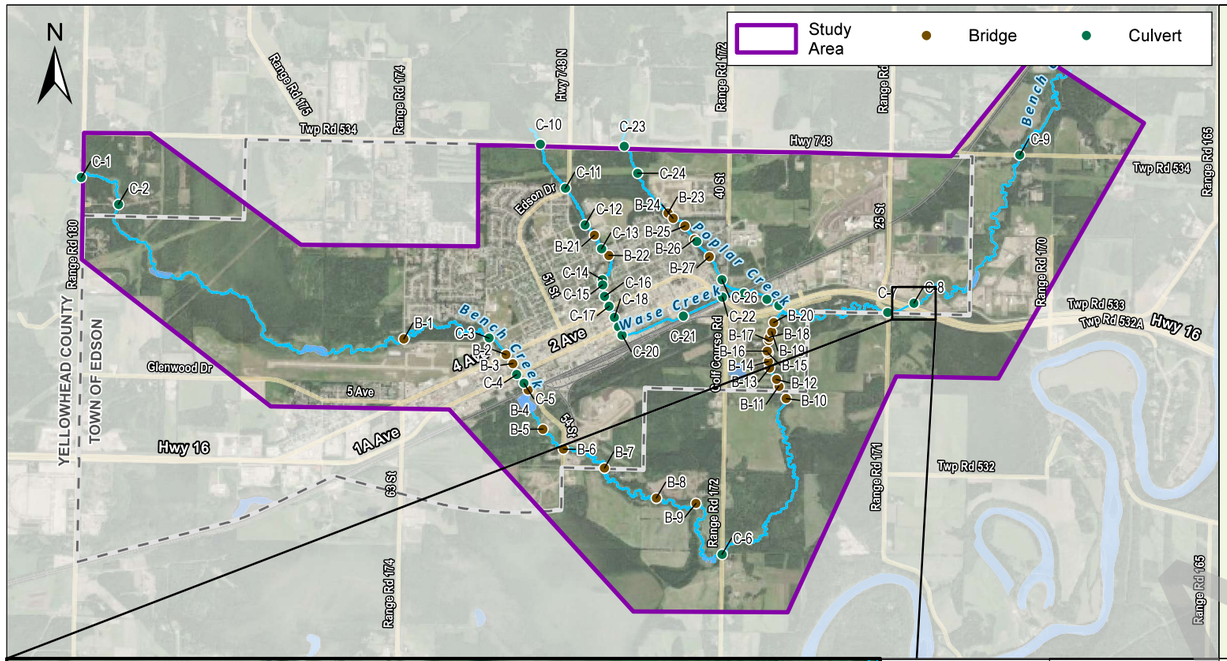
Figure A-44

Classification: Public

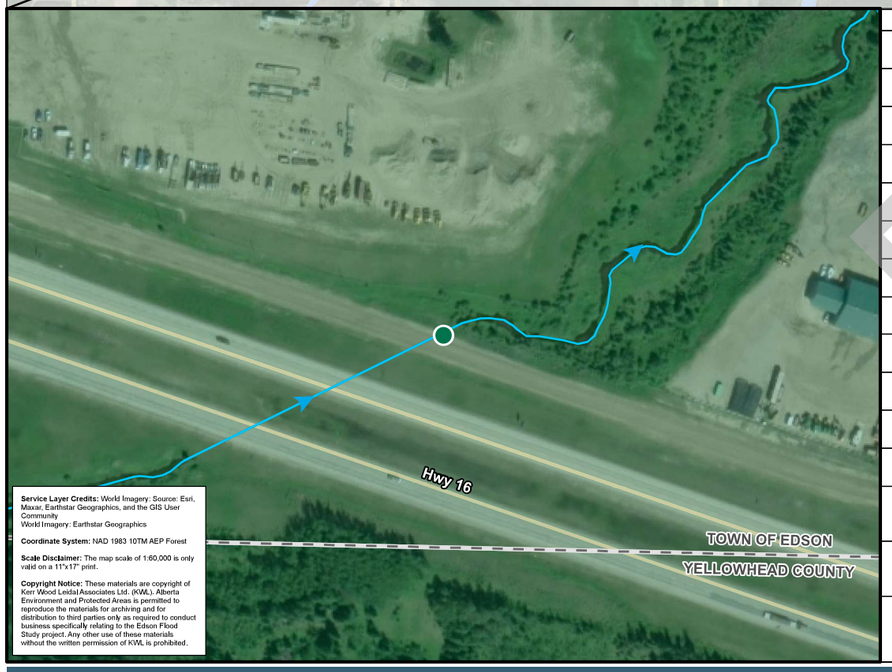
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

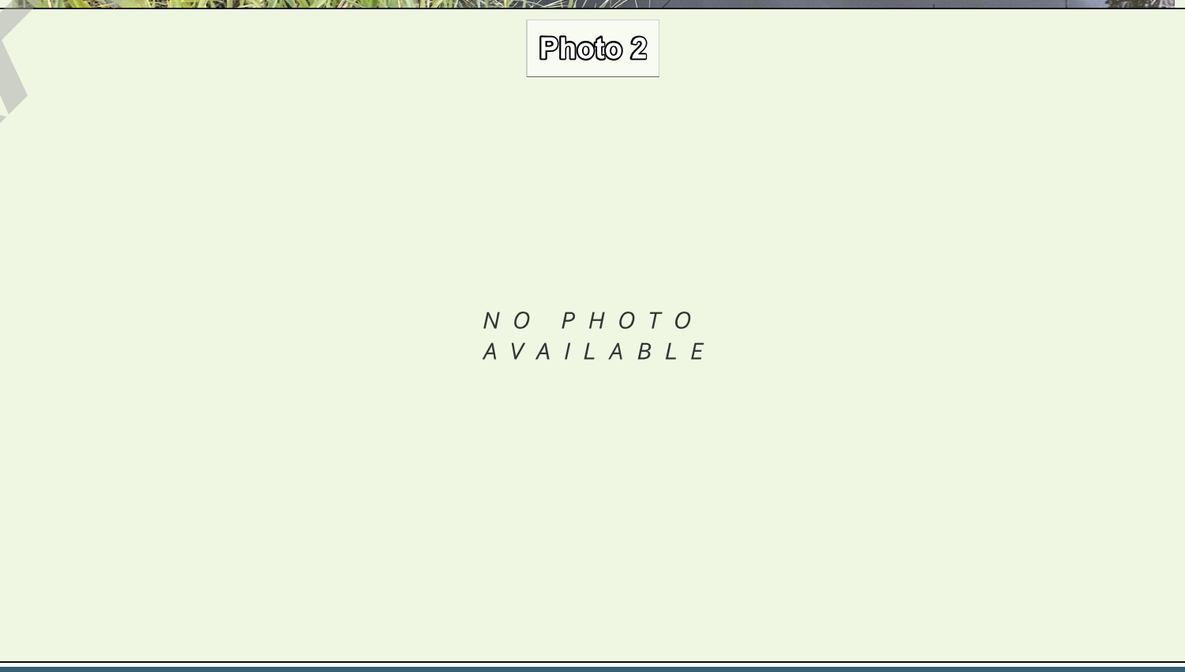
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-8	
DESCRIPTION: HIGHWAY 16	
FILE #: 13598	
CROSSING TYPE: TRAFFIC	
CREEK: BENCH	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 3850	**SHAPE OF PIERS:**
LENGTH: 151,570	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 884.470	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 883.890	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-8

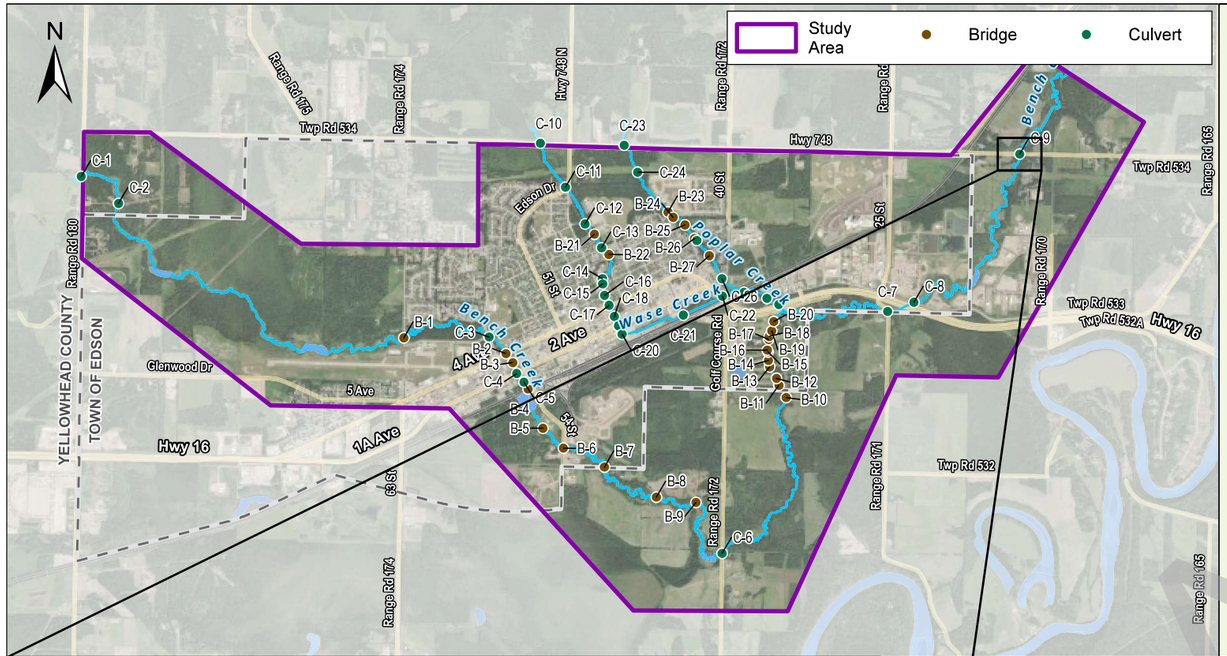
Figure A-45

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







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World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-9	
DESCRIPTION: TOWNSHIP ROAD 534	
FILE #: 9883	
CROSSING TYPE: TRAFFIC	
CREEK: BENCH	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: HEADWALL	**WIDTH OF PIERS:**
DIMENSIONS: 5000	**SHAPE OF PIERS:**
LENGTH: 40.820	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 876.580	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 876.370	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: GRAVEL ROAD	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-9

Figure A-46

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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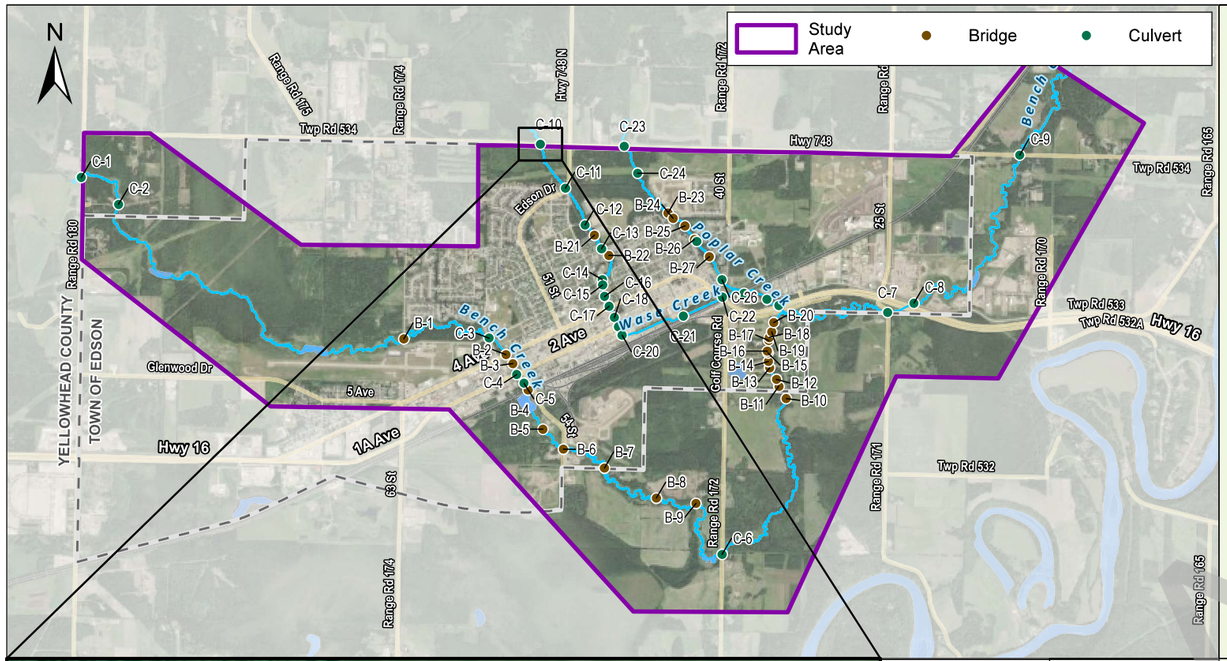
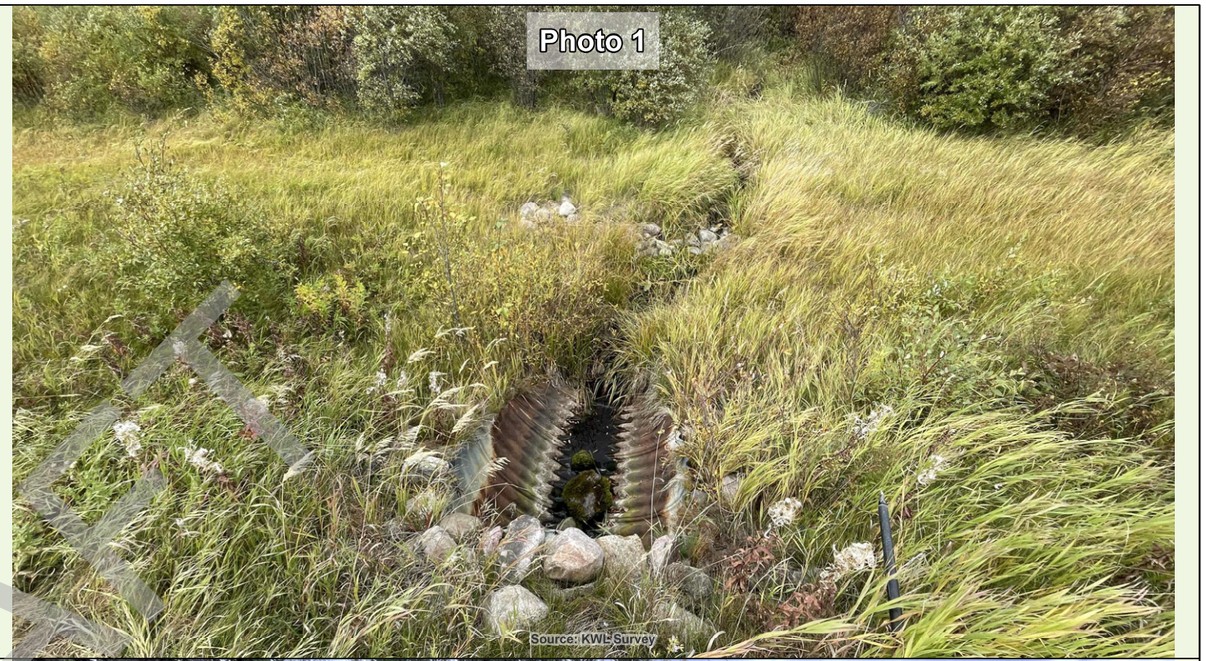
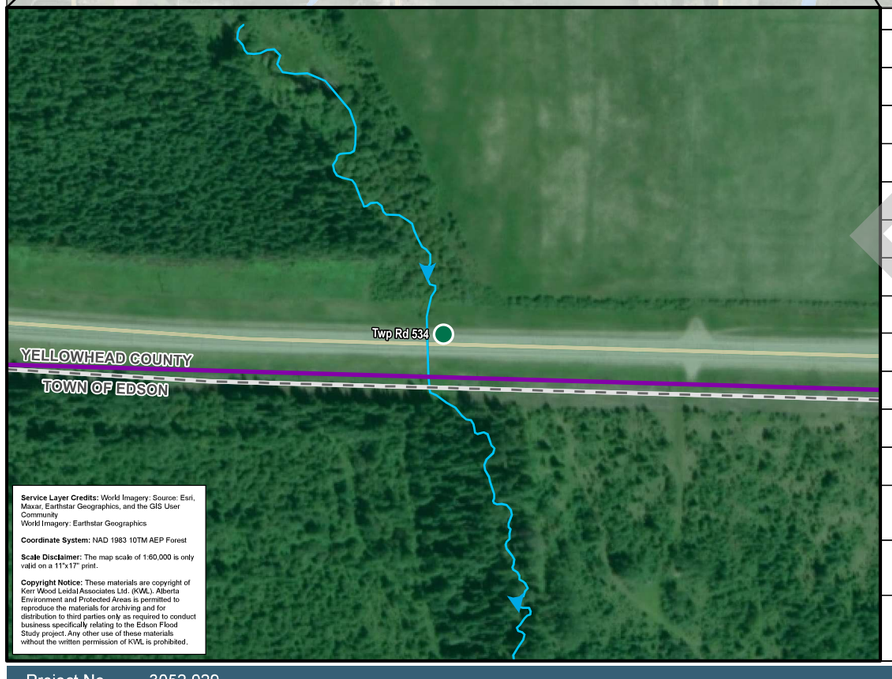
KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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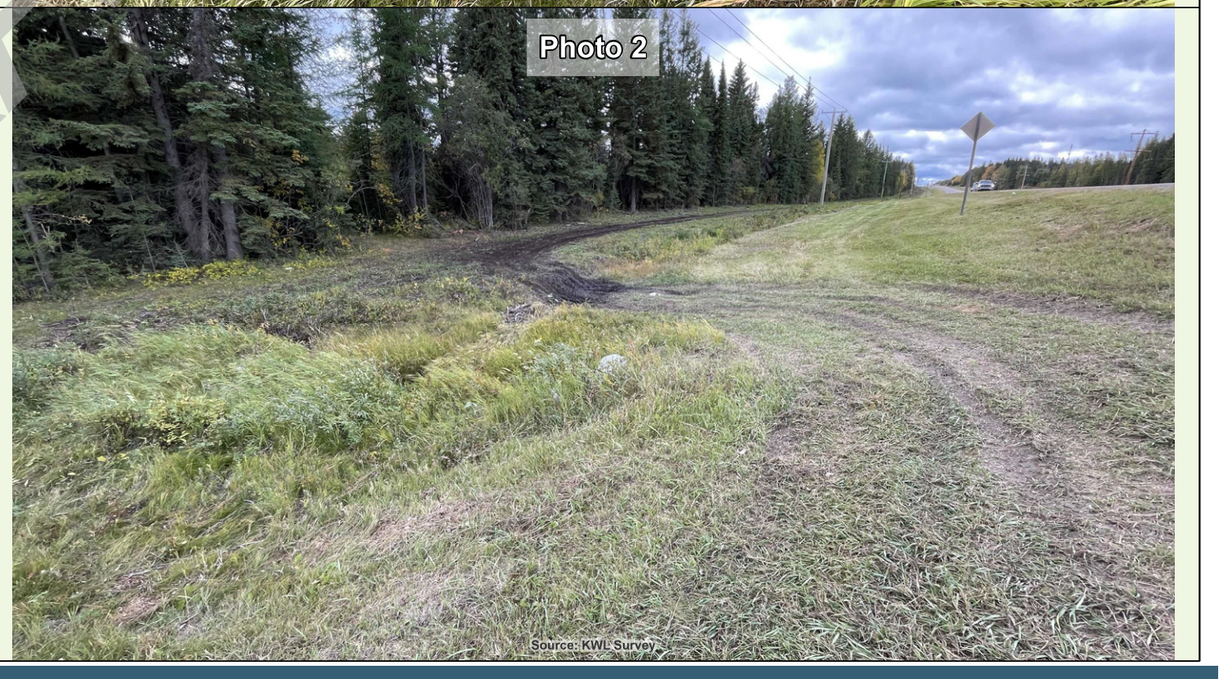
CULVERT	BRIDGE
ID: C-10	
DESCRIPTION: HIGHWAY 748 (TOWNSHIP ROAD 534)	
FILE #: 79694	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1700	**SHAPE OF PIERS:**
LENGTH: 28.839	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 928.290	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 927.580	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-10

Figure A-47

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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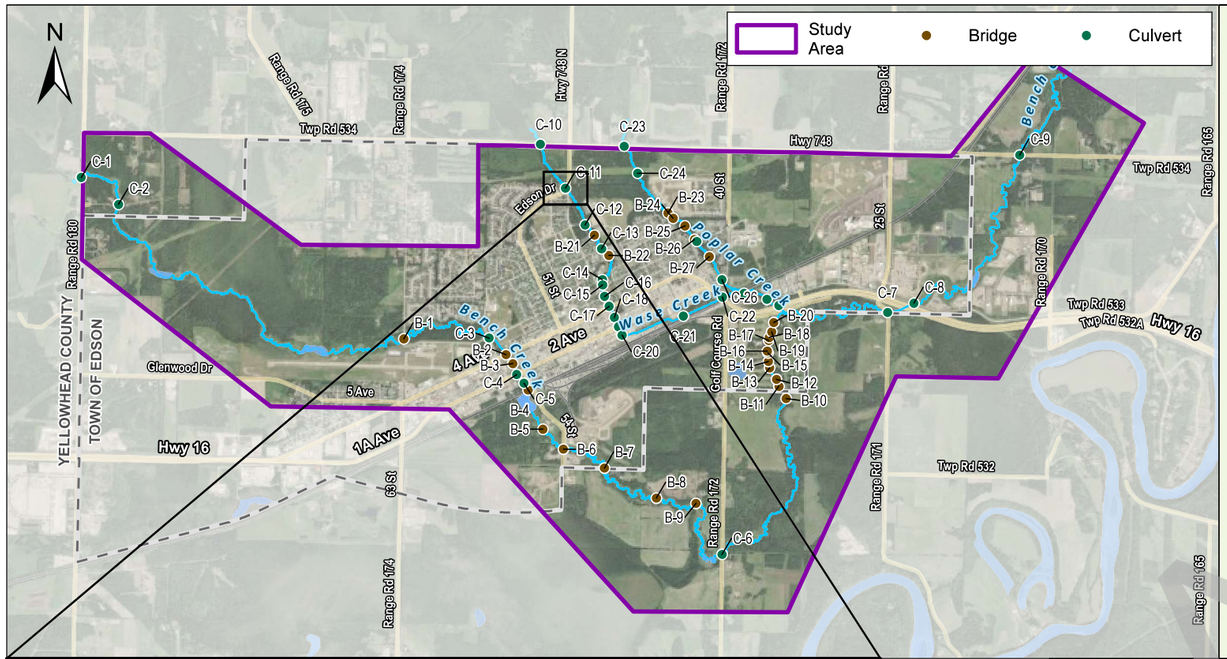



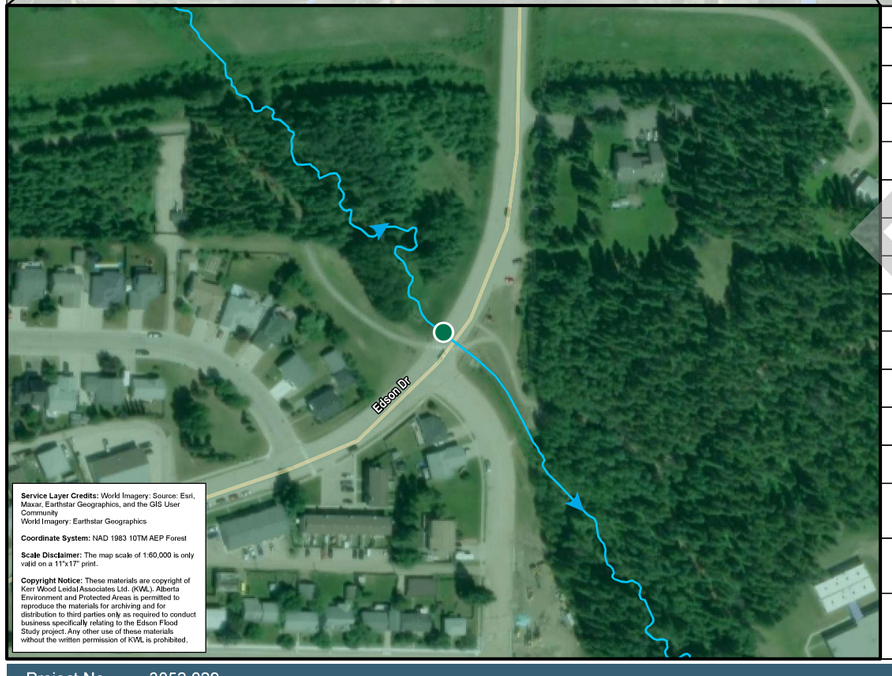

CULVERT	BRIDGE
ID: C-11	
DESCRIPTION: EDSON DRIVE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ARCH	# OF PIERS:
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	WIDTH OF PIERS:
DIMENSIONS: 2000 X 1500	SHAPE OF PIERS:
LENGTH: 35.034	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 923.680	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 923.680	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-11

Figure A-48

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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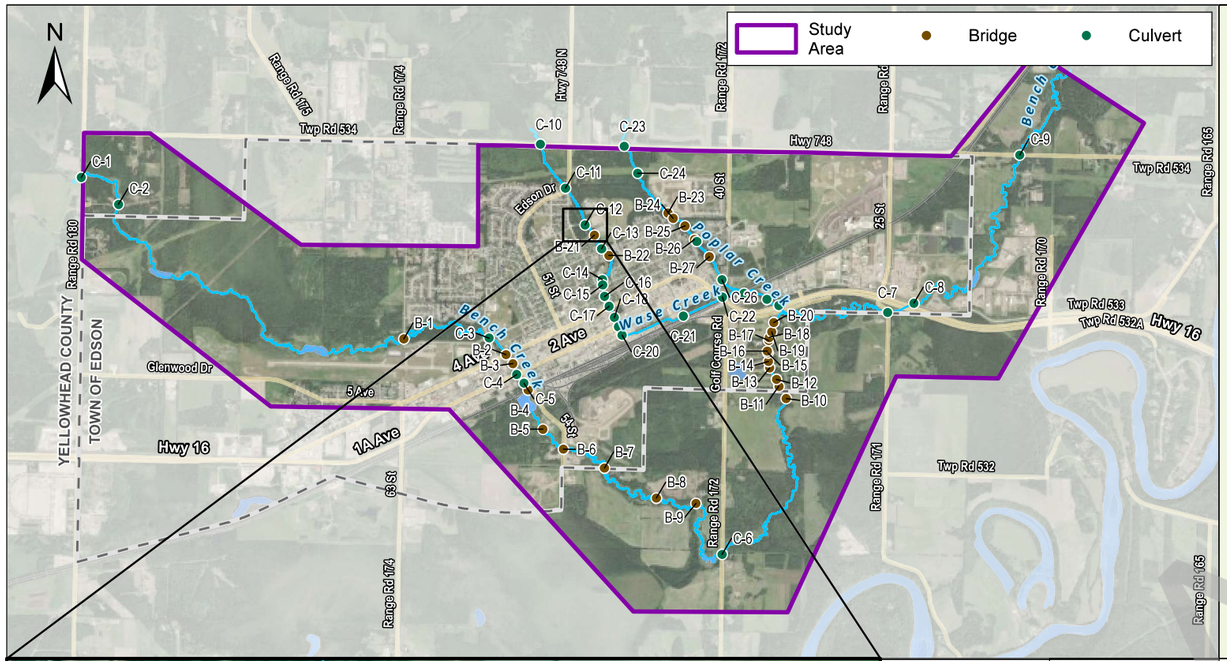



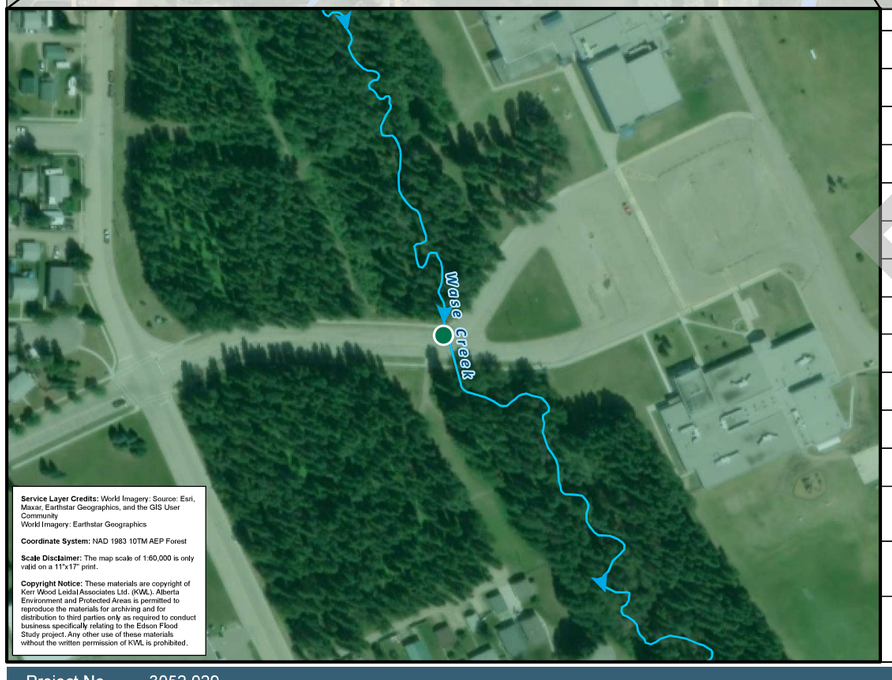

CULVERT	BRIDGE
ID: C-12	
DESCRIPTION: 12TH AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1100	**SHAPE OF PIERS:**
LENGTH: 32.660	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 920.506	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 920.650	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-12

Figure A-49

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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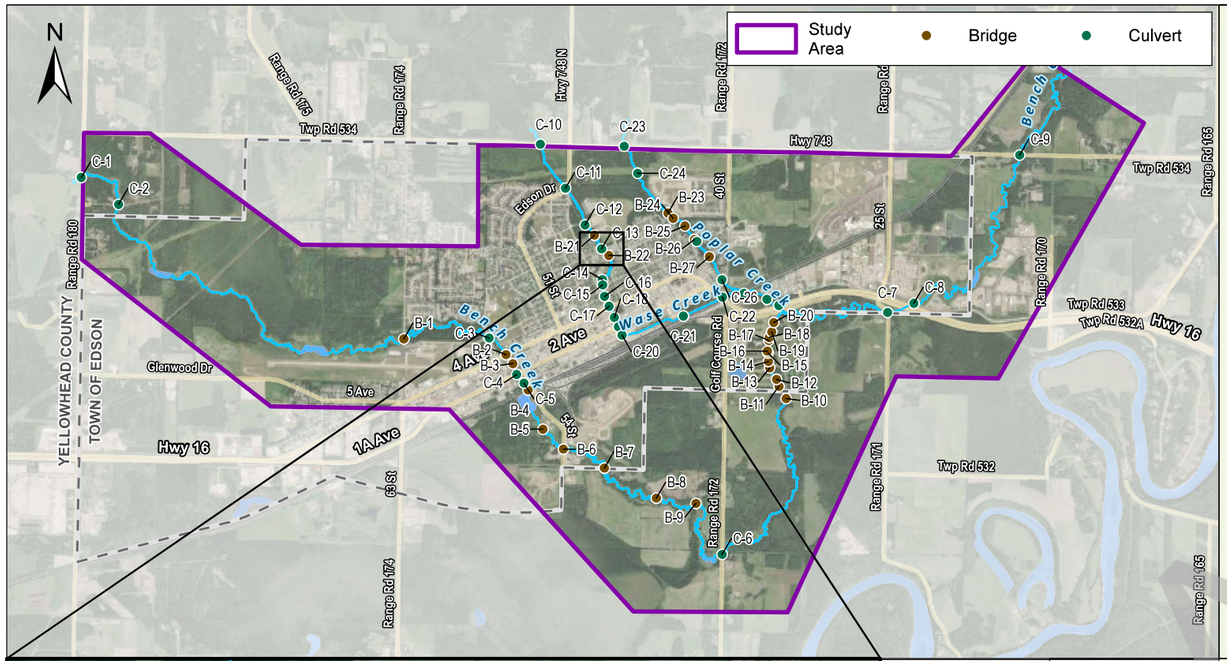
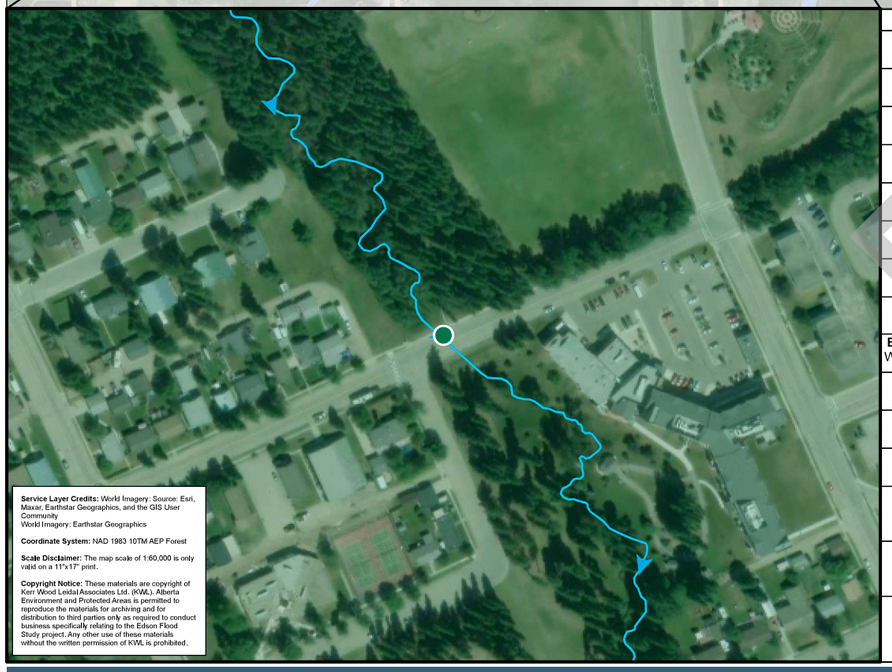
KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-13	
DESCRIPTION: 9TH AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 3	**# OF SPANS:**
TYPE: CONCRETE	**WIDTH:**
SHAPE: BOX	**# OF PIERS:**
ENTRANCE CONDITIONS: WINGWALL FLARED 0 DEG	**WIDTH OF PIERS:**
DIMENSIONS: 1200 X 600	**SHAPE OF PIERS:**
LENGTH: 40.036	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 917.789	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 917.600	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: DS END ON PARKLAND LODGE PROPERTY	

Photo 2

NO PHOTO AVAILABLE

Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-13

Figure A-50

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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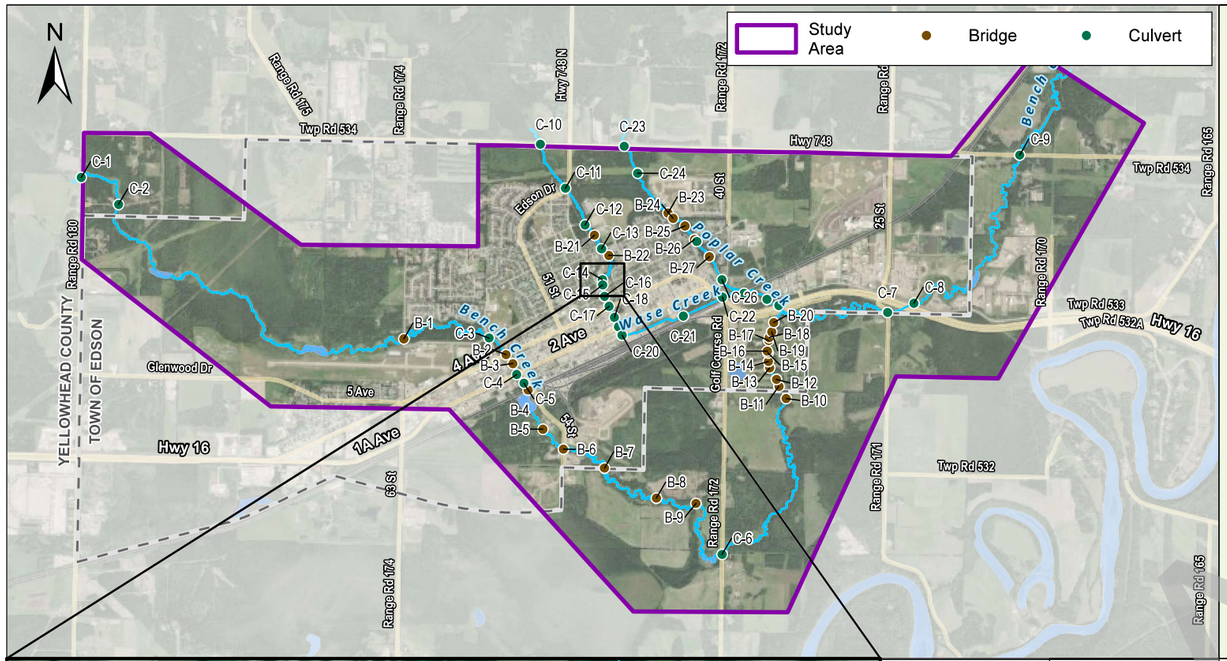
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-14	
DESCRIPTION: 7TH AVENUE ALLEY	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 2	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ROUND	# OF PIERS:
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	WIDTH OF PIERS:
DIMENSIONS: 1000	SHAPE OF PIERS:
LENGTH: 34.096	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 914.990	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 914.750	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: GRASS	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-14

Figure A-51

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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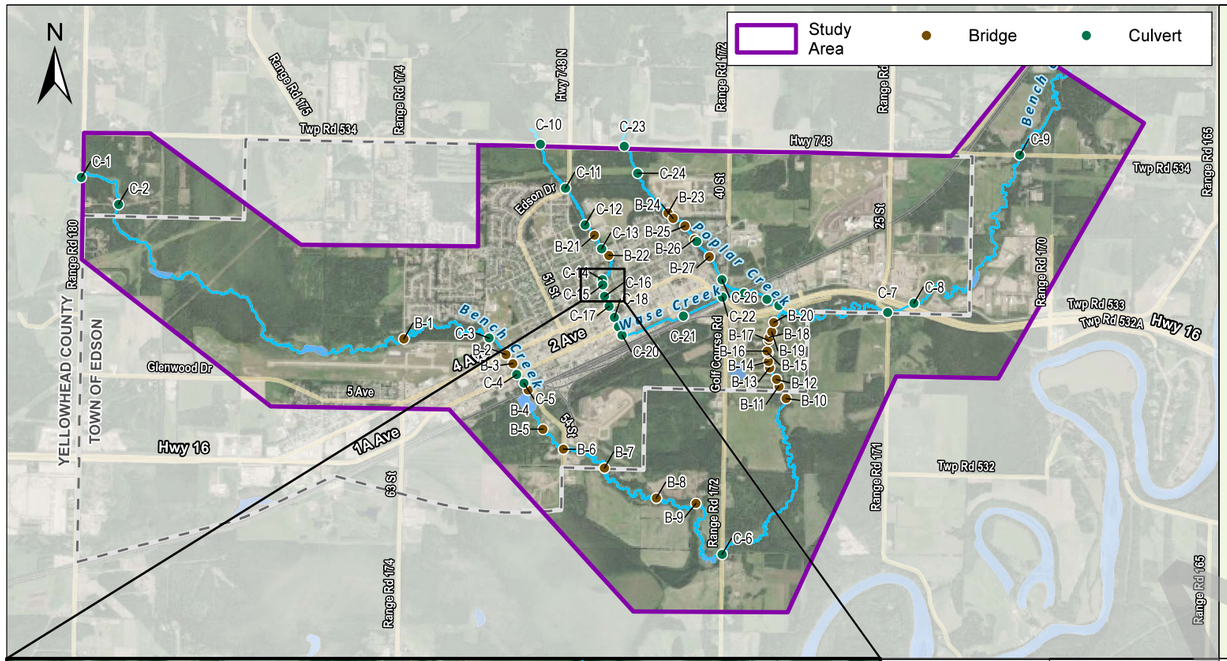
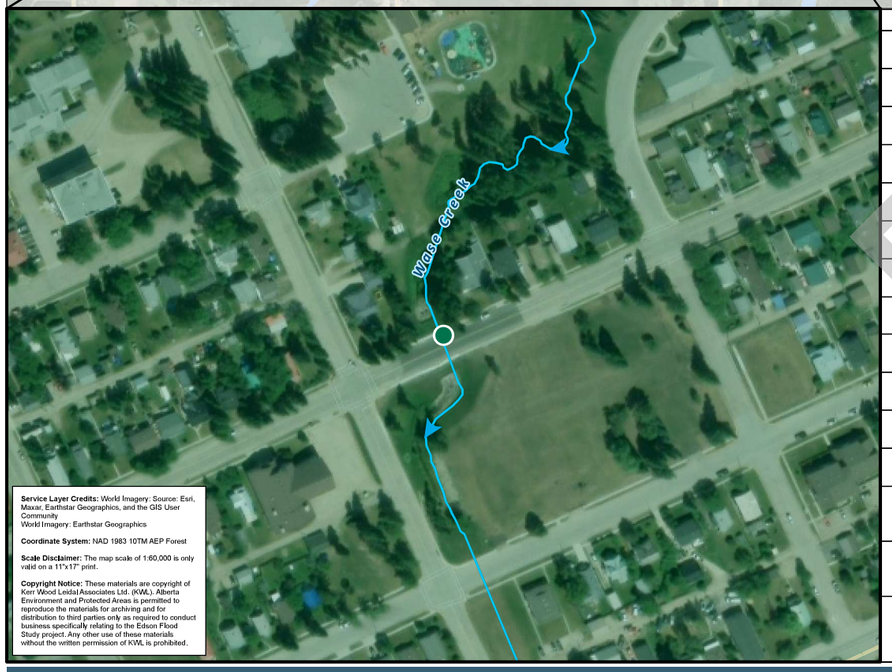
KERR WOOD LEIDAL consulting engineers







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World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-15	
DESCRIPTION: 6TH AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 2	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1200	**SHAPE OF PIERS:**
LENGTH: 35,558	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 914,560	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 914,390	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-15

Figure A-52

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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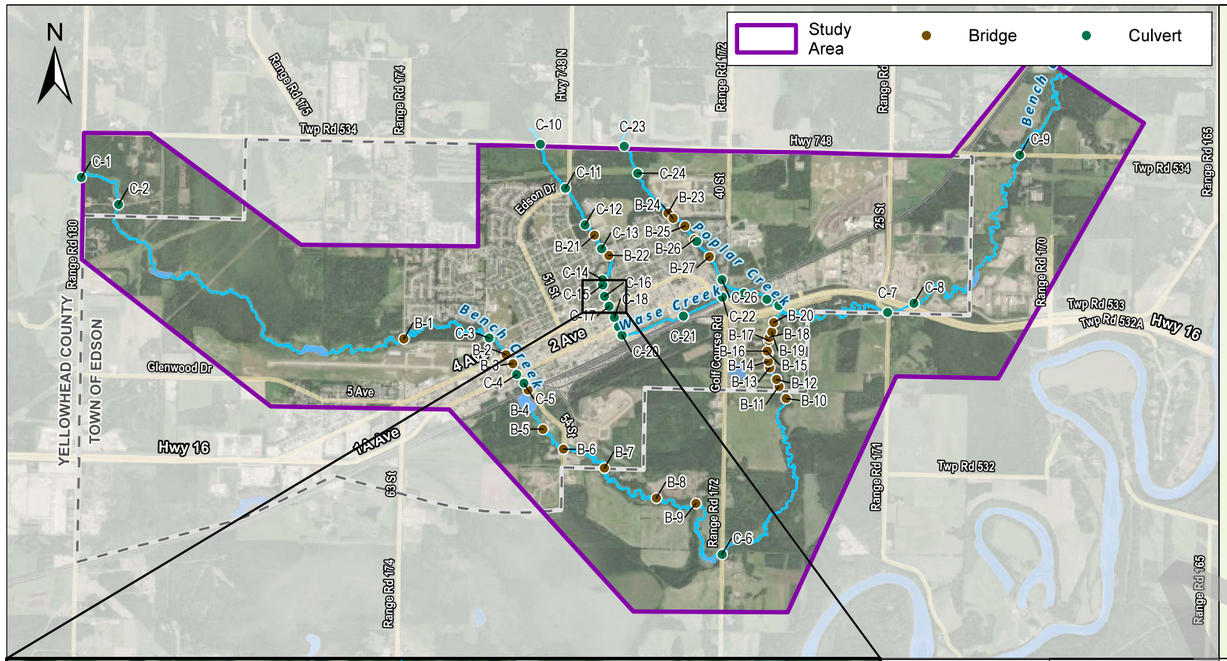
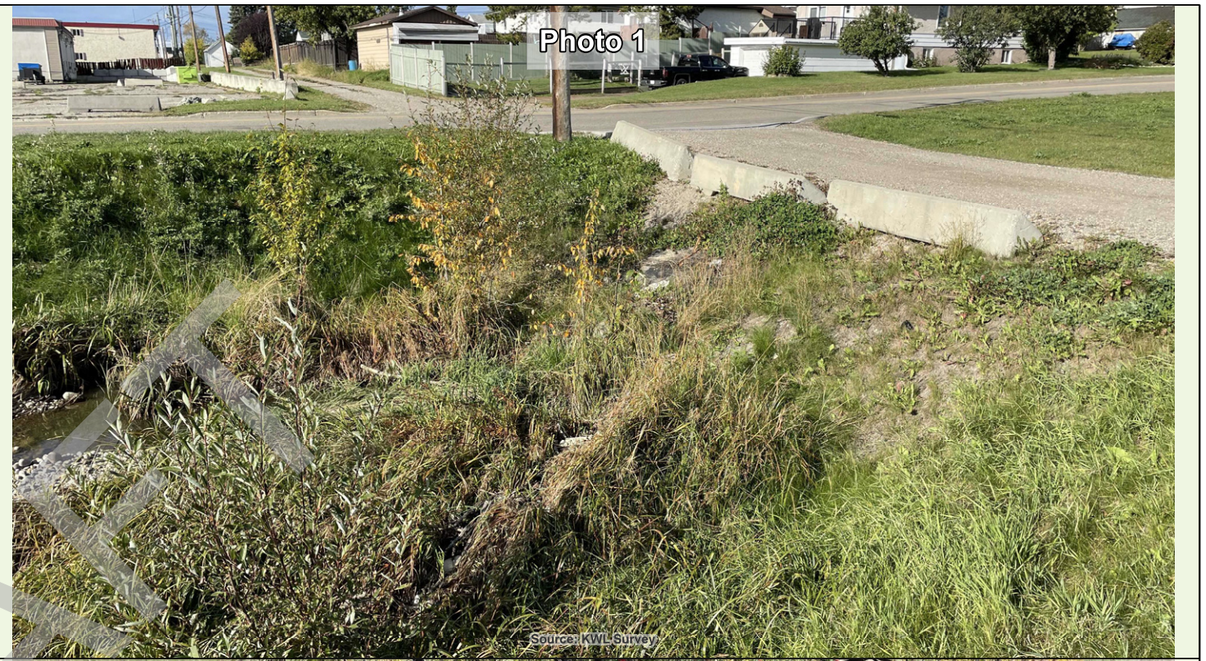
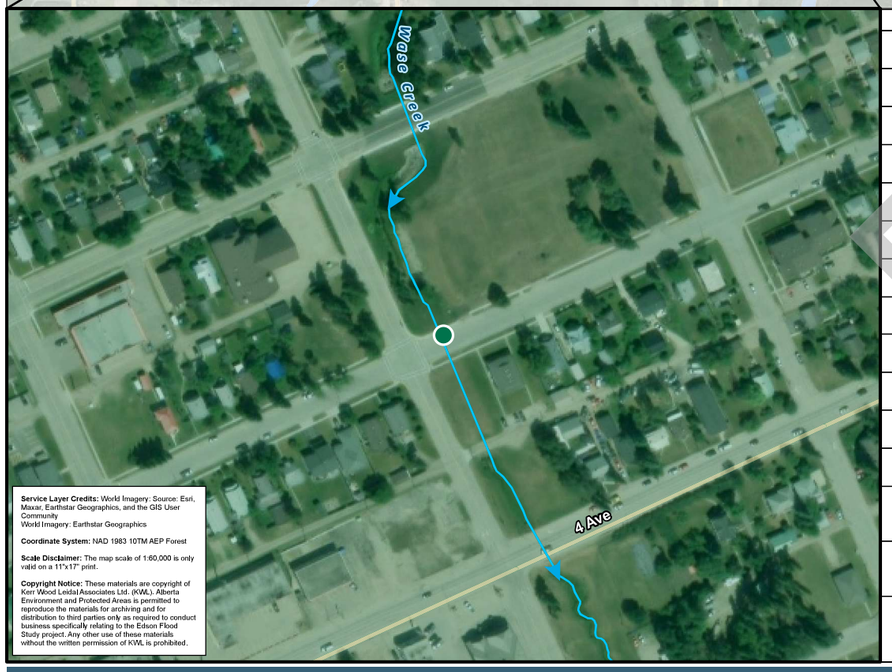
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-16	
DESCRIPTION: 5TH AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 2	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1200	**SHAPE OF PIERS:**
LENGTH: 84.160	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 913.622	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 912.261	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: DS INVERT BURIED IN GRAVEL	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-16

Figure A-53

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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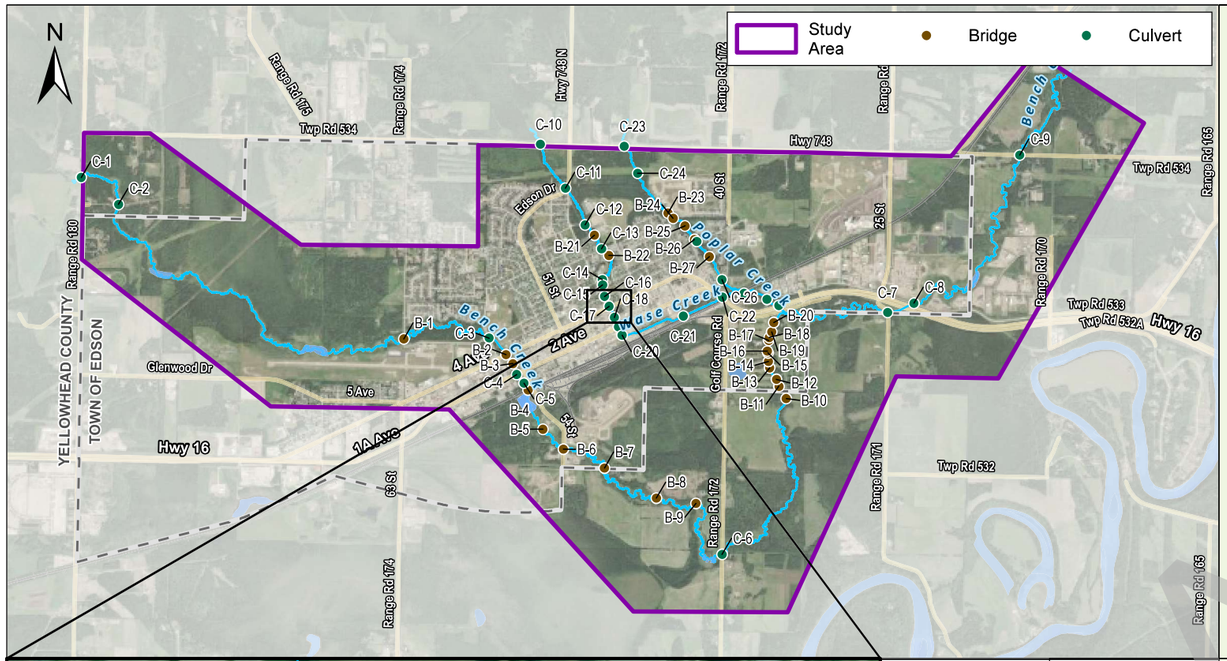



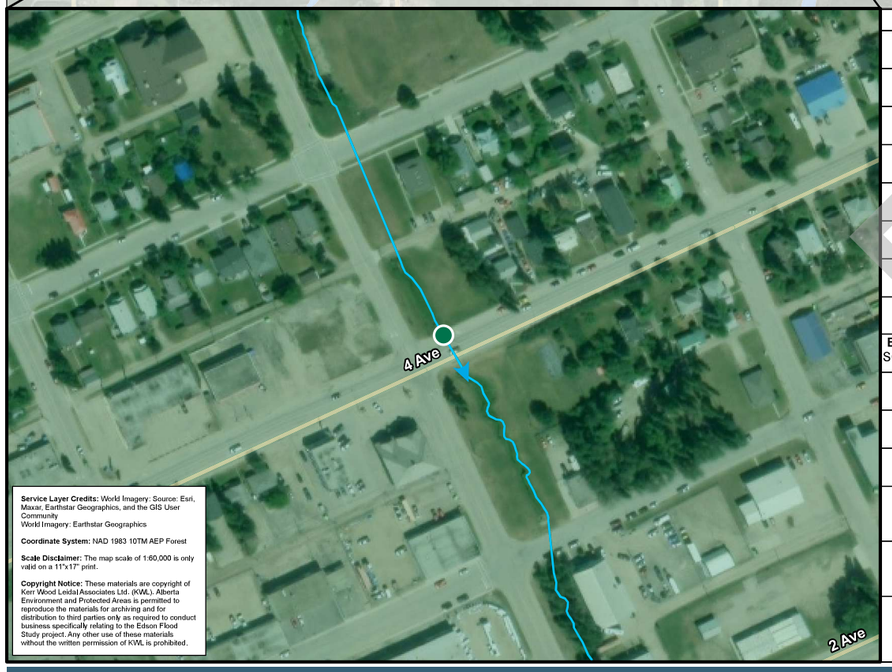

Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-17	
DESCRIPTION: 4TH AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: SQUARE EDGE ENTRANCE	**WIDTH OF PIERS:**
DIMENSIONS: 1200	**SHAPE OF PIERS:**
LENGTH: 23,880	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 912.090	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 911.704	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-17

Figure A-54

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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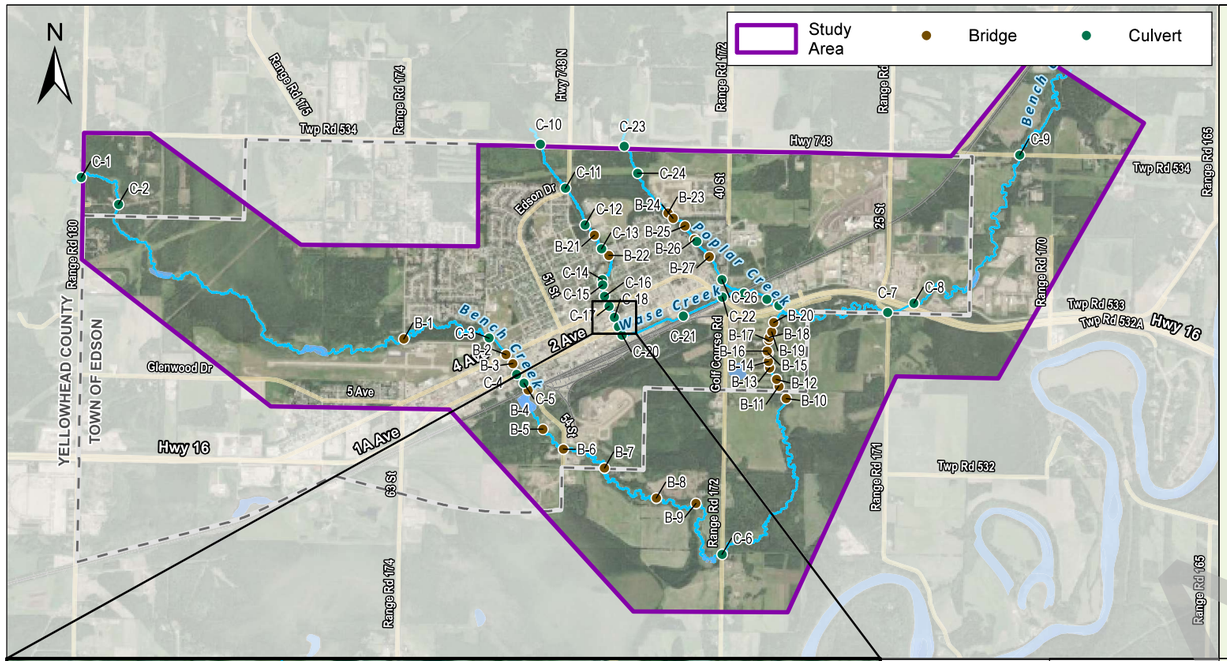





CULVERT	BRIDGE
ID: C-18	
DESCRIPTION: 3RD AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ROUND	# OF PIERS:
ENTRANCE CONDITIONS: PROJECTING	WIDTH OF PIERS:
DIMENSIONS: 1000	SHAPE OF PIERS:
LENGTH: 25.030	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 909.734	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 909.581	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-18

Figure A-55

Alberta Environment and Protected Areas
Edson Flood Study

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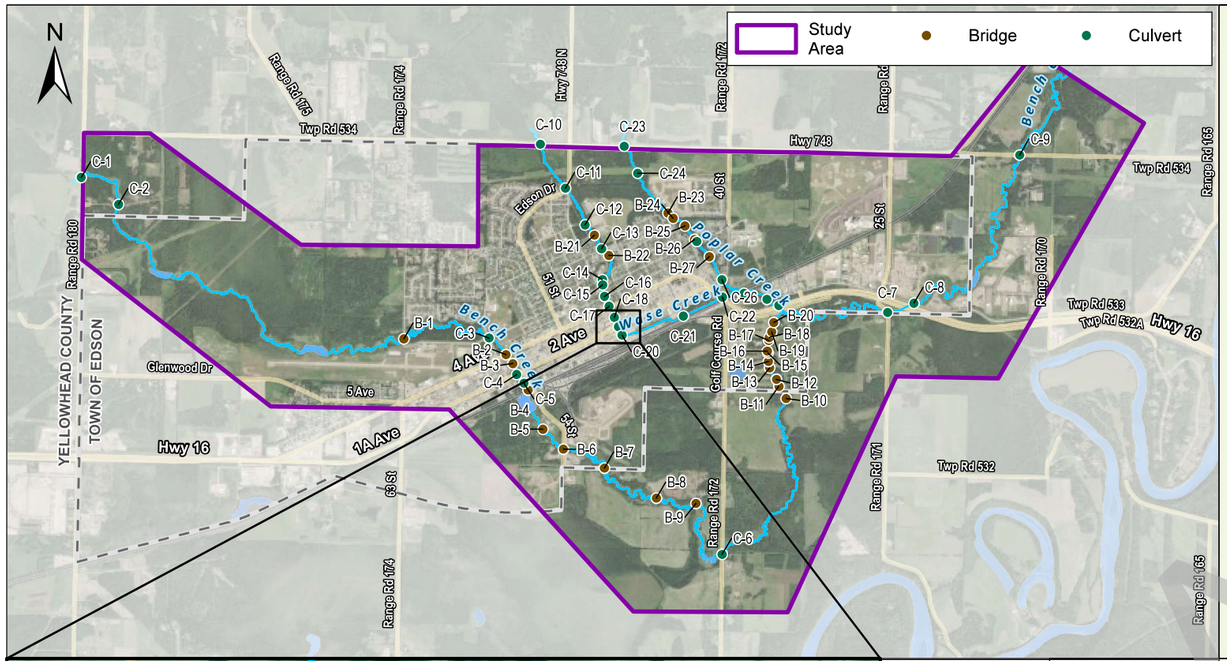
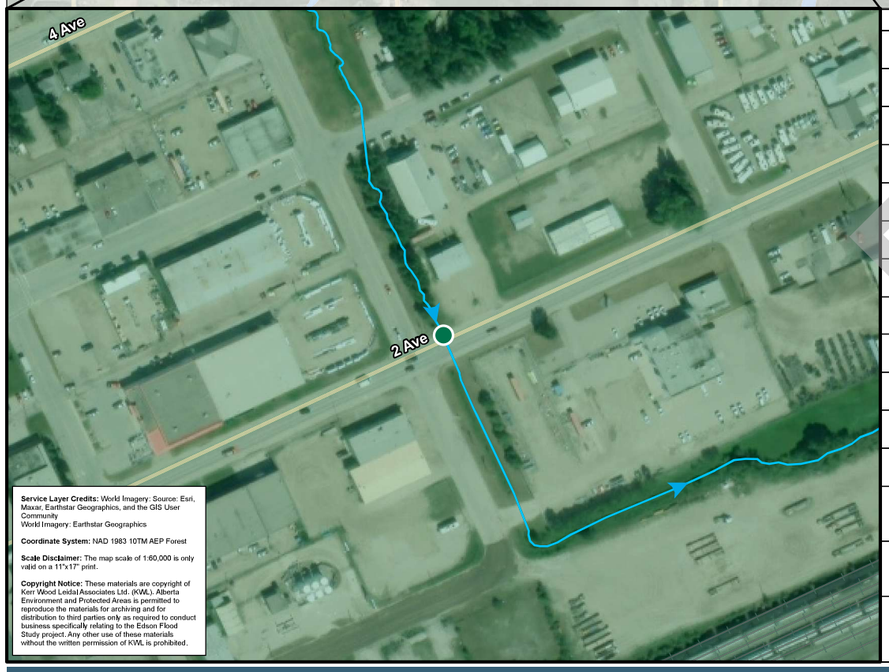
KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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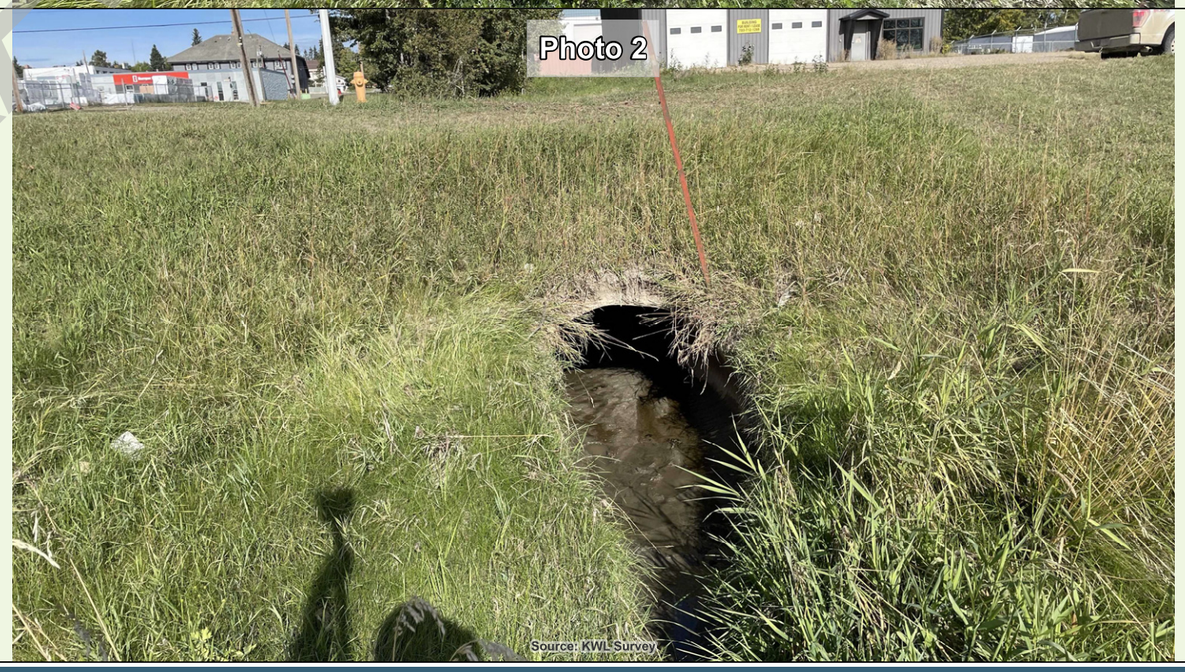
CULVERT	BRIDGE
ID: C-19	
DESCRIPTION: 2ND AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1000	**SHAPE OF PIERS:**
LENGTH: 23.620	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 908.364	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 908.164	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	





Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-19

Figure A-56

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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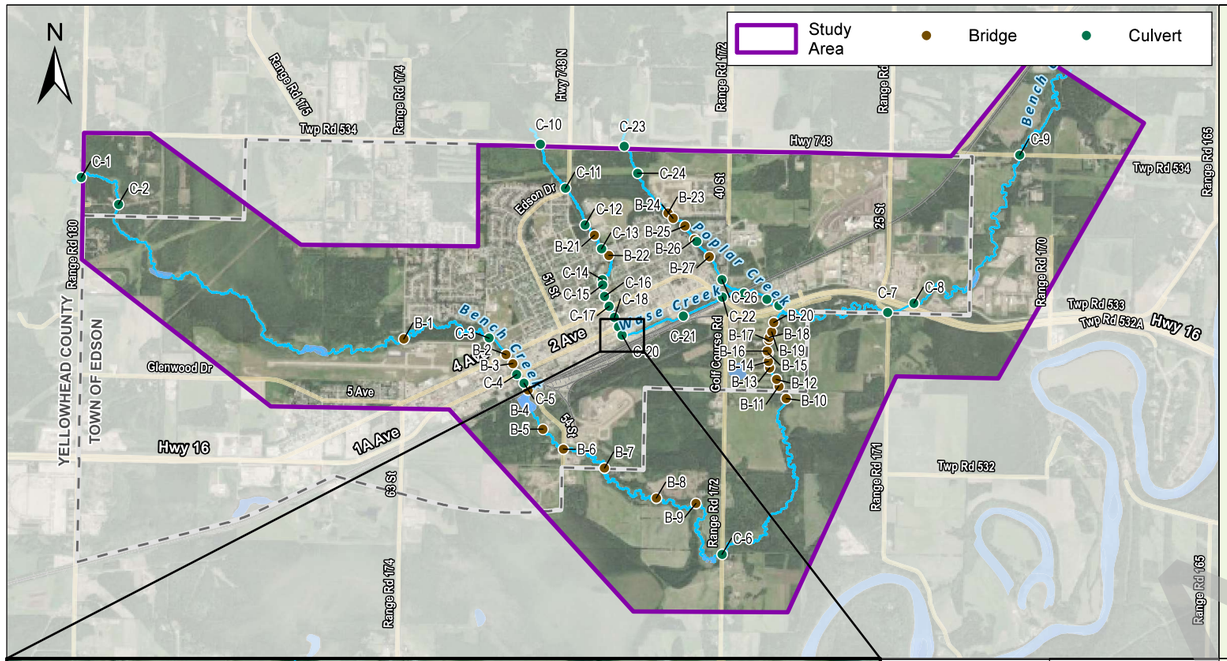



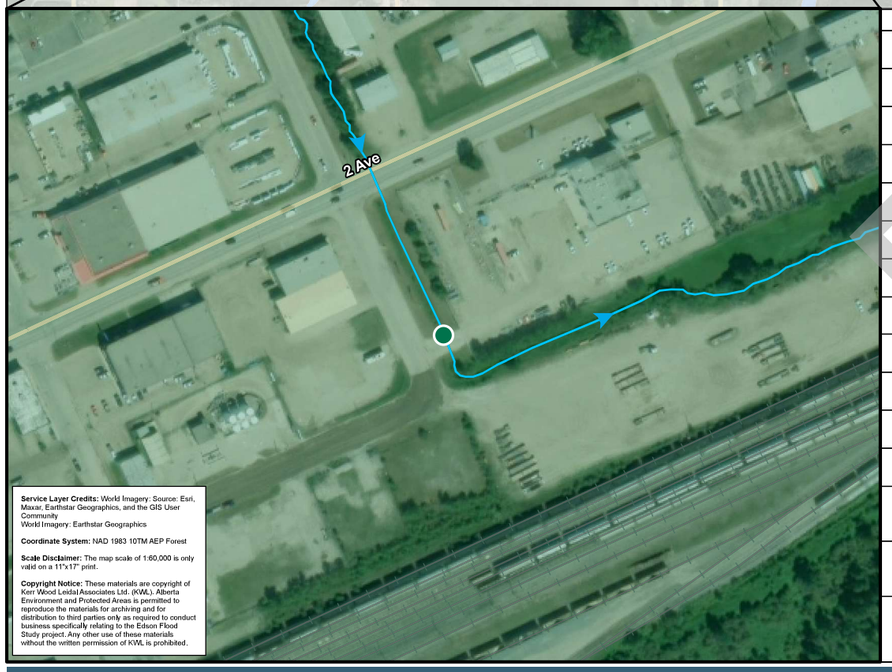

CULVERT	BRIDGE
ID: C-20	
DESCRIPTION: PRIVATE ACCESS OFF 48TH STREET	
FILE #:	
CROSSING TYPE: PRIVATE	
CREEK:	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ARCH	# OF PIERS:
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	WIDTH OF PIERS:
DIMENSIONS: 1300 X 800	SHAPE OF PIERS:
LENGTH: 19.850	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 907.690	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 907.310	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: GRAVEL ROAD	



Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

Scale Disclaimer: The map scale of 1:60,000 is only valid on a 11"x17" print.

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Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-20

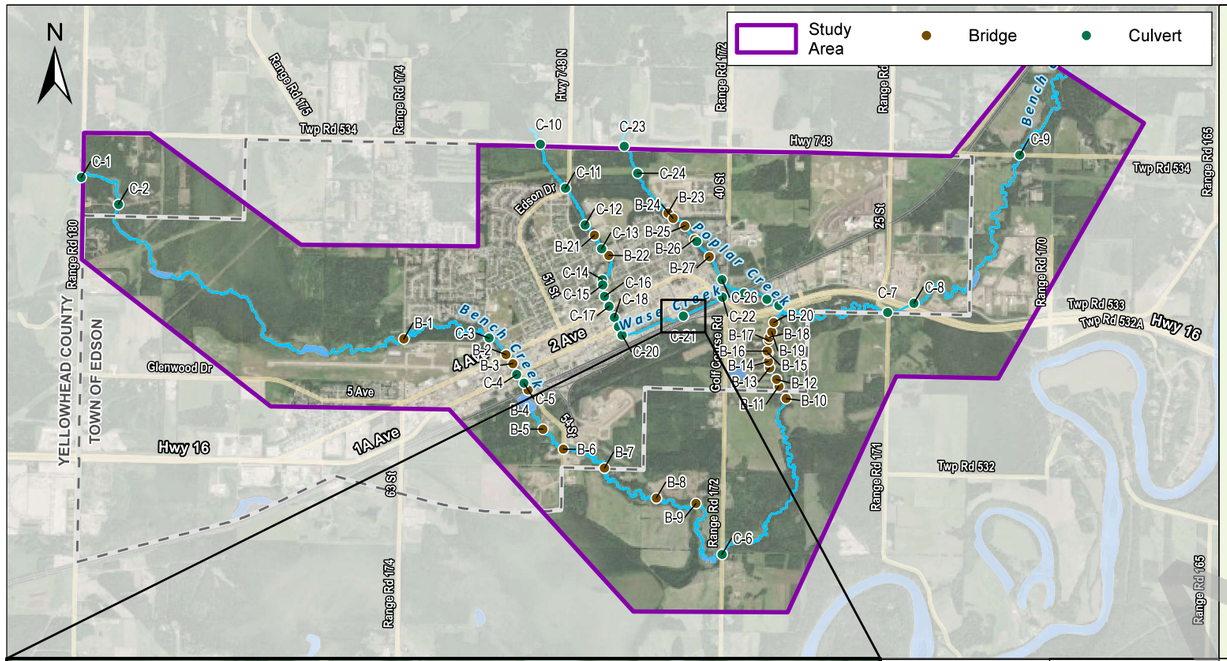
Figure A-57

Classification: Public

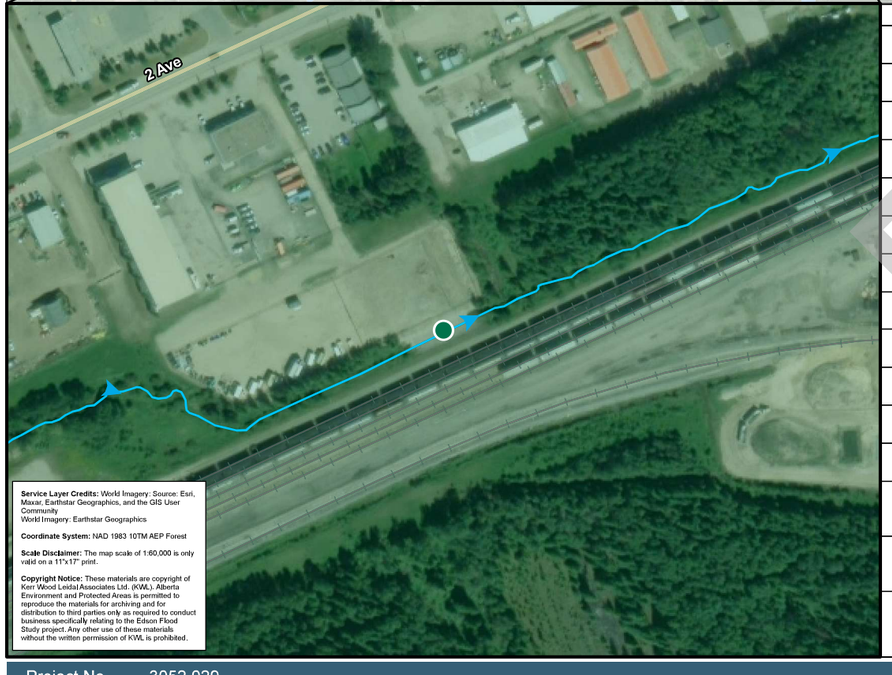
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-21	
DESCRIPTION: PRIVATE ACCESS ADJACENT TO CN RAIL	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: WASE	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1200	**SHAPE OF PIERS:**
LENGTH: 31.973	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 904.200	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 903.980	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-21

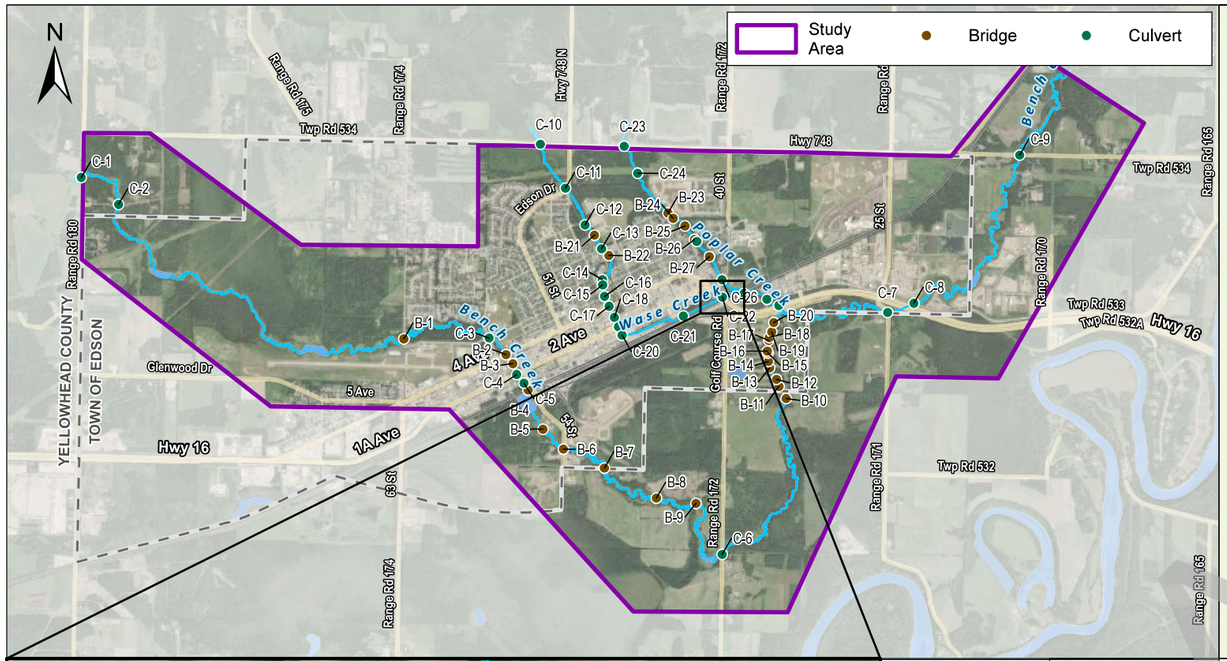
Figure A-58

Classification: Public

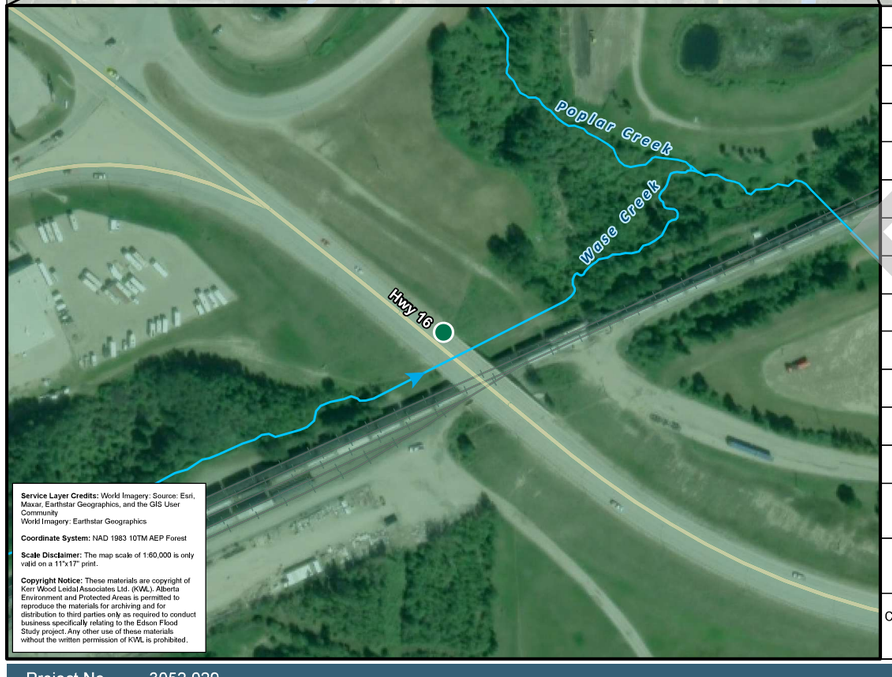
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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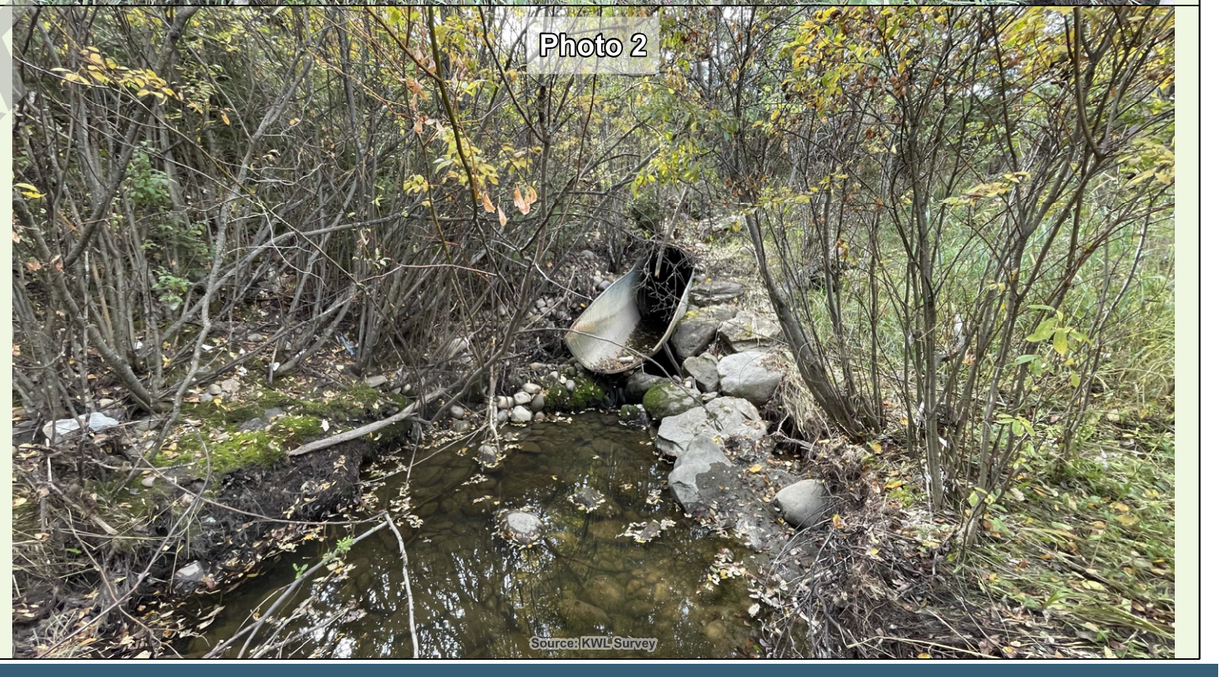
CULVERT	BRIDGE
ID: C-22	
DESCRIPTION: HIGHWAY 16	
FILE #: 77315	
CROSSING TYPE: TRAFFIC	
CREEK: WASE	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1350	**SHAPE OF PIERS:**
LENGTH: 108,840	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 902.240	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 900.350	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: CULVERT COINCIDES WITH HWY 16 BRIDGE OVER CN RAIL	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-22

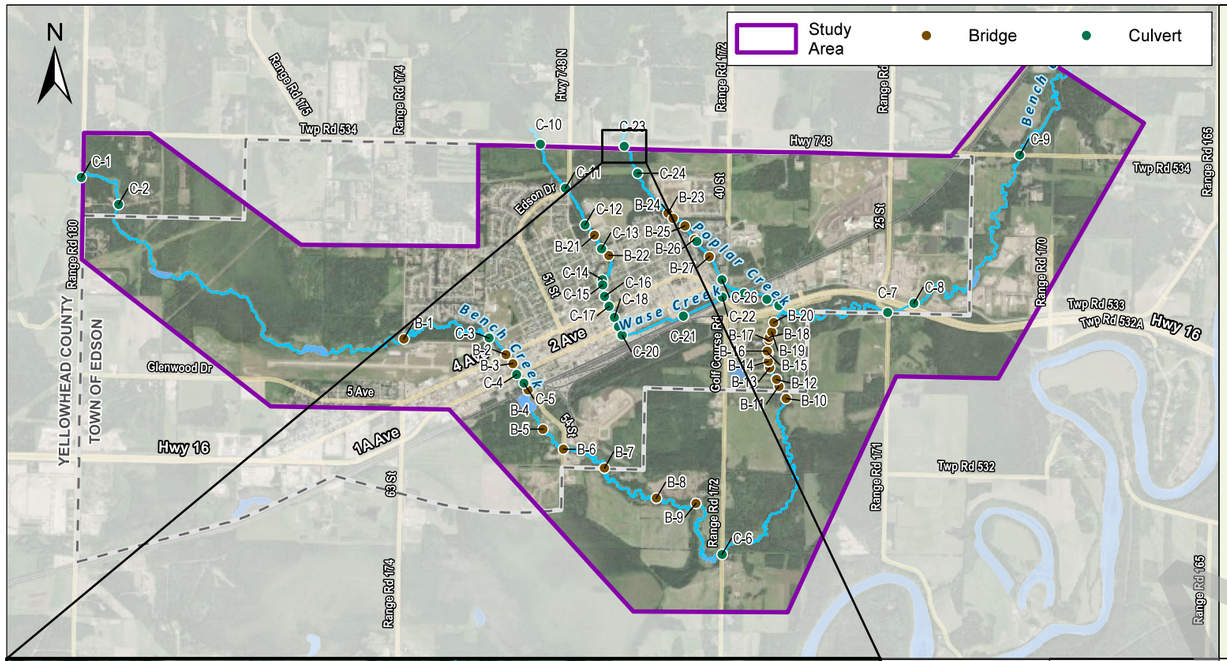
Figure A-59

Classification: Public

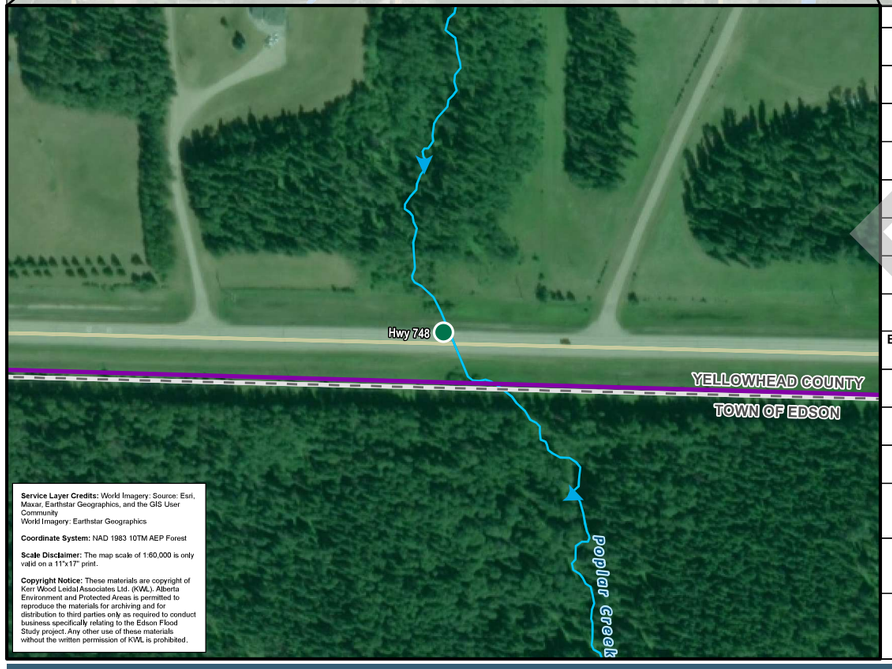
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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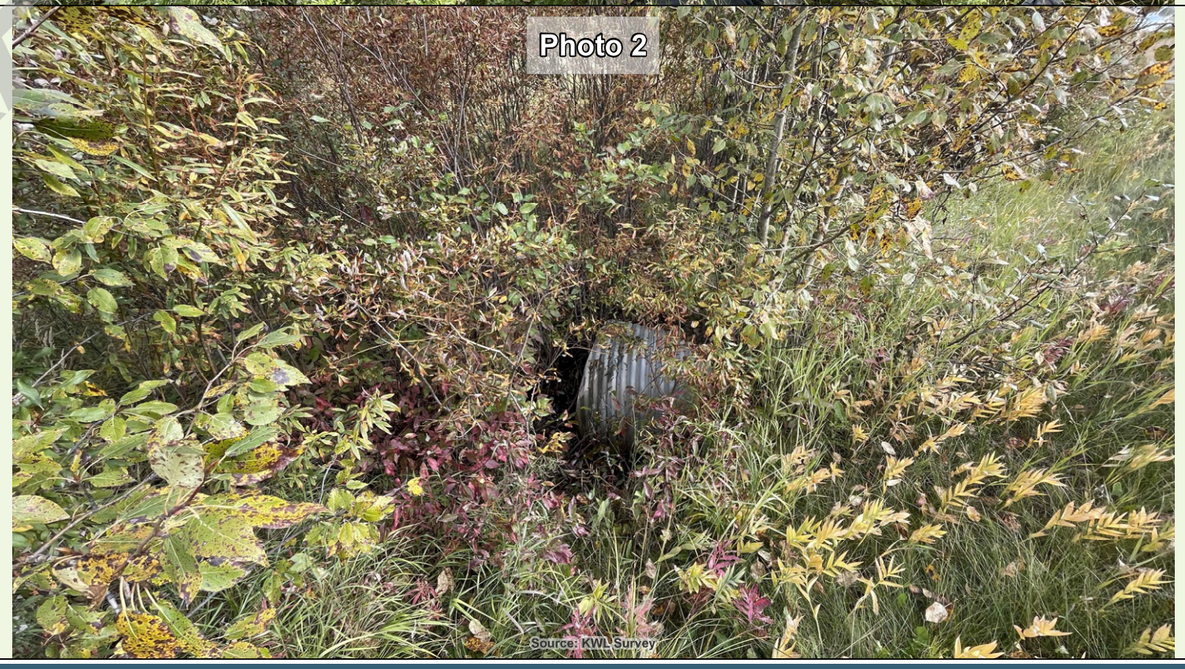
CULVERT	BRIDGE
ID: C-23	
DESCRIPTION: HIGHWAY 748 (TOWNSHIP ROAD 534)	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: POPLAR	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: PROJECTING	**WIDTH OF PIERS:**
DIMENSIONS: 1100	**SHAPE OF PIERS:**
LENGTH: 33.010	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 926.090	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 926.150	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-23

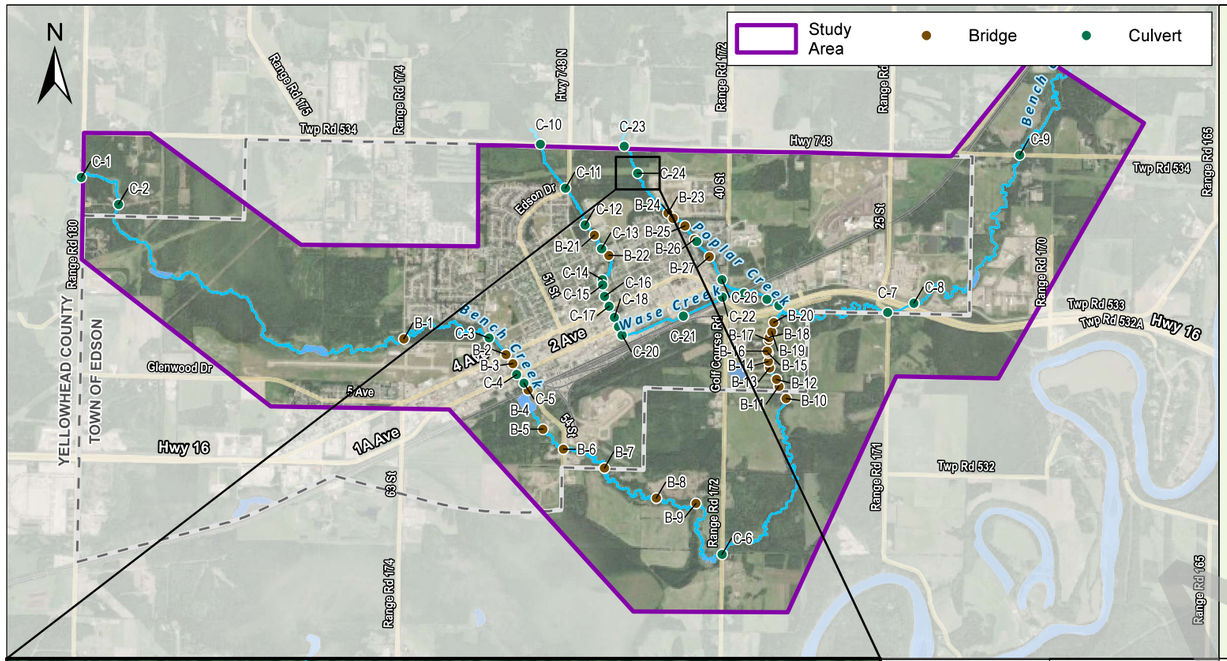
Figure A-60

Classification: Public

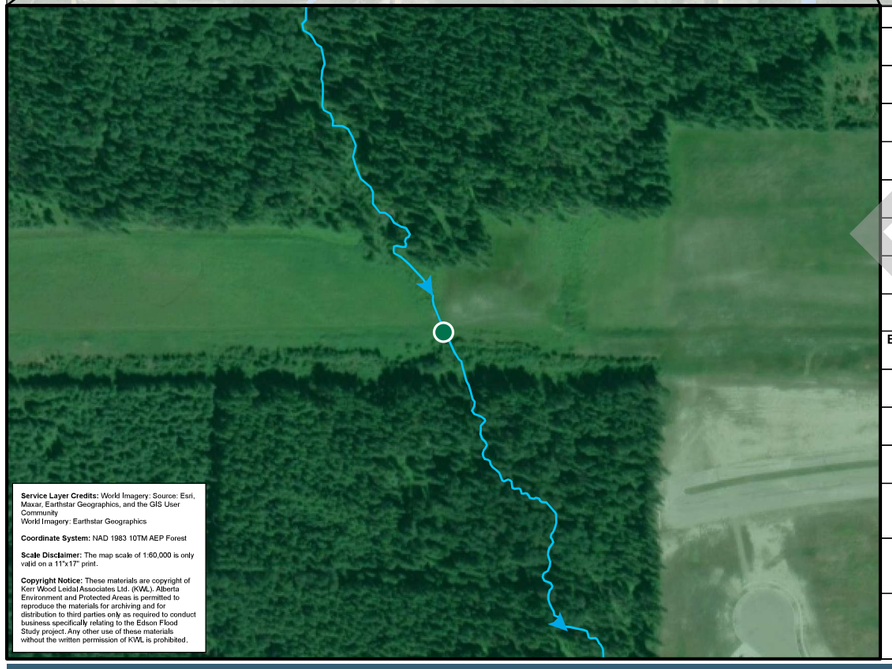
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-24	
DESCRIPTION: ATCO PIPELINE	
FILE #: N/A	
CROSSING TYPE: PRIVATE	
CREEK: POPLAR	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ROUND	# OF PIERS:
ENTRANCE CONDITIONS: PROJECTING	WIDTH OF PIERS:
DIMENSIONS: 600	SHAPE OF PIERS:
LENGTH: 18,450	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 921.460	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 921.500	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: GRASS WITH RUTS	



Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-24

Figure A-61

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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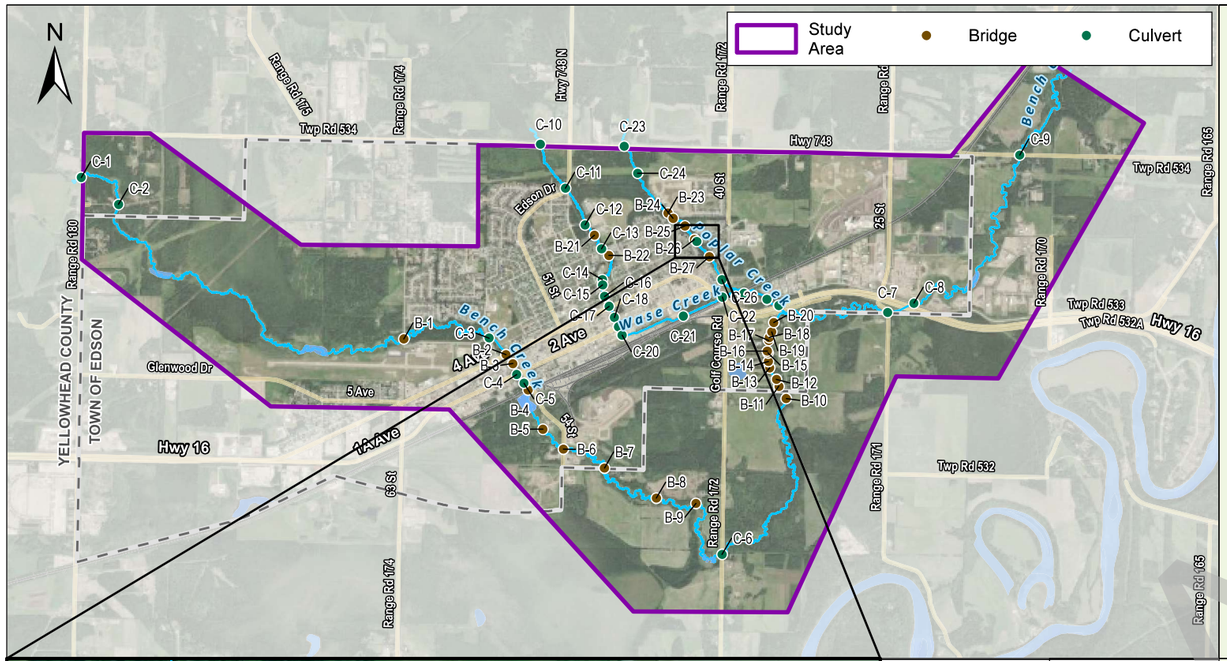
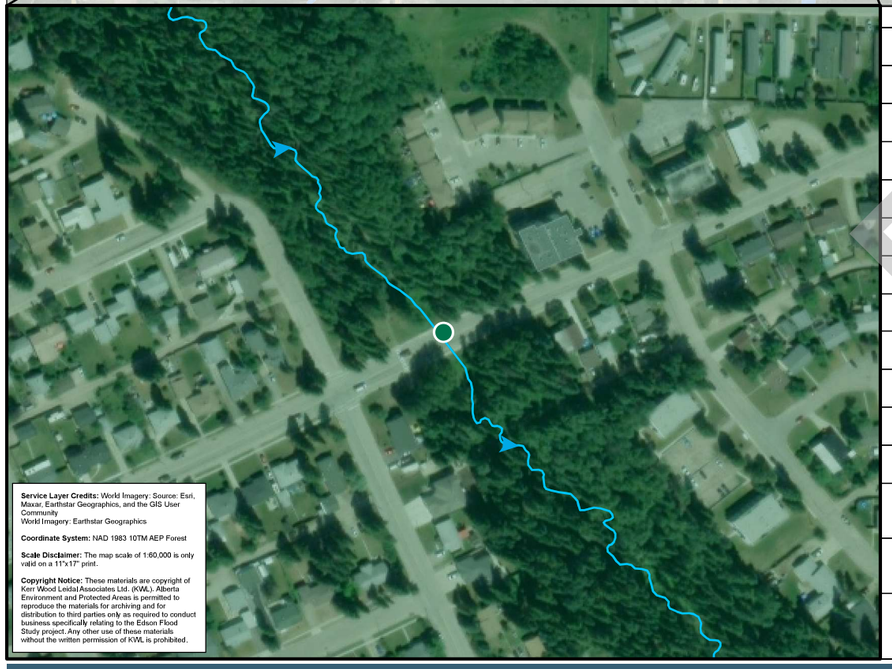
KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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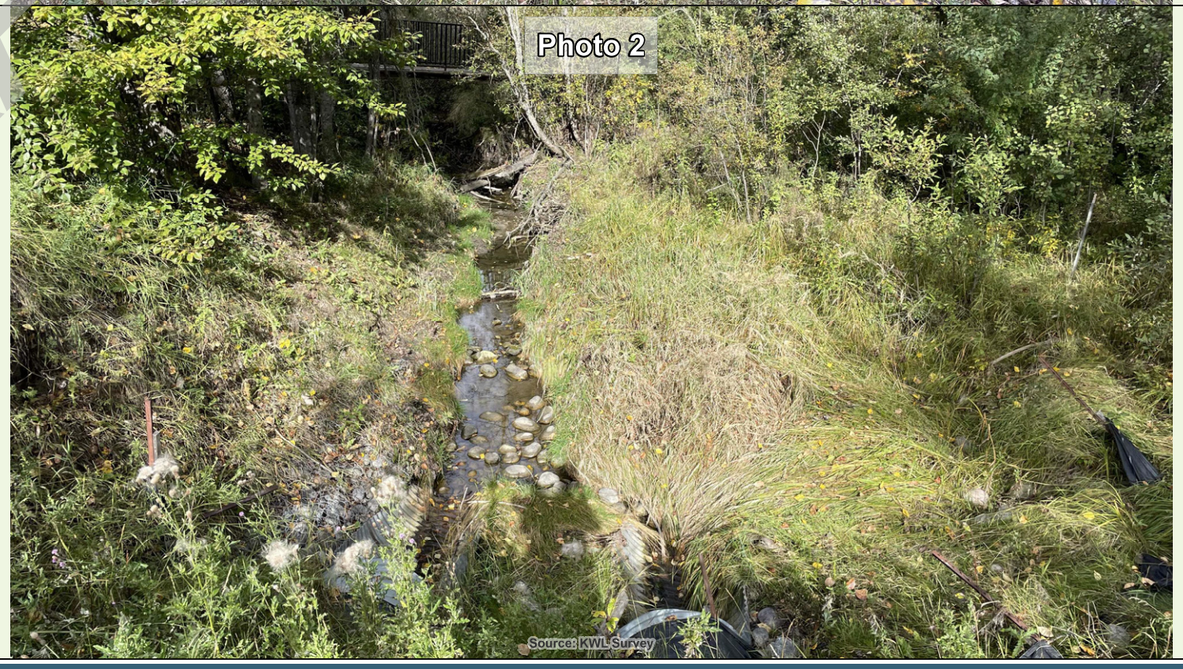
CULVERT	BRIDGE
ID: C-25	
DESCRIPTION: 6TH AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: POPLAR	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 900	**SHAPE OF PIERS:**
LENGTH: 39.000	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 907.180	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 906.410	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: LOCAL MINIMUM ROAD ELEVATION	





Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-25

Figure A-62

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

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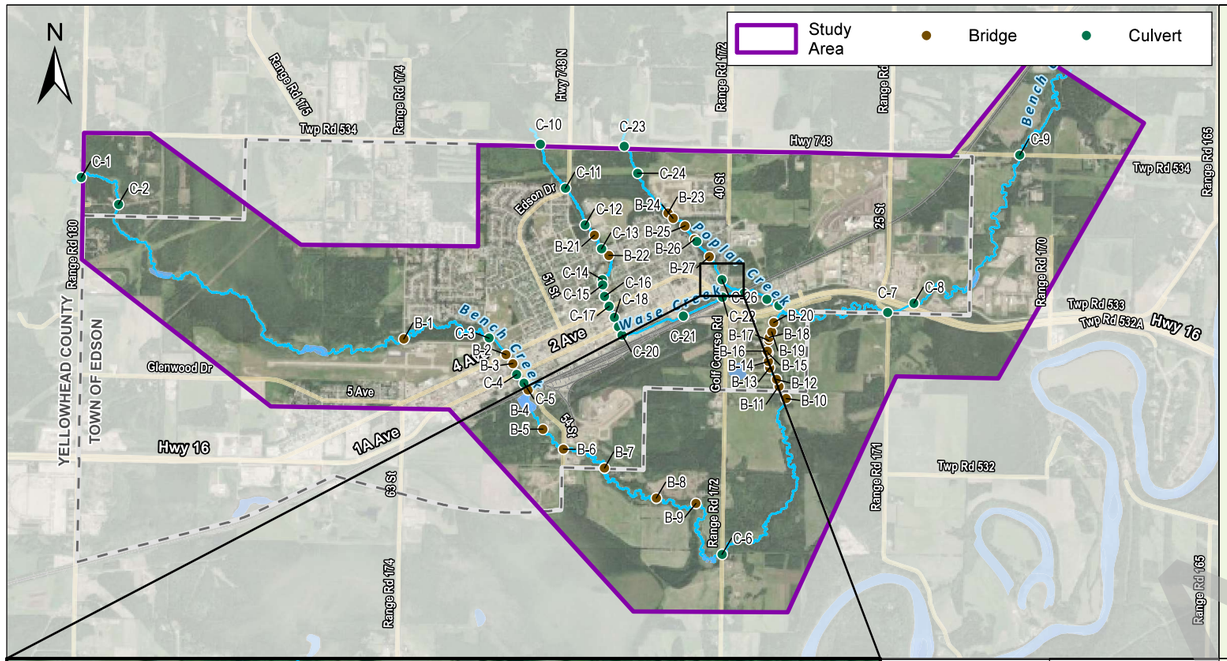
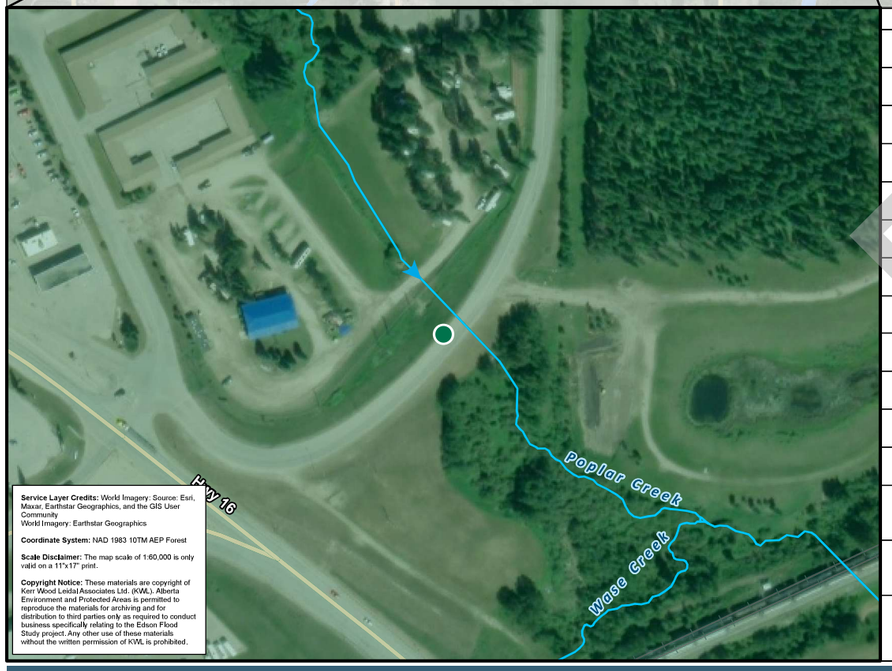
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-26	
DESCRIPTION: 2ND AVENUE/BEAR LAKE ROAD/40TH STREET	
FILE #: 9920	
CROSSING TYPE: TRAFFIC	
CREEK: POPLAR	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 1800	**SHAPE OF PIERS:**
LENGTH: 65.027	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 899.600	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 899.390	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES: CAMPRGOUND ROAD AND PUBLIC ROAD	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-26

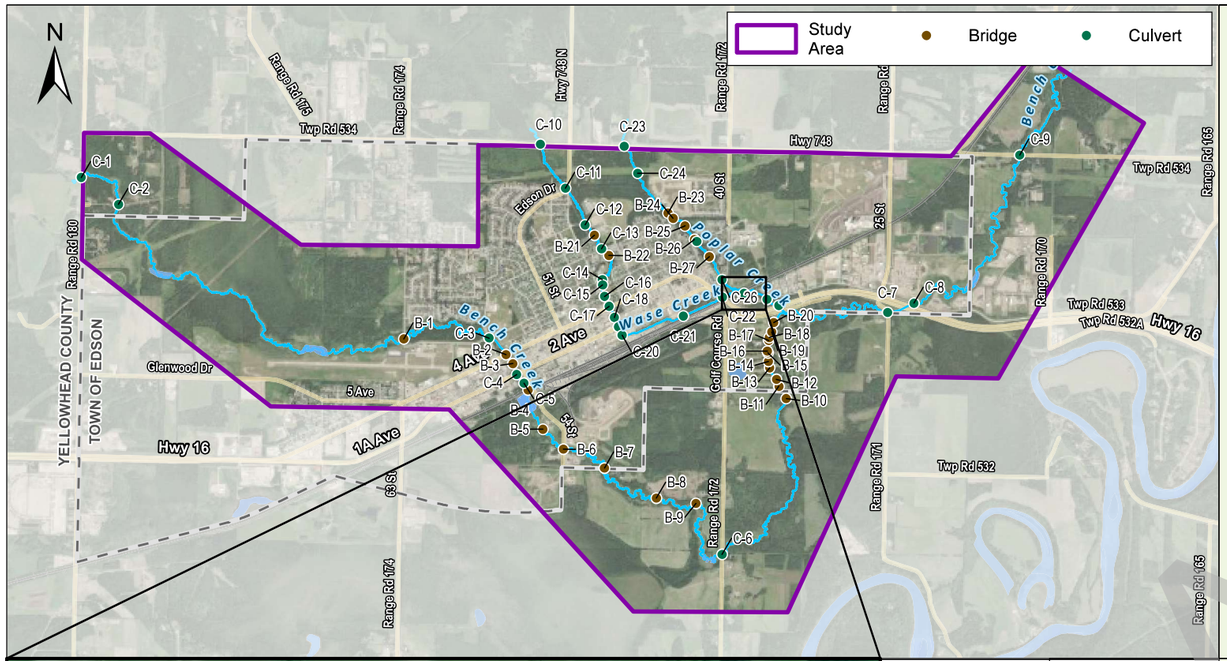
Figure A-63

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers







Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-27	
DESCRIPTION: CN RAIL	
FILE #: N/A	
CROSSING TYPE: RAILWAY	
CREEK: BENCH	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: HEADWALL	**WIDTH OF PIERS:**
DIMENSIONS: 1100, 2000	**SHAPE OF PIERS:**
LENGTH: 186.385	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 896.410	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 893.950	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:

TOP OF ROADWAY NOTES:
US TO DS: HEADWALL NORTH OF CN RAIL, 2 M VERTICAAL IN OPEN DITCH, 2 M VERTICAL IN TREED DITCH, OUTLET IN DITCH BESIDE POND; SWITCHES FROM 1100 TO 2000 AT THE DOWNSTREAM DAYLIGHT



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-27

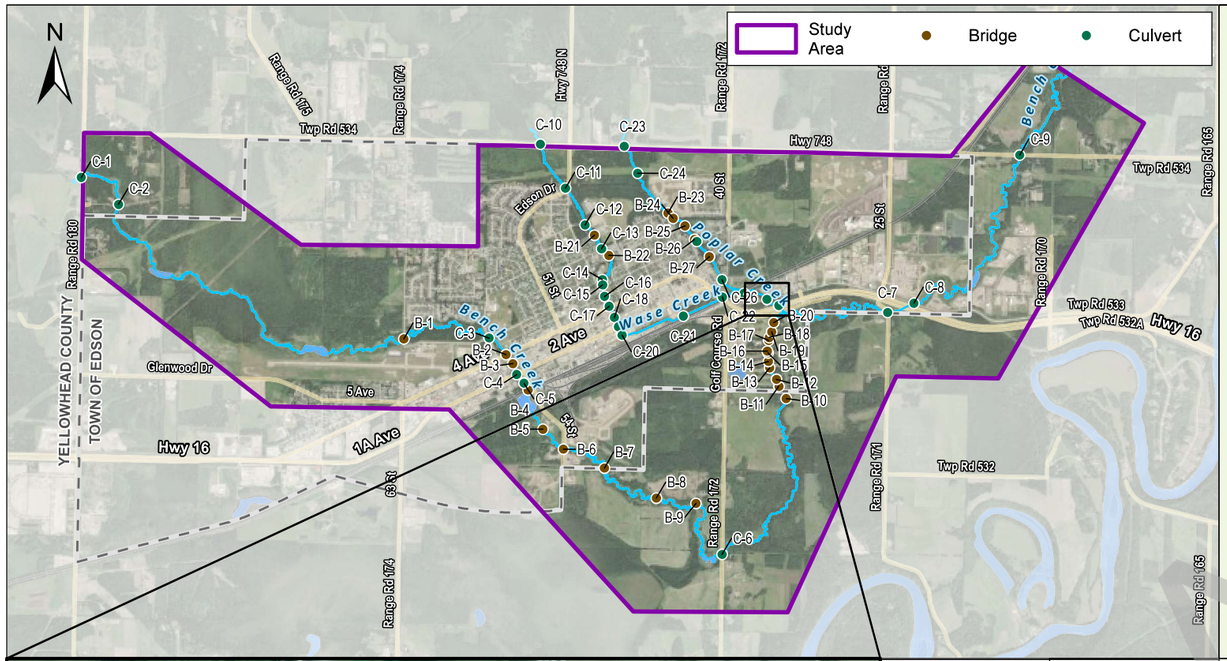
Figure A-64

Classification: Public

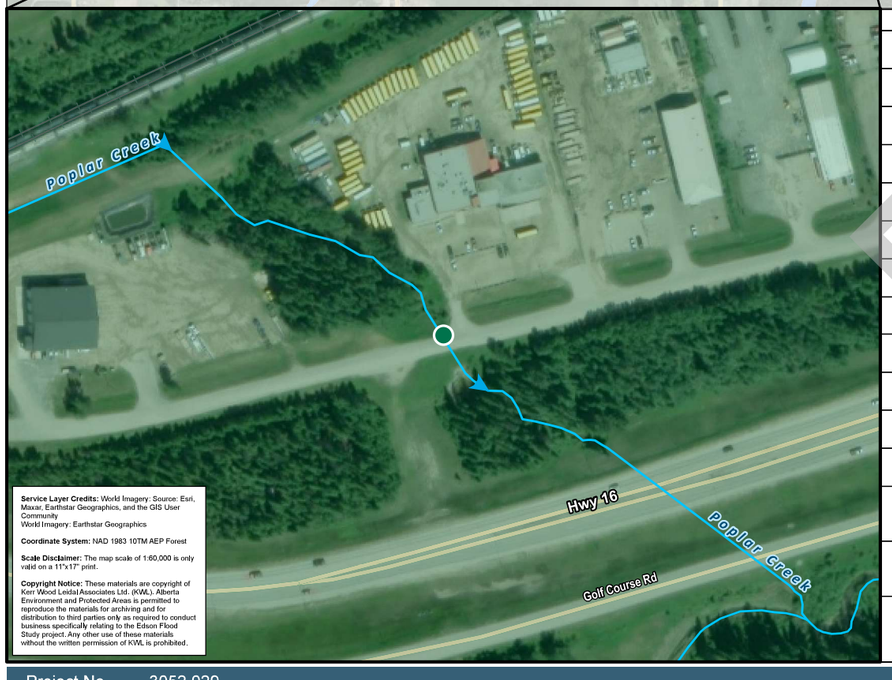
Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

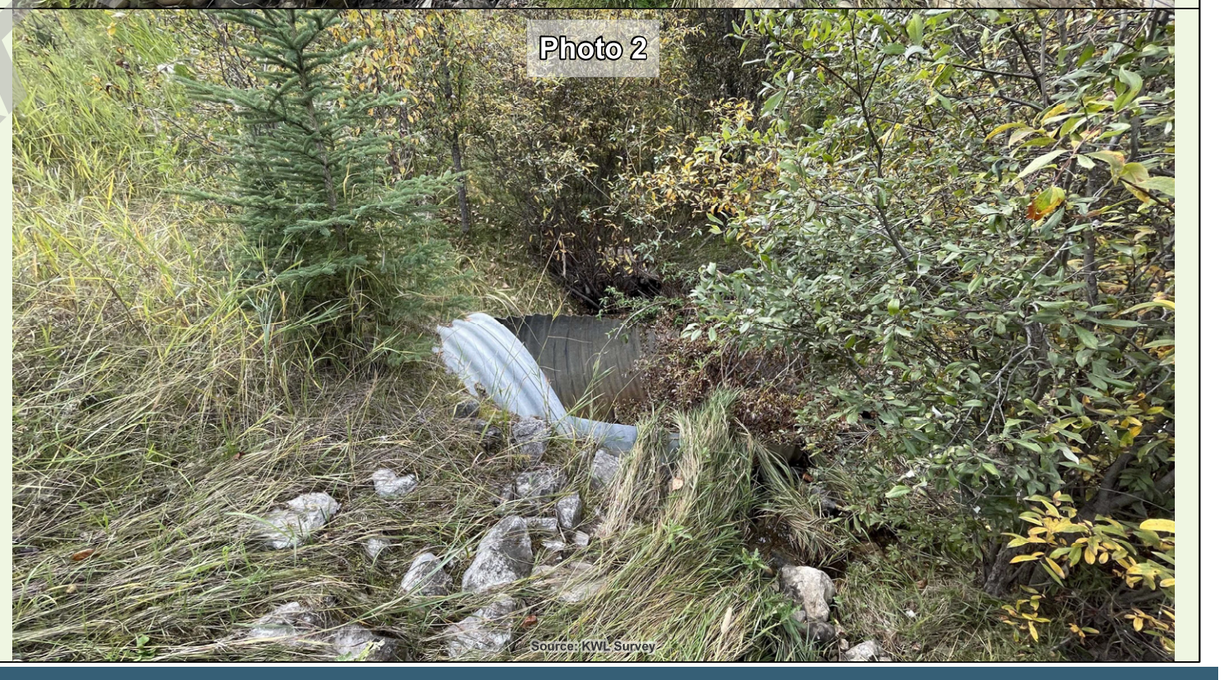
KERR WOOD LEIDAL consulting engineers







CULVERT	BRIDGE
ID: C-28	
DESCRIPTION: 1ST AVENUE	
FILE #: N/A	
CROSSING TYPE: TRAFFIC	
CREEK: POPLAR	
# OF BARRELS: 1	# OF SPANS:
TYPE: CMP	WIDTH:
SHAPE: ROUND	# OF PIERS:
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	WIDTH OF PIERS:
DIMENSIONS: 1900	SHAPE OF PIERS:
LENGTH: 34.715	U/S LOW CHORD ELEV:
U/S INVERT ELEV: 891.570	D/S LOW CHORD ELEV:
D/S INVERT ELEV: 891.120	U/S TOP OF CURB / GUARD RAIL ELEV:
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	



Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

Bridge and Culvert Survey - C-28

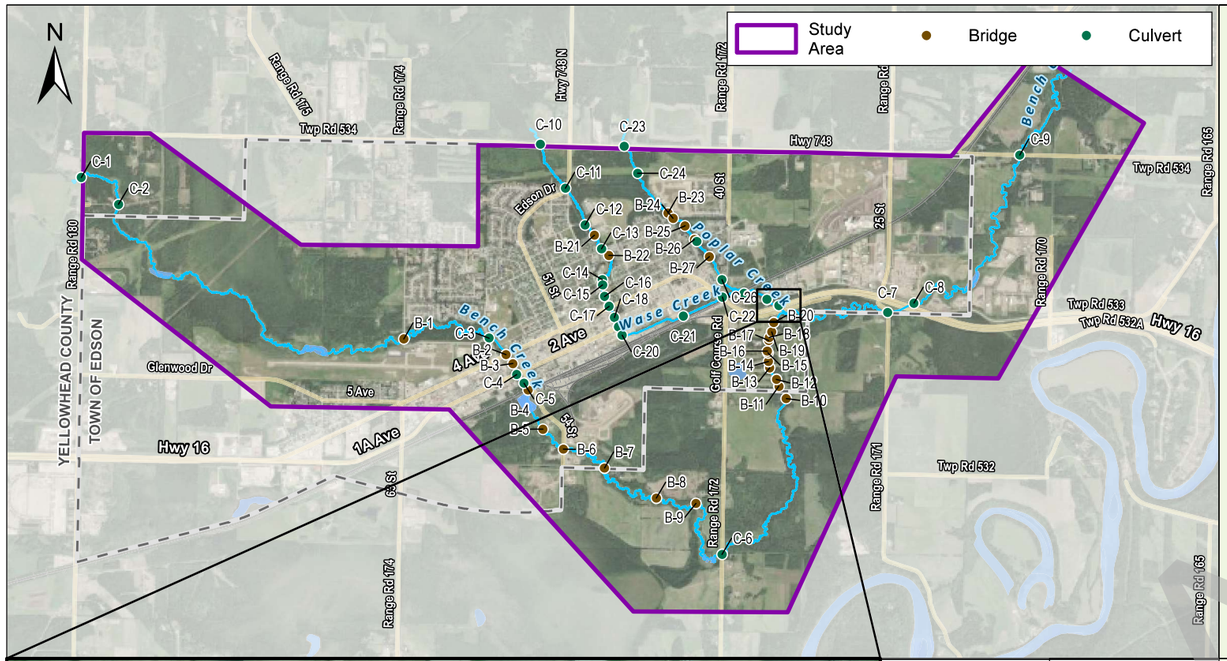
Figure A-65

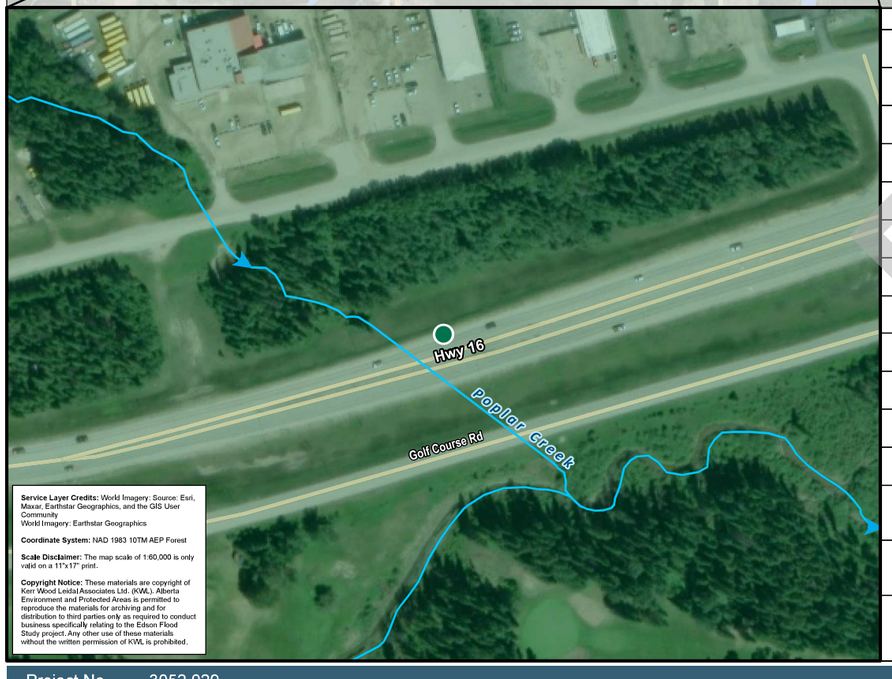
Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

DRAFT

KERR WOOD LEIDAL consulting engineers





Service Layer Credits: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Coordinate System: NAD 1983 10TM AEP Forest

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CULVERT	BRIDGE
ID: C-29	
DESCRIPTION: HIGHWAY 16	
FILE #: 511	
CROSSING TYPE: TRAFFIC	
CREEK: POPLAR	
# OF BARRELS: 1	**# OF SPANS:**
TYPE: CMP	**WIDTH:**
SHAPE: ROUND	**# OF PIERS:**
ENTRANCE CONDITIONS: MITRED TO CONFORM TO SLOPE	**WIDTH OF PIERS:**
DIMENSIONS: 2300	**SHAPE OF PIERS:**
LENGTH: 117,940	**U/S LOW CHORD ELEV:**
U/S INVERT ELEV: 890,390	**D/S LOW CHORD ELEV:**
D/S INVERT ELEV: 888,983	**U/S TOP OF CURB / GUARD RAIL ELEV:**
	D/S TOP OF CURB / GUARD RAIL ELEV:
TOP OF ROADWAY NOTES:	





Project No. 3052.029
Date October 2025
Scale 1:60,000
0 250 500 1,000 Metres

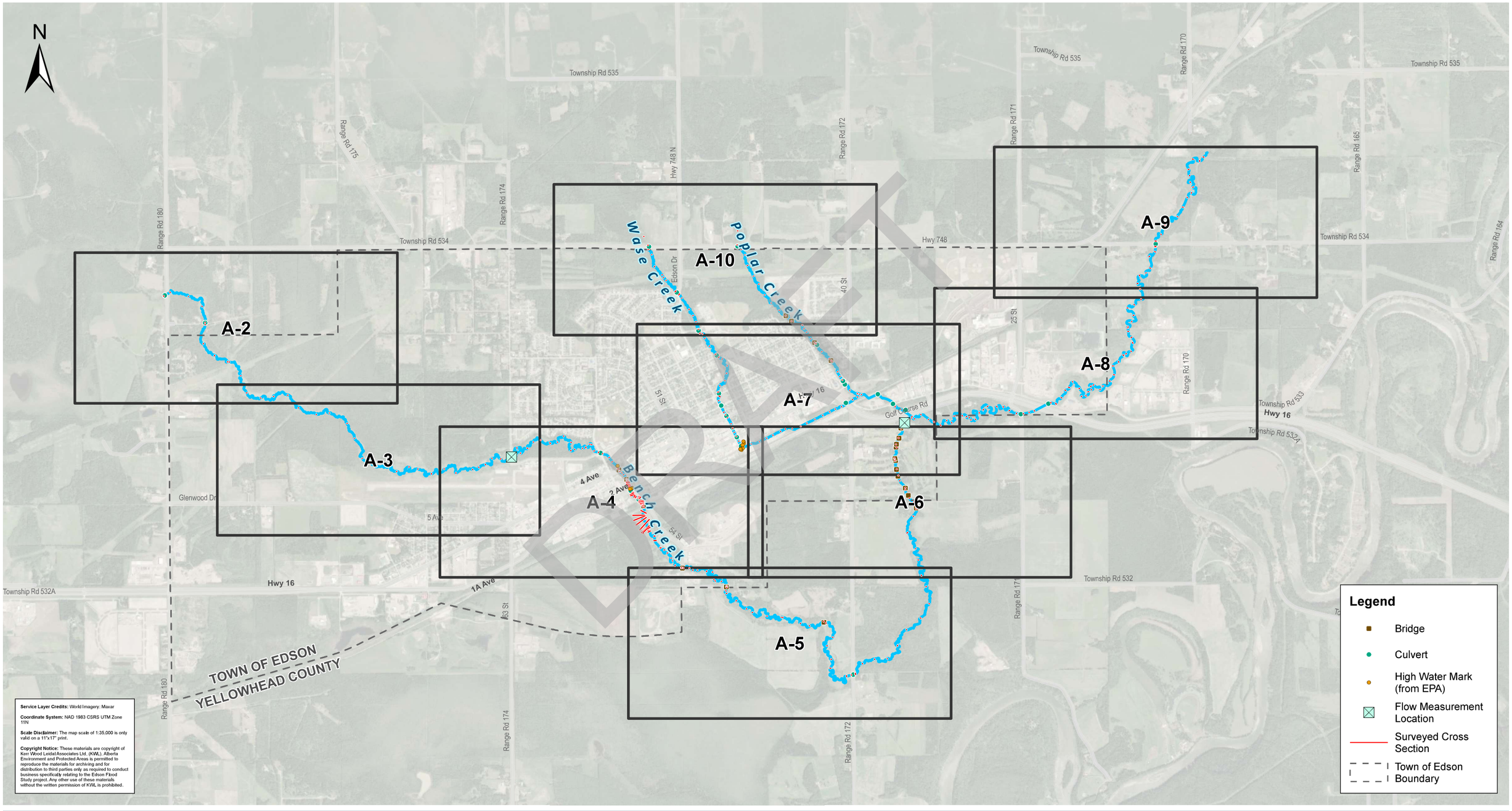
Bridge and Culvert Survey - C-29

Figure A-66

Classification: Public

Alberta Environment and Protected Areas
Edson Flood Study

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: Maxar

Coordinate System: NAD 1983 CSRS UTM Zone 11N

Scale Disclaimer: The map scale of 1:35,000 is only valid on a 11"x17" print.

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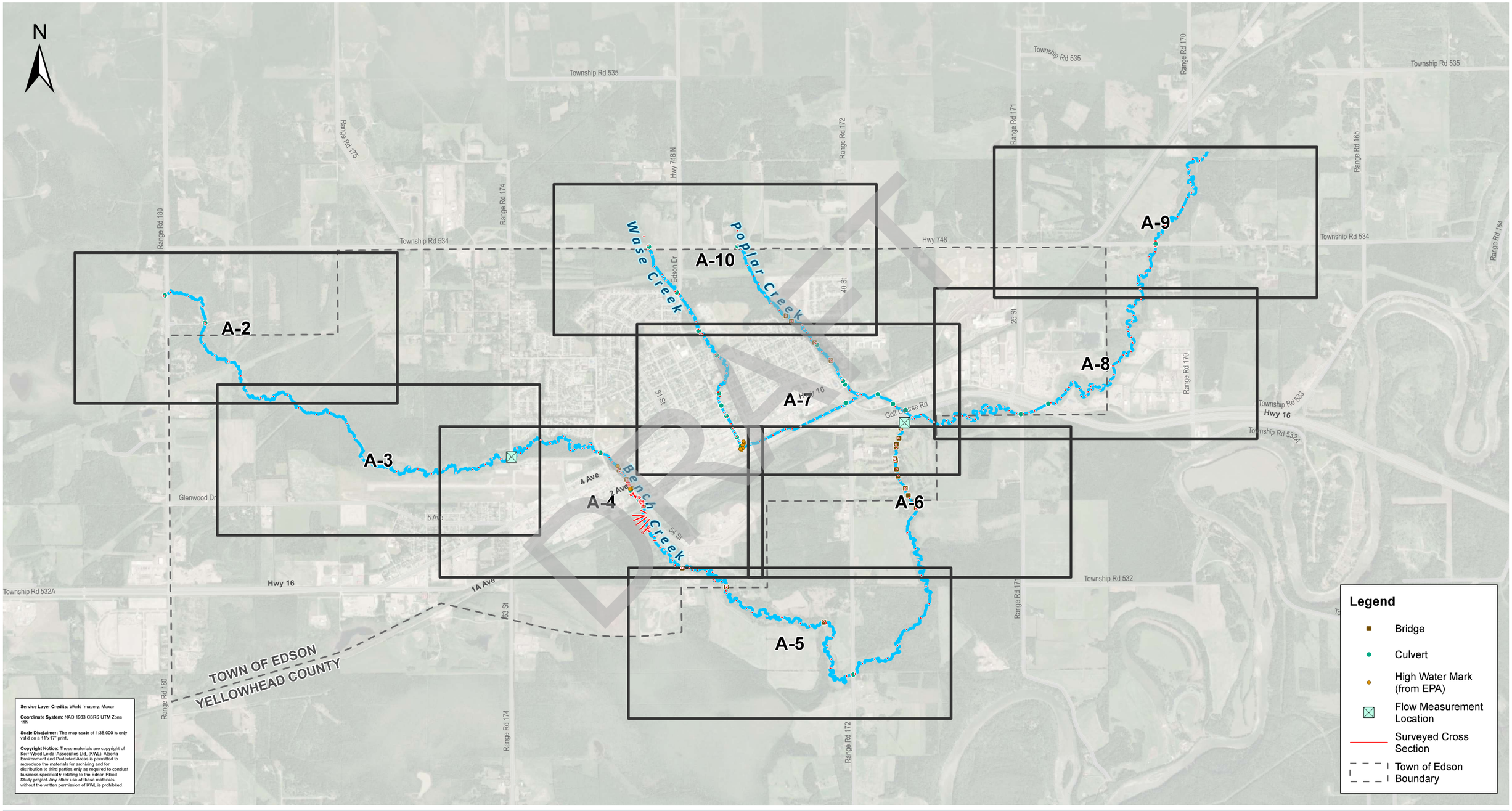
Project No. 3052.029
Date October 2025
Scale 1:35,000
0 250 500 1,000 Metres

Field Survey Overview

Figure A-1

Alberta Environment and Protected Areas
Edson Flood Study

KERR WOOD LEIDAL
consulting engineers



Service Layer Credits: World Imagery: Maxar

Coordinate System: NAD 1983 CSRS UTM Zone 11N

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Project No. 3052.029
Date October 2025
Scale 1:35,000
0 250 500 1,000 Metres

Field Survey Overview

Figure A-1

Alberta Environment and Protected Areas

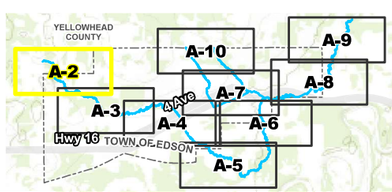


▼ FIGURE A-3

N

Legend

- Municipal Boundary
- 1 km Creek Station
- 100 m Creek Station
- Creek Centreline
- Flow Direction
- Bridge
- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section



Project No. 3052.029
Date October 2025
Scale 1:7,500
0 50 100 200 Metres

Field Survey Overview

Figure A-2

Classification: Public

Alberta Environment and Protected Areas

▲ FIGURE A-2



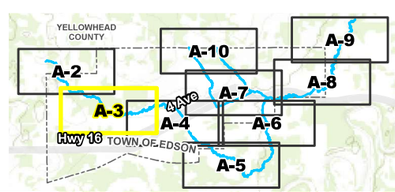
▼ FIGURE A-4

DRAFT

N

Legend

- Municipal Boundary
- 1 km Creek Station
- 100 m Creek Station
- Creek Centreline
- Flow Direction
- Bridge
- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section



Project No. 3052.029
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Field Survey Overview

Figure A-3

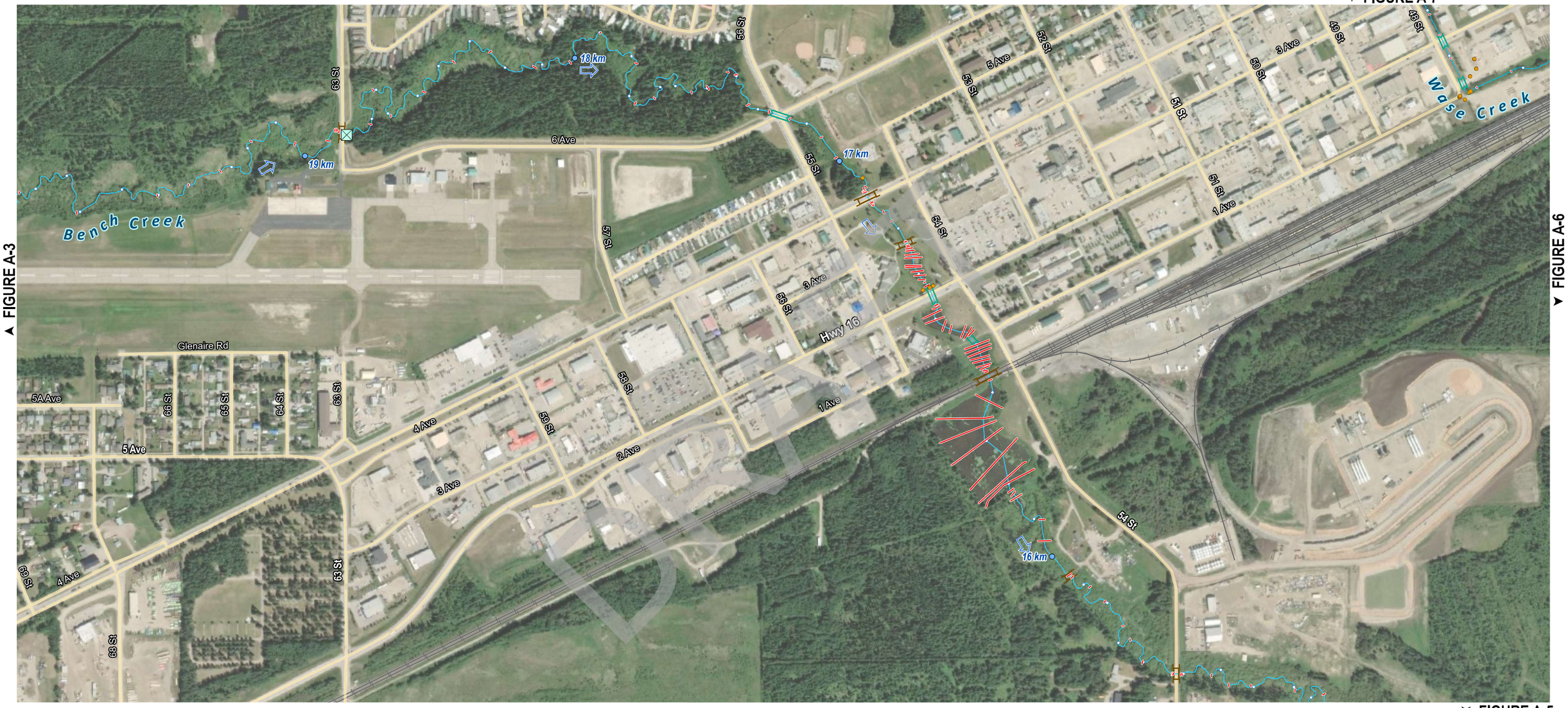
Classification: Public

Alberta Environment and Protected Areas

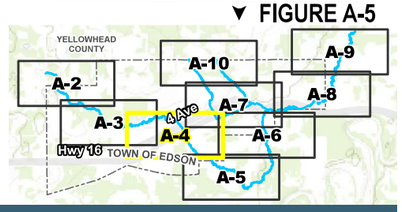
◄ FIGURE A-3

▲ FIGURE A-7

▼ FIGURE A-6



▼ FIGURE A-5



N

Legend

- Municipal Boundary
- 1 km Creek Station
- 100 m Creek Station
- Creek Centreline
- Flow Direction
- Bridge
- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section

Project No.	3052.029
Date	October 2025
Scale	1:7,500

0 50 100 200 Metres

Field Survey Overview

Figure A-4

Classification: Public

Alberta Environment and Protected Areas

▲ FIGURE A-4

▲ FIGURE A-6

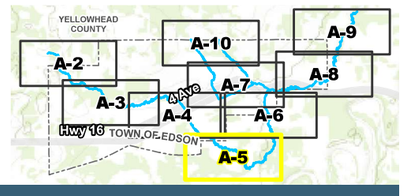


DRAFT

N

Legend

- Municipal Boundary
- 1 km Creek Station
- 100 m Creek Station
- Creek Centreline
- Flow Direction
- Bridge
- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section



Project No. 3052.029
Date October 2025
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0 50 100 200 Metres

Field Survey Overview

Figure A-5

Classification: Public

Alberta Environment and Protected Areas

▶ FIGURE A-7

▲ FIGURE A-8

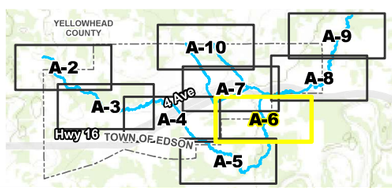


▼ FIGURE A-5

N

Legend

- Municipal Boundary
- 1 km Creek Station
- 100 m Creek Station
- Creek Centreline
- Flow Direction
- Bridge
- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section



Project No. 3052.029
Date October 2025
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Field Survey Overview

Figure A-6

DRAFT

Classification: Public

Alberta Environment and Protected Areas

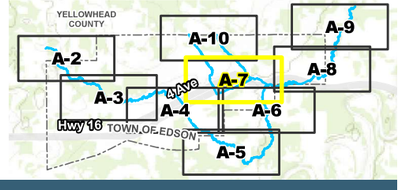
▲ FIGURE A-10



▲ FIGURE A-4

▼ FIGURE A-8

▼ FIGURE A-6



N

Legend

- Municipal Boundary
- 1 km Creek Station
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- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section

Project No.	3052.029
Date	October 2025
Scale	1:7,500

0 50 100 200 Metres

Field Survey Overview

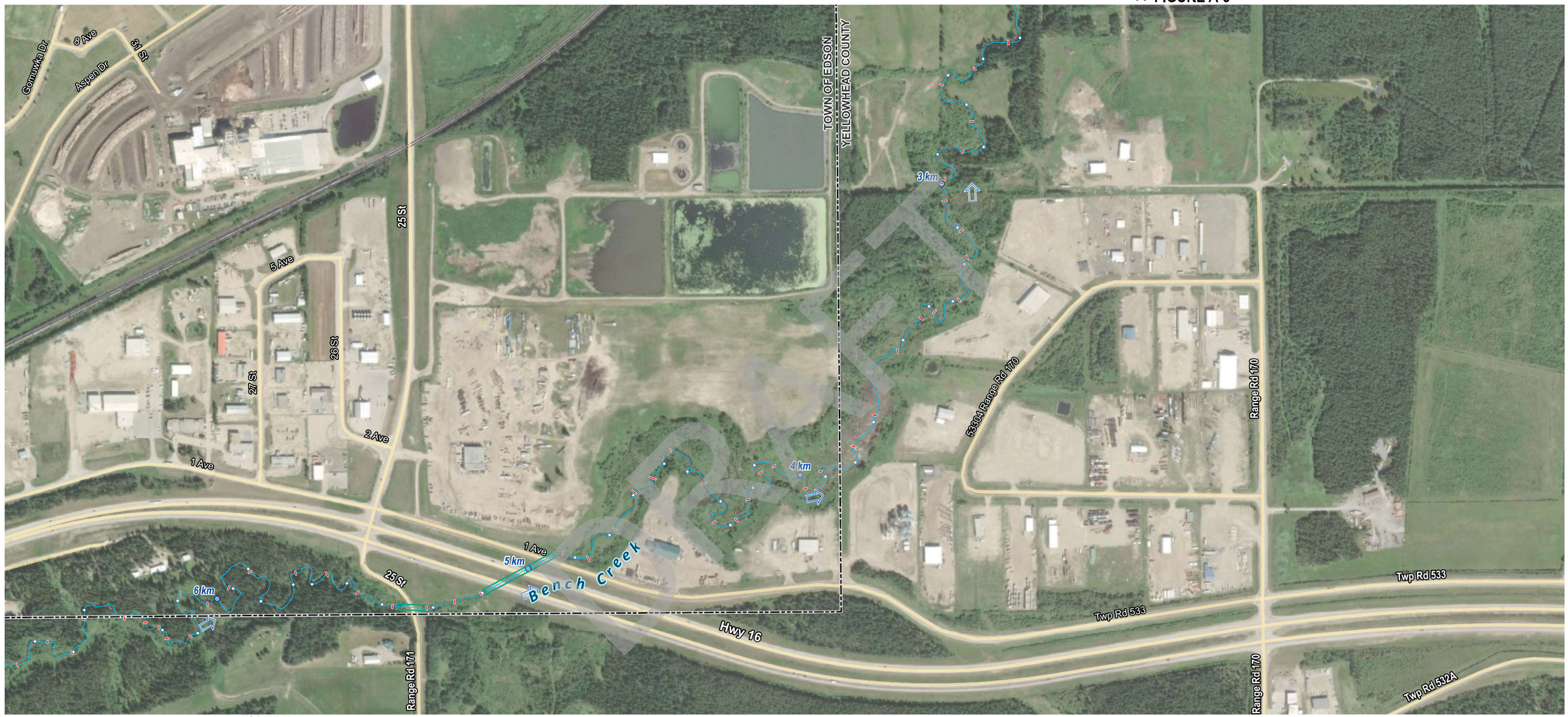
Figure A-7

Classification: Public

Alberta Environment and Protected Areas

▲ FIGURE A-9

▲ FIGURE A-7



▼ FIGURE A-6

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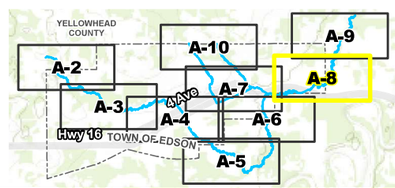
Legend

- Municipal Boundary
- 1 km Creek Station
- 100 m Creek Station
- Creek Centreline
- Flow Direction
- Bridge
- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section



Project No. 3052.029
Date October 2025
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Field Survey Overview

Figure A-8

Classification: Public

Alberta Environment and Protected Areas



▼ FIGURE A-8

N

Legend

- Municipal Boundary
- 1 km Creek Station
- 100 m Creek Station
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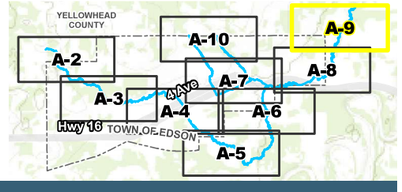
- Flow Direction
- Bridge
- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section



Project No. 3052.029
Date October 2025
Scale 1:7,500
0 50 100 200 Metres

Field Survey Overview

Figure A-9

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.

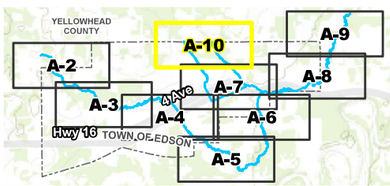


▼ FIGURE A-7

N

Legend

- Municipal Boundary
- 1 km Creek Station
- 100 m Creek Station
- Creek Centreline
- Flow Direction
- Bridge
- Culvert
- Road
- Railway
- High Water Mark (from EPA)
- Flow Measurement Location
- Surveyed Cross Section



Project No. 3052.029
Date October 2025
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Field Survey Overview

Figure A-10

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Classification: Public

Innovation. Integrity. Employee-Owned.

DRAFT

Appendix B

Open Water Hydrology Assessment

Classification: Public

Innovation. Integrity. Employee-Owned.

Calgary
100 – 239 10th Avenue SE
Calgary, AB T2G 0V9
T 403 262 4241

Technical Memorandum

DATE: June 11, 2025

TO: Alberta Environment and Protected Areas

FROM: Bill Zhao, M.Sc., P.Eng.
Deighen Blakely, P.Eng.

RE: **EDSON FLOOD STUDY**
Open Water Hydrology - Final Draft Technical Memorandum
Our File 3052-029

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1. Introduction

1.1 Study Background and Objectives

The Edson Flood Study was initiated by Alberta Environment and Protected Areas (EPA) as part of the provincial Flood Hazard Identification Program (FHIP), with the goal of identifying and assessing river and flood hazards along Bench, Wase, and Poplar Creeks within the Town of Edson and surrounding Yellowhead County. It is intended that the results of this study will increase the ability of Edson and Yellowhead County to form effective flood mitigation strategies, plan for flood mitigation infrastructure, and inform local development decisions.

1.2 Memo Scope

The objective of this Open Water Hydrology Assessment Memo is to provide estimates of the open water flood frequency flows for the creeks in the study area at each of the thirteen flood frequencies established in the Request for Proposals (RFP).

Section 2 provides a summary of data collected for this study. Section 3 provides a detailed discussion of the methods used throughout subsequent sections. Section 4 presents the single station flood frequency analyses (FFAs) completed preparatory to regional flood frequency analysis (RFFA), including a discussion on the investigation of mixed population FFA. The RFFA is described in Section 5. The validation of flood estimates corresponding to return periods of 200 years and greater is described in Section 6. Section 7 provides detail on the deterministic modeling task. A summary of recommended design floods is included in Section 8, along with a discussion of uncertainty associated with all aspects of the hydrology assessment, and a comparison of the recommended design floods with corresponding estimates from previous hydrotechnical reports. A discussion on climate change impact is provided in Section 9.

Classification: Public

1.3 Study Area and Reach

The Town of Edson is located about 200 kilometers west of Edmonton, situated in the southwestern part of the Athabasca Basin. The Canadian National Railway (CNR) mainline and Highway 16 both pass through the community. Bench Creek crosses under both; Wase Creek cross under Highway 16, and Poplar Creek crosses under the railway.

Within the town, all the creeks flow southeastward, with Wase Creek feeding into Poplar Creek, which in turn flows into Bench Creek (IBI, 2014). The reaches of Bench Creek through the study area have an average channel slope of approximately 0.3%, while Wase and Poplar creeks are steeper at approximately 0.9% and 1.1%, respectively. The headwaters of Bench, Wase, and Poplar creeks are located at elevations of roughly 970 m, 950 m, and 955 m, respectively, and the study basin extends downstream along Bench Creek to a minimum elevation of 872 m.

The study area covers approximately 25 km of Bench Creek, 4 km of Wase Creek and 3 km of Poplar Creek. As stated in the RFP, the study reach for Bench Creek runs downstream from Range Road 180 (the western boundary of NW 19-53-17-W5M) to the eastern boundary of SE 25-53-17-W5M. The study reach for Poplar Creek runs downstream from Highway 748 (the northern boundary of NW 22-53-17-W5M) to its confluence with Bench Creek. For Wase Creek, the study reach extends downstream from Township Road 534 (the northern boundary of NE 21-53-17-W5M) to the confluence with Poplar Creek. These limits define the general domain for hydraulic modeling and flood mapping.

To provide inflows for the hydraulic model, KWL delineated watershed boundaries for seven flow locations along Bench, Wase and Poplar creeks. The flow locations and the extent of the drainage basins are shown in Figure 1-1.

Land cover in the project watershed is comprised largely of a mix of coniferous and deciduous forest, with significant minority portions of grassland, shrubland, and agricultural (primarily grazing) land. The remainder of the watershed is composed of approximately equal parts wetland and open water, and barren or developed land, the latter of which is primarily concentrated in the Town of Edson.

The land use of the project watershed is summarized in Table 1-1.

Table 1-1: Land Use Summary of Project Watershed

Land Use	Percent %
Agriculture	13.1
Grassland	15.1
Forest	42.5
Shrubland and Herbs	13.1
Wetland	7.20
Water	0.85
Barren or Developed	8.31
Source: The land-use and land-cover (LULC) classification of Alberta dataset, 2020	

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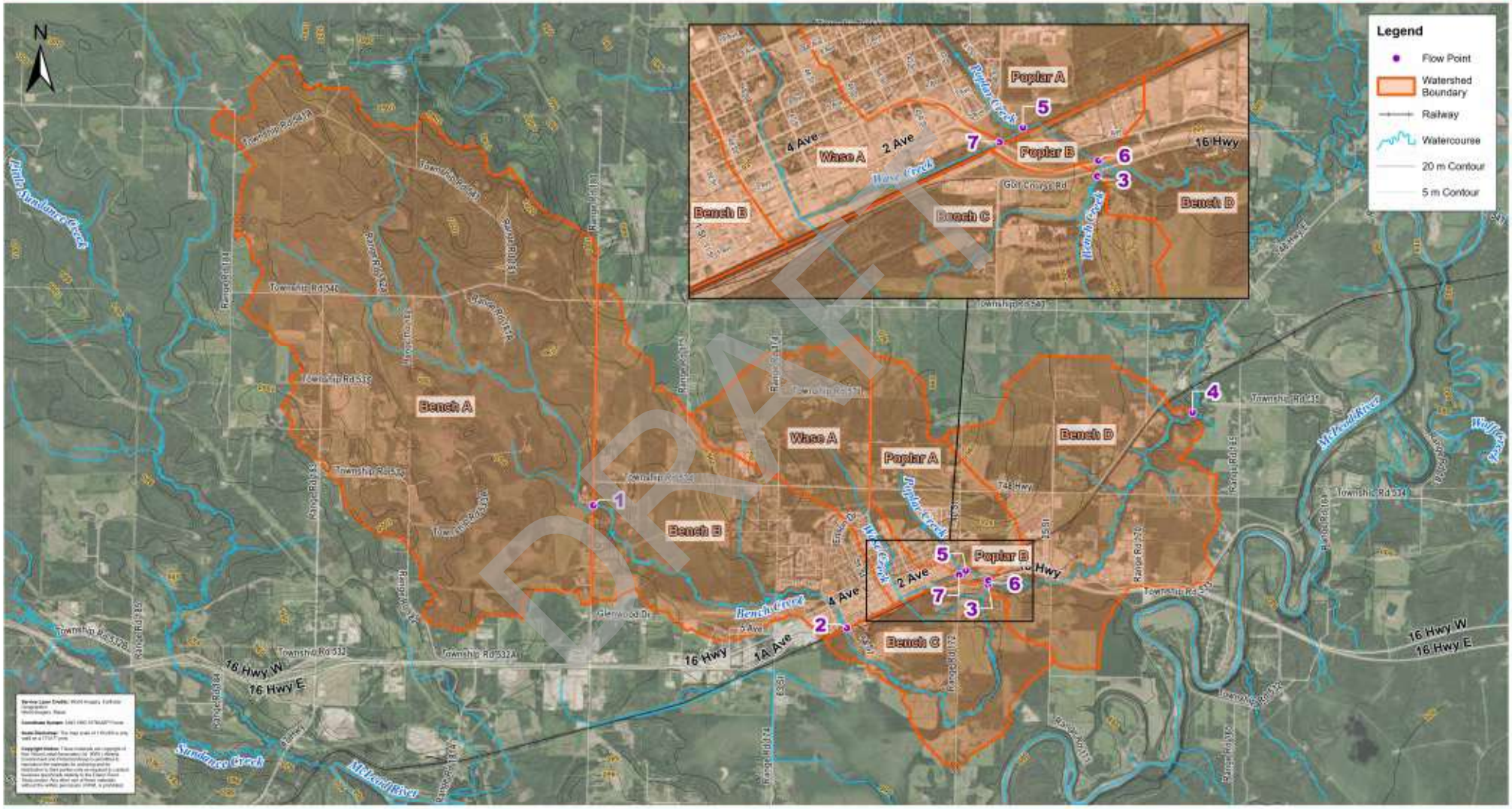
Alberta Environment and Protected Areas
Edson Flood Study

KERR WOOD LEIDAL consulting engineers



Project No.	3052.029
Date	June 2025
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Study Area - Watershed Delineation

Figure 1-1

Classification: Public

2. Available Data

The following sections describe the data sets used in the hydrologic analysis, including both the RFFA and the deterministic model.

2.1 Hydrometric Data

Due to the absence of streamflow gauging stations and observed flow data for the creeks in the study area, hydrometric data from nearby Water Survey of Canada (WSC) gauge stations on hydrologically similar watersheds were considered. Two rounds of screening were conducted for station selection, as detailed in Section 4.2. WSC gauges typically record both annual maximum daily average flow and instantaneous annual peak flow. A relationship between the two was established for each station and used to extend the instantaneous peak flow series if the daily average annual maximum record had additional years of record.

2.2 Meteorological Data

There are six hourly Environment and Climate Change Canada (ECCC) stations around the Town of Edson. Edson Climate (ID 3062246) has the longest hourly rainfall records and ECCC has published Intensity-Duration-Frequency (IDF) curves using rainfall records from this station. The latest published IDF curve (version 3-30) includes rainfall records based on observed data from 1970 through 2020. Considering its long record length and its proximity to the study basins, data from Edson Climate (ID 3062246) was used in this project.

Additional data dating back to 1914 are also available for the Town of Edson but include gaps and do not provide sub-daily data. A qualitative review confirmed that data were generally represented by the range of annual maxima reported at Edson Climate (ID 3062246).

Rainfall data from the ECCC station Edson Climate (ID 3062246) was used to update ECCC's version 3-30 IDF data to include 2021, 2022 and the June 2023 event at 1-, 2-, 6-, 12-, and 24-hour durations. Data from this station was also used to obtain the rainfall distribution of the June 2023 event for use as a potential design hyetograph. The IDF update is further described in Section 7.2.

2.3 Geophysical Data

Digital Elevation Models and LiDAR

The Canadian Digital Elevation Model (CDEM) published by Natural Resources Canada (2011) was used to delineate the initial drainage basin boundary and calculate overland slope and channel slopes. A LiDAR-derived digital elevation model (DEM) of the study area was acquired by EPA in spring 2024. This DEM was used to delineate subbasin boundaries around the Town of Edson.

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Land Use

The land-use and land-cover (LULC) classification of Alberta dataset is derived from 2020 Sentinel-2 multispectral imagery (10 m spatial resolution) of Alberta (Chowdhury, S. 2021). This land classification raster dataset contains 14 classes:

1. Water
2. Bryoids
3. Wetland - Treed
4. Herbs
5. Exposed/Barren Land
6. Shrubland
7. Wetland
8. Grassland
9. Coniferous
10. Broadleaf
11. Mixed Wood
12. Agriculture
13. Developed
14. Burned Areas

Soil Texture

Soil texture is defined by the relative proportions of the sand, silt, and clay particles present and represents the drainage property of the soil. Alberta Open Government data portal (Alberta Agriculture Flood and Rural Development, 2002) hosts a soil texture map that illustrates the distribution of soil parent material textures in the agricultural region of Alberta derived from Agriculture Region of Alberta Soil Inventory Database AGRASID 3.0 in 2002.

2.4 Other Peak Flow Information

Historical flood data and previous studies can provide important context for a flood study. For this project, this information can also provide important background for the open water hydrology assessment as the descriptions of historical floods provide the only direct estimates of peak flow within the study watershed. Historical floods that include peak flow estimates at Edson are described below and considered in Section 6 as validation for the peak flow estimates developed herein. A full discussion of historical flood events is provided in the main study report.

1954 Edson Flood

Greater than 85 mm of rain was recorded at the Edson meteorological station over a 72-hour period from 4 to 6 June 1954, causing such high flows in Bench Creek as to overtop Highway 16 at the downstream end of town. High flows may also have been experienced on Wase and Poplar creeks during this event but are not documented.

The hydrotechnical file history for Bridge File (BF) 13598 (Highway 16 over Bench Creek, with approximate drainage area of 70 km^2) estimates an associated instantaneous maximum flow of 500 ft^3/s (14.2 m^3/s). The hydrotechnical file history for BF 70506 (25th Street over Bench Creek) notes that several structures on Bench Creek washed out during this event.

1965 Edson Flood

The road surface of 25th Street was reportedly overtopped by Bench Creek during the 1965 flood event (BF 70506). This event is likely associated with the 125.8 mm of rain recorded at the Edson meteorological station between 7 to 9 July 1965, 68.6 mm of which fell on 8 July. The instantaneous maximum flow was estimated as 720 ft^3/s (20.4 m^3/s).

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1974 Edson Flood

For the 1974 flood, the hydrotechnical file history for Bench Creek at Highway 16 (BF 13598) provides an instantaneous maximum flow estimate of 800 ft^3/s (22.7 m^3/s). At 4th Avenue over Bench Creek (BF 72123, approximate drainage area 60 km^2), it is noted that an estimated instantaneous maximum flow of 400-600 ft^3/s (11.3 to 17.0 m^3/s) occurred in the early 1970s. It is likely that these two sources refer to the same event, given that the drainage area at Highway 16 is approximately 35% greater than at 4th Avenue and includes contributions from Wase and Poplar Creeks, which may have also experienced coincident high flows. Although no date is provided in the hydrotechnical file history, it is probable that this flood was associated with the 59.4 mm of rain recorded at the Edson Airport meteorological station on 11 July 1974.

1986 Regional Flood

Precipitation described as “very heavy” (Public Safety Canada, 2013) occurred between 13 to 24 July 1986, with the highest concentration falling about 60 km southwest of Edson. The Edson Airport meteorological station recorded 149.7 mm during the 11 days of the event, 72.7 mm of which occurred on 17 July. Rapidly rising water levels and extensive damage in floodplain areas were experienced along the McLeod River (of which Bench Creek is a primary tributary), as well as the Pembina, Athabasca, and North Saskatchewan Rivers. No flood damage was reported in Edson, but the event remains hydrologically relevant in the context of the regional flood frequency analysis described in Section 4.2. Alberta Transportation’s rainfall database contains a rainfall spatial pattern for this event (see Figure 2-1).

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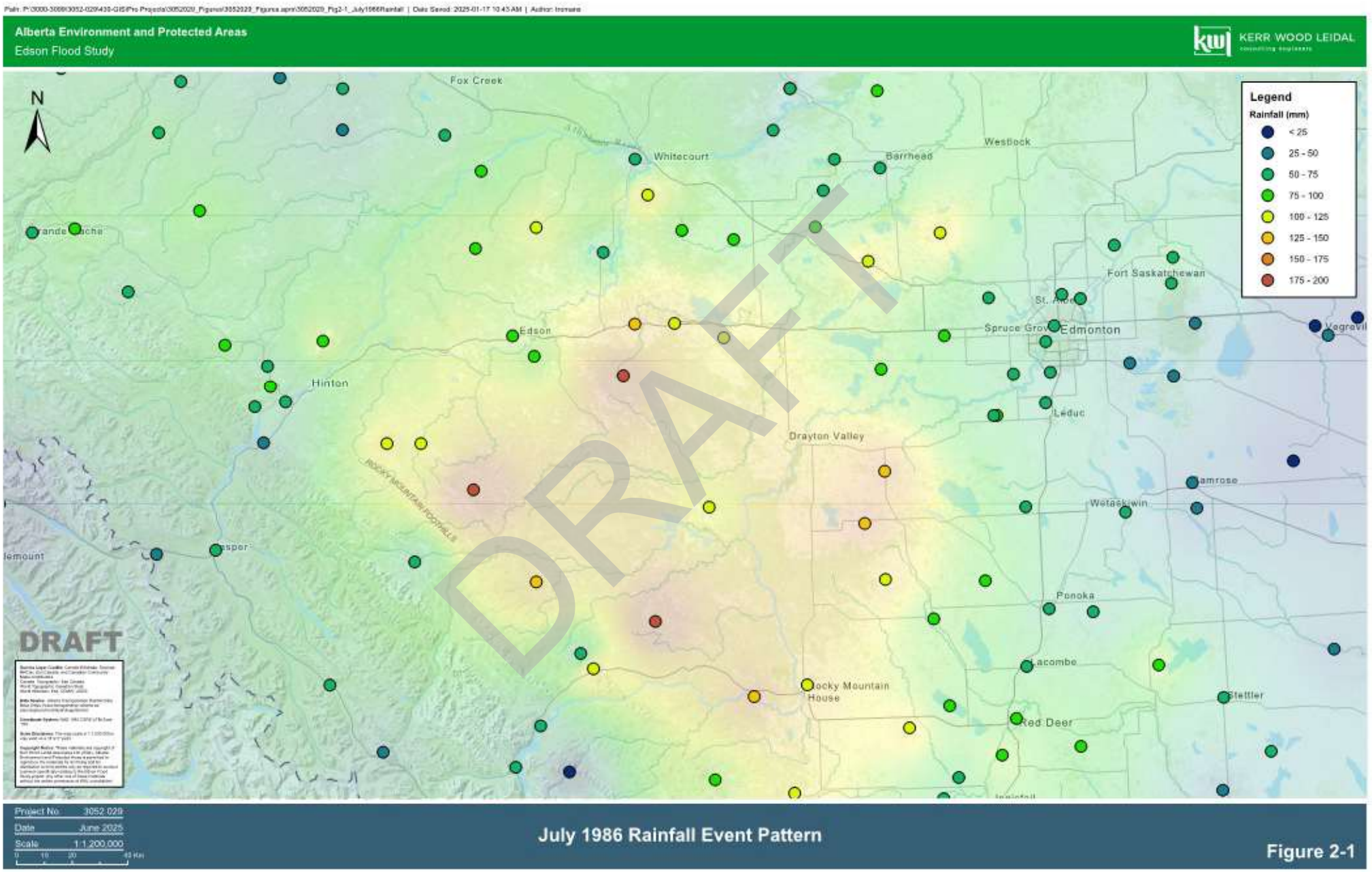
Classification: Public



Classification: Public

A preliminary screening of the WSC database identified several stations clustered around the geographic centre of the 1986 rainfall event. These stations also experienced very high instantaneous maximum flows. Their recorded instantaneous maximum and unit instantaneous maximum values are listed in the table below, where an E indicates that the value was estimated by WSC.

Table 2-1: Instantaneous Maximum and Unit Instantaneous Maximum Flows of the 1986 July Event at WSC Gauges

Station Name	Station Number	Gross Drainage Area (km^2)	WSC Instantaneous Maximum for 1986 Event (m^3/s)	Unit Instantaneous Maximum (m^3/s per km^2)
Rat Creek Near Cynthia	07BA002	606	580 E	0.96
Wolf Creek At Highway No. 16A	07AG003	826	570	0.69
Erith River Below Hanlan Creek	07AF907	595	337 E	0.57
McLeod River Near Rosevear	07AG007	7140	2300	0.32
Pembina River Below Paddy Creek	07BA001	2900	1100	0.38
Nordegg River At Sunchild Road	05DD009	876	620	0.71

A simple regression analysis was prepared to relate the drainage areas to the recorded instantaneous maxima for the 1986 event (excluding Rat Creek Near Cynthia due to a reported high level of uncertainty in the instantaneous maximum estimate). The relationship is shown in Figure 2-2. If this relationship is extrapolated to the downstream end of the study area (drainage area 96.6 km^2), the resulting instantaneous maximum flow would be 117 m^3/s. It should be noted that this simple analysis is based exclusively on stations much larger than the study watersheds and is presented herein for context and an order of magnitude estimate.

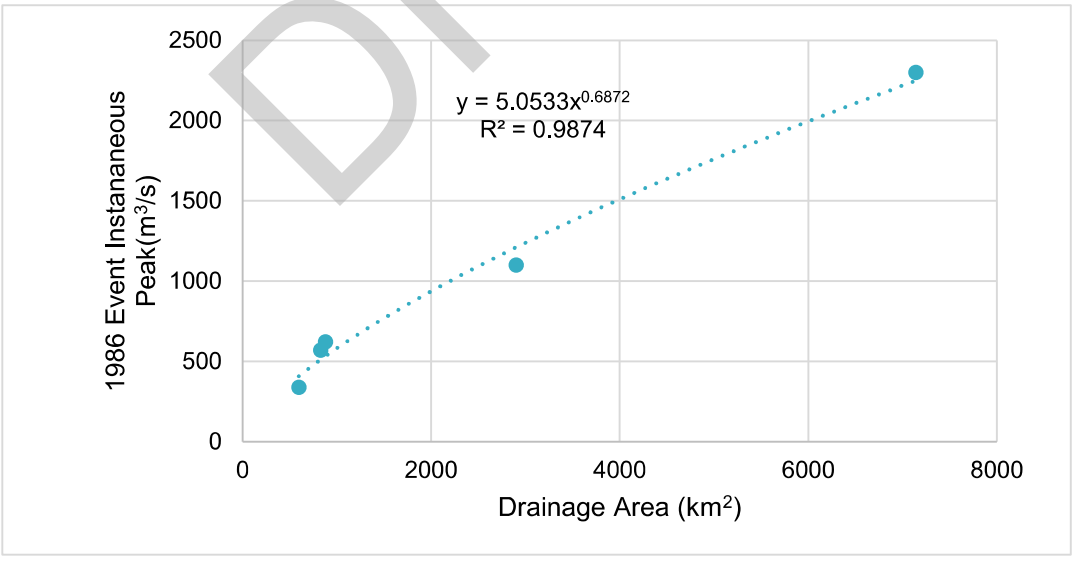


Figure 2-2: Relationship Between Drainage Area and Instantaneous Peak Flow reported for selected WSC stations during the 1986 Event

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Classification: Public

While the ECCC station Edson A is some distance from the centre of the 1986 storm, it still recorded substantial precipitation. More importantly, the record provides key information about antecedent conditions. The largest single day of rainfall occurred on 17 July, prior to which there were four consecutive days of a moderate amount of rainfall (from 13 to 16 July). In addition, most days prior to 13 July also experienced continuous small amounts of rainfall (Figure 2-3). This suggests that the antecedent soil moisture conditions leading up to the 17 July rainfall event were likely very wet. Flow reported at the Wolf Creek hydrometric station on 12 July, five days before the heaviest rainfall event, is about twice the long-term monthly average flow for July, indicating that flows in the local watercourses were already elevated prior to the onset of the wettest period of the storm. It is reasonable to conclude that the runoff response to the 1986 event was substantially exacerbated by the saturated antecedent conditions.

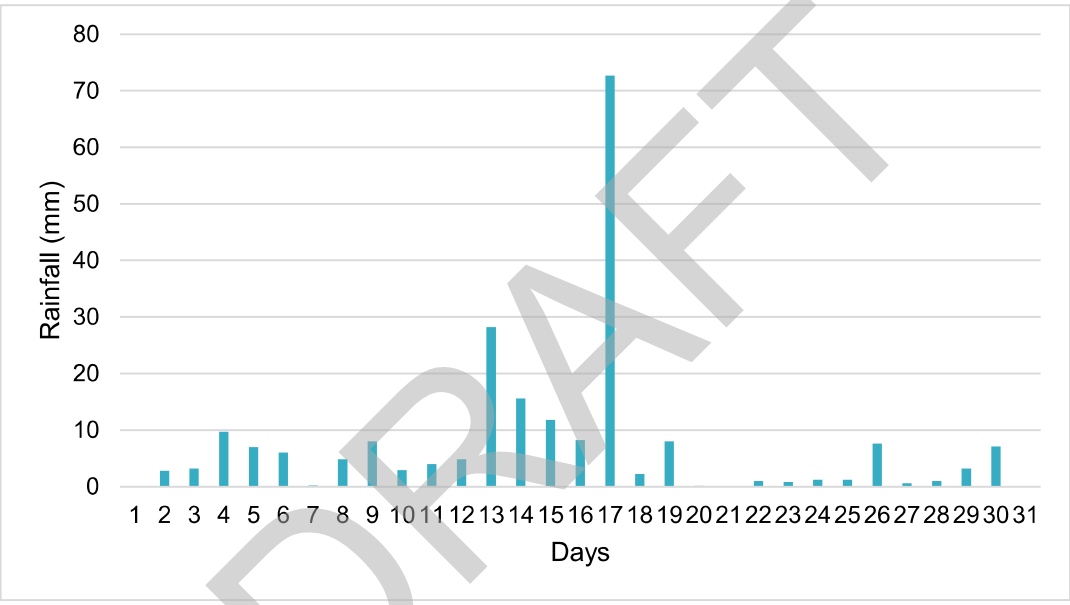

Figure 2-3:Daily Precipitation Record for July 1986 – Edson A 3062244

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Classification: Public

3. Methodology Overview

In the absence of hydrometric data for watercourses within the study area, KWL utilized two RFFA methods, two supplemental validation methods (for events with return periods of 200 years or greater), and a deterministic model to estimate the required instantaneous maximum flows. The use of multiple methods provides secondary checks as recommended in the Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation in Natural Resources Canada (NRCan) Flood Mapping Guidelines (NRCan, 2023). The methodology is illustrated in Figure 3-1 and described in detail below.

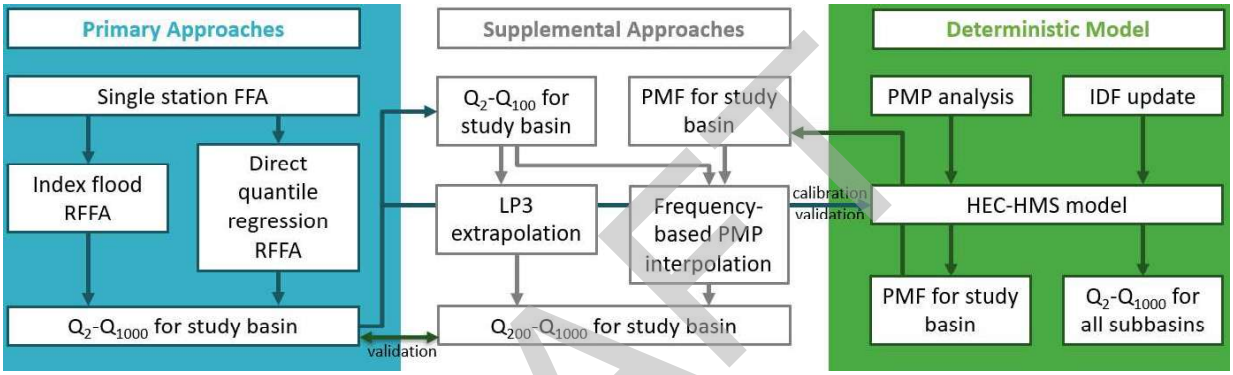

Figure 3-1: Methodology Flowchart

The primary approach involves two widely used RFFA approaches (the index flood method and the direct quantile regression method), each applied to a common set of regional data. Both approaches require selection of hydrologically similar reference stations and single-station FFAs of the corresponding data. The selection of index stations is presented in Section 4.2, the single-station FFAs are presented in Section 4.4, and details of both RFFA methods are provided in Sections 5.1 and 5.2. The results from the RFFA methods were used to calibrate and validate the deterministic model (see Section 7) at the downstream end of the Bench Creek model domain and for Bench Creek at the railway west of 54th Street.

Recognizing the high uncertainty associated with estimation of flood events between the 200-year and 1,000-year events, two supplemental methods were used to validate results extrapolated from the RFFAs. The first involves fitting a Log-Pearson Type III (LP3) curve to the estimated quantiles up to and including Q_{100} (100-year flow) and then extrapolating this curve out to Q_{1000} (1000-year flow). The second is a frequency-based interpolation method involving interpolation between the 100-year RFFA peak flow estimate and the Probable Maximum Flood (PMF). The PMF for Bench Creek was estimated by applying the validated deterministic model to simulate the watershed's response to a Probable Maximum Precipitation (PMP) event. This frequency-based interpolation method is recommended by Alberta Transportation (2004). Details of the frequency-based interpolation method, including PMP and PMF analysis, are provided in Section 6.2.

As detailed in Section 7, the validated deterministic model was used to produce flow quantiles for each subbasin in the study area, including Bench, Wase, and Poplar Creeks. This approach is considered the most reasonable way to account for the different characteristics of sub-watersheds whose size is not well suited for RFFA. A comparison of results from all methods and the recommended design flows are summarised in Section 8.1.

Further details on the approaches used for each creek are discussed below.

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Approaches for Bench Creek

RFFA approaches rely on the identification of gauged watersheds that may be considered hydrologically similar to the ungauged study watershed(s). For this study, an initial review of nearby gauged watersheds found very few candidate stations with drainage areas less than 100 km² and none in the less than 10 km² range that would be required to provide a robust RFFA estimate for the smaller sub-watersheds.

As described in Section 1.3, Bench Creek at the downstream extent of the study area has a drainage area of 96.6 km² and is therefore of a suitable size for RFFA instantaneous maximum flow estimates. As such and considering the lack of deterministic model calibration data on Bench Creek, regional analysis was considered the primary approach for estimating instantaneous maximum flows on Bench Creek at the downstream extent of the study area. RFFA estimates were also generated for Bench Creek at the railway west of 54th Street (drainage area 59.7 km²). While this second location has a smaller watershed and is less well-suited to regional analysis, it provides a second point of comparison for the deterministic model.

The RFFA estimate was used to provide a degree of calibration and validation for the deterministic model, which is not considered to have the same confidence as a model calibrated using an extensive record of local observations but is preferable to using an uncalibrated model. The deterministic model was then used to simulate instantaneous maximum flows for sub-watersheds where RFFA results are considered less suitable due to smaller drainage areas.

Approaches for Wase and Poplar Creeks

The drainage areas of Wase and Poplar creeks are much smaller than the corresponding areas for the RFFA reference stations, so deterministic modeling is considered the primary approach for estimating instantaneous maximum flows on these two creeks.

KWL initially proposed to use observed high-water marks (HWMs) from the 2023 flood, as well as the well-understood hydraulic properties of structures such as culverts to calibrate the deterministic model parameters for Wase and Poplar Creeks. However, after inspection of the HWMs and communication with the Town of Edson, KWL learned that the culverts on Wase and Poplar Creeks where HWMs were obtained were likely blocked by debris during the flood event. These blockages likely created complex and dynamic hydraulic conditions, which make flow estimation at these locations highly unreliable and uncertain.

As a result, the initial proposed approach for model calibration was adjusted so that the validation of the hydrologic model would be integrated iteratively (if necessary) with calibration and validation of the hydraulic model. The revised model validation approach is completed by simulating an initial estimate of 2023 instantaneous maximum flows using the deterministic model with the recorded 2023 event hyetograph. The flow estimates are then used as inputs to the hydraulic model and the output water levels are assessed directly against the HWMs. Hydraulic model parameters and potential blockage assumptions will be explored to see if reasonable assumptions can reproduce the HWMs. If the HWMs cannot be simulated with reasonable hydraulic parameters, hydrologic model parameters can then be further adjusted to provide revised instantaneous maximum flows for the 2023 event that allow the hydraulic model output to match the HWMs with reasonable parameter values and within an acceptable margin of error.

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Classification: Public

4. Flood Frequency Analysis

4.1 Methodology

Using HYFRAN software and a complementary in-house spreadsheet tool, frequency analysis was completed on the annual instantaneous maximum flow data set for selected hydrometric stations. Prior to analysis, the instantaneous peak flow record for each station was extended through correlation with its annual maximum daily average flow record.

The independence, stationarity, and annual homogeneity of each sample was tested using the Wald-Woldwitz, Kendall, and Wilcoxon tests, respectively. All samples passed each test at a 5% significance level.

Generalized Extreme Value (GEV), Log-Pearson Type III (LP3), and Three-Parameter Log-Normal (3LN) distributions were fit to the empirical distribution, using the method of moments for the former two and the method of maximum likelihood for the latter.

The chi-squared test was used to evaluate the compatibility of each of the above distributions with the empirical sample. Chi-squared is calculated using the following formula:

$$\chi^2 = \frac{(O_i - E_i)^2}{E_i}$$

where χ^2 is chi-squared, O_i is the observed (empirical) value, and E_i is the expected value based on the theoretical distribution. This test tends to bias toward distributions that fit better at the right tail where absolute magnitudes are larger, which is important in FFA. However, an acceptable chi-squared test result does not ensure beyond reasonable doubt that a given distribution is an acceptable representation of a sample.

Where the χ^2 value indicated acceptance of the distribution as underlying the sample at 5%, the associated distribution was examined visually for goodness of fit. Reasonableness screening checks – such as all instantaneous maximum flow values in the quantile series remaining above zero – were also applied. Distributions with unacceptably high χ^2 values or failing inspection criteria were rejected from further consideration. Among passing distributions, confidence interval extents and standard deviations were compared to help identify the single best distribution. Quantiles of the best distribution were selected for each of the thirteen specified return periods.

Due to the aggregated uncertainty in extrapolating FFAs beyond the 100-year event, alternative methods were used to verify floods with return periods of 200 years or more; details are provided in Section 5.3.

4.2 Regional Reference Station Selection

Screening Process

Selection criteria for the RFFA reference stations included drainage area, proximity to the study area, period of record, and watershed characteristics such as land use and mean elevation. Representation of the regionally significant 1986 flood event was also considered.

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Primary Screening

Initial screening of the WSC gauge stations is based on the criteria listed below applied to all WSC stations that fall within Western Alberta Upland ecoregion where Edson is located.

Table 4-1: Criteria for Initial Index Station Screening

Criteria	Values
Distance to Study Area	< 75 km
Years of Instantaneous Maxima	> 15
Drainage Area	< 970 km^2 (10x study watershed size) >9.7 km^2 (0.1x study watershed size)

A search radius of approximately 75 km was applied to the center of the study basins. This distance was chosen with consideration for variation in general precipitation pattern and general elevation, which can change rapidly in the foothills region. In addition, KWL examined the record length of selected gauges and removed any gauges with less than 15 years of annual instantaneous maximum records. A drainage area criterion was also used during initial screening and basins with drainage areas larger than 970 km^2, or ten times larger than the drainage area of the study basins are removed. Candidate stations had to have a non-regulated flow regime. Candidate stations identified by the initial screening process are shown in Table 4-2.

Table 4-2: RFFA Candidate Stations included after Initial Screening

WSC Station Name	WSC Station Number
Wampus Creek Near Hinton	07AF003
Deerlick Creek Near Hinton	07AF004
Eunice Creek Near Hinton	07AF005
Sundance Creek Near Bickerdike	07AF010
Embarras River Near Weald	07AF014
Wolf Creek at Highway No. 16A	07AG003
Groat Creek Near Whitecourt	07AG008
Christmas Creek Near Blue Ridge	07AH002
Rat Creek Near Cynthia	07BA002
Lovett River Near the Mouth	07BA003
Little Paddle River Near Mayerthorpe	07BB005
Paddle River Near Anselmo	07BB011

Secondary Screening

A second screening was carried out considering land use distribution and general hydrologic characteristics in each basin. Little Paddle River Near Mayerthorpe (07BB005) was excluded during secondary screening due to higher amounts of, and more concentrated, agricultural land with more intensive use of ditch drainage than the project watersheds around Edson. The gauged Little Paddle River watershed is also outside the Ecoprovince of the study watershed.

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Classification: Public

Sundance Creek Near Bickerdike (07AF010) is the closest hydrometric station to the study area and shares many similarities in terms of basin characteristics including similar natural land use and drainage area. However, the recorded unit instantaneous maximum flows (in $m^3/s/km^2$) and instantaneous to daily maximum flow ratios were noted to be well below those of most other regional stations. Further review of the watershed land cover identified significant overland storage in the form of wetland abutting the mainstem and directly upstream of the hydrometric gauge (Figure 4-1). This wetland area may heavily attenuate the flood peaks, differentiating it from the project watersheds. KWL visually inspected the placement of wetlands in all other index stations, including the project watersheds, and found that the case present on Sundance Creek appears to be unique. In the absence of local hydrometric data showing that the regionally unique flood hydrology of Sundance Creek is a suitable proxy for the Bench Creek watershed, inclusion of Sundance Creek Near Bickerdike in the RFFA would be non-conservative and the station was excluded from the analysis.

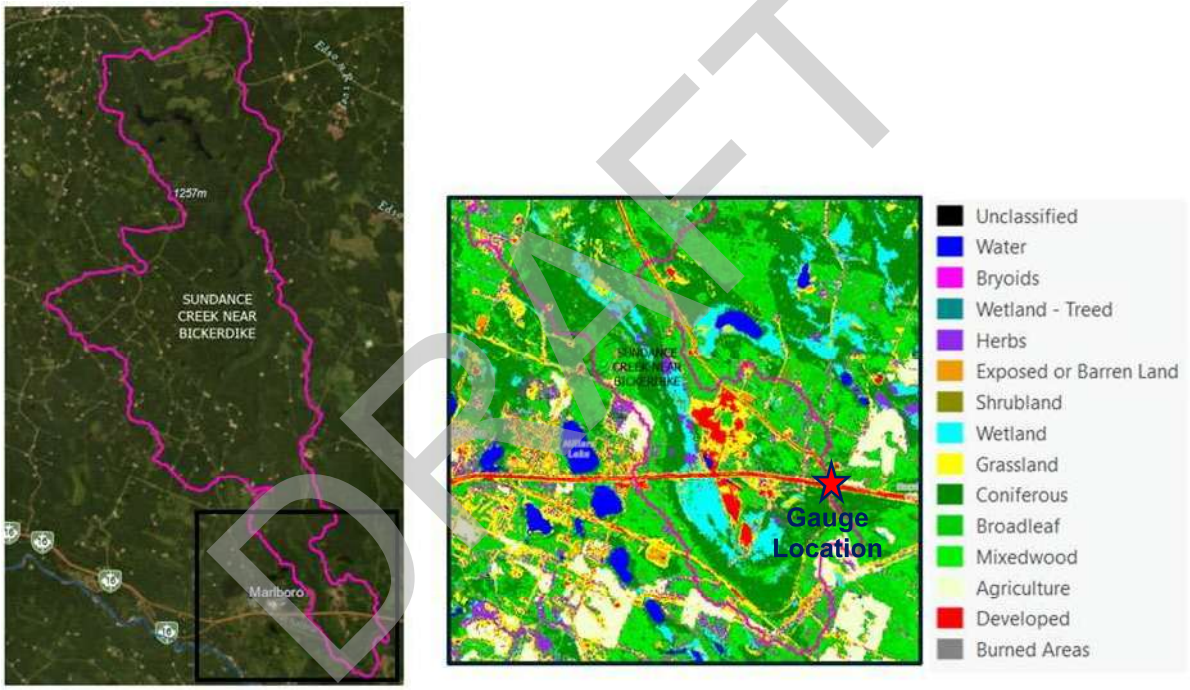

Figure 4-1: Sundance Creek drainage basin showing location of hydrometric gauge (left) and detailed inset showing significant wetland landcover (Chowdhury, S. 2021) located at the downstream end of the watershed (right)

Hydrometric stations on Wolf Creek at Highway No. 16A and Rat Creek near Cynthia, both located south of Edson, report very high instantaneous maximum flows for the July 1986 flood event. The instantaneous maximum flow on Wolf Creek was recorded by the gauge, while the instantaneous maximum flow on Rat Creek was estimated by WSC using slope-area analysis and the HWMs surveyed at the gauging location (email communication with WSC, 2024). WSC stated that the Rat Creek estimate was produced to the best of their ability using the methods available at the time and that there are currently no plans for a data revision. Despite the uncertainty in the peak flow estimate, these two stations are both included in the RFFA as they provide valuable information on the highest recorded flow event near Edson.

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Wampus Creek Near Hinton (07AF003), Deerlick Creek Near Hinton (07AF004), and Eunice Creek Near Hinton (07AF005) share watershed borders and many similarities, including drainage area, land use, aspect, and slope characteristics. These stations can contribute important data from a watershed size similar to those of the study watersheds but are farther away and less hydrologically similar than other gauges. Including three sets of overlapping flow records for small, adjacent watersheds would skew the RFFA towards this potentially less-representative region. Wampus Creek has the longest record of the three stations and was therefore chosen for inclusion while the other two stations were excluded.

The secondary screening process reduced the initial group of 11 candidate stations to eight stations for use in the RFFA.

Selected Stations

The period of record for each of the chosen stations is presented in Table 4-3, Figure 4-2, and Figure 4-3. The chosen stations are also shown geographically in Figure 4-4.

Table 4-3: RFFA Candidate Stations after Secondary Screening

Station Name	Station Number	Years of Record	Number of Annual Instantaneous Maximum Flows (Recorded)	Number of Annual Instantaneous Maximum Flows (Extended)	Watershed Area (km^2)
Wampus Creek Near Hinton	07AF003	1966-2023	53	56	25.9
Embarras River Near Weald	07AF014	1984-2023	35	40	640
Wolf Creek at Highway No. 16A	07AG003	1954-2023	36	68	826
Groat Creek Near Whitecourt	07AG008	1984-2022	26	37	133
Christmas Creek Near Blue Ridge	07AH002	1972-2023	47	51	423
Rat Creek Near Cynthia	07BA002	1972-2023	41	50	606
Lovett River Near the Mouth	07BA003	1975-2023	42	44	103
Paddle River Near Anselmo	07BB011	1980-2022	36	42	253

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Figure 4-2: Hydrometric Data Period of Record Plot

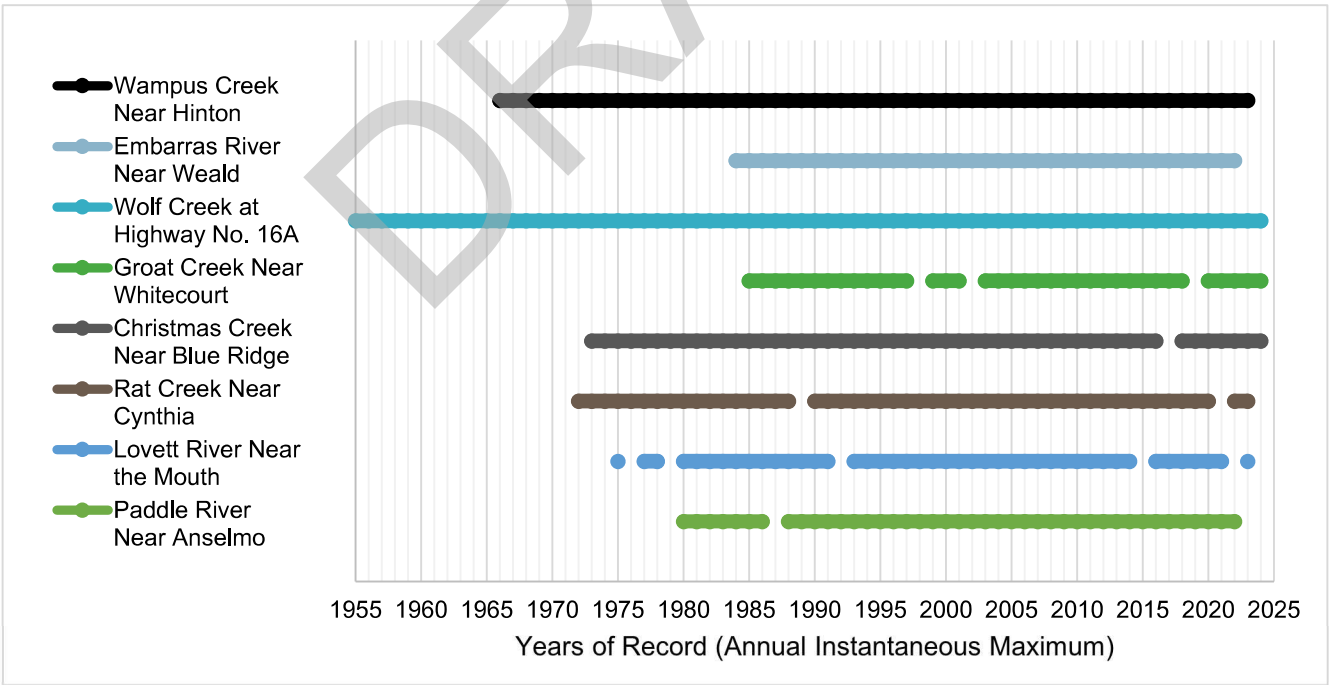

Figure 4-3: Hydrometric Data Period of Record Plot (Extended Records)

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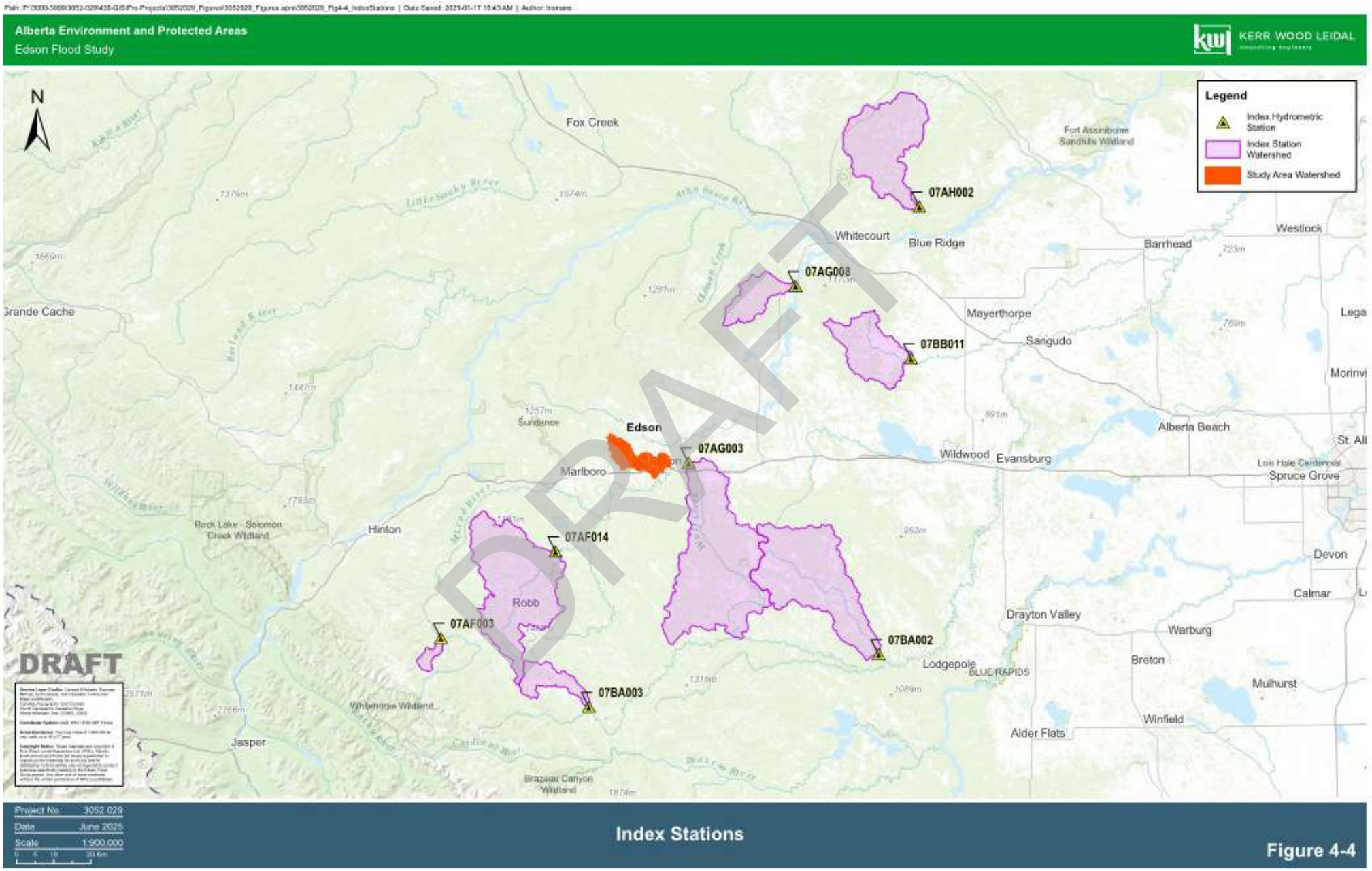
Classification: Public



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Among the selected stations, only Wolf Creek at Highway No. 16A and Rat Creek Near Cynthia (having effective drainage areas of 807 km^2 and 582 km^2, respectively) are reported by WSC to have non-contributing area. Their non-contributing areas comprise 2% and 3% of the gross drainage areas, respectively, which is considered negligible for the purposes of this study. In addition, during a significant flood such as a 100-year event or larger, non-contributing areas typically contribute to the peak flow, therefore gross drainage areas are used in this study.

For this project, annual maximum instantaneous records were used. Missing annual instantaneous maximum flow records from selected hydrometric stations were interpolated by using the annual instantaneous maximum to annual daily maximum (I:D) ratio. Annual instantaneous and daily maximum tables for each selected station are presented in Appendix 1.

An RFFA typically assumes that each reference station contributes with equal weight to estimated instantaneous maximum flows at the target site. As such, a gauge that sampled a short period with a disproportionate number of (or absence of) higher instantaneous maximum flows can increase uncertainty in the results. KWL conducted a “representativeness” review of the available record length at the selected gauges. For this purpose, Wolf Creek is used as the benchmark due to its long period of recorded annual instantaneous maxima spanning the records of the other stations, as shown in Figure 4-3.

Due to the significant magnitude of the 1986 flood event recorded at Wolf Creek (detailed in Section 2.4) and the lack thereof a similar response in other selected stations, the 1986 instantaneous maximum values were excluded from consideration to avoid biasing the record length check. The annual instantaneous maximum records are divided at 1985 as that was when the majority of the other stations also have records. The average of annual instantaneous maximum records from 1950 to 1985 and from 1950 to 2023 (excluding 1986) are calculated as 70.8 m^3/s and 70.5 m^3/s respectively, resulting a negligible difference.

4.3 Mixed Population Analysis

The initial screening of annual maximum flow records identified that annual maximum flows at most index stations were seasonally distributed between spring and summer. Spring season peak flows are often driven by snowmelt or rain-on-snow. Peak flows recorded in summer and fall are typically due to heavy rainfall events. As such, KWL conducted additional analysis to determine whether there was a need to separate these two populations prior to completing the FFA.

Empirical probability plots at each index station were found not to exhibit any noticeable discontinuity that could be attributed to a sample being comprised of two distinct populations. Additionally, the composition of seasonal annual maxima reveals that not only do annual maximum events consist of more summer/fall events (>60%), but most of these summer/fall events are also much higher in magnitude compared to spring events. This suggests that the governing mode of large floods is dominated by rainfall events.

To confirm that mixed population analysis was not required, KWL conducted a mixed population FFA at two candidate stations. Results from the mixed population FFA were found to be very close to the results of the conventional combined-population FFA. Based on these findings, the FFA described below applies a combined-population approach that assumes a homogeneous record of instantaneous maximum flows at each station.

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Classification: Public

4.4 Flood Frequency Analysis at Index Stations

A summary of the FFA at each index station is provided below. Plots of the GEV, 3LN, and LP3 distribution computed by HYFRAN for each station are included in Appendix 2.

Wampus Creek

Wampus Creek originates in the foothills, about 40 km southeast of the Town of Hinton. WSC Station 07AF003 (Wampus Creek Near Hinton) is located just upstream of its confluence with the McLeod River, at which point the mean basin elevation is the highest among index stations at 1,454 m. WSC reports a drainage area of 25.9 km^2 and its hydrometric record includes 53 years of available annual instantaneous maximum flow records spanning 1966-2023. An instantaneous to daily peak flow (I/D) relationship was established using the 31 years of overlapping annual instantaneous and daily maximum flow records, from which three missing years of annual instantaneous maxima were calculated. The Wampus Creek annual instantaneous maximum flow events occur 77% during the summer/fall months and are therefore considered to be heavily rainfall dominated.

The procedure described in Section 4.1 was used to complete a FFA for the extended record at WSC Station 07AF003 (Wampus Creek Near Hinton). GEV, 3LN, and LP3 distributions all passed the chi-squared test at 5% significance; however, only 3LN and LP3 yielded satisfactory visual goodness of fit test results, with LP3 having a better fit to the data. The LP3 distribution is recommended for this basin.

Embarras River

The Embarras River headwaters are approximately 60 km southwest of the Town of Edson in the Rocky Mountain foothills. WSC Station 07AF014 (Embarras River Near Weald) has a reported drainage area of 640 km^2 and a mean basin elevation of 1,151 m. The Embarras River drains into the McLeod River shortly downstream of the WSC station. The period of record encompasses 35 years of instantaneous maximum flow records between 1984-2023. An I/D relationship was used to calculate missing years, extending the record to 40 data points. The peak flow events are heavily rainfall dominated: 82% of annual instantaneous maxima occur during the summer/fall months.

Following the procedure outlined in Section 4.1, a FFA was completed for the extended record at WSC Station 07AF014 (Embarras River Near Weald), which yielded 5% significance level passing chi-squared test results with GEV, 3LN, and LP3 distributions, and acceptable visual goodness of fit test results with 3LN and LP3 distributions. The 3LN distribution is recommended for this basin due to its better fit to the data.

Wolf Creek

Wolf Creek originates about 55 km south of the Town of Edson and drains a reported 826 km^2 with a mean basin elevation of 1,014 m at WSC Station 07AG003 (Wolf Creek at Highway No. 16A). It enters the McLeod River shortly downstream of the WSC station. Most of the wetlands in the basin are located near the upstream extent of smaller tributaries, causing them to minimally affect peak flows in the basin overall. The period of record includes 36 years of instantaneous maximum flows from 1954-2023. An I/D relationship was used to calculate an additional 31 data points, and a provisional instantaneous maximum flow from 2024 was included, extending the record to 68 data points in total. Annual instantaneous maxima in Wolf Creek occur 80% during the summer/fall months, making it a heavily rainfall dominated basin.

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A FFA was completed for the extended record at WSC Station 07AG003 (Wolf Creek at Highway No. 16A) according to the procedure outlined in Section 4.1. The sample passed the chi-squared test at 5% significance with GEV, 3LN, and LP3 distributions, and yielded acceptable visual goodness of fit test results with 3LN and LP3 distributions. Due to its better fit to the data, the 3LN distribution is recommended for this basin.

Groat Creek

Groat Creek's headwaters are approximately 50 km northwest of the Town of Edson. At WSC Station 07AG008 (Groat Creek Near Whitecourt), the creek reportedly drains an area of 133 km^2 and has a mean basin elevation of 1,019 m. Its confluence with the McLeod River is immediately downstream of the WSC station. The period of record extends from 1984-2022 and includes 26 annual instantaneous maximum flow records. Provisional annual instantaneous maxima were included for 2023 and 2024, and an I/D relationship was used to extend the record to 37 data points in total. Annual instantaneous maxima in Groat Creek occur 60% during the summer/fall months.

According to the procedure described in Section 4.1, a FFA was completed for the extended record at WSC Station 07AG008 (Groat Creak Near Whitecourt). The sample yielded passing chi-squared test results at 5% significance with GEV, 3LN, and LP3 distributions, and acceptable visual goodness of fit test results with 3LN and LP3 distributions. The LP3 distributions is recommended for this basin due to its better fit to the data than other distributions for return periods up to 350 years, and fairly good fit for greater return periods.

Christmas Creek

The headwaters of Christmas Creek are located about 55 km northwest of the Town of Whitecourt. The mean watershed elevation is 904 m, and the drainage area of the creek is reported at WSC Station 07AH002 (Christmas Creek Near Blue Ridge) as 423 km^2. The station is at the Highway 658 bridge, located about 5 km upstream of the Athabasca River confluence. The period of record extends from 1972 to 2024 and includes 47 annual instantaneous maximum flow records. Using an I/D relationship two missing years were calculated, and provisional annual instantaneous maxima were included for 2023 and 2024, which brought the total number of data points to 51. Similar to Groat Creek, the annual instantaneous maxima occur 61% during the summer/fall months.

Following the procedure described in Section 4.1, a FFA was completed for the modified record at WSC Station 07AH002 (Christmas Creek Near Blue Ridge). Passing chi-squared test results at 5% significance with GEV, 3LN, and LP3 distributions, and acceptable visual goodness of fit test results with the 3LN distribution were obtained from the sample. 3LN also yielded the best fit to the data and the most robust confidence interval extents. It is therefore recommended for this basin.

Rat Creek

Rat Creek's origins are located about 40 km east of the Town of Edson. At WSC Station 07BA002 (Rat Creek Near Cynthia) it drains a reported area of 606 km^2 and has a mean basin elevation of 975 m. Shortly downstream of the station, Rat Creek empties into the Pembina River. The period of record at the station is from 1972 to 2023, including 41 annual instantaneous maximum flow records. Using an I/D relationship, eight additional data points were calculated. A provisional instantaneous maximum flow from 2023 was also included to appropriately capture the flooding that occurred in that year. The total number of data points analyzed was therefore 50. Rainfall dominates the high flows, with 70% of the Rat Creek annual instantaneous maxima occurring during the summer/fall months.

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A FFA was completed for the extended record at WSC Station 07BA002 (Rat Creek Near Cynthia) following the procedure described in Section 4.1. Comparison of the empirical distribution to GEV, 3LN, and LP3 distributions yielded passing chi-squared test results at 5% significance for 3LN and LP3 distributions. While the LP3 distribution fits the 1986 flood more closely, it has a right tail that is extremely steep and produces physically implausible quantiles when extrapolated to long return periods. 3LN fits the low return period data points of the empirical distribution well, but it plots the 1986 flood outside the confidence intervals; given that the 1986 flood is the largest on record in the region and therefore potentially highly significant to the regional analysis, further investigation was warranted before accepting this distribution.

To investigate further, a drainage area-based record extension was applied to obtain a longer record of 67 years by correlating the Rat Creek record with that of the adjacent gauge in the Wolf Creek watershed. When LP3 and 3LN distributions were fit to this extended record and compared, their right tails are both less steep than LP3 on the original dataset, resulting quantile estimates that are close to the 3LN estimates for the original data set. While this validation is itself subject to significant uncertainty, it is considered sufficient to support the recommendation of the 3LN quantiles for the Rat Creek watershed in the context of this RFFA.

Lovett River

Lovett River originates about 60 km southwest of the Town of Edson and encompasses a drainage area of 103 km^2 at WSC Station 07BA003 (Lovett River Near the Mouth), which is approximately at the confluence with the Pembina River. Its mean basin elevation is 1,430 m. The period of record includes 42 annual instantaneous maximum flow records between 1975 and 2023. Two additional annual instantaneous maxima were calculated using an I/D relationship, bringing the total number of years of record to 44. Rainfall heavily dominates the peak flows, with 85% of the annual instantaneous maxima occurring during the summer/fall months.

A FFA was completed for the extended record at WSC Station 07BA003 (Lovett River Near the Mouth) according to the procedures described in Section 4.1. Comparison of the empirical distribution to GEV, 3LN, and LP3 distributions yielded passing chi-squared test results at 1%, 5%, and 5% significance, respectively. Visual goodness of fit testing resulted in the acceptance of LP3, and the rejection of GEV and 3LN. The LP3 also has a better fit to the data. The quantile estimates of the LP3 distribution are therefore recommended for this basin.

Paddle River

The Paddle River headwaters are approximately 65 km northeast of the Town of Edson. The WSC Station 07BB011 (Paddle River Near Anselmo), just downstream of Range Road 101 has a reported drainage area of 253 km^2 and the lowest mean basin elevation among index stations at 853 m. The period of record comprises 36 years of annual instantaneous maxima between 1980 and 2022 and was extended to 42 years of record by using an I/D relationship to calculate annual instantaneous maxima for seven missing years. With 60% of its annual instantaneous maximum flows occurring during the summer/fall months, Paddle River is a rainfall dominated basin.

According to the procedure described in Section 4.1, a FFA was carried out for the extended record at WSC Station 07BB011 (Paddle River Near Anselmo). GEV, 3LN, and LP3 distributions all provided passing chi-squared test results at 5% significance. GEV and LP3 were rejected due to a poor visual goodness of fit, and the 3LN quantiles are recommended for this basin.

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4.5 Summary of Flood Frequency Analysis for Index Stations Used in Regional Flood Frequency Analysis

A summary of the flood frequency analysis results, including values and confidence limits associated with the recommended distribution for selected index stations, is presented in Table 4-4.

Table 4-4:Flood Frequency Analysis Results

Station Name	Station Number	Quantile Estimates and Confidence Limit (m^3/s)												
		Return Period	2	5	10	20	35	50	75	100	200	350	500	750	1000
Wampus Creek Near Hinton	07AF003	0.05 Confidence Limit	5.60	10.9	15.9	22.3	28.5	33.2	39.3	44.1	57.8	71.1	81.5	95.0	104
		Value	4.58	8.93	12.6	16.7	20.4	23.0	26.1	28.4	34.5	39.9	43.6	48.0	51.3
		0.95 Confidence Limit	3.80	7.20	9.90	12.5	14.5	15.9	17.4	18.4	20.7	22.5	23.8	25.2	26.1
Embarras River Near Weald	07AF014	0.05 Confidence Limit	54.5	113	173	247	320	373	440	492	634	767	862	986	1080
		Value	43.2	86.9	126	173	215	245	283	311	386	454	502	560	603
		0.95 Confidence Limit	31.8	60.4	80.0	97.8	111	118	125	130	138	142	142	142	142
Wolf Creek at Highway No. 16A	07AG003	0.05 Confidence Limit	61.5	135	211	310	407	480	572	644	844	1030	1170	1340	1480
		Value	50.8	108	162	228	291	336	392	435	552	661	738	832	905
		0.95 Confidence Limit	40.1	80.5	113	146	174	191	212	226	260	288	305	322	333
Groat Creek Near Whitecourt	07AG008	0.05 Confidence Limit	30.4	73.2	119	185	257	315	394	460	663	869	1050	1290	1460
		Value	22.6	53.7	83.4	119	153	177	207	230	291	347	386	433	469
		0.95 Confidence Limit	16.6	38.3	56.6	75.8	90.9	101	111	119	135	148	157	167	172
Christmas Creek Near Blue Ridge	07AH002	0.05 Confidence Limit	19.8	41.6	62.9	89.5	115	134	157	175	224	269	301	341	371
		Value	15.9	32.6	47.5	64.8	80.7	91.8	105	116	143	168	185	206	222
		0.95 Confidence Limit	12.0	23.7	32.1	40.1	46.4	50.0	54.1	56.8	62.8	67.1	69.3	71.3	72.3
Rat Creek Near Cynthia	07BA002	0.05 Confidence Limit	25.8	58.1	97.6	159	232	295	387	469	732	1030	1300	1690	1980
		Value	21.2	45.9	72.6	109	148	179	219	253	353	457	537	644	732
		0.95 Confidence Limit	17.9	36.3	53.1	73	91.3	104	120	132	164	193	213	239	256
Lovett River Near the Mouth	07BA003	0.05 Confidence Limit	16.4	35.2	54.8	81.7	110	133	164	189	264	341	404	492	556
		Value	12.9	27.4	40.8	56.7	71.7	82.3	95.5	106	133	158	175	197	213
		0.95 Confidence Limit	10.2	21.0	29.8	38.6	45.9	50.5	55.5	59.0	67.8	74.8	79.6	85.1	88.5
Paddle River Near Anselmo	07BB011	0.05 Confidence Limit	25.5	66.9	114	182	259	320	407	478	705	936	1130	1405	1600
		Value	18.6	48.5	78.9	117	154	180	213	239	308	372	418	473	515
		0.95 Confidence Limit	13.5	34.3	53.1	73.3	89.6	99.8	112	120	139	154	164	175	182

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Engineering practice typically limits the extrapolation of FFA to a frequency that is not drastically different from the length of the observed data record. Questions of representativeness, sampling bias, and stationarity become increasingly more important as extrapolation exceeds several times the observed record length. Interpretation of such results should include careful consideration of the uncertainty associated with a flood driven by processes and conditions that may differ substantially from those represented within the historical record.

For this study, EPA has requested estimates of instantaneous maximum flow extending to the 1,000-year return period (0.1% AEP) event. In response to this, both single-station FFA and RFFA quantiles are presented at long extrapolations. A detailed discussion of the uncertainty associated with these estimates is provided in Section 8.3.

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5. Regional Flood Frequency Analysis

Statistical analysis of long-term stream flow records is regarded as one of the most reliable sources for predicting future events of specific return periods given stationary climate and land use (Joy and Whiteley, 1996). For ungauged watersheds, as well as watersheds where the available gauge record may not yield robust results, consideration of multiple regional stations is a preferred approach for estimating instantaneous maximum flows. In this sense, the regional analysis attempts to *substitute space for time*.

Two RFFA methods are recommended in the Federal Flood Mapping Guidelines published by Natural Resources Canada, version 2.0 (Natural Resources Canada, 2023): (1) the index flood method, and (2) the direct quantile regression method.

5.1 Index Flood Method

The index flood method was commonly employed for estimating instantaneous maximum flows in many Canadian provinces during the 1960s and 1970s (Watt et al., 1989). This approach establishes a relationship between physiographic parameters and an "index flood", defined for this project as the instantaneous mean annual flood (MAF). Dimensionless scaling factors (Q_T / MAF, where Q_T is instantaneous maximum flow at a given return period T) are then calculated to link this index flood to flood quantile estimates at each return period T.

The index flood RFFA method begins with conducting data reviews and single-site FFA on a set of hydrologically similar reference watersheds with robust hydrometric records. The regional reference stations selected for this study are described in Section 4.2.

Single-site results from the reference stations are used to establish a predictive relationship for estimating the index flood at the target site. This relationship is typically based on watershed area and may be expanded to include other physical characteristics of the watershed such as slope and land use. For this study, the combined relationship of MAF with both watershed area and wetland percentage was found to produce significantly better correlations than a relationship based on watershed area alone or in combination with slope or elevation. The regression equation and its parameters are listed in Table 5-1. The parameters were obtained by minimizing the sum of squared errors (SSE) between the calculated and observed MAFs. Table 5-2 and Figure 5-1 show the comparison between the two MAFs. The 1:1 ratio line is also plotted on Figure 5-1 for reference.

Table 5-1: Regression Equation used for MAF

Regression Equation	Constants			R^2
	a	b	n	
$MAF = a * W^b * A^n$	0.442	-0.416	0.858	0.73

Note:
A = watershed area (km^2)
W = percent of watershed area classified as wetland (%)
a = area coefficient
n = area exponent
b = wetland exponent

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Classification: Public

Table 5-2: MAF predicted by regression equation and calculated from flow records

Station Name	Station Number	MAF	
		Predicted from regression equation	Calculated from flow records
Wampus Creek Near Hinton	07AF003	4.91	6.11
Embarras River Near Weald	07AF014	63.3	60.0
Wolf Creek at Highway No. 16A	07AG003	64.4	77.8
Groat Creek Near Whitecourt	07AG008	26.3	36.3
Christmas Creek Near Blue Ridge	07AH002	43.6	22.1
Rat Creek Near Cynthia	07BA002	46.0	43.8
Lovett River Near the Mouth	07BA003	13.6	18.8
Paddle River Near Anselmo	07BB011	29.3	34.6

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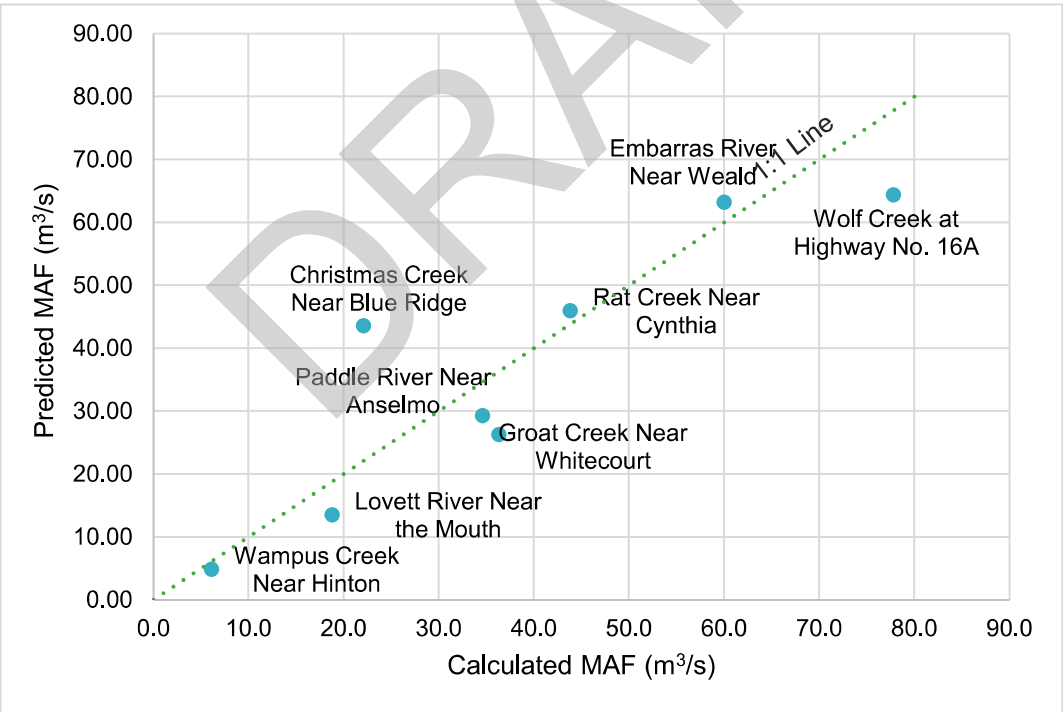

Figure 5-1: MAF predicted by regression equation and calculated from flow records

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Regional estimates of the dimensionless scaling factors Q_T / MAF are calculated as the average of Q_T / MAF ratios at each return period for all index stations. The regional Q_T / MAF factors are then combined with the target site MAF estimate and used to calculate flow quantiles for the location of interest. The regional scaling factors are shown in Table 5-3.

Table 5-3: Scaling Factor at each return period

Return Period	Average Scaling Factor (Q_T/MAF)
2	0.7
5	1.4
10	2.1
20	3.0
35	3.8
50	4.4
75	5.1
100	5.6
200	7.1
350	8.4
500	9.3
750	10.5
1,000	11.4

For Bench Creek at the downstream end of the study area, the estimated MAF is 9.84 m^3/s and the regional scaling factor for the 100-year event is 5.6. The product of these components yields an instantaneous maximum flow estimate of approximately 55.2 m^3/s for the 100-year return period (1% AEP) event. Full results are presented in Section 5.3.

5.2 Direct Quantile Regression Method

The second RFFA technique, known as direct quantile regression, involves developing a regression-based relationship (similar to the one developed relative to the MAF in the index flood approach) at each flood quantile. Separate regression relationships are developed for the 2-year event through to the 1,000-year event.

As with the index flood approach, the regression relationships consider watershed area and potentially other relevant physiographic and/or climatic parameters. For consistency, the form and composition of the relationship is held constant across all flood quantiles while the parameters are allowed to vary based on the data.

Watt et al. (1989) provides a detailed discussion of direct quantile regression and its various applications, suggesting that direct regression of quantiles for different return periods represents an advancement over the index flood method. However, all regression-based methods come with limitations and should only be applied to watersheds that exhibit basin characteristics within the same range as those used to develop the regression equations (Watt et al., 1989). Furthermore, the data should reflect natural flow conditions, and these equations should not be used for watersheds with basin characteristics outside the established parameters.

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The direct quantile regression method described in this section utilizes the same station selection and relationship form as the previously described index flood approach; the regression relates instantaneous maximum flow to drainage area and percent wetland. The regression equation and parameter values are listed in Table 5-4. The parameters were obtained by minimizing the SSE between the flow quantiles calculated using the regression equation and those calculated in the single station FFA. The R^2 values for each return period show a slight decrease as return period increases. Figures comparing the flow quantiles calculated from regression equations and FFA are presented in Appendix 3.

Table 5-4: Direct Quantile Regression Equation used for Flow quantiles

Return Period (years)	Constants $Q_T = a * W^b * A^n$			R^2
	a	b	n	
2	0.13	-0.36	0.99	0.82
5	0.39	-0.35	0.93	0.78
10	0.64	-0.34	0.91	0.76
20	0.90	-0.33	0.90	0.73
35	1.16	-0.32	0.90	0.72
50	1.34	-0.31	0.90	0.71
75	1.68	-0.32	0.88	0.70
100	1.71	-0.30	0.89	0.69
200	2.15	-0.29	0.89	0.68
350	2.43	-0.28	0.89	0.67
500	2.73	-0.26	0.89	0.66
750	2.85	-0.26	0.90	0.66
1,000	3.28	-0.24	0.88	0.66

Note:
A = watershed area (km^2)
W = percent wetland (%)
a = area coefficient
n = area exponent
b = wetland exponent

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Applying this approach to the drainage area of 96.6 km^2 above the downstream study limit yields a 100-year event instantaneous maximum flow estimate of 56.0 m^3/s. Full results are presented and compared to results obtained from the Index Flood method in Section 5.3.

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5.3 Regional Analysis Results Summary

Based on the above relationship, flow quantiles at the downstream end of the study area were estimated (drainage area 96.6 km^2). These estimates are summarized in Table 5-5. The index flood method and direct quantile regression method yield comparable results. The values obtained by extrapolating the index flood and direct quantile regression differ by 3.5% at the 1,000-year return period The index flood method quantiles, which are marginally lower at the 100-year flood and provide a closer approximation of estimated historical flood events (see discussion in Section 8.2), are recommended for the study area.

Table 5-5: Regional Flood Frequency Analysis Results at Downstream End of Study Area

Return Period	Index Flood Method (m^3/s)	Direct Quantile Regression Method (m^3/s)
	Q_T (m^3/s)	
2	6.44	5.8
5	13.9	13.6
10	20.9	20.8
20	29.3	29.2
35	37.2	37.5
50	42.8	43.3
75	49.8	50.3
100	55.2	56.0
200	69.5	70.9
350	82.6	84.8
500	91.8	94.5
750	103	107
1000	112	116

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6. Validation of High Return Period Flow Quantiles

Estimates for events with large return periods (i.e., 200 years or more) cannot be derived with reasonable confidence from flood frequency analysis without a long period of record and a reasonable amount of scatter among points at the high range of the fitting curve. Although the Federal Flood Mapping Guidelines (Natural Resources Canada, 2023) do not prohibit the extrapolation of frequency curves above 100-year, other guidelines for similarly high-risk engineering deliverables, such as the Canadian Dam Association (CDA) Guidelines, discourage extrapolation of flood frequency curves based on limited flow records beyond the 100-year flood event (Canadian Dam Association, 2007).

Due to the uncertainty associated with extrapolating FFAs beyond the 100-year event, two additional approaches were investigated to validate the results of the RFFA for flows with return periods of 200 years and greater:

1. the LP3 Extrapolation Method; and
2. the Frequency-Based PMF Interpolation Method.

Each of these is discussed below, and a comparison of results to the RFFA results is presented in Section 6.3.

6.1 LP3 Extrapolation Method

This approach fits a LP3 distribution to the curve of estimated Q_T vs. T for the study site, which is then extrapolated to a return period of 1,000 years. The LP3 distribution was chosen due to its flexibility as a three-parameter distribution and its ease of implementation. Figure 6-1 shows the LP3 distribution fitted to RFFA-derived quantiles up to and including the 100-year event for Bench Creek at the downstream end of the study area (drainage area 96.6 km^2), where quantiles are estimated using index flood (Section 5.1) and direct quantile regression methods (Section 5.2).

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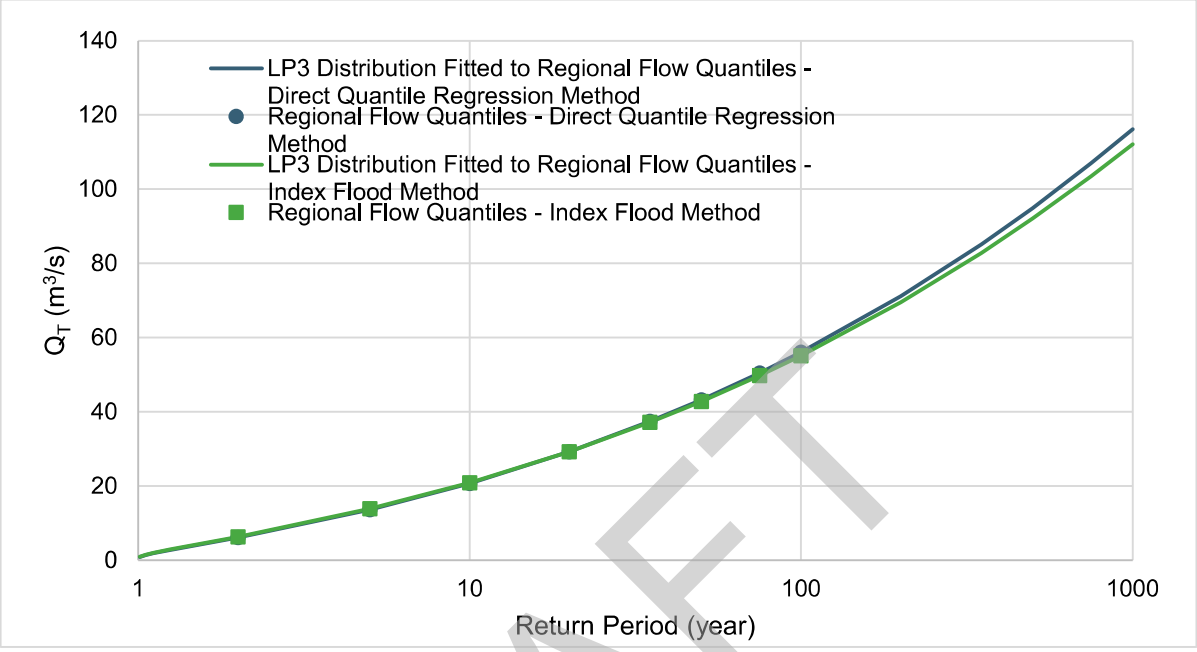

Figure 6-1: Extrapolation of RFFA Flood Quantile Estimates to 1,000-Year Flood Using Log-Pearson III

While this validation check reduces the influence of scatter among the reference stations on the results of an extreme extrapolation (thereby reducing the potential influence of individual unrealistic components), the index flood and direct quantile results are based on the same underlying data and analyses. The degree of validation obtained is therefore similarly constrained.

6.2 Frequency-Based PMF Interpolation Method

The "Guidelines on Extreme Flood Analysis" (Alberta Transportation, 2004) recommend a frequency-based interpolation method to estimate the 1,000-year instantaneous maximum flood. The frequency-based interpolation method estimates the $Q_{1,000}$ using frequency interpolation between the estimated 100-year instantaneous maximum flood and the PMF (see Section 6.3). There is no established standard on the likely probability of a PMF; however, a 100,000-year return period is suggested by the Alberta Transportation Guidelines (2004).

For consistency, and as described in Section 3, the frequency-based interpolation approach is extended to provide estimates of all quantiles between the 200-year (0.5% AEP) and 1,000-year (0.1% AEP) floods for Bench Creek at the downstream end of the study area.

Probable Maximum Precipitation and Probable Maximum Flood

To estimate the PMP, KWL adopted the method outlined in Hopkinson's *Point Probable Maximum Precipitation for the Prairie Provinces*, (Hopkinson, 1999) with inclusion of an areal reduction factor derived from Hydrometeorological Report No. 55A (HMR55A) (Hansen, et al, 1994). A statistical method outlined in World Meteorological Organization's Manual on Estimation of PMP (WMO, 2009) was applied to validate the PMP results.

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The PMP values for a 24-hour duration calculated using both the Hopkinson and WMO methods are comparable at 399 mm and 351 mm respectively. The Hopkinson method is derived specifically for the Canadian prairies where the study area lies, accounting for meteorological conditions characteristic of this region. The table below summarizes the PMP calculated for the 1-, 6-, and 24-hour durations using the Hopkinson method for the study basin (drainage area 96.6 km^2).

Table 6-1: PMP Calculation Results using Hopkinson Method for 1-, 6-, and 24-hour Durations

Duration (hr)	PMP – Hopkinson Method (mm)
1	264
6	280
24	399

The Hopkinson Method specifies that the first 8 hours of the 24-hour PMP should include 93.3% of the total rainfall (372 mm) and the remaining precipitation is distributed over the last 16 hours. While Hopkinson did not specify the distribution of rainfall within the first 8 hours, KWL adopted a front-loaded 24-hour hyetograph that incorporates nested 1-hour and 6-hour PMP values, with the 1-hour PMP placed in the first hour to preserve the 6-hour total.

Instantaneous maximum flow records of the index stations and at other hydrometric gauges revealed that the largest historical rainfall events have occurred during summer and fall when snow has completely melted. This matches KWL's previous experience working on other projects in the Alberta Rocky Mountain foothills and along the Continental Divide. Therefore, no snowmelt component or seasonal rainfall adjustment was considered in simulating the PMF. In addition, Hopkinson recommends "average" conditions antecedent to a prairie province PMP.

The PMF was simulated using the rainfall-runoff model set forth in Section 7. The PMF estimate produced for Bench Creek at the downstream end of the study area using average antecedent conditions and the nested 24-hour PMP hyetograph is 510 m^3/s.

6.3 Validation Results Summary

The results of the two additional approaches for peak flow extrapolation were very similar, with the frequency-based PMF interpolation method being more conservative.

All methods listed in Table 6-2 are associated with significant uncertainties, but the frequency-based PMF interpolation method is accepted as the best estimate for extrapolating quantile estimates up to the 1,000-year event since it is recommended by Alberta Transportation.

Table 6-2: Regional Flood Frequency Analysis Results at Downstream End of Study Area (T>100 years)

Return Period	RFFA (Index Flood Method)	LP3 Extrapolation of Index Flood	RFFA (Direct Quantile Regression)	LP3 Extrapolation of Direct Quantile	Frequency-Based PMF Interpolation
	Q_T (m^3/s)				
200	69.5	69.5	70.9	71.1	73.5
350	82.6	82.7	84.8	85.1	91.2
500	91.8	92.0	94.5	94.9	104
750	103	103	107	107	120
1,000	112	112	116	116	133

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7. Deterministic Modeling for Return Period Flood Estimates

A deterministic hydrologic model was created to transpose the RFFA quantiles for the entire study area to smaller subbasins for use as inflows in the hydraulic model, to produce streamflow estimates for the 2023 rainfall event for the high flow calibration of the hydraulic model, and to produce a PMF estimate from the calculated PMP.

The model was created using the US Army Corps of Engineers' Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) software version 4.12. The two main components of the model are: (1) the basin model, which includes drainage area, loss method, and transform method, and (2) the meteorological model, comprised in this case of a hyetograph. The software applies the meteorological model to the basin model and computes flow at specified points.

7.1 Basin Model Setup

The basin model uses a lumped approach with eight nested subbasins based on seven individual local contributing areas, as outlined in Figure 1-1. Drainage area, and the upstream and downstream limit of each local drainage area is listed in Table 7-1.

Table 7-1: Summary of local drainage areas that make up the nested subbasins

Name	Upstream Extent	Downstream Extent	Local Drainage Area (km^2)
Bench A	Bench Creek headwaters	Range Road 180	43.6
Bench B	Range Road 180	Canadian National Railway	16.1
Bench C	Canadian National Railway	Bench-Poplar confluence	6.92
Bench D	Bench-Poplar confluence	Downstream end of study area	16.3
Wase A	Wase Creek headwaters	Poplar-Wase confluence	7.83
Poplar A	Poplar Creek headwaters	Poplar-Wase confluence	5.67
Poplar B	Poplar-Wase confluence	Bench-Poplar confluence	0.19

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The drainage basin areas were delineated in ArcGIS using a combination of the LiDAR-derived DEM of the study area and the publicly available CDEM described in Section 2.3. Information collected during field visit and survey was used to refine the delineation around the Town of Edson.

The Soil Conservation Service (SCS) Curve Number (CN) loss method and SCS dimensionless unit hydrograph transform method were chosen for this study. The SCS method, now commonly referred to as the NRCS (Natural Resources Conservation Service) method, is a widely used approach for estimating runoff in small and medium-sized watersheds. It was developed by the United States Department of Agriculture (USDA) to help with soil conservation and water resource management. Key inputs to the SCS method are the CN, time of concentration (T_c), and rainfall hyetographs (presented in Section 7.2).

CN values for each watershed were obtained by assigning a representative CN value to each land use class and then taking an area-weighted average of the CN values within each watershed. The CN values associated with each land use and soil group were obtained from tables published in TR-55 (USDA, 2019). There is no published CN value for wetland areas, and an appropriate value was established as part of the model calibration/validation process, constrained by engineering judgement and values identified in other studies. The land use and soil information are extracted in ArcGIS using

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the Land-use/Land-cover Classification of Alberta (Chowdhury, 2021) and Soil Texture of Alberta (Alberta Agriculture Flood and Rural Development, 2002), respectively. In addition to the normal Antecedent Moisture Condition (AMC II), the CN value for the wet condition (AMC III) was also computed and used as the upper bound of CN value during model calibration for the most extreme events.

Time of concentration for each subbasin was calculated using the widely accepted Kerby-Kirpich Method (Roussel et al. 2005). This method calculates the time of concentration of overland and channel components separately. The overland component assumes a maximum overland flow length of 366 m, or 1200 ft (Roussel et al. 2005), while the flow length of the channelized component is estimated in ArcGIS based on the longest flow path in each basin. Similarly, the slope used in the overland component is calculated in ArcGIS using the average overland slope raster derived from the CDEM, while the slope used in the channelized component is estimated based on the elevation difference from upstream to downstream along the longest flow path and its length. For simplicity, time of concentration is assumed to be time-invariant (i.e., not dependent on storm seasonality) and constant for all values of excess runoff. Table 7-2 summarizes the calculated parameters for each subbasin.

Table 7-2: HEC-HMS Model Nested Subbasin Characteristics

Subbasin	Drainage area (km^2)	Weighted CN (AMC II)	Weighted CN (AMC III)	Longest Channel Length (km)	Channel Slope (%)	Average Overland Slope (%)	T_c, Kerby-Kirpitch (hours)
Bench A	43.6	76	88	11.9	0.36	4.1	8.2
Bench AB	59.7	77	88	17.9	0.38	3.8	11
Bench ABC	66.6	77	88	24.2	0.33	3.6	14
Entire Basin	96.6	77	88	30.6	0.33	3.2	17
Wase A	7.83	78	89	5.99	0.85	2.7	3.8
Poplar A	5.67	77	89	4.89	1.2	2.8	3.0
Poplar AB and Wase A	13.7	78	89	6.41	0.92	2.8	4.1

7.2 Meteorological Model Setup

Edson Intensity-Duration-Frequency Update

ECCC published short duration Rainfall Intensity-Duration-Frequency (IDF) Data for Edson Climate (ID 3062246) in October 2022, based on rainfall data from 1970 to 1992, and 2006 to 2020, inclusive. For the durations considered herein, (1, 2, 6, 12, and 24 hours) the record of annual maxima is complete for the years mentioned.

Updated IDF data for the durations mentioned was produced, including rainfall data from 2021 through 2023 to capture the June 2023 event. The maximum 24-hour depth of the 2023 event (88.8 mm) equate to approximately a 100-year event based on the 2022 IDF Data. As only a partial year of data is available for 2024 at the time of writing, 2024 rainfall maxima were not considered. The frequency analysis procedure described in Section 4.1 was followed. Multiple distributions were evaluated including GEV, LP3, Gumbel, and Gamma. Gumbel results produced an acceptable fit and are recommended for this study to match ECCC's approach, which exclusively uses Gumbel.

Rainfall quantiles were calculated for each of the thirteen return periods specified in the RFP. Quantiles are presented in Table 7-3.

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Table 7-3: Edson Climate (ID 2062246) Updated IDF Data

Storm Duration (hr)	Return Period Maximum Rainfall (mm)												
	2	5	10	20	35	50	75	100	200	350	500	750	1,000
1	15.7	21.0	24.5	27.8	30.5	32.2	34.1	35.4	38.7	41.3	42.9	44.8	46.2
2	18.7	25.1	29.3	33.4	34.7	36.6	38.6	40.9	42.5	46.5	49.6	51.6	53.9
6	25.6	32.6	37.3	41.8	45.4	47.6	50.2	52.0	56.3	59.8	62.1	64.6	66.4
12	32.8	42.8	49.4	55.7	60.7	63.9	67.5	70.1	76.2	81.1	84.3	87.9	90.4
24	43.2	56.9	66.0	74.7	81.6	86.0	90.9	94.4	103	110	114	119	122

Selection of Hyetograph

Three hypothetical rainfall events were considered as potential design storms:

1. A 24-hour event with an SCS Type II hyetograph scaled to achieve the calculated rainfall intensity at durations critical to the study watersheds;
2. A 24-hour rainfall event with a Chicago-style rainfall hyetograph that “nests” the calculated rainfall intensity at all durations within a single event; and
3. A 72-hour rainfall event based on the recorded June 2023 severe rainfall event, scaled so that the maximum 24-hour recorded rainfall matches the desired return period.

The three hyetographs were fitted to the 100-year rainfall total to simulate runoff with AMC II conditions for the uncalibrated model. The simulation results show that the 24-hour Chicago and SCS Type II hyetograph resulted in very similar instantaneous maximum flow estimates (60.2 m^3/s and 57.2 m^3/s, respectively) at the downstream study extent.

Unsurprisingly, given its longer duration and higher total precipitation, the 72-hour 2023 hyetograph resulted in a higher peak flow estimate (75.7 m^3/s) at the downstream end of the study area. However, when the 2023 hyetograph is scaled to match the 100-year value at 24-hour duration, shorter duration totals fall significantly below the 100-year IDF values. This may cause the deterministic model to underestimate peak flows for smaller drainage basins such as Wase and Poplar creeks.

Using the SCS Type II method and adjusting it to the time of concentration of the basin can ensure that the rainfall return period remains consistent at the critical duration for basins with different T_c values, but it requires a different adjustment factor for each simulated sub-basin. As a result, the 24-hour total precipitation will not be the same, leading to potentially significant differences in antecedent conditions at the onset of the critical duration.

Based on the above commentary, the Chicago-style hyetograph is adopted as the most appropriate choice for the design storm in this analysis. By definition, it provides 100-year return period rainfall inputs for all subbasins regardless of their T_c.

7.3 Model Calibration

The deterministic model was calibrated to match RFFA peak flow estimates up to the 100-year return period event at the downstream end of the study area (drainage area 96.6 km^2). Calibration also included events obtained from the frequency-based PMF interpolation method (Section 6.2) for events with return periods of 200 years and greater.

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The peak rate factor (PRF) is a measure of the proportion of runoff occurring prior to the peak flow in the SCS dimensionless unit hydrograph. The standard value is 484, but for regions that tend to retain and store water resulting in a delayed, lower peak, the PRF tends towards 300 or lower (Wanielista, et al. 1997).

The standard PRF and AMC II conditions were adopted for the 100-year simulation. The CN value for wetland was then adjusted such that the composite CN for the entire study watershed yielded a 100-year instantaneous maximum that matched the RFFA results. The adjusted CN value for wetland (75) was used for all return periods.

Wetland areas are expected to have a more significant attenuating effect for smaller storms than for the 100-year return period event. This effect was addressed in calibration by manually adjusting PRF and holding the AMC II condition constant to match flood simulations between the 2-year and the 75-year return period events to the corresponding RFFA estimates. For events with return periods between 200 and 1,000 years, the PRF was held constant at 484 and the composite CN was manually adjusted between AMC II and AMC III such that the simulated instantaneous maxima matched the frequency-based PMF interpolation method estimates.

Table 7-4 displays the PRF, CN, simulated flow quantiles, and percent difference with RFFA or frequency-based PMF interpolation methods for each return period in the calibrated model. All simulated flow quantiles are within ±5% of their calibration target.

Table 7-4: Model Calibration Summary (drainage area 96.6 km^2)

Return Period (years)	PRF	CN	HEC-HMS Simulation	RFFA or Frequency-Based PMF Interpolation[1]	Difference %
			Q_T (m^3/s)		
2	300	AMC II	6.69	6.44	4%
5	300	AMC II	13.8	13.9	-1%
10	350	AMC II	21.5	20.9	3%
20	400	AMC II	30.9	29.3	5%
35	400	AMC II	36.8	37.2	-1%
50	450	AMC II	44.1	42.8	3%
75	450	AMC II	49.6	49.8	0%
100	484	AMC II	55.2	55.2	0%
200	484	AMC II.2[2]	71.6	74.0	-3%
350	484	AMC II.555[2]	94.9	92.2	4%
500	484	AMC II.6[2]	102	105	-2%
750	484	AMC II.81[2]	118	122	-2%
1,000	484	AMC III	130	135	-2%

Notes:

1. Q_2 to Q_{100} values are taken from the RFFA. Q_{200} to $Q_{1,000}$ are taken from the frequency-based PMF interpolation method.
2. Digits after "AMC II." denote the addition of a progressive fraction of the difference between AMC II and AMC III to the AMC II value (e.g., AMC II.2 = AMC II + 0.2 * (AMC III – AMC II)).

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7.4 Sensitivity Analysis

A simple sensitivity analysis was conducted by varying the CN value and the basin lag time for the entire basin (drainage area 96.6 km^2) for the 100-year rainfall event. The results are presented in Table 7-5. The analysis revealed that the model simulation is most sensitive to increases in the CN value, which validates the calibration approach of capping the maximum CN value at the value corresponding to the AMC III condition.

Table 7-5: Sensitivity Test Results

Test Parameter	Change	Peak Flow Change[1]
CN	+5	25%
CN	-5	-22%
Lag time	+10%	-5.8%
Lag time	-10%	6.4%

Notes:
1. Change with respect to the 100-year peak flow at the model downstream end using calibrated parameters (55.2 m^3/s).

7.5 Model Validation

The calibrated deterministic model was validated through simulation runs on the subbasin draining to Bench Creek at the railway bridge west of 54th Street (drainage area 59.7 km^2). RFFA and frequency-based PMF interpolation method quantiles were produced for the smaller basin and compared to the corresponding simulated flows. Table 7-6 displays the simulated flow quantiles and error magnitude for each return period in the model validation.

Table 7-6: Model Validation Summary (drainage area 59.7 km^2)

Return Period (years)	HEC-HMS Simulation	RFFA or Frequency-Based PMF Interpolation[1]	Difference %
	Q_T (m^3/s)		
2	5.22	4.21	24%
5	10.8	9.10	19%
10	16.4	13.7	20%
20	23.5	19.1	23%
35	28.3	24.3	16%
50	34.1	28.0	22%
75	38.3	32.5	18%
100	43.2	36.1	20%
200	57.1	49.8	15%
350	76.3	63.5	20%
500	81.8	73.6	11%
750	95.1	86.6	10%
1,000	105	96.8	8%

Notes:
1. Q_2 to Q_{100} are taken from the RFFA. Q_{200} to $Q_{1,000}$ are taken from the frequency-based PMF interpolation method.

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Peak flows estimated from the deterministic model were between 8-24% higher than from RFFA and frequency-based PMP method. The RFFA and the frequency-based PMF interpolation method (to the extent that it is based on the RFFA) are intended for use in a basin nearly twice this size. It is therefore expected that the numbers for this smaller drainage area are subject to greater uncertainty as the watershed becomes less similar to the reference gauges. In the absence of local site data, it is reasonable to accept a conservative bias and the validation is considered acceptable.

7.6 2023 Flood Simulation

Using the full 72-hour precipitation recorded at the ECCC station Edson Climate (ID 3062246) as forcing data, a simulation of the June 2023 flood event was carried out. This simulation was performed in conjunction with the high flow calibration of the hydraulic model. Hydrologic model was adjusted to reflect the conditions of this event, as described below.

Significant drought conditions prevailed across most of southern Alberta in 2023. The Agricultural Moisture Situation Update on June 6 reported soil moisture around Edson to be at a 6- to 12-year low (Government of Alberta, 2023). Although a moderate amount of rainfall (21.9 mm) occurred on June 14, it was likely insufficient to alleviate the prevailing soil moisture deficit within the soil column. Due to the dry antecedent conditions, CN values corresponding to AMC I – representing low soil moisture that has not yet reached the wilting point – were applied to all sub-basins. A PRF of 400 was selected to reflect the influence of overland storage on peak flow.

The resulting flow estimates produced water levels within acceptable tolerances of 2023 HWMs in the hydraulic model. This is discussed in detail in the main report. Flow estimates are presented in Table 7-7.

Table 7-7: Flow Estimates for the June 2023 Event

Instantaneous Maximum Flow (m^3/s)						
Bench Creek				Wase Creek	Poplar Creek	
Range Road 180	Railway West of 54th Street	Upstream of Poplar Creek	Downstream End of Study Area	Upstream Poplar Creek	Upstream of Wase Creek	Upstream of Bench Creek
14.1	18.3	18.5	25.6	3.53	2.81	6.41

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8. Summary of Flood Estimates

8.1 Recommended Flood Estimates

Table 8-1 provides the recommended flood frequency estimates for use in the hydraulic model.

Table 8-1: Recommended Flow Rates for Flood Mapping

Return Period (Years)	Instantaneous Maximum Flow (m^3/s)		
	Bench Creek	Wase Creek	Poplar Creek
2	5.22	1.14	1.08
5	10.8	2.54	2.37
10	16.4	4.09	3.77
20	23.5	6.15	5.45
35	28.3	7.44	6.54
50	34.1	9.18	8.03
75	38.3	10.3	9.04
100	43.2	11.8	10.5
200	57.1	15.5	13.7
350	76.3	20.6	17.9
500	81.8	22.0	19.2
750	95.1	25.4	22.1
1,000	105	27.9	24.2

Note:
1. Peak flows should be applied at the upstream end of each creek reach.

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The presented flows are appropriate for use in the Edson Flood Study as 2D model inflows for each stream. These values are deemed representative for the entire modelled reach.

The 2D model was run in quasi-steady state. 2D modelling of a complex system of tributary streams will result in flows accumulating below tributary confluences that are greater than those derived from the regional hydrologic analysis. However, based on discussion with the hydraulic modelling team, this difference has negligible impact on the mapped flood extents.

8.2 Comparison with Previous Studies

The hydrotechnical reports in Table 8-2 for bridges along Bench Creek contain design flow estimates for a 100-year flood, and they were examined as part of the hydrologic analysis.

Table 8-2: Bench Creek design flows provided in previous Bridge Assessment Reports

Bridge File #	Bridge Location	Stream	Report Author	Report Year	Drainage Area (km^2)	100-year Peak Flow (m^3/s)	100-year Unit Peak Flow (m^3/s per km^2)
75766	63rd Street	Bench Creek	AECOM	2009	54	23	0.43
74695	54th Street	Bench Creek	AECOM	2009	59	25	0.42
72123	4th Avenue	Bench Creek	MPA Engineering Ltd.	Unknown	59	23	0.39

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Bridge File #	Bridge Location	Stream	Report Author	Report Year	Drainage Area (km^2)	100-year Peak Flow (m^3/s)	100-year Unit Peak Flow (m^3/s per km^2)
09883	Township Road 534	Bench Creek	Assenheimer Consulting Ltd.	Unknown	78	21	0.27
13589	Highway 16	Bench Creek	Unknown	Unknown	79	18	0.23
70506	Range Road 171	Bench Creek	Unknown	Unknown	79	18	0.23

For comparison purposes, the peak flows are converted to unit peak flows (i.e., in $m^3/s/km^2$). Overall, the 100-year return period unit peak flow of 0.57 m^3/s per km^2 estimated at the downstream end of this study area is higher than the values suggested in previous hydrotechnical reports for Bench Creek, which range from 0.23 to 0.43 m^3/s per km^2. Another point of comparison is the channel capacity of Bench Creek near the confluence with Poplar Creek, which was estimated to be 14.1 m^3/s at the 63rd Street bridge. This capacity is similar to the 5-year return period instantaneous maximum flow (a reasonable approximation of bank full flow) of 10.8 m^3/s simulated on the same reach for this study, which corroborates the lower magnitude flood estimates produced herein.

A hydrotechnical report for a bridge on Wase Creek containing a design flow estimate for a 100-year flood was also examined and is presented in Table 8-3.

Table 8-3: Wase Creek design flows provided in previous Bridge Assessment Reports

Bridge File #	Bridge Location	Stream	Report Author	Report Year	Drainage Area (km^2)	100-year Peak Flow (m^3/s)	100-year Unit Peak Flow (m^3/s per km^2)
85041	Pipeline West of Edson Drive	Wase Creek	AECOM	2009	7.55	6.0	0.79

The 100-year return period unit peak flow of 1.51 m^3/s per km^2 estimated on Wase Creek at the confluence with Poplar Creek is higher than the 0.79 m^3/s per km^2 suggested in the hydrotechnical reports for the pipeline west of Edson Drive.

These differences at the 100-year return period are expected, as the regional analysis used for bridges at 63rd Street, 54th Street, Township Road 534, 4th Avenue, and the pipeline west of Edson Drive included low unit peak flow stations, such as Sundance Creek Near Bickerdike. An explanation for the exclusion of this station in this study is provided in Section 4.2. Furthermore, all the above analyses were completed prior to and therefore necessarily exclude the 2023 flood event.

In addition, KWL identified two historical peak flow estimates associated with known extreme events. Maximum instantaneous flow estimates for Bench Creek during the 1954 and 1965 floods (Section 2.4) are summarized in Table 8-4 below. A corresponding modeled event is also selected based on the estimated 24-hour rainfall depth, and the modeled peak flow for Bench Creek is provided. Since the historical document only included the 72-hour rainfall for the 1954 event, no corresponding modeled event was chosen. For the 1965 event, a 10-year modeled event was selected for comparison, based on a 24-hour rainfall depth of 68 mm. The peak flow obtained from the model at the downstream end is used for comparison with the 1965 peak flow estimate due to their proximity.

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Table 8-4: Historical flow estimates and corresponding modeled peak flow

Year	24-hour Rainfall Estimate (mm)	Flow Location	Historical Peak Estimate (m^3/s)	Corresponding Modeled Event	Modeled peak at downstream end of study area (m^3/s)
1954	<85	Highway 16 on Bench Creek	14.2	N/A	N/A
1965	68	Just upstream of Highway 16 on Bench Creek	20.4	10-year	21.5

The comparison shows that the modeled flow aligns well with the historical flow estimate of the 1965 event.

8.3 Uncertainty and Confidence

Uncertainty is inherent to any hydrologic analysis. The main sources of uncertainty for each step of the analysis herein are discussed below.

Flood Frequency Analysis at Index Stations

Uncertainty in single station FFA is mainly from two sources: errors in published hydrometric data and uncertainty in the application of statistical procedures and models to data samples that may not perfectly represent the population.

Concerning hydrometric data published by WSC, error is more prevalent in extreme high flow events – which are, of course, also those that are most important to FFA. These errors tend to be random in direction and do not necessarily lead to inaccurate or biased estimates of sample mean and variance. However, error may be carried forward into the calculation of sample skewness, which has a direct effect on the quantiles of three-parameter distributions such as the LP3 distribution. Evaluating the accuracy of flood peaks published by WSC is beyond the scope of this study; it is assumed that published peak flows reported by WSC are accurate. This includes the estimated 1986 peak flow on Rat Creek, which was confirmed to be the best available data following an examination that included correspondence with WSC.

Additional uncertainty is introduced through the correlation of instantaneous and daily average annual maximum flood peaks, as well as the application of the resulting relationship to extend the series of observed flood maxima. However, the additional information captured by extending the record in this process contributes to reducing the second source of uncertainty (i.e., due to small sample size) and is widely recognized as a net benefit to the FFA process.

Effort has been made to mitigate against uncertainty associated with the application of statistical models that demand data samples to be independent, identically distributed, stationary, and random from year to year. The independence of each sample was assessed using the Wald-Wolowitz test; all samples yielded passing results at a 5% significance level. Stationarity was assessed using the Kendall test; all samples also yielded passing results at a 5% significance level. And, while not a direct assessment of randomness, the chi-squared test used to determine whether a distribution underlies a sample does so by testing if the observed frequencies of events align with the expected frequencies of a random process. All samples yielded passing chi-squared test results with at least one empirical distribution at a 5% significance level. These tests indicate that the data are of sufficient quality for the application of the required statistical processes despite the remaining uncertainty regarding randomness.

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The final source of uncertainty is in the selection of a specific model to suit a data sample drawn from an unknown population. The calculation of confidence limits based on methods such as the standard error of the estimate or bootstrapping provides an indication of uncertainty arising from a less representative sample. This study reports “best estimate” values from the FFA results; however, in high-risk situations EPA has discretion to specify use of a higher threshold such as an upper confidence limit. This study has not received such direction and the use of “best estimate” values are recommended for hydraulic modelling and mapping of open water flood events.

While useful, confidence limits do not reflect potential uncertainties associated with the selection of different statistical models. This study provided some consideration of the potential uncertainties by investigating three different distributions for each sample. Typically, a “best fit” distribution was apparent. In some cases (such as the Rat Creek FFA), the different distributions suggested a very broad range of distribution uncertainty. In such cases, engineering judgement was used to identify and recommend the most reasonable distribution.

Regional Flood Frequency Analysis

The RFFA process builds upon the results of several single station FFAs and is therefore subject to the uncertainty associated with each of them. If errors are carried through the single station FFAs, it is assumed that they are random in direction and that their impact on the RFFA is mitigated by pooling, averaging, and regression fitting processes.

Further uncertainty inherent to RFFA is due to method selection. Reliance on a single method has potential to introduce bias and propagate error. Two methods (index flood and direct quantile regression) were used and found to converge to a high degree. Furthermore, due to the added uncertainty surrounding high return period (200 years and greater) flood estimation, two independent validation methods (LP3 extrapolation and frequency-based PMF interpolation) were used at these return periods and were also found to converge to a high degree.

Deterministic Hydrologic Model

In deterministic hydrologic modeling, such as using the HEC-HMS model with the SCS Curve Number loss method and the SCS dimensionless unit hydrograph, there are several uncertainties that can impact the accuracy and reliability of the results. These uncertainties primarily arise from the data and assumptions used in the modeling process.

Land use and soil data are crucial in determining the CN value, but several uncertainties can affect its accuracy. Errors in land use classification can arise from outdated, inaccurate, or improperly classified data, which may lead to incorrect CN values. Additionally, the resolution and scale of land use data play a role in uncertainty, whereby lower resolution data may overly generalize land cover and surface conditions, impacting CN calculations. Published CN values are often based on generalized empirical studies and may not reflect the specific governing surface or sub-surface conditions of a given watershed. These values are typically derived for regional conditions, which may not fully account for the heterogeneity within a smaller basin, leading to inaccurate predictions when applied universally. The uncertainties associated with estimating CN result in it typically being adjusted during model calibration. The calibration and validation process is explicitly intended to mitigate uncertainty.

Basin lag time is often estimated using simplified empirical formulas, such as those provided by the SCS. These formulas rely on approximations of basin geometry and hydrologic properties, which may not fully capture the unique characteristics of each basin. Variability in topography, such as irregular or complex basin shapes, adds uncertainty to lag time estimates. Furthermore, hydrologic flow paths, which depend on how water moves through the basin, are influenced by factors such as rainfall patterns, channel networks, and human modifications (e.g., roads or drainage systems), all of which are

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difficult to estimate. Additionally, lag time may vary with different rainfall events (Eleni, 2018), adding another layer of uncertainty when modeling dynamic hydrologic conditions. Like CN, basin lag time is often fine-tuned during model calibration.

For this study, the lack of local data means that the deterministic model cannot be fully calibrated and is subject to more uncertainty than most rainfall-runoff model applications. To rectify this, the very simple SCS model structure was selected to minimize parameterization and maximize transparency while still leveraging both the available RFFA data and capturing the key characteristic differences between sub-basins. A simple sensitivity analysis is presented to illustrate the uncertainty associated with varying the most important model parameters.

Based on the above discussion, the analysis herein utilizes the best available data and is consistent with typical industry practice. The findings and results are therefore considered sufficient for the assessment of creek hazards. Further reduction of uncertainty will be possible if and when local streamflow data become available to support robust calibration of the rainfall-runoff model at multiple locations.

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9. Climate Change Impact Assessment

This section provides a qualitative interpretation of climate and hydrological projections at seasonal and event time scales. A conservative assumption was made to adopt Shared Socioeconomic Pathway SSP5-8.5 as the basis of discussion for this assessment. The Intergovernmental Panel on Climate Change (IPCC, 2023) applies the term “shared socioeconomic pathway” to refer to a suite of assumptions that define a projected socioeconomic future including greenhouse gas emissions under different climate policies. SSP5-8.5 represents a world heavily reliant on fossil fuels, facing significant challenges in mitigating climate change.

9.1 Future Temperature and Precipitation – Seasonal Perspective

Data from regional climate models (RCMs) (CIMP6-CanDCSM6) hosted on ClimateData.ca is used to gain a general understanding of projected climate change at seasonal and annual temporal scale. CanDCS-M6 is a dataset of statistically downscaled CMIP6 climate scenarios developed by the Pacific Climate Impacts Consortium (PCIC) using a multivariate bias correction method. Projected climate data for a grid cell including the Town of Edson (approximately 10 km by 6 km grid resolution) indicate that both temperature and precipitation are expected to increase. For the 1990s reference period (1981-2010), the annual average temperature was 2.8ºC. Under SSP5-8.5, annual average temperatures are projected to be 4.3ºC (+1.7°C) for the 2021-2050 period, 6.0ºC (+3.2°C) for the 2051-2080 period and 7.8ºC (+5.0°C) for the last 30 years of this century. Increasing trends in temperature are observed in all four seasons.

The same climate data extracted at the same grid cell indicate that the average annual precipitation for the baseline period (1981 to 2010) was 541 mm. Under SSP5-8.5, average annual precipitation is projected to be 4% higher for the 2050s (2041-2070) period and 6% higher for the 2080s (2071-2100). Examining seasonal precipitation totals reveals that average fall, winter, and spring precipitation is projected to increase by 11%, 20% and 32% respectively by the 2080s (2071-2100) relative to the baseline period. In contrast, summer precipitation is projected to be reduced by 6%. These findings are in line with those of Eum and Shrestha (2017) concerning the effects of climate change on Athabasca River basin including the area around Edson.

Table 9-1: Seasonal Percent Change in Total Precipitation at Edson

Seasons	2011-2040	2041-2070	2071-2100
	% Change in total precipitation		
Winter	7	13	20
Spring	6	17	32
Summer	0	-3	-6
Fall	0	10	11

Historically, the dominant flood mode affecting Edson is heavy precipitation during summer and fall. However, increases in winter temperature could potentially change the type of precipitation from snow to winter rain and cause rain on snow events with high peak runoff coefficients. This, coupled with significant increase in precipitation by the 2080s (2071-2100), may cause a shift in the seasonality of floods. It is unclear if or when such a shift would occur based on currently available data; additional investigation may be warranted in future studies.

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9.2 Future Precipitation – Event Perspective

Increases in global temperature are widely understood to increase both the moisture-holding capacity of the atmosphere and the potential energy available for storms. Literature related to the effect of climate change on event-driven peak flow for small drainage basins around Edson is limited; some studies have focused on much larger watersheds such as the Peace-Athabasca River watershed or the Mackenzie River watershed (DeBeer 2021; DFO 2013; Eum 2017; Sharad 2024; Shrestha 2017). However, these may not be applicable to the small drainage basins considered for this project; as such, a qualitative assessment is provided based on climate model results and established methods and tools.

Two different approaches are explored to assess the potential impact of these changes on event precipitation: statistically downscaled extreme rainfall projects and adjustments following the Clausius Clapeyron relationship.

Statistically Downscaled Extreme Rainfall Projections (IDF-CC Tool)

The IDF-CC tool was developed at Western University to examine the effect of climate change at the temporal scale of the event storms (Simonovic, 2015). IDF-CC uses data from Global Circulation Models (GCMs) downscaled by the Pacific Climate Impacts Consortium to assess projected changes in future precipitation intensity. Version 7.5 of the IDF-CC tool was applied for this analysis.

For this study, rainfall durations from 1 hour to 24 hours at the ECCC station Edson Climate (ID 3062246) are considered. The 100-year return period IDF rainfall projections are based on median estimates from PCIC's CMIP6-CanDCSM6 multivariate downscaling ensemble results under SSP5-8.5 for the 2080s period (2070-2100). The downscaled GCM projections are compared with IDF values at corresponding durations derived from historical rainfall records (Section 7.2). No attempt was made to correct for local model bias given the intended qualitative nature of this climate change impact assessment. The percentage change is summarised in Table 9-2.

The comparison indicates that by the 2080s (2071-2100) rainfall depth will increase between 12% and 19% when compared to the baseline period of 1970 to 2023, with shorter duration rainfall events having a larger proportional increase than longer duration rainfall events. This suggests that smaller basins with shorter T_c such as those of Wase and Poplar creeks are likely to experience a larger increase in peak flow than larger basins such as Bench Creek if emissions continue to track the SSP5-8.5 scenario.

Projected Increase in Precipitable Moisture (Clausius-Clapeyron Relationship)

Canadian Standards Association (CSA) recommends the temperature-based Clausius-Clapeyron method for estimating the potential effect of climate change on IDF curves. The Clausius-Clapeyron relationship uses projected changes in temperature to calculate future rainfall intensity based on a well-recognized relationship between temperature and precipitable moisture in the atmosphere. No specific guidance is given on which temperature projection to use, so the maximum annual air temperature from the CIMP6-CanDCSM6 model ensemble hosted on ClimateData.ca was used.

With a projected increase of 5.1°C in maximum annual air temperature by the 2080s (2071-2100) when compared to the baseline period of 1981 to 2010 under SSP5.85, the Clausius-Clapeyron Relationship resulted in a 41% increase in event precipitation at all durations.

The average increase in event precipitation over the baseline period at each storm duration change is shown in Table 9-2 for both the IDF-CC data and the Clausius-Clapeyron method.

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Table 9-2:Percent Change in IDF values at Edson Climate for 2080s (2071-2100)

Durations (hr)	IDF-CC	Clausius-Clapeyron
	% Change in total 24-hour rainfall compared to baseline conditions[1]	
1	19	41
2	19	41
6	20	41
12	19	41
24	19	41

Note:
1. The baseline period is 1970-2022 for IDF-CC tool method, and 1981-2010 for the Clausius-Clapeyron method. These baseline periods were selected to best reflect the period of data collection supporting the published IDF relationship.

Additional Considerations for Event Precipitation at Sub-Daily Durations

Current climate models are limited in their ability to project future changes to precipitation at sub-daily timesteps. Estimates for these are inferred by mapping historical statistics to the available future projections. As a result of this uncertainty, there has been discussion in the literature of the potential for sub-daily increases scaling at a rate greater than that indicated by the Clausius-Clapeyron relationship (so-called “super-CC scaling”; Lenderink, 2017). While this potential relationship is not yet fully understood, some organizations (including KWL) will consider the risk of failure and, where merited, adopt projections that are more conservative than the ensemble median value (e.g., by adopting the upper 10% confidence limits on projected future rainfall drawn from the ensemble of downscaled results).

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10. References

Alberta Agriculture Flood and Rural Development, (2002). Alberta Soil Texture Map - Agricultural Land Resource Atlas of Alberta. https://open.alberta.ca/opendata/gda-27139e46-b3c4-4d5a-8e30-99b40461eb40, retrieved in October, 2024

Alberta Environment and Parks, River Engineering and Technical Services. (2022). Flood Hazard Identification Program Flood Study Technical Guidelines. June 2022.

Alberta Transportation. (2004). Guidelines on Extreme Flood Analysis. Prepared for Alberta Transportation, Transportation and Civil Engineering Division, Civil Projects Branch. November 2004.

Alberta Transportation. (2015). Storm Database, https://www.transportation.alberta.ca/planningtools/Tools/Hydrology/Storm/, retrieved in November, 2024

Canadian Dam Association (2007). Dam Safety Guidelines(revised 2013) and associated technical bulletins.

Chowdhury, S. (2021): Land-use/Land-cover classification of Alberta, derived from 2020 sentinel-2 multispectral data (image data, TIFF format); Alberta Energy Regulator / Alberta Geological Survey, AER/AGS Digital Data 2021-0019.

DeBeer, C. M., Wheater, H. S., Pomeroy, J. W., Barr, A. G., Baltzer, J. L., Johnstone, J. F., Turetsky, M. R., Stewart, R. E., Hayashi, M., van der Kamp, G., Marshall, S., Campbell, E., Marsh, P., Carey, S. K., Quinton, W. L., Li, Y., Razavi, S., Berg, A., McDonnell, J. J., Spence, C., Helgason, W. D., Ireson, A. M., Black, T. A., Elshamy, M., Yassin, F., Davison, B., Howard, A., Thériault, J. M., Shook, K., Demuth, M. N., and Pietroniro, (2021) A.: Summary and synthesis of Changing Cold Regions Network (CCRN) research in the interior of western Canada – Part 2: Future change in cryosphere, vegetation, and hydrology, Hydrol. Earth Syst. Sci., 25, 1849–1882, https://doi.org/10.5194/hess-25-1849-2021.

DFO(2013). Risk-based assessment of Climate Change impacts and Risks on the Biological systems and Infrastructure within Fisheries and Ocean Canada mandate-Freshwater Large Aquatic Basin. DFO Canada, Science Advisory Secretariat, Science Response 2013/011, July 2013

Eleni Maria Michailidi, Sylvia Antoniadi, Antonis Koukouvinos, Baldassare Bacchi & Andreas Efstratiadis (2018) Timing the time of concentration: shedding light on a paradox, Hydrological Sciences Journal, 63:5, 721-740, DOI: 10.1080/02626667.2018.1450985

England, J. F., Cohn, T. A., Faber, B. A., Stedinger, J. R., Thomas, W. O., Veilleux, A. G., Mason, R. R. (2019). Guidelines *for Determining Flood Flow Frequency, Bulletin 17C (ver. 1.1, May 2019): U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p.,* https://doi.org/10.3133/tm4B5.

Eum, H., Dibike, Y., and Prowse, T. (2017). Climate-induced alteration of hydrologic indicators in the Athabasca River Basin, Alberta, Canada. Journal of Hydrology, 544, 327-342

Government of Alberta. (2023, June 8). *Agricultural Moisture Situation Update*. Agriculture and Irrigation. https://open.alberta.ca/publications/moisture-situation-update, retrieved in February 2025.

Hansen, E.M., et al. (1994). Hydrometeorological Report No. 55A. Probable Maximum Precipitation Estimates-United States Between the Continental Divide and the 1 03rd Meridian. Published by the US National Weather Service, June 1988.

Hopkinson, R.F. (1999). Point Probable Maximum Precipitation for the Prairie Provinces. Rept. # AHSD-R99-01, Environment Canada, Regina, 51 pp.

DRAFT

Classification: Public

IBI Group & Golder Associates. (2014). *Feasibility study - Athabasca River basins: Report*. Submitted to Government of Alberta - Flood Recovery Task Force. Alberta Environment and Parks. Updated May 1, 2014.

IPCC, (2023): *Climate Change 2023: Synthesis Report.* Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647.

Joy, D. M., & Whiteley, H. R. (1996). *The Modified Index Flood Method Justification of Recommended Improvements.* Guelph: School of Engineering, University of Guelph.

Lenderink, G., Barbero, R., Loriaux, J. M., & Fowler, H. J. (2017). Super-Clausius–Clapeyron Scaling of Extreme Hourly Convective Precipitation and Its Relation to Large-Scale Atmospheric Conditions. *Journal of Climate*, *30*(15), 6037-6052. https://doi.org/10.1175/JCLI-D-16-0808.1

National Oceanic and Atmospheric Administration (NOAA). 2005. Unit Hydrograph (UHG) Technical Manual. NOAA National Weather Service Office of Hydrology.

Natural Resources Canada, (2023) Environment and Climate Change Canada Public Safety Canada, Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation version 2.0, 2023 Federal Flood Mapping Guidelines Series.

Public Safety Canada. (2013). *Flood event in North-central Alberta (July 13–24, 1986).* Retrieved from https://cdd.publicsafety.gc.ca/dtpg-eng.aspx?cultureCode=en-Ca&eventTypes=%27FL%27%2C%27TO%27%2C%27WF%27%2C%27SW%27%2C%27EQ%27&normalizedCostYear=1&dynamic=false&eventId=568, retrieved in November 2024.

Roussel, Meghan C., David B. Thompson, Xing Fang, Theodore G. Cleveland, and C. Amanda Garcia. (2005). Time-Parameter Estimation for Applicable Texas Watersheds Developed for Texas Department of Transportation Research Project Number 0–4696.

Sharad A., Mukand S. B., Anil G., Babak F., Dibesh K., Quazi K. H. (2024), Assessment of hydrological baseline condition and its alteration in Athabasca River Basin, Canada, Journal of Hydrology.

Shrestha, K. N., Du, X. and Wang, J. (2017). Assessing climate change impacts on fresh water resources of the Athabasca River Basin, Canada. Science of the Total Environment, 601-602, 425-440.

Simonovic, S.P., A. Schardong, R. Srivastav, and D. Sandink (2015), IDF_CC Web-based Tool for Updating Intensity-Duration-Frequency Curves to Changing Climate – ver 7.5, Western University Facility for Intelligent Decision Support and Institute for Catastrophic Loss Reduction, open access https://www.idf-cc-uwo.ca.

USDA Agricultural Research Service (2019). Small Watershed Hydrology (WinTR-55). United States Department of Agriculture.

Wanielista, Martin, Robert Kersten, & Ron Eaglin, (1997). Hydrology: Water Quantity and Quality Control, 2nd Edition, Wiley and Sons, Inc., New York, NY.

Watt, W. E., Lathem, K. W., & Neill, C. R. (1989). *Hydrology of Floods in Canada: A Guide to Planning and Design.* Ottawa: National Research Council of Canada.

World Meteorological Organization, (2009), Manual on Estimation of Probable Maximum Precipitation (PMP) WMO-No. 1045, Chapter 3.

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11. Report Submission

Prepared by:

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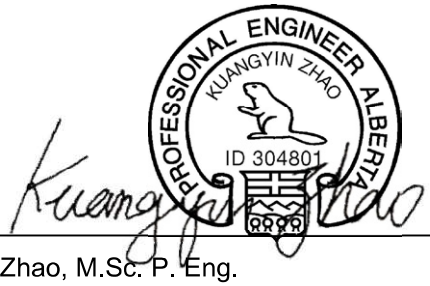

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Encl.: Appendix 1: Index Station Hydrometric Data Tables
Appendix 2: Index Station Frequency Plots
Appendix 3: Index Station Flow Quantile Regression Plots

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Revision History

Revision #	Date	Status	Revision	Author
0	June 11, 2025	Final	Issued	KBZ/JDD

APEGA Permit # P07929

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Appendix 1: Index Station Hydrometric Data Tables

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Annual Maximum Discharges for Embarras River Near Weald (07AF014)

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
1984	20.1	09--22		
1985	35.4	09--13		
1986	118	07--18		
1987	145	08--02		
1988	22.7	06--09		
1989	36.4	08--17		
1990	71.3	06--13	59.9	06--13
1991	51.2	05--10	45.4	05--10
1992	10.1	04--24	9.88	04--24
1993	**8.44**		7.16	08--29
1994	33.4	08--18	27.0	08--18
1995	131	08--09	106	08--09
1996	109	06--01	93.0	06--01
1997	68.0	07--12	61.1	07--12
1998	50.2	06--30	45.9	06--30
1999	143	07--08	115	07--08
2000	37.6	06--12	35.1	06--12
2001	51.8	07--26	45.3	07--26
2002	16.7	05--22	15.8	05--22
2003	**41.3**		35.0 B	04--26
2004	26.6	07--12	24.7	07--12
2005	**112**		95.0 E	06--29
2006	45.4	06--16	38.5	06--16
2007	26.8	07--19	22.7	07--19
2008	79.2	06--07	64.8	06--07
2009	28.0	07--09	26.4	07--09
2010	20.2	06--11	18.1	06--11
2011	**116**		98.0 E	06--20
2012	63.9	06--09	49.1	06--10
2013	72.1	05--26	62.2	05--26
2014	22.2	06--17	20.8	06--17
2015	11.3	04--30	10.6	04--30
2016	29.3	05--24	26	05--24
2017	34.2	06--10	27.5	06--11
2018	27.8	07--05	24.4	07--04
2019	108	07--08	96.2	07--08
2020	123 E	07--02	107 E	07--02
2021	20.5	09--02	16.9	09--02
2022	22.5	07--03	19.7	07--03
2023	**211**		179 E	06--20

Notes:

1. Maximum instantaneous discharges from 1993, 2003, 2005, 2011, and 2023 (bold) are calculated using the I/D relationship (R2=0.9978).

2. E denotes an estimated value (2020 instantaneous, 2005, 2011, 2020, and 2023 daily). B denotes ice conditions (2003 daily).

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Annual Maximum Discharges for Wampus Creek Near Hinton (07AF003)

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
1968	2.13	07--20		
1969	20.4	08--05		
1970	3.94	06--16		
1971	7.50	06--08		
1972	10.3	06--25		
1973	8.38	05--15		
1974	2.42	05--06		
1975	0.954	06--17		
1976	1.45	05--03		
1977	8.75	05--29		
1978	8.04	05--16		
1979	1.57	06--20		
1980	19.1	06--04		
1981	3.34	07--30		
1982	7.43	07--04		
1983	1.85	06--24		
1984	2.26	10--04		
1985	3.06	08--15		
1986	11.9	07--17		
1987	8.92	08--01		
1988	3.28	06--08		
1989	6.29	08--16		
1990	8.11	06--13	6.24	06--13
1991	5.30	05--09	3.46	05--09
1992	1.24	05--29	0.752	05--30
1993	**1.75**		1.19	06--24
1994	6.73	08--17	3.67	08--17
1995	5.87	08--08	4.74	08--08
1996	5.85	06--01	5.46	06--01
1997	3.39	06--23	2.38	06--24
1998	4.85	05--16	3.93	06--29
1999	16.8	07--03	11.1	07--03
2000	2.12	05--15	1.60	05--16
2001	2.64	07--25	2.04	07--25
2002	1.91	05--20	1.61	05--20
2003	**2.94**		2.00	05--12
2004	4.26	07--11	2.43	07--11
2005	10.5	09--10	7.43	06--18
2006	3.41	06--15	2.39	06--16
2007	2.69	06--06	2.36	06--06
2008	6.67	06--07	5.05	06--07
2009	1.45	07--09	1.18	07--09
2010	1.48	06--10	1.41	06--10
2011	12.1	06--17	7.60	06--17
2012	8.82	06--09	6.07	06--09
2013	6.39	06--21	4.46	06--21

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Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
2014	1.74	05--19	1.60	05--18
2015	1.11	05--09	0.996	05--10
2016	14.0	08--06	5.70	08--06
2017	3.67	06--10	3.17	05--13
2018	8.15	07--04	5.56	07--04
2019	8.41	06--21	7.36	06--21
2020	10.4	07--01	5.72	07--02
2021	4.15	09--01	3.00	09--01
2022	3.22	06--24	2.21	06--24
2023	**16.9**		11.5	06--20

Notes:

1. Maximum instantaneous discharges from 1993, 2003, and 2023 (bold) are calculated using the I/D relationship (R2=0.9595).

2. Maximum instantaneous and daily discharges were not associated with the same event in 1998, 2005, and 2017 (underlined).

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Annual Maximum Discharges for Wolf Creek at Highway No. 16A (07AG003)

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
1955	27.4	06--01	27.2	06--01
1956	**14.1**		11.2	06--18
1957	**37.0**		29.4	04--26
1958	84.1	06--29	80.4	06--29
1959	26.6	06--18	23.5	06--19
1960	**66.2**		52.7	07--03
1961	9.40	07--31	8.61	07--31
1962	**25.8**		20.5	05--21
1963	**51.7**		41.1	04--27
1964	**76.2**		60.6	05--08
1965	**109**		86.9	07--10
1966	**62.0**		49.3	08--06
1967	**24.1**		19.2	05--09
1968	**17.7**		14.1	08--07
1969	**173**		138	08--06
1970	**51.3**		40.8	06--17
1971	**112**		89.2	07--12
1972	260	06--26	218	06--26
1973	**42.4**		33.7	05--05
1974	**74.0**		58.9	04--27
1975	**55.6**		44.2	06--29
1976	**31.6**		25.1	04--13
1977	**117**		92.9	05--30
1978	**44.1**		35.1	06--15
1979	**37.2**		29.6	06--15
1980	**199**		158	06--06
1981	**27.9**		22.2	05--09
1982	**229**		182	07--05
1983	**41.1**		32.7	07--02
1984	**34.7**		27.6	05--17
1985	35.6	09--14	33.1	09--14
1986	570	07--18	391 A	07--18
1987	11.8	05--23	11.4	05--23
1988	20.5	06--12	17.8	06--13
1989	118	08--17	100 A	08--17
1990	102	06--13	86.7 E	06--13
1991	66.9	07--07	64.1	07--07
1992	**12.1**		9.66	04--24
1993	**34.8**		27.7	06--28
1994	42.8	06--09	39.9	06--09
1995	112	08--09	110 E	08--09
1996	59.6	06--02	55.2	06--02
1997	69.5	06--24	62.8	06--24
1998	46.7	07--01	43.9	07--03
1999	93.2	07--08	80.1	07--09
2000	48.4	07--11	43.8	07--11

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Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
2001	**148**		118	07--30
2002	37.4	05--17	35.2	05--17
2003	31.2	05--11	29.0	05--12
2004	31.2	07--10	29.2	07--10
2005	65.9	06--28	61.0	06--28
2006	18.9	09--23	18.4	09--23
2007	96.9	05--06	83.0	05--06
2008	41.7	06--08	39.7	06--08
2009	45.8	07--10	41.9	07--10
2010	41.4	05--22	37.2	05--23
2011	105	06--20	97.6	06--20
2013	55.4	06--04	51.9	06--04
2014	**35.7**		28.4	05--02
2015	**16.3**		13.0 B	04--01
2016	49.9	08--03	46.3 E	05--28
2017	**69.5**		55.3 E	06--11
2018	**64.7**		51.5	07--05
2019	**162**		129 A	07--09
2020	211	05--23	192	05--23
2021	15.1	05--26	14.0	05--26
2022	60.0	07--03	57.5	07--03
2023	344	06--20	291	06--20
2024	16.9 P			

Notes:

1. Maximum instantaneous discharges from 1956-1957, 1960, 1962-1971, 1973-1984, 1992-1993, 2001, 2014-2015, and 2017-2019 (bold) are calculated using the I/D relationship (R2=0.9843).

2. Maximum instantaneous and daily discharges were not associated with the same event in 2016 (underlined).

3. E denotes an estimated value (1990, 1995, 2016-2017 daily). B denotes ice conditions (2015 daily). A denotes a partial day (1986, 1989, and 2019 daily). P denotes a provisional value (2024 instantaneous).

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Annual Maximum Discharges for Groat Creek Near Whitecourt (07AG008)

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
1985	82.7	06--24		
1986	64.0	07--19		
1987	4.96	09--02		
1988	40.2	07--06		
1989	129	08--17		
1990	43.0	07--03	21.2 A	07--03
1991	**30.9**		18.3	05--14
1992	**2.74**		1.62 B	03--24
1993	**13.6**		8.07 A	06--24
1994	22.0	06--14	13.9 A	06--15
1995	23.8	08--09	13.2 A	08--09
1996	37.2	05--31	32.3	05--31
1997	55.0	06--22	19.4 E	06--22
1998				
1999	**58.4**		34.6 A	05--02
2000	25.1	06--11	13.0	06--11
2001	**34.4**		20.4 A	07--25
2002				
2003	**10.3**		6.12 B	04--24
2004	13.0	09--03	7.43	09--03
2005	30.3	06--27	14.4	06--28
2006	**5.57**		3.30	04--20
2007	41.0	05--05	29.6	05--05
2008	**7.04**		4.17 B	05--03
2009	31.7	07--07	15.7	07--08
2010	5.53	05--21	3.37	05--21
2011	52.7	07--08	36.6	07--08
2012	230		122 E	07--22
2013	20.4	05--05	14.5	05--05
2014	11.0	05--01	9.17	05--01
2015	4.31	03--29	3.99	03--29
2016	9.88	05--23	7.30	05--23
2017	21.7	05--13	13.6 A	05--13
2018	**25.3**		15.0 B	04--24
2019				
2020	46.3	05--21	19.4 E	04--22
2021	4.88	05--19	4.18	05--19
2022	25.6	06--29	12.8	06--29
2023	76.3 P	06--19	67 P	06--19
2024	4.31 P	08--07	4.19 P	04--12

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Notes:

1. Maximum instantaneous discharges from 1991-1993, 1999, 2001, 2003, 2006, 2008, and 2018 (bold) are calculated using the I/D relationship (R2=0.9588).

2. Maximum instantaneous and daily discharges were not associated with the same event in 2020 and 2024 (underlined).

3. E denotes an estimated value (1997, 2012, and 2020 daily). B denotes ice conditions (1992, 2003, and 2018 daily). A denotes a partial day (1990, 1993-1995, 1999, 2001, and 2017 daily). P denotes provisional values (2023-2024 instantaneous and daily).

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Annual Maximum Discharges for Christmas Creek Near Blue Ridge (07AH002)

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
1973	9.80	06--27		
1974	31.1	05--14		
1975	24.7	06--29		
1976	13.6	08--28		
1977	27.5	05--30		
1978	17.6	07--12		
1979	38.1	07--03		
1980	8.22	04--18		
1981	3.88	04--25		
1982	5.29	05--04		
1983	17.1	07--10		
1984	35.4	06--08		
1985	27.5	06--26		
1986	17.1	07--19		
1987	4.64	08--02		
1988	26.3	07--08		
1989	32.9	07--10		
1990	7.94	07--04	6.78	07--03
1991	28.0	05--15	26.5	05--14
1992	**3.14**		2.47	03--24
1993	**11.6**		9.13	06--24
1994	16.1	06--15	15.4	06--15
1995	17.3	08--09	16.4	08--09
1996	29.0	06--02	24.9	05--31
1997	29.2	04--22	27.0	06--22
1998	2.47	07--01	2.36	
1999	10.9	05--03	9.59	05--02
2000	33.4	07--25	27.9	06--11
2001	45.8	07--27	42.4	07--25
2002	8.11	05--14	7.82	
2003	14.8 B	04--23	13.5 B	04--24
2004	20.0	07--13	17.4	09--03
2005	16.2	06--29	15.2	06--28
2006	6.68	06--18	6.47	04--20
2007	47.6	05--06	45.5	05--05
2008	17.2	05--23	15.5	05--03
2009	3.74 A	04--13	3.25	07--08
2010	2.93	07--24	2.39	05--21
2011	145 A	07--09	92.1 A	07--08
2012	43.9	07--25	41.1	07--22
2013	21.9	05--07	21.3	05--05
2014	31.4	04--25	27.3	05--01
2015	6.82	04--13	5.57	03--29
2016	13.2	06--10	11.7	05--23
2017				05--13
2018	19.9	04--28	19.2	04--24

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Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
2019	31.9	06--29	28.2	
2020	20.8	04--23	18.4	04--22
2021	6.37	05--20	5.83	05--19
2022	14.0	06--19	13.1	06--29
2023	75.6 P	07--27	62.0 E	06--19
2024	6.01 P	07--27	5.57 P	04--12

Notes:

1. Maximum instantaneous discharges from 1992-1993 (bold) are calculated using the I/D relationship (R2=0.9705).

2. Maximum instantaneous and daily discharges were not associated with the same event in 2006 and 2015 (underlined).

3. E denotes an estimated value (2023 daily). B denotes ice conditions (2003 instantaneous and daily). A denotes a partial day (2009 and 2011 instantaneous, 2011 daily). P denotes provisional values (2023-2024 instantaneous, 2024 daily).

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Annual Maximum Discharges for Rat Creek Near Cynthia (07BA002)

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
1972	76.7	06--28		
1973	18.9	04--30		
1974	36.5	04--29		
1975	26.6	07--01		
1976	10.8	08--08		
1977	42.5	05--31		
1978	28.9	06--17		
1979	16.5 B	04--29		
1980	64.9	06--08		
1981	11.4	06--02		
1982	111	07--08		
1983	24.1	07--05		
1984	13.1	05--18		
1985	24.5	09--15		
1986	580	07--		
1987	15.3	08--06		
1988	19.8	07--08		
1989				
1990	52.9	06--14	51.6	06--14
1991	18.5	07--08	18.1	07--08
1992	**5.43**		5.19 B	03--03
1993	**9.86**		9.42	06--29
1994	**16.2**		15.5	07--06
1995	**21.1**		20.2 A	08--10
1996	12.6	06--02	12.1	06--02
1997	23.7	06--24	22.6	06--25
1998	15.3	07--07	15.1	07--07
1999	**24.0**		22.9	05--04
2000	18.7	07--12	17.9	07--12
2001	88.3	08--01	82.0	08--01
2002	16.5	05--16	15.4	05--17
2003	13.6	05--13	12.7	05--13
2004	10.7	07--12	9.74	09--05
2005	17.0	05--19	14.8	05--19
2006	4.40	05--29	3.82	09--23
2007	47.0	05--07	43.2	05--07
2008	9.59	06--12	8.94	06--12
2009	24.4	07--10	23.6	07--10
2010	13.5	05--23	12.5	05--23
2011	59.9	06--21	58.8	06--21
2012	28.1	05--03	27.1	05--03
2013	22.1	06--04	21.3	06--04
2014	**29.9**		28.6 B	04--23
2015	**8.37**		8.00 B	04--12
2016	34.4	08--25	33.2	08--25
2017	25.6	06--12	25.0	06--12

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Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
2018	25.3	07--06	24.1	07--06
2019	**93.9**		89.7	07--11
2020	62.0	07--04	60.7	07--04
2021				
2022	33.2	07--08	31.1	07--08
2023	184 P	06--22	176 E	06--22

Notes:

1. Maximum instantaneous discharges from 1992-1995, 1999, 2014-2015, and 2019 (bold) are calculated using the I/D relationship (R2=0.9997).

2. Maximum instantaneous and daily discharges were not associated with the same event in 2004 and 2006 (underlined).

3. E denotes an estimated value (2023 daily). B denotes ice conditions (1979 instantaneous, 1992, 2014-2015 daily). A denotes a partial day (1995 daily). P denotes provisional values (2023 instantaneous).

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Annual Maximum Discharges for Lovett River Near the Mouth (07BA003)

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
1975	3.34	05--10		
1976				
1977	9.15	06--01		
1978	14.0	05--15		
1979				
1980	73.0	06--04		
1981	9.83	07--30		
1982	29.0	07--05		
1983	4.19	06--24		
1984	2.87	06--08		
1985	8.94	09--13		
1986	51.5	07--18		
1987	25.4	08--02		
1988	6.29	06--09		
1989	14.5	08--17		
1990	25.7	06--13	22.7	06--13
1991	19.2	07--06	13.6	05--13
1992				
1993	**4.58**		3.66	06--24
1994	7.64	08--17	5.63	07--05
1995	35.7	08--08	24.4	08--08
1996	29.7	06--01	21.5	06--01
1997	**6.41**		5.12	06--23
1998	21.6	07--02	16.8	07--02
1999	30.1	07--15	23.9	07--15
2000	5.01	06--11	4.08	06--12
2001	10.5	07--25	7.33	07--26
2002	3.15	05--28	2.93	05--28
2003	3.76	05--13	3.43	05--13
2004	7.94	07--11	5.91	07--12
2005	25.5	06--18	16.6	06--18
2006	17.5	06--16	11.3	06--16
2007	3.92	06--17	3.65	06--17
2008	33.2	06--07	26.4	06--07
2009	5.90	07--09	5.27	07--09
2010	8.66	06--10	7.51	06--10
2011	41.5	06--17	33.8	06--17
2012	25.7	06--09	16.4	06--09
2013	34.3	06--21	26.5	06--21
2014	7.14	05--29	6.10	05--29
2015				
2016	5.06	05--27	4.78	05--27
2017	9.34	06--10	7.54	05--25
2018	24.2	07--04	21.6	07--04
2019	18.9	06--21	16.7	06--21
2020	30.0	07--02	23.1	07--02

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Classification: Public

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
2021	7.98	05--25	6.78	05--25
2022				
2023	64.0	06--20	55.4	06--20

Notes:

1. Maximum instantaneous discharges from 1993 and 1997 (bold) are calculated using the I/D relationship (R2=0.9906).

2. Maximum instantaneous and daily discharges were not associated with the same event in 2017 (underlined).

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Annual Maximum Discharges for Paddle River Near Anselmo (07BB011)

Year	Maximum Instantaneous Discharge (m3/s)	Date (MM--DD)	Maximum Daily Discharge (m3/s)	Date (MM--DD)
1980	25.8	06--17		
1981	34.2	06--01		
1982	20.6	07--15		
1983	22.0	07--09		
1984	17.1	06--08		
1985	32.7	06--25		
1986	110	07--18		
1987				
1988	47.7	07--07		
1989	225 E	08--02		
1990	71.2	07--04	46.8	07--04
1991	27.3	05--14	22.0	05--14
1992	**2.45**		1.70 B	03--01
1993	**19.0**		13.2	07--22
1994	15.8	05--17	12.5 A	05--17
1995	17.9	06--06	14.9	06--06
1996	28.6	06--01	25.3	06--01
1997	59.7	06--23	43.7	06--23
1998	9.33	06--30	6.48	07--01
1999	24.3	05--02	19.0	05--03
2000	6.96	06--12	5.89	06--12
2001	42.6	07--30	32.3	07--30
2002	**8.57**		5.96 A	04--22
2003	**6.36**		4.42 A	04--13
2004	**1.78**		1.24	07--12
2005	12.6	05--18	11.0	05--18
2006	1.84	05--25	1.20	05--26
2007	56.2	05--05	39.6	05--05
2008	3.91	05--15	3.54	06--12
2009	8.67	07--09	8.07	07--09
2010	2.13	05--21	1.63	05--22
2011	133	07--09	82.0	07--09
2012	97.7	07--24	68.7	07--24
2013	15.8	04--26	14.1	04--27
2014	35.4	04--24	29.9	04--24
2015	4.63	04--25	4.26	04--25
2016	9.37	08--23	7.65	05--23
2017	15.8	04--22	14.4	04--22
2018	**28.9**		20.1	04--27
2019	46.7	07--07	31.5	07--08
2020	31.1	05--05	27.1	05--05
2021	4.70	05--19	3.95	05--19
2022	7.33	06--18	5.61	06--18

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Notes:

1. Maximum instantaneous discharges from 1992-1993, 2002-2004, and 2018 (bold) are calculated using the I/D relationship (R2=0.9884).

2. Maximum instantaneous and daily discharges were not associated with the same event in 2008 and 2016 (underlined).

3. B denotes ice conditions (1992 daily). A denotes a partial day (1994, 2002-2003 daily).

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Appendix 2: Index Station Frequency Plots

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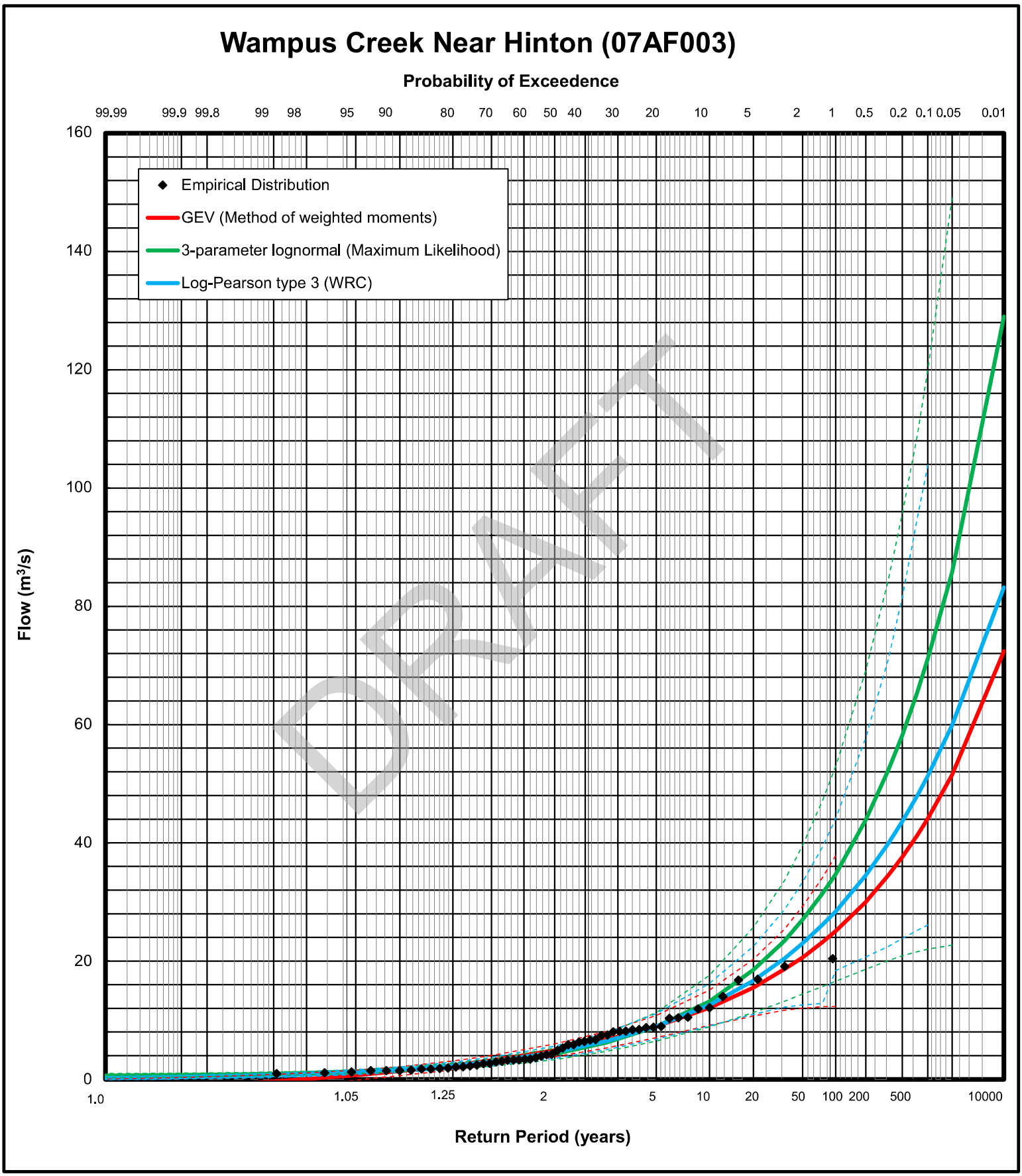
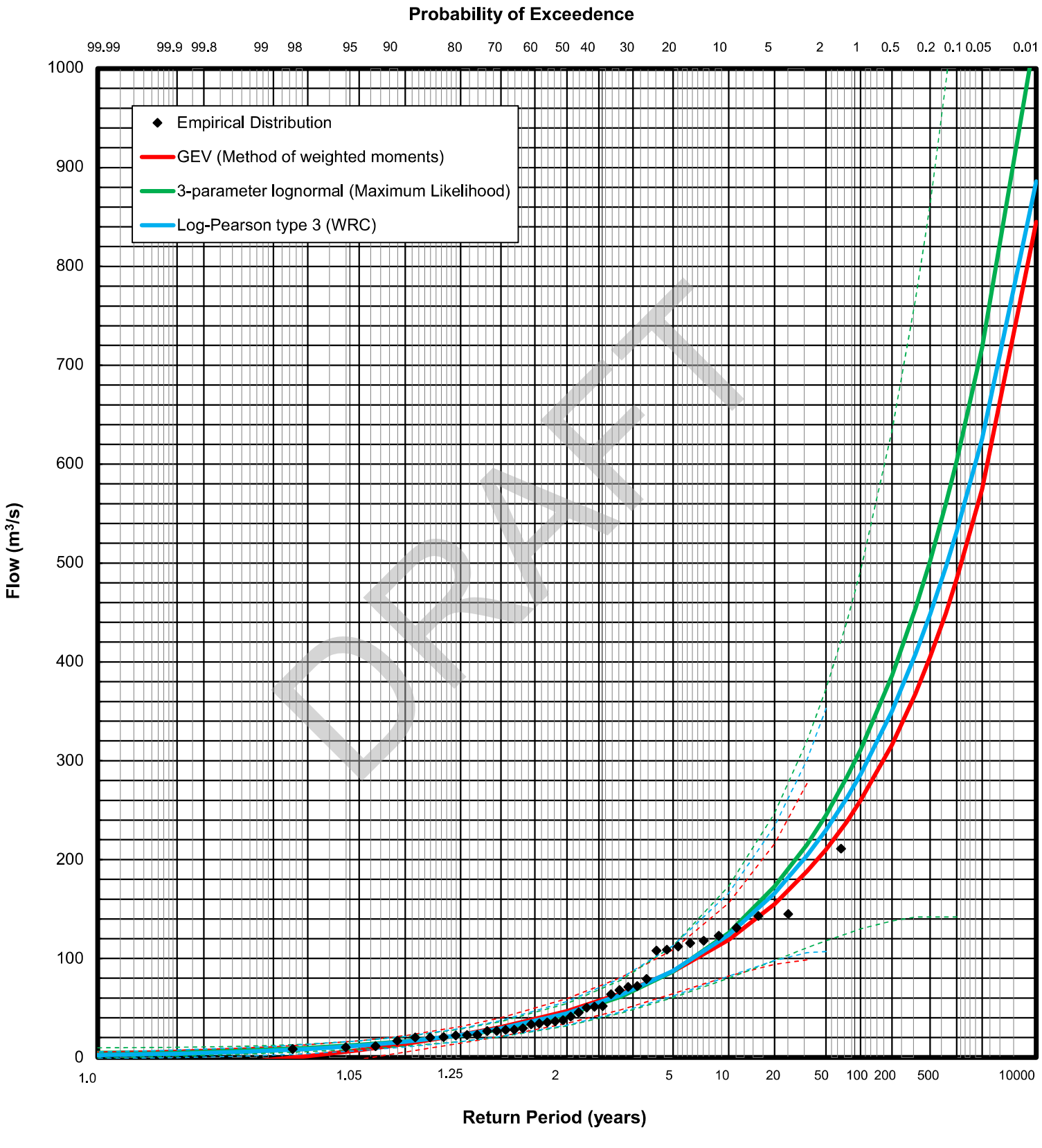
Classification: Public



Classification: Public

Embarras River Near Weald (07AF014)



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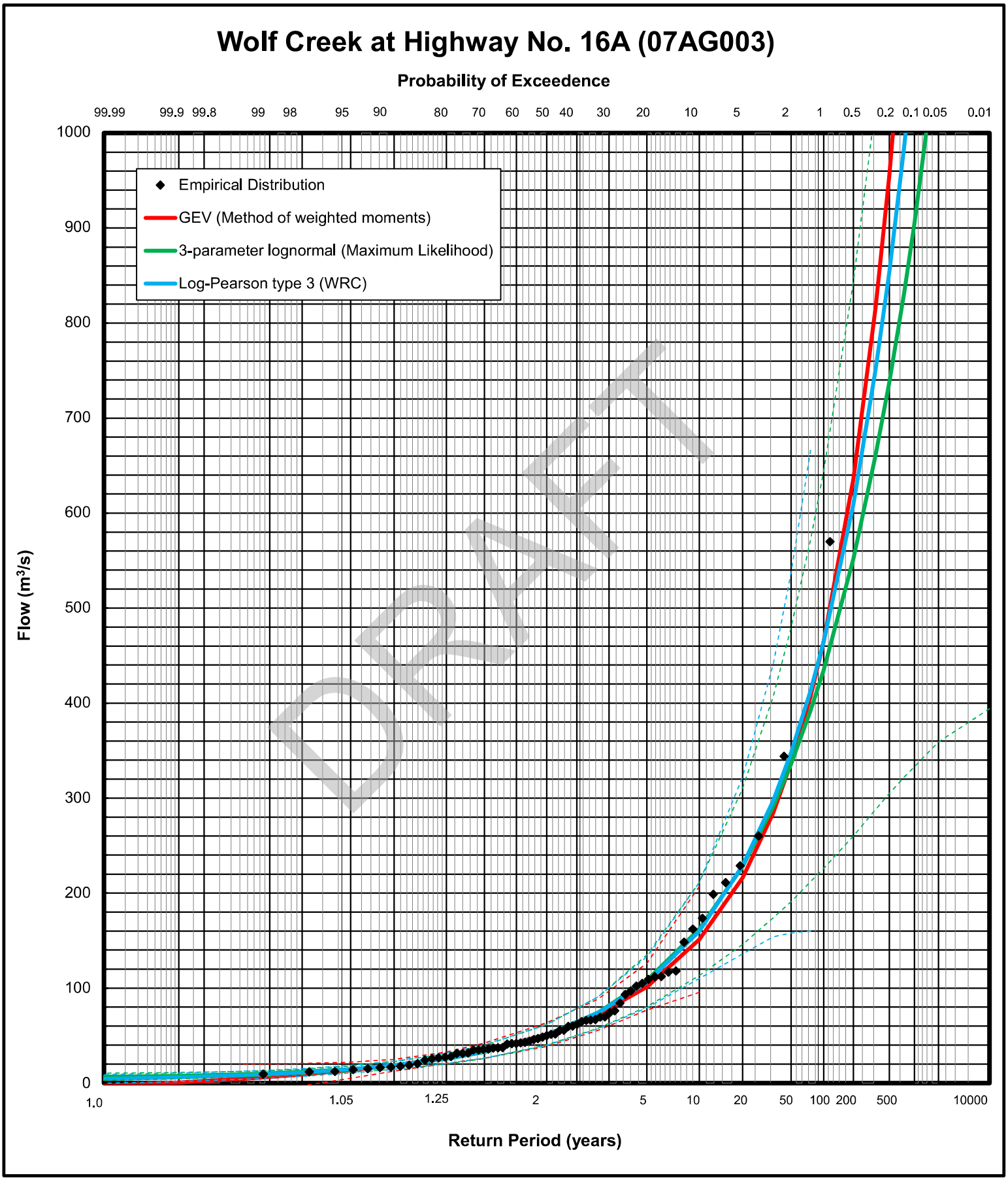
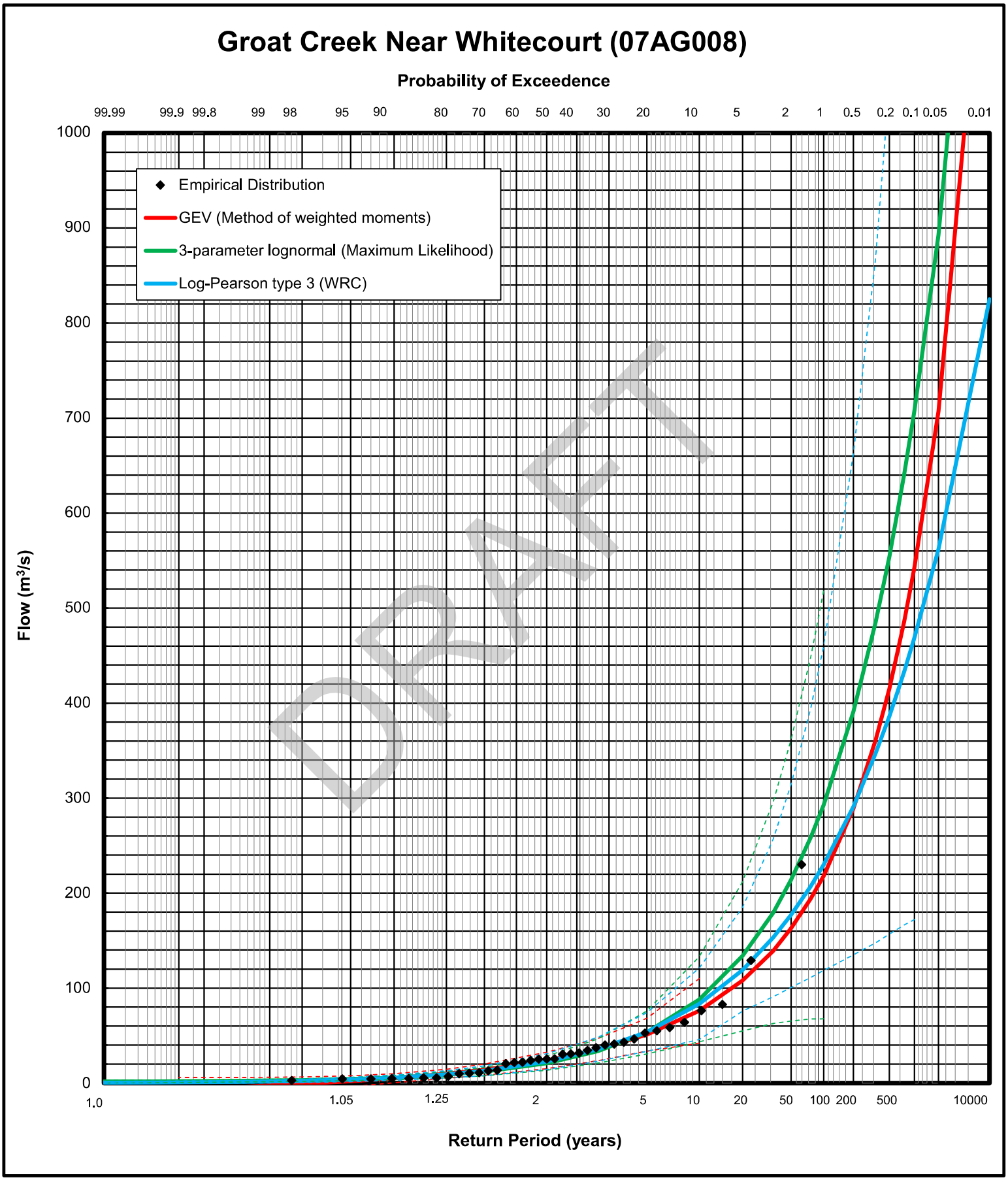
Classification: Public



Classification: Public



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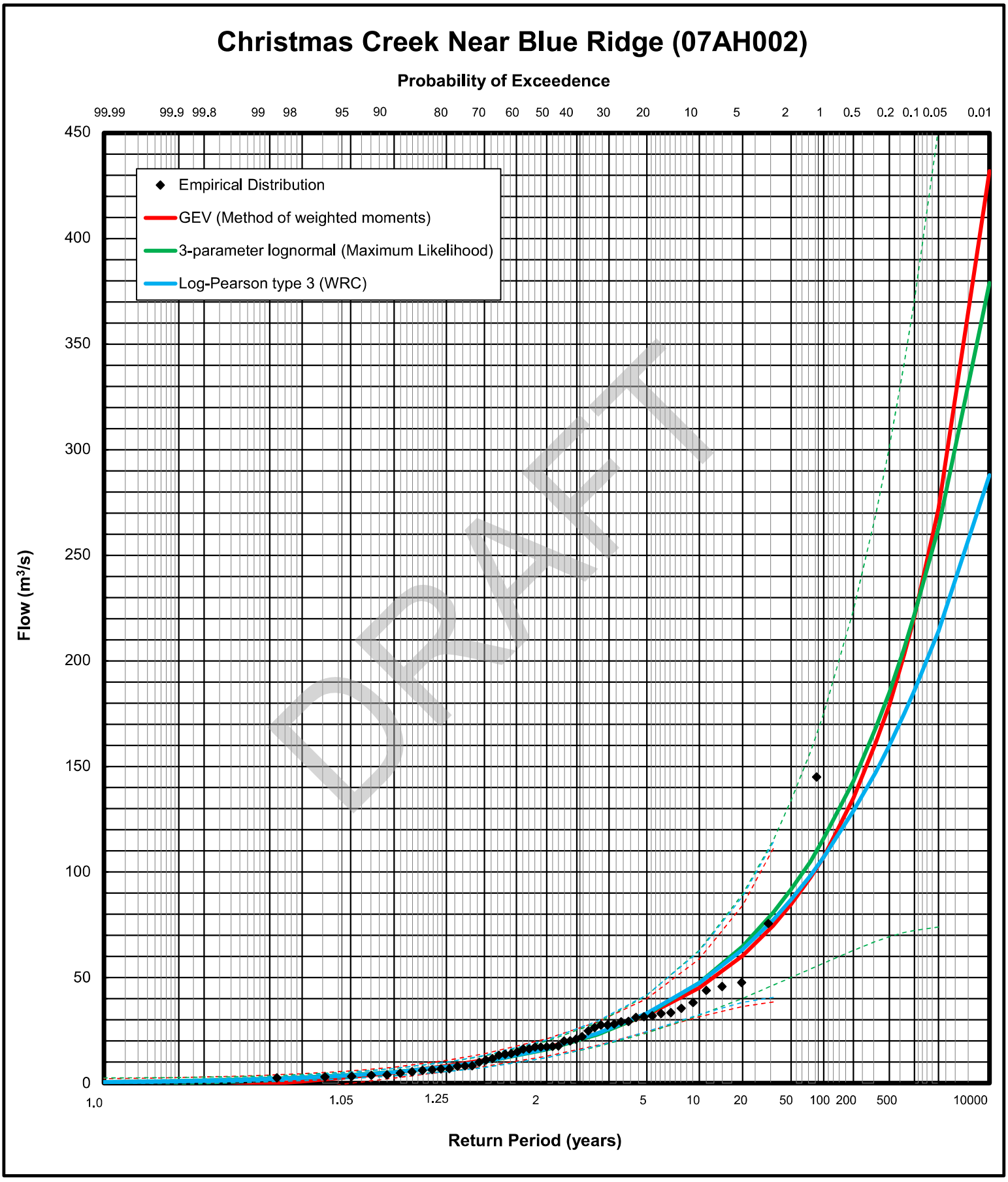
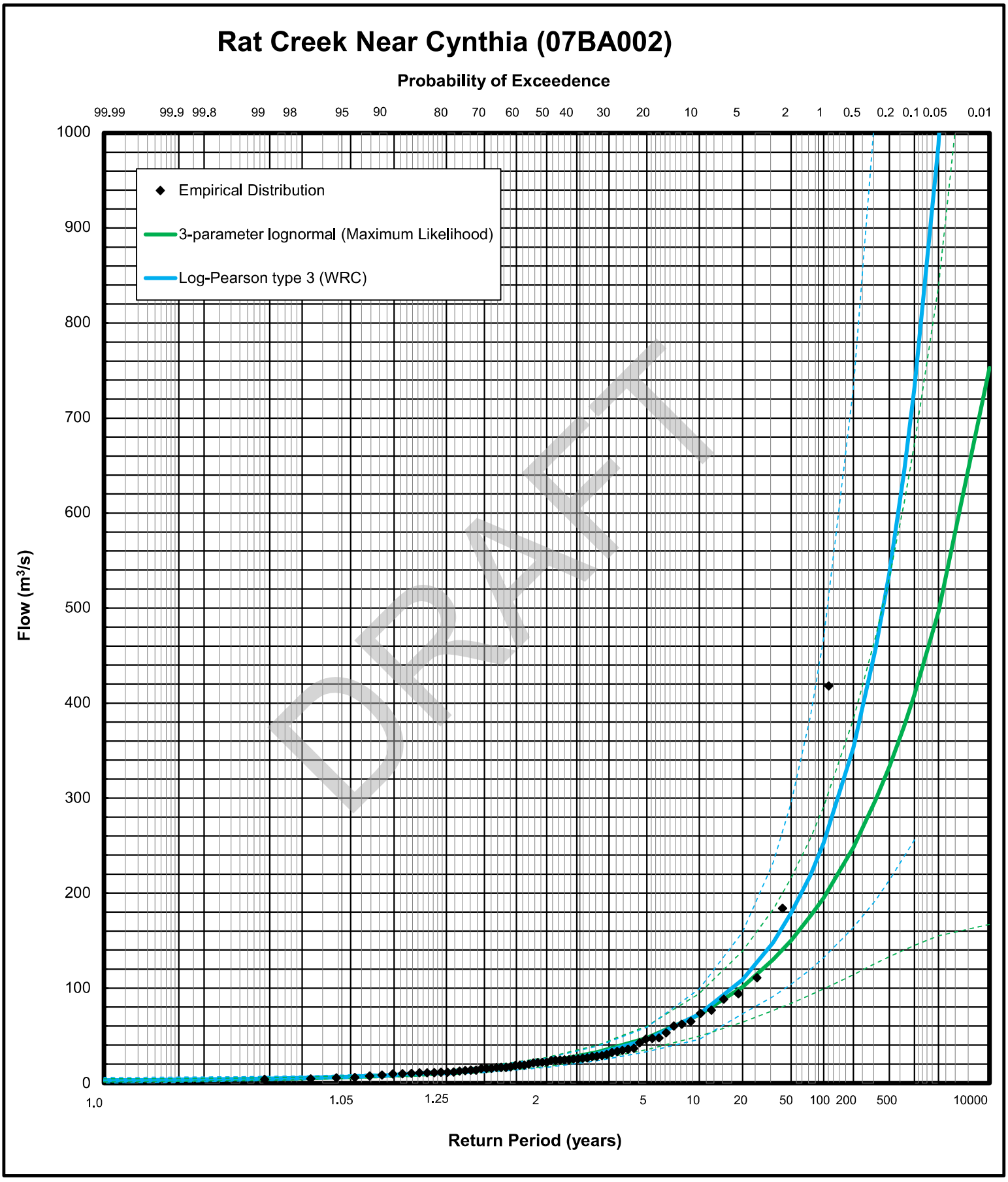
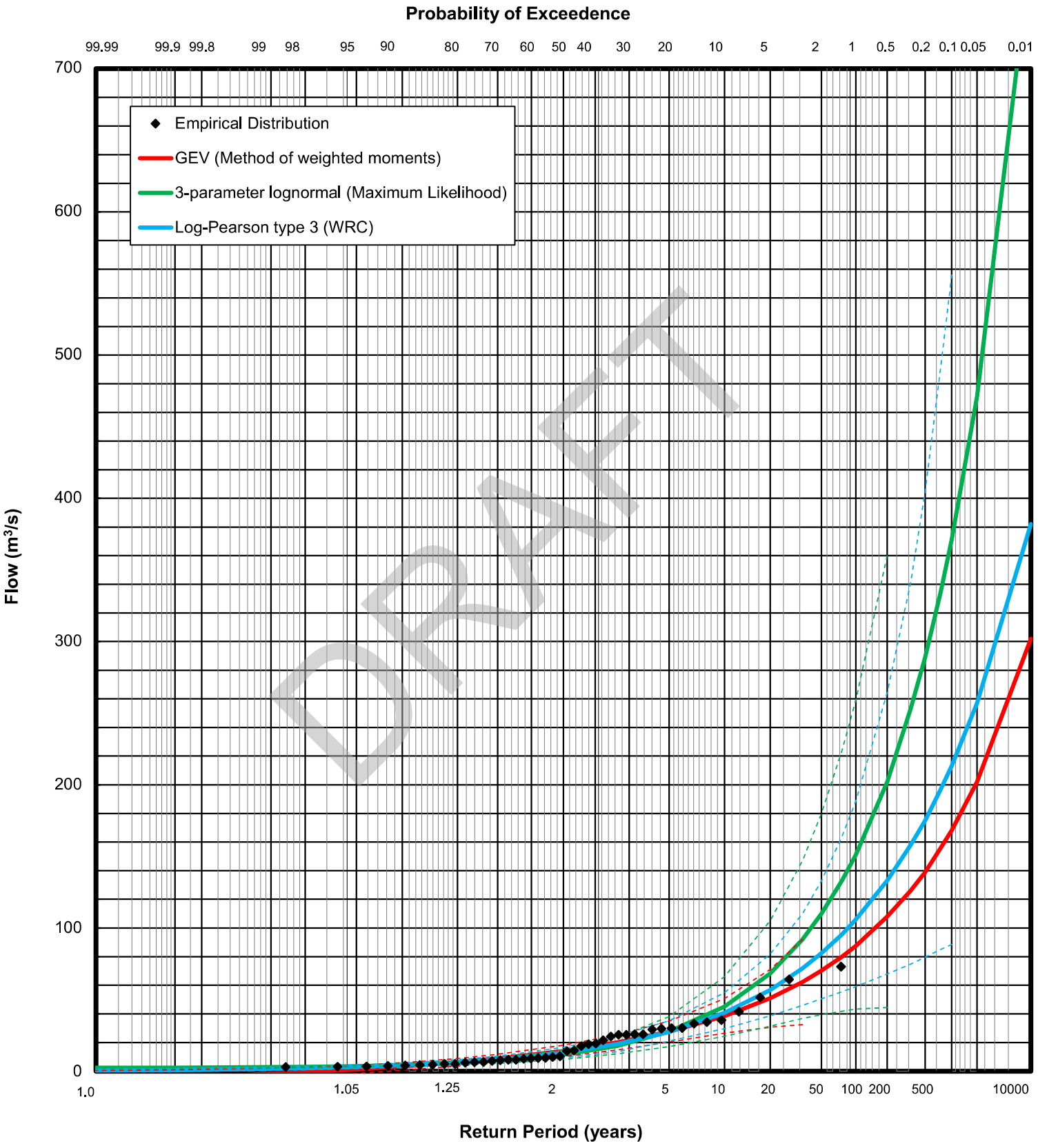


Classification: Public



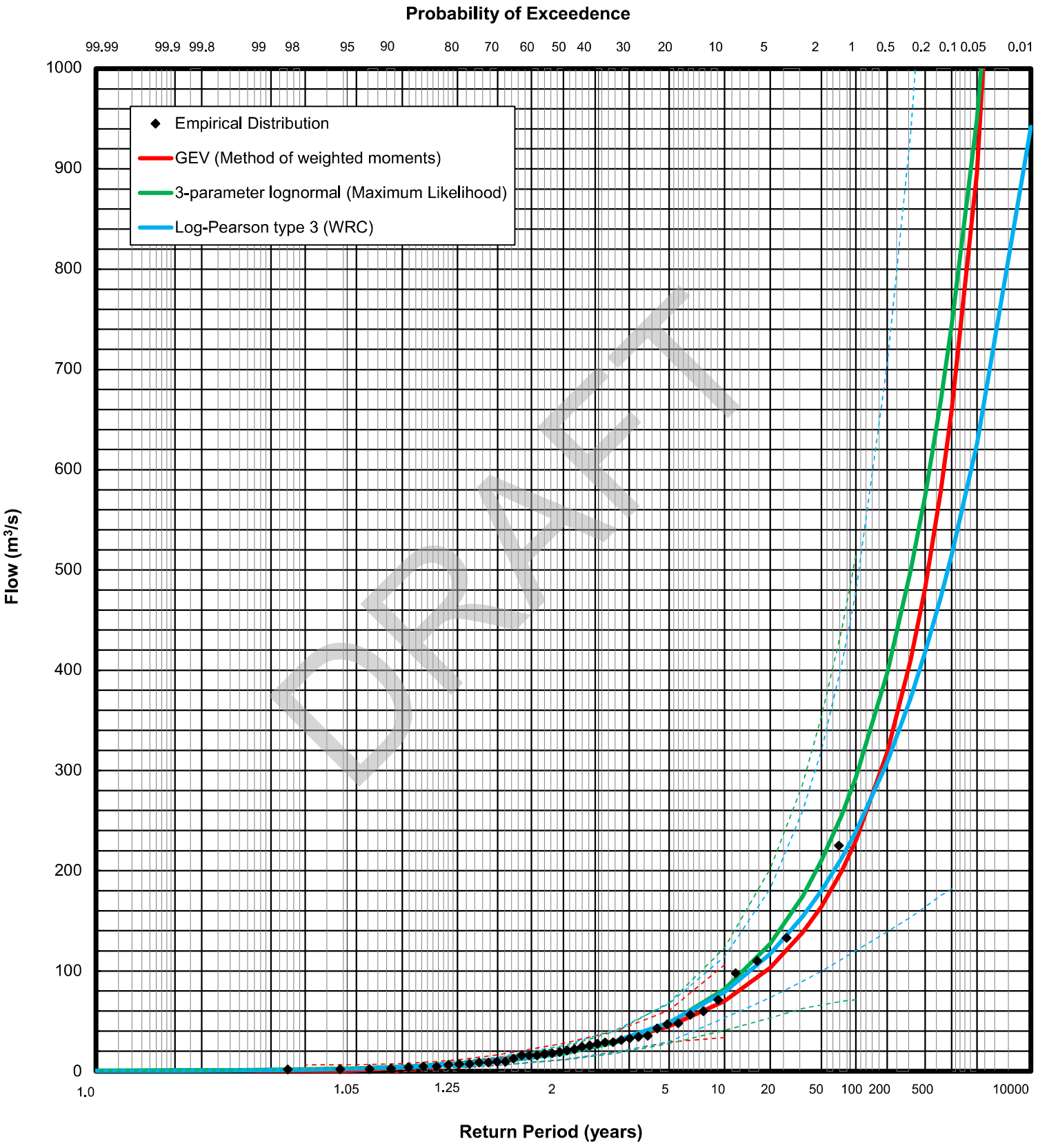
Classification: Public

Lovett River Near the Mouth (07BA003)



Classification: Public

Paddle River Near Anselmo (07BB011)



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Appendix 3: Index Station Flow Quantile Regression Plots

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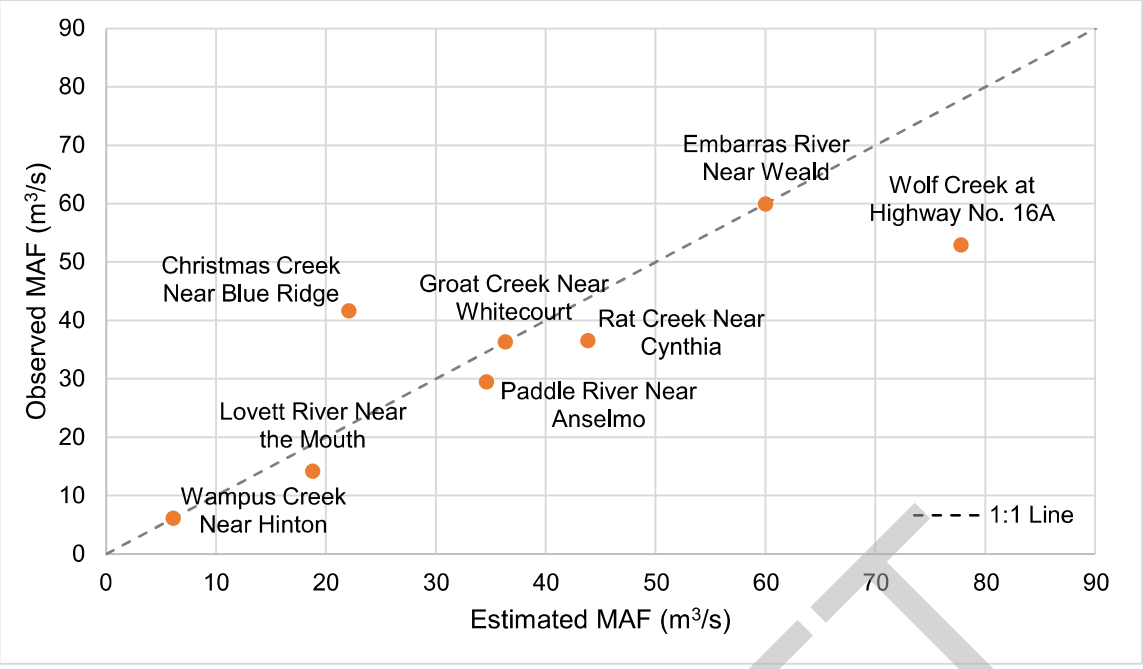
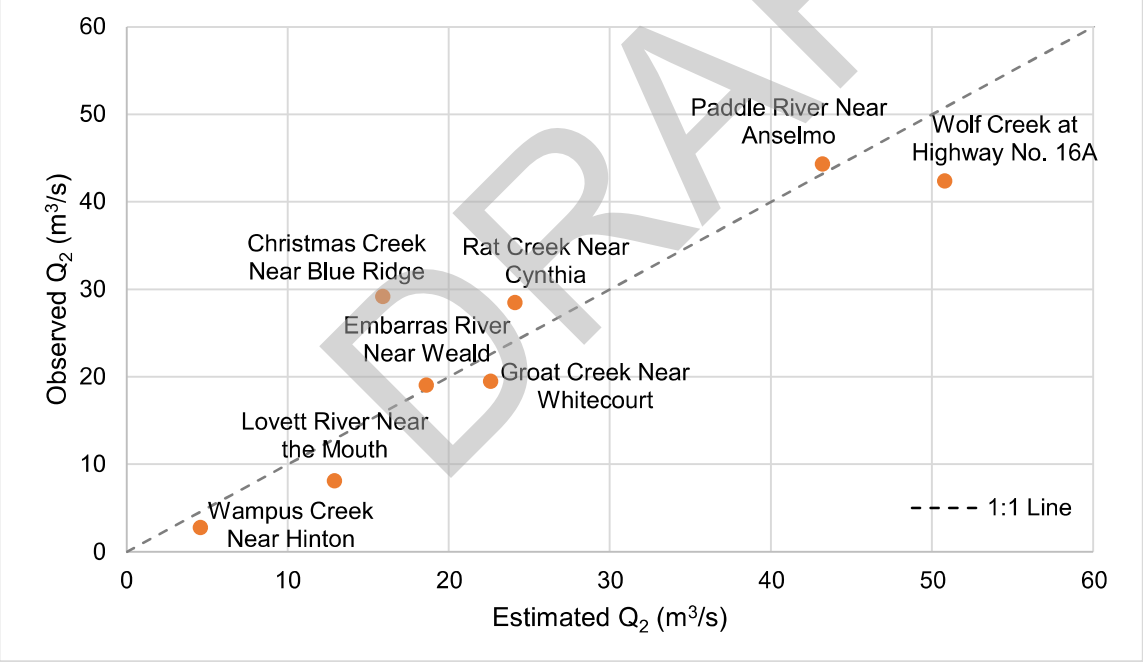
Classification: Public

Index Flood - MAF



Direct Quantile Regression - Q_2



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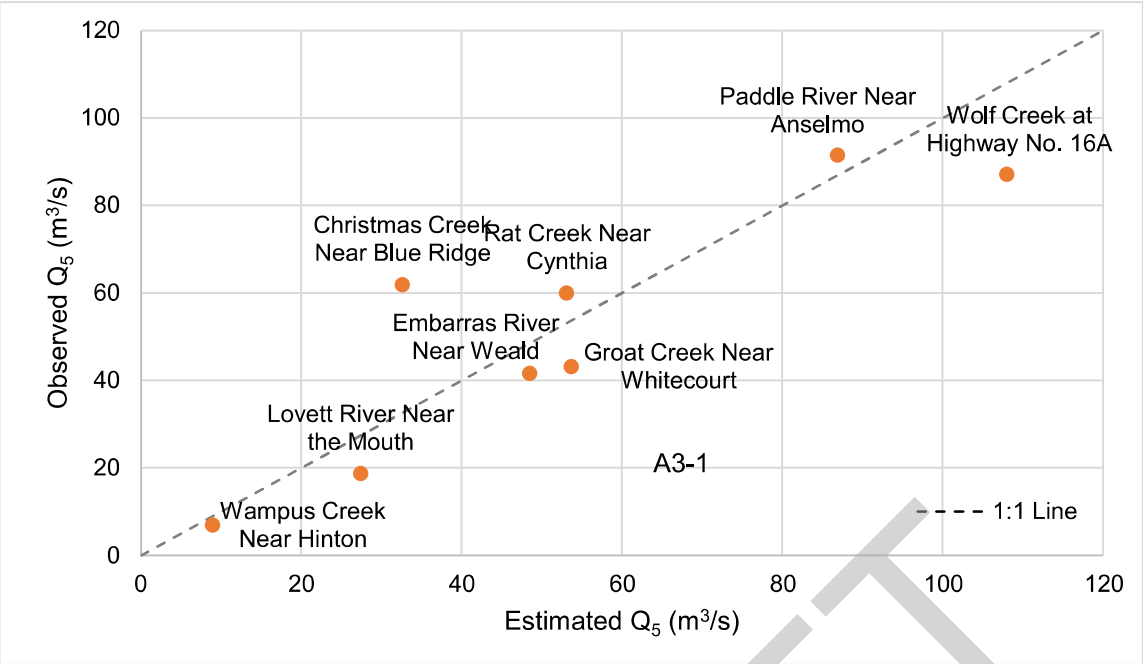
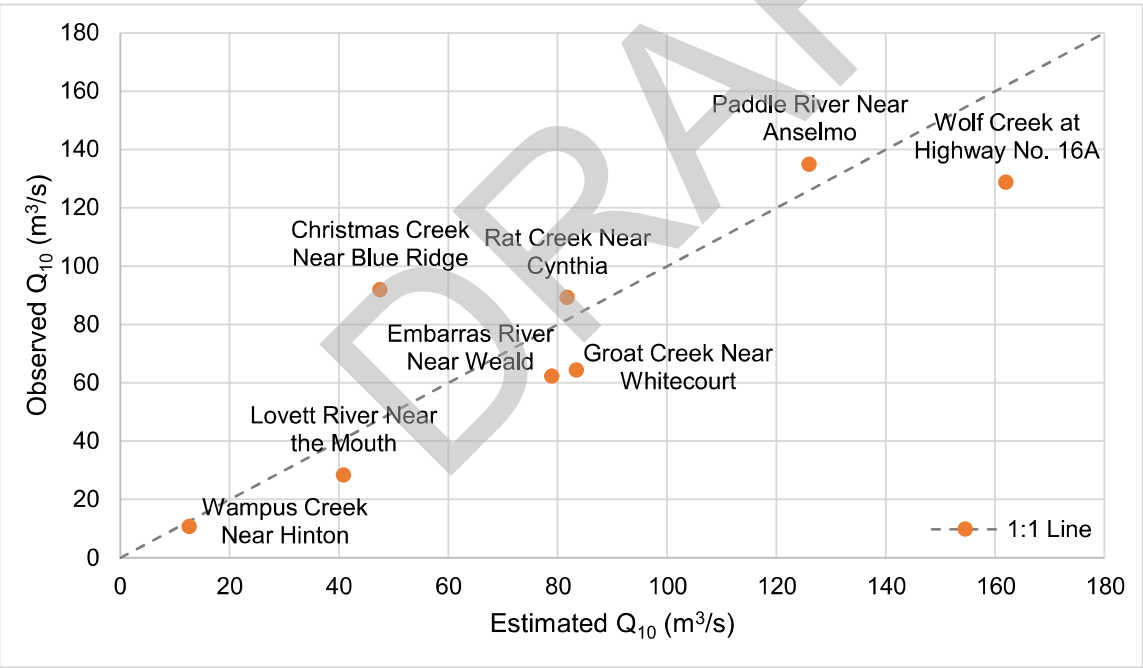
Classification: Public

Direct Quantile Regression - Q_5



Direct Quantile Regression - Q_{10}



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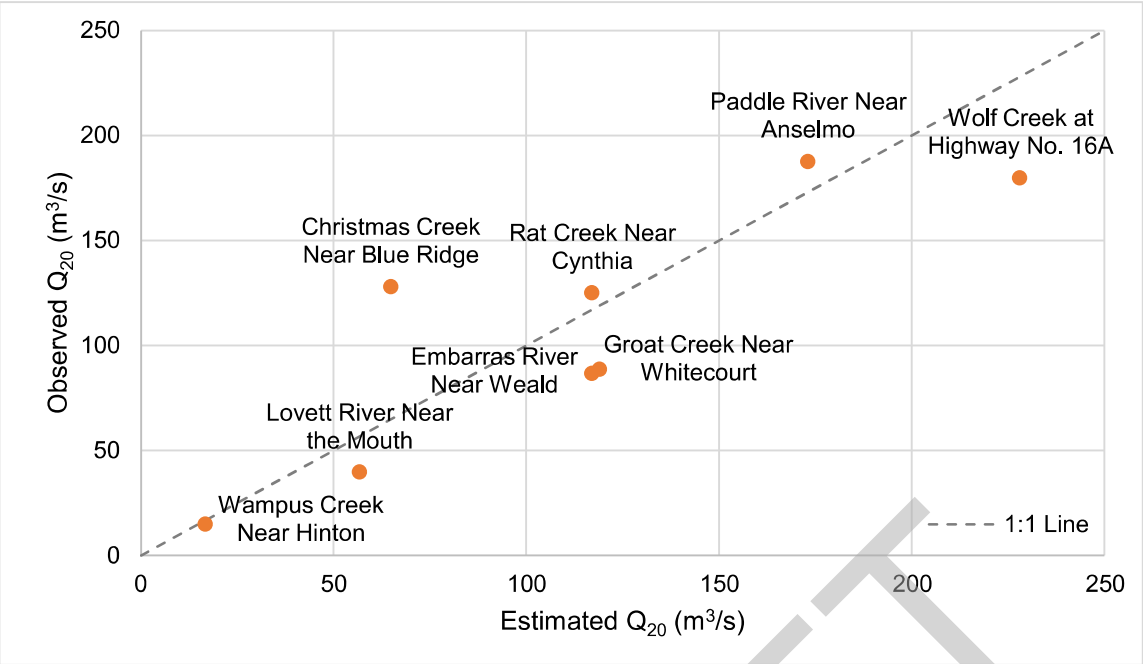
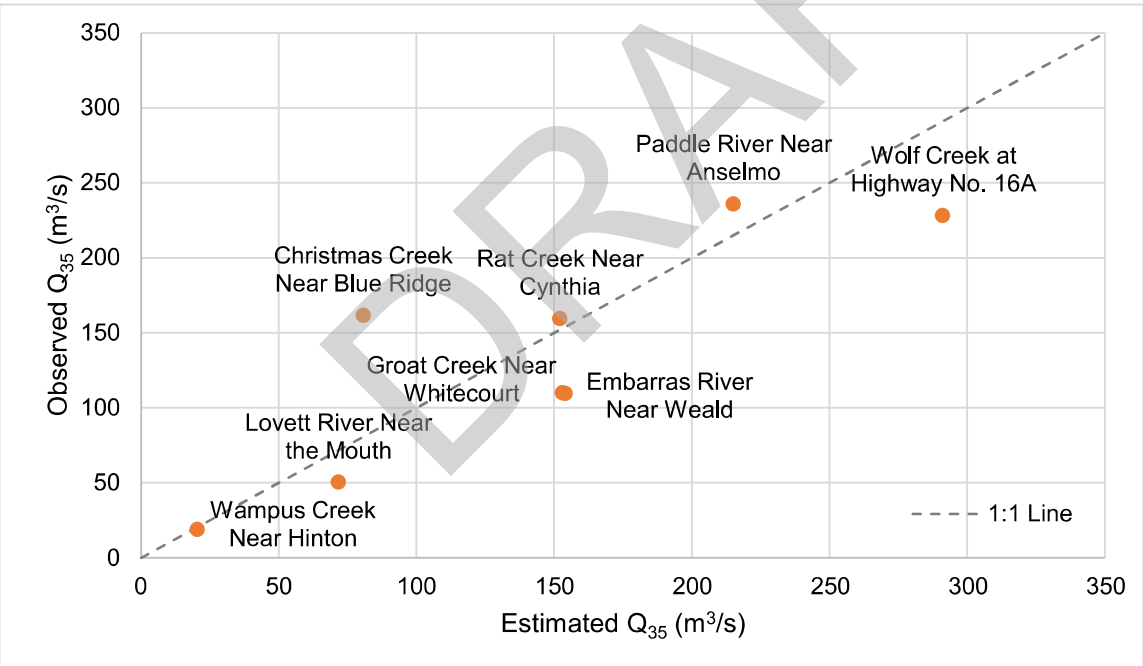
Classification: Public

Direct Quantile Regression - Q_{20}



Direct Quantile Regression - Q_{35}



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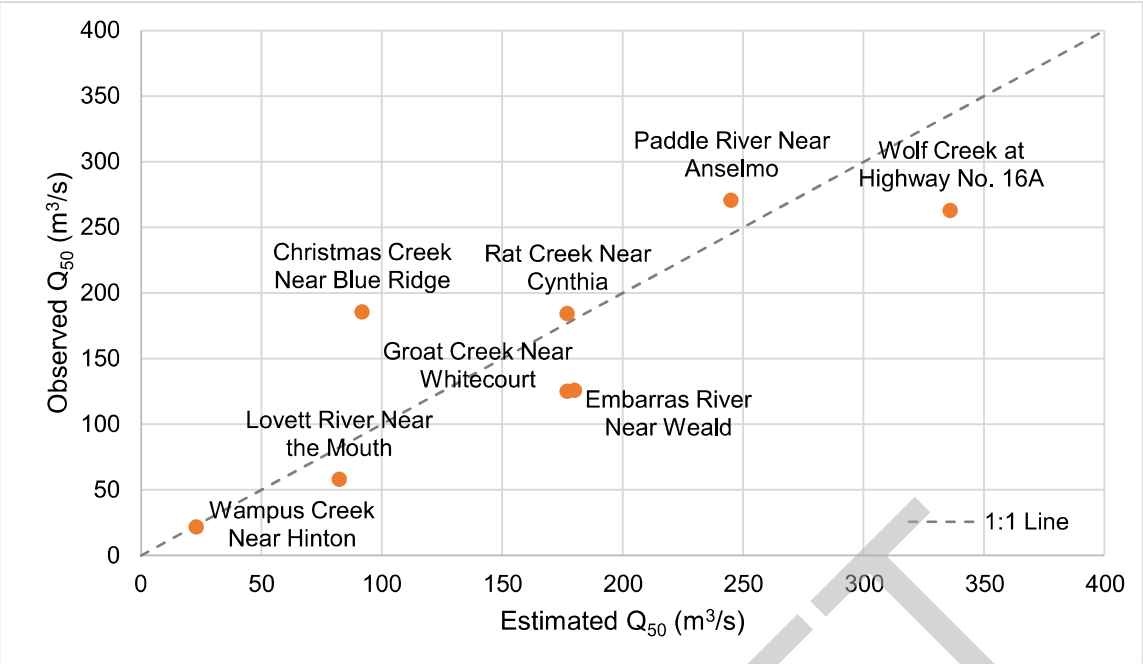
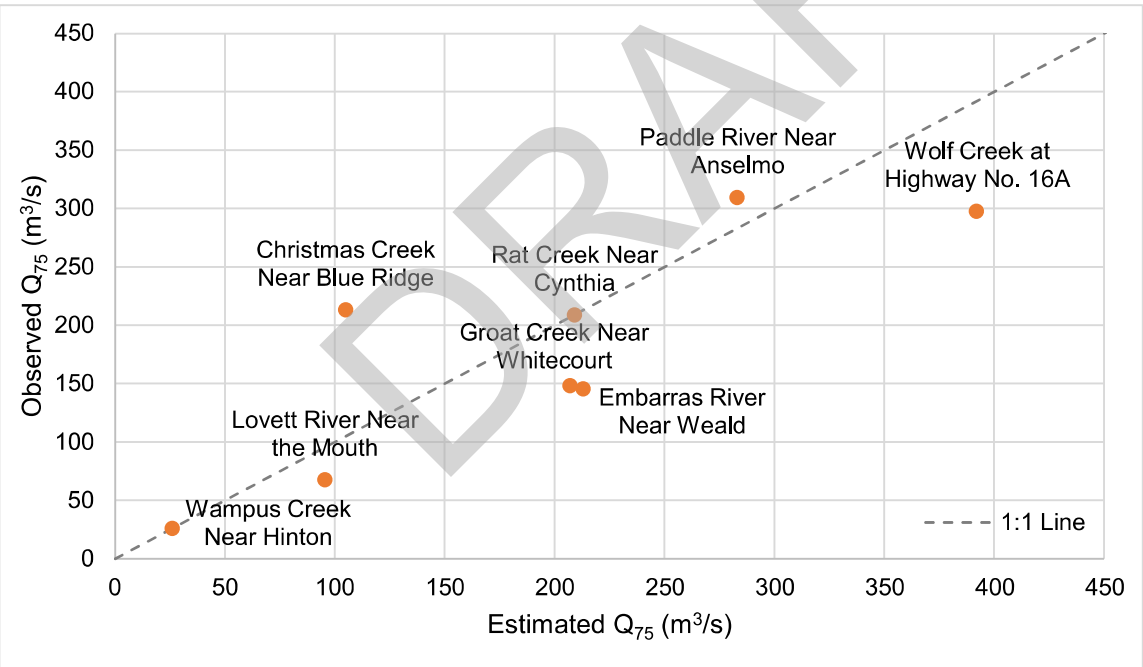
Classification: Public

Direct Quantile Regression - Q_{50}



Direct Quantile Regression - Q_{75}



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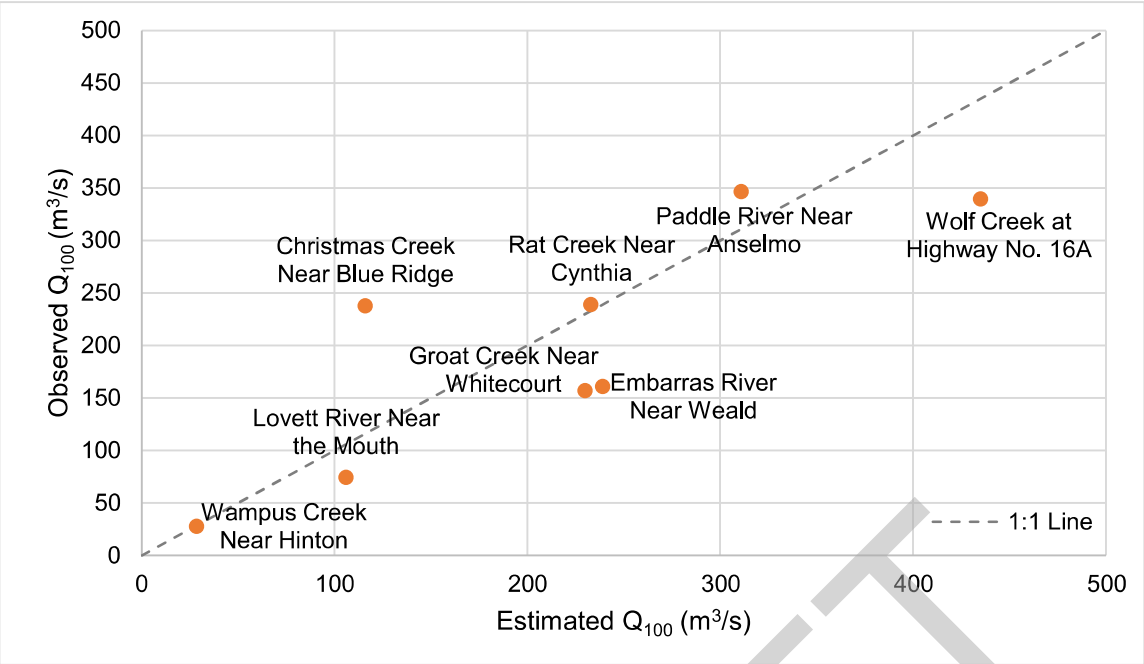
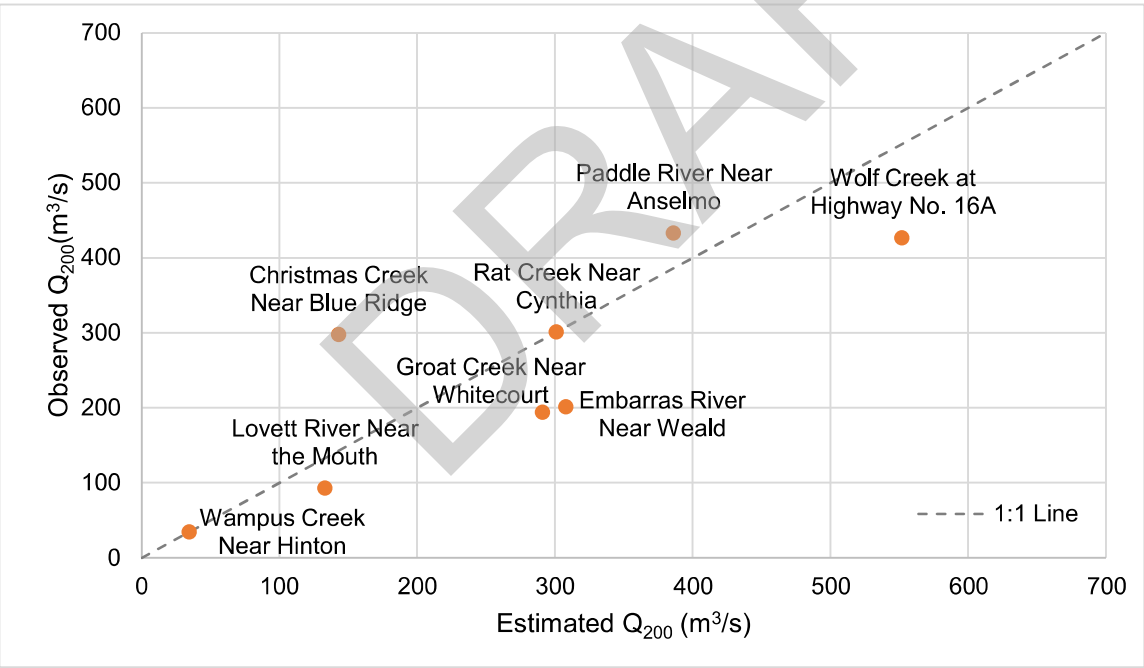
Classification: Public

Direct Quantile Regression - Q_{100}



Direct Quantile Regression - Q_{200}



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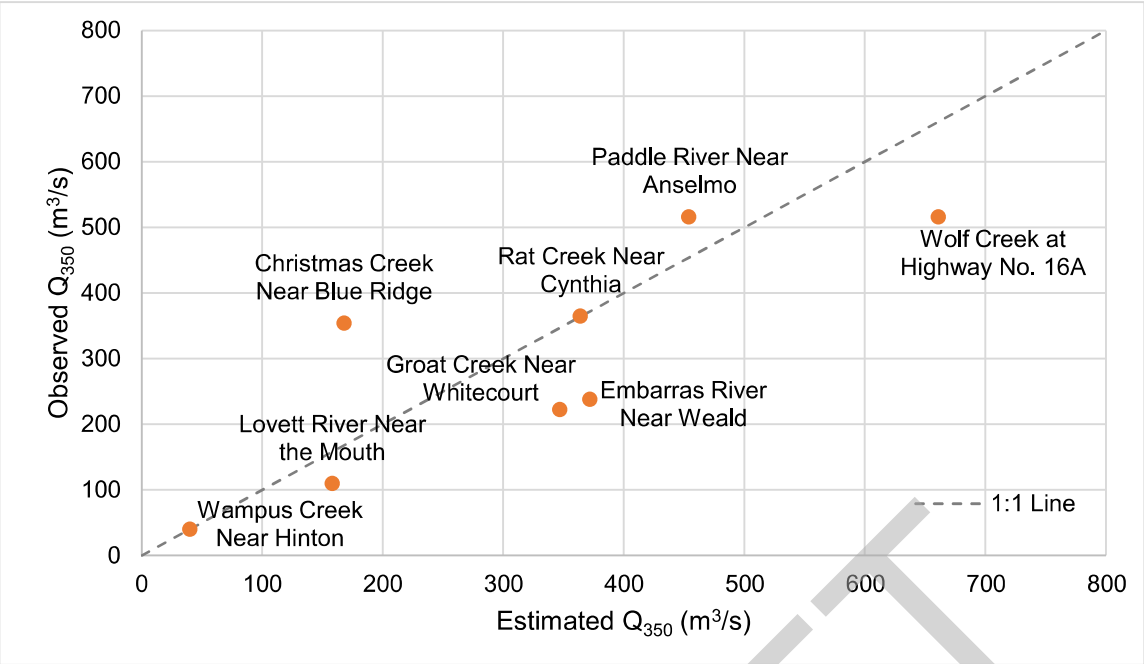
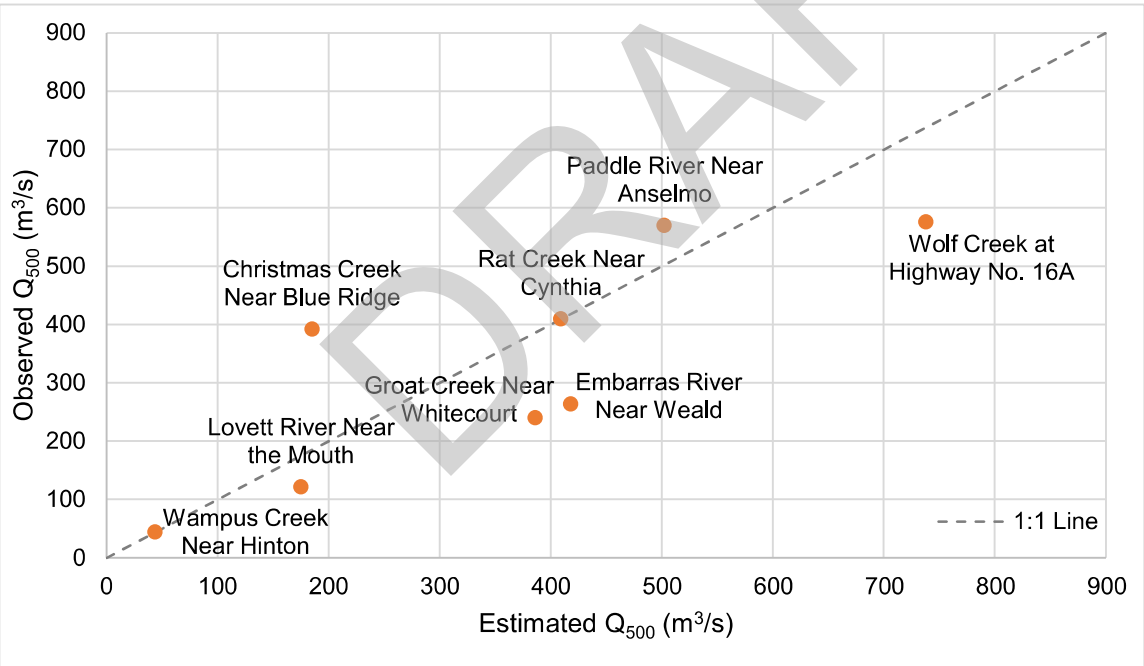
Classification: Public

Direct Quantile Regression - Q_{350}



Direct Quantile Regression - Q_{500}



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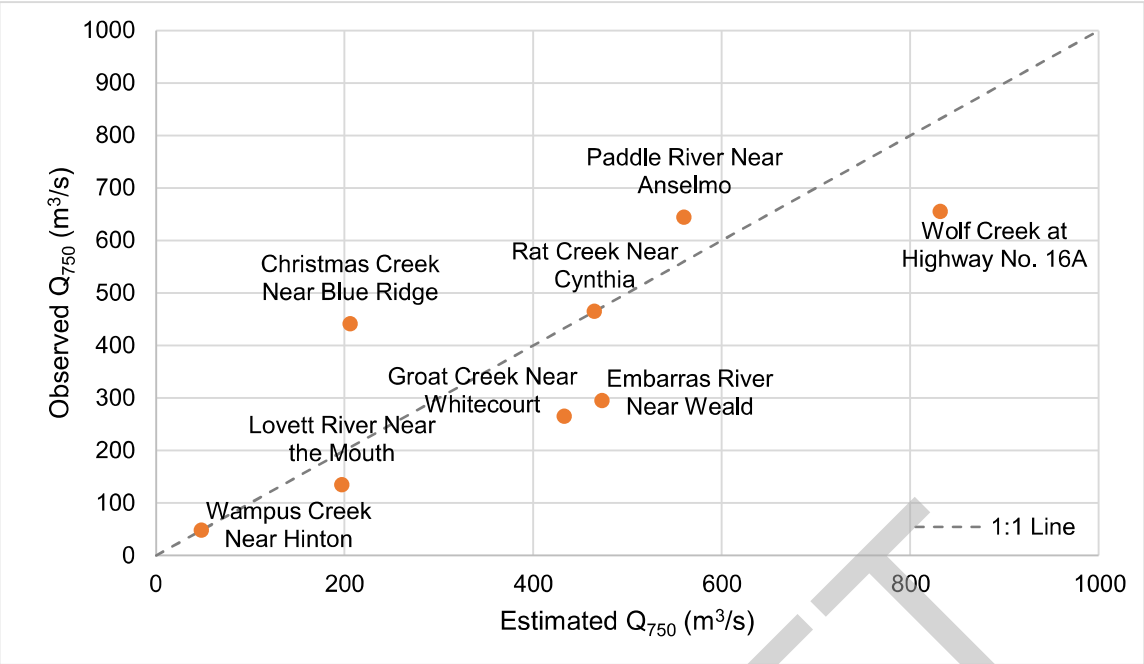
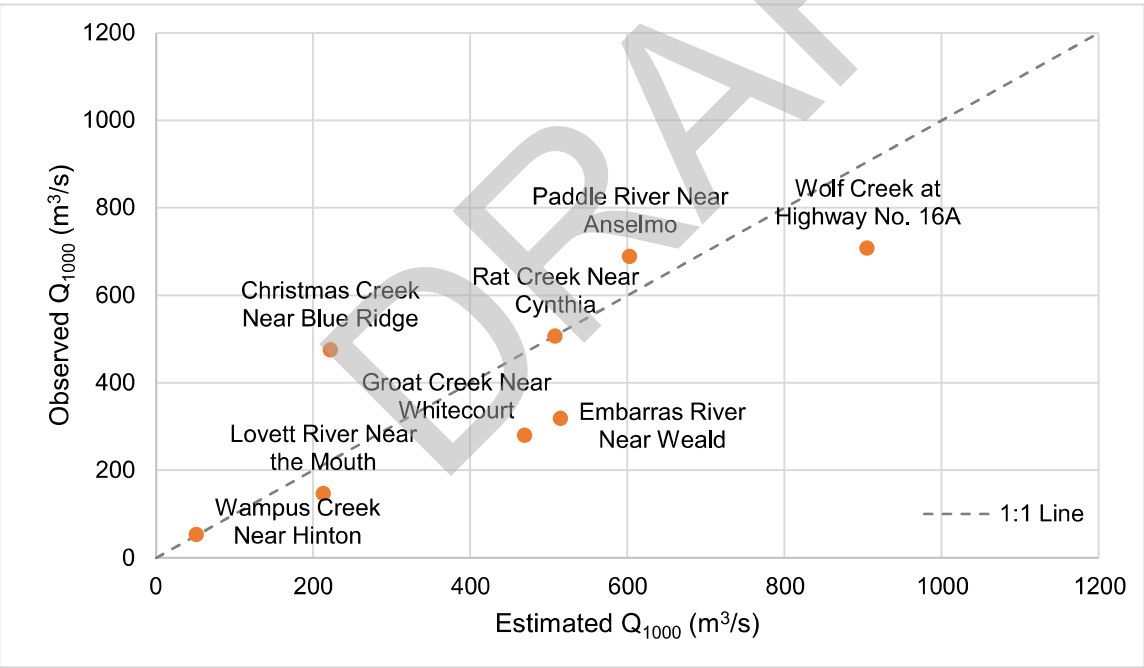
Classification: Public

Direct Quantile Regression - Q_{750}



Direct Quantile Regression - Q_{1000}



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Classification: Public

Innovation. Integrity. Employee-Owned.

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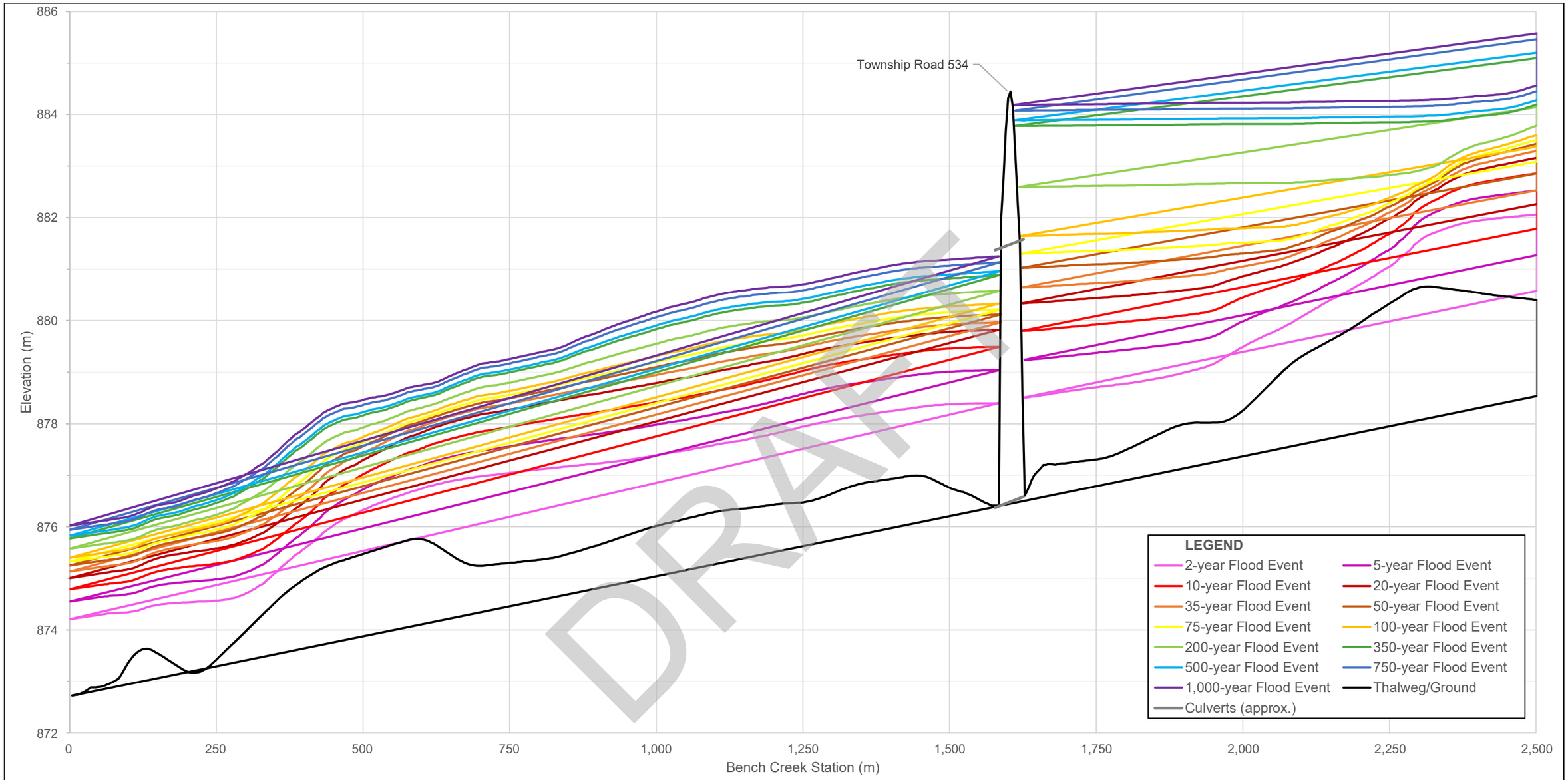
Appendix C

Open Water Flood Frequency Profiles

Classification: Public



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kwl 50 Innovation. Integrity. Employee-Owned.

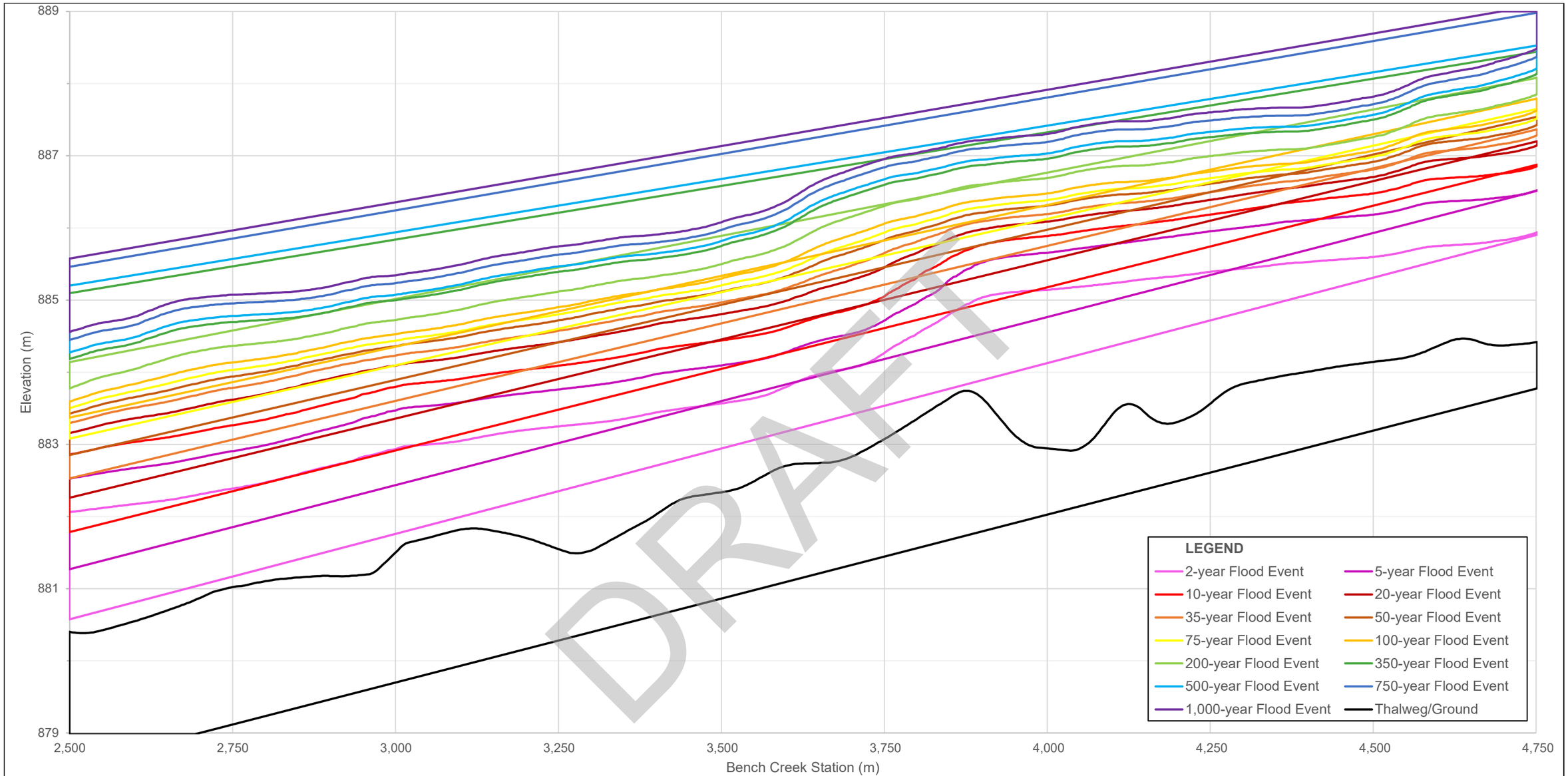
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-1
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 000-2,500)

Classification: Public



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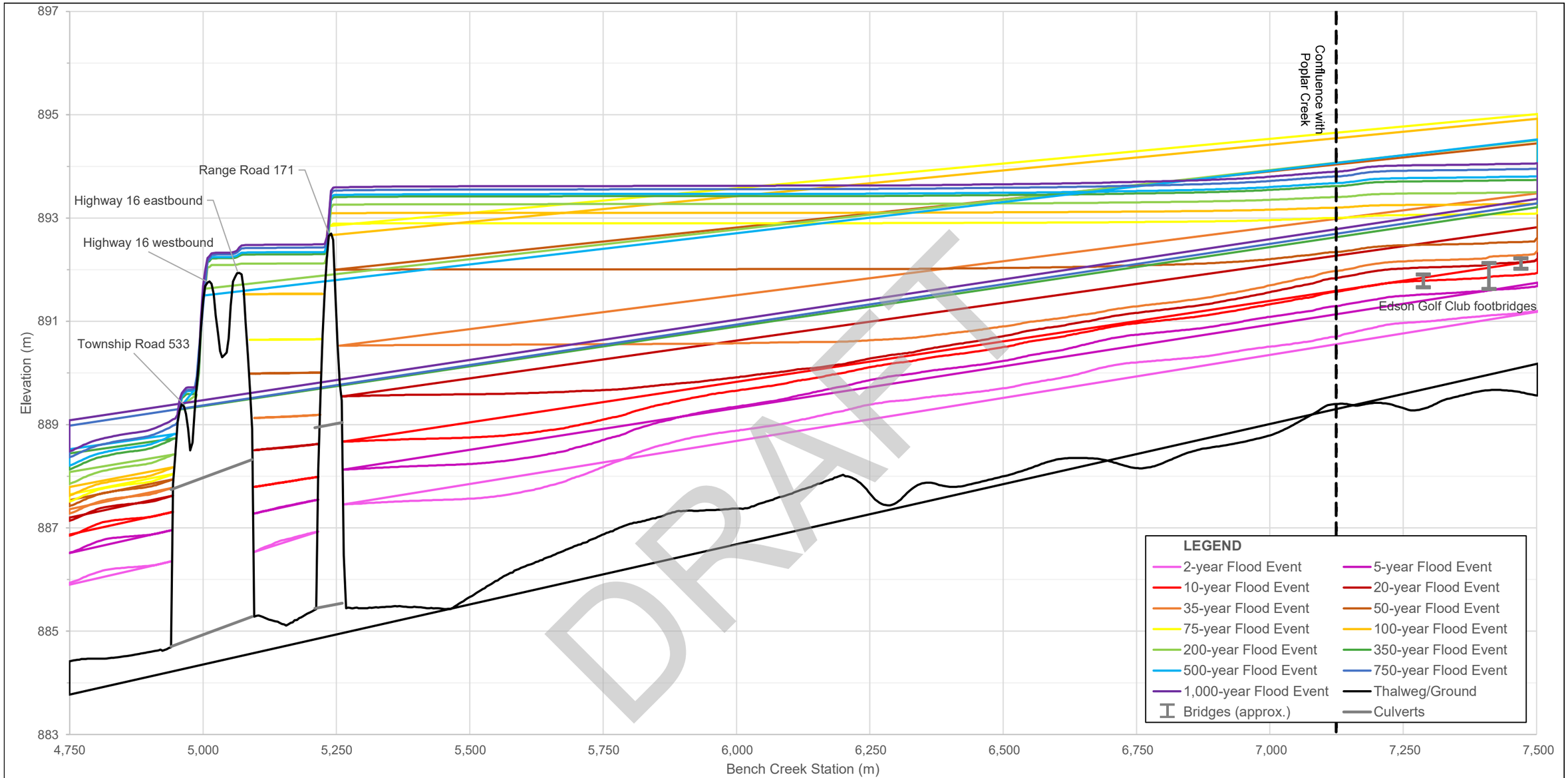
KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-2
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 2,500-4,750)

Classification: Public



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kwl 50 Innovation. Integrity. Employee-Owned.

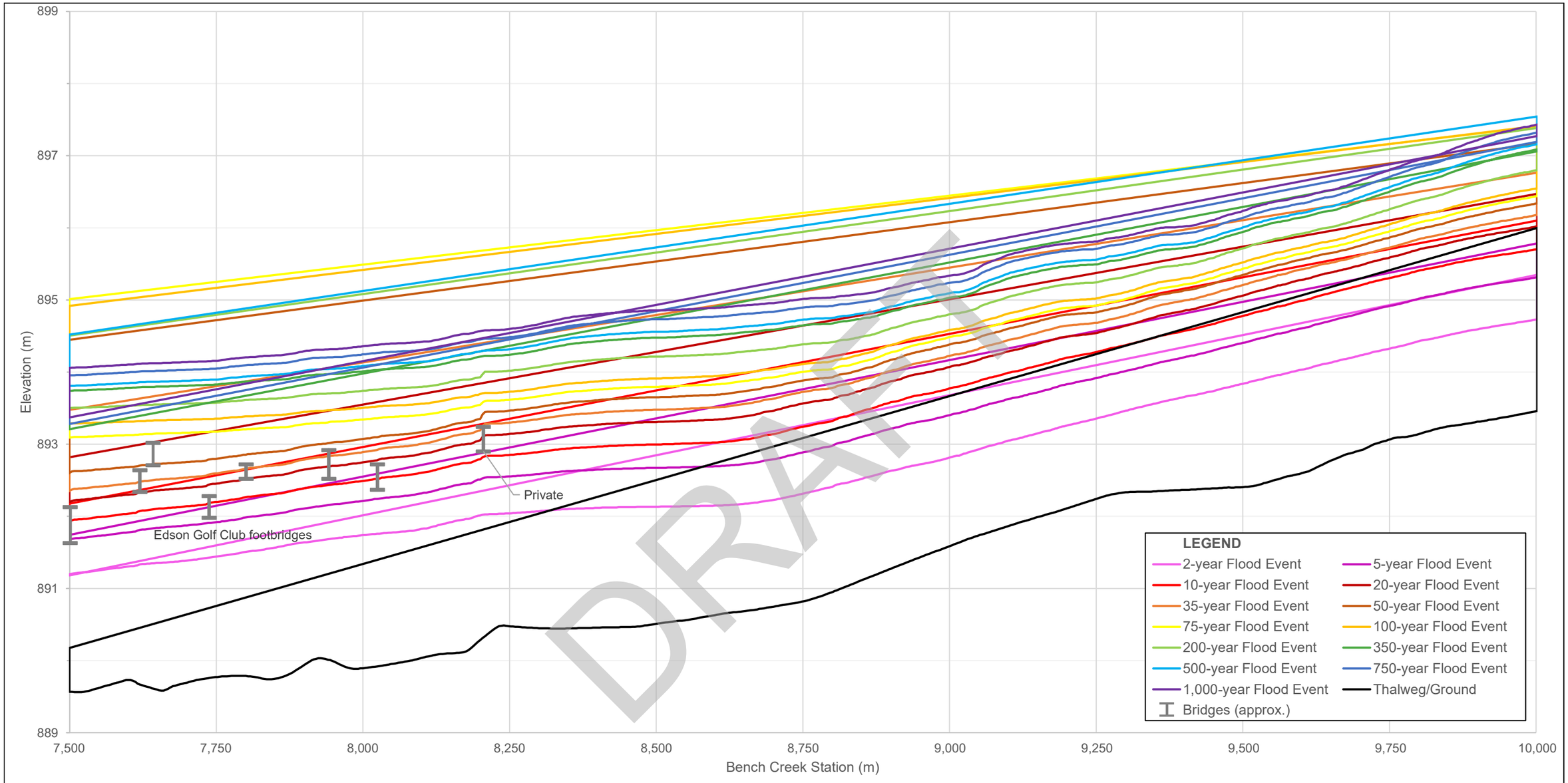
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-3
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 4,750-7,500)

Classification: Public



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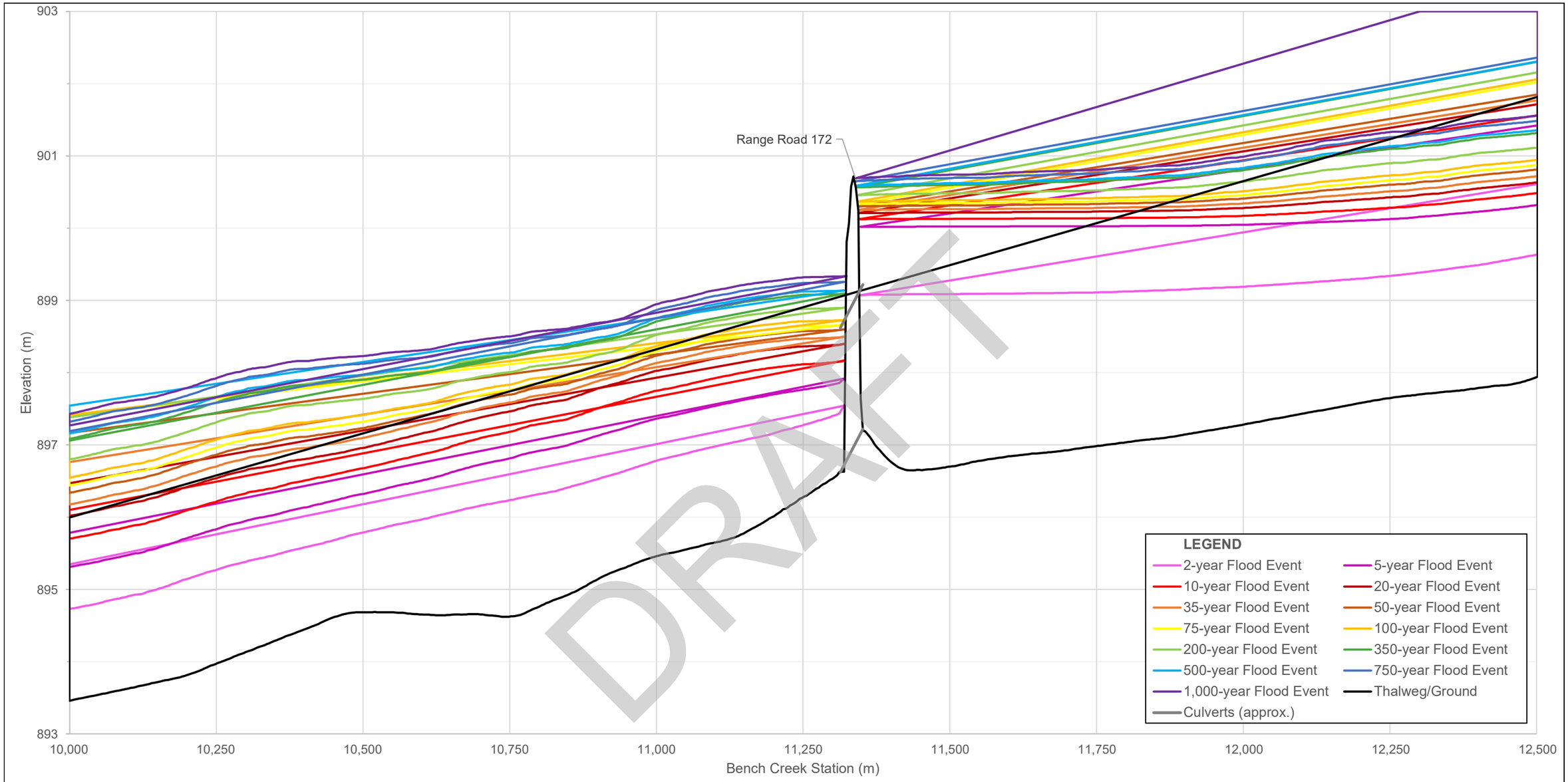
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-4
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 7,500-10,000)

Classification: Public



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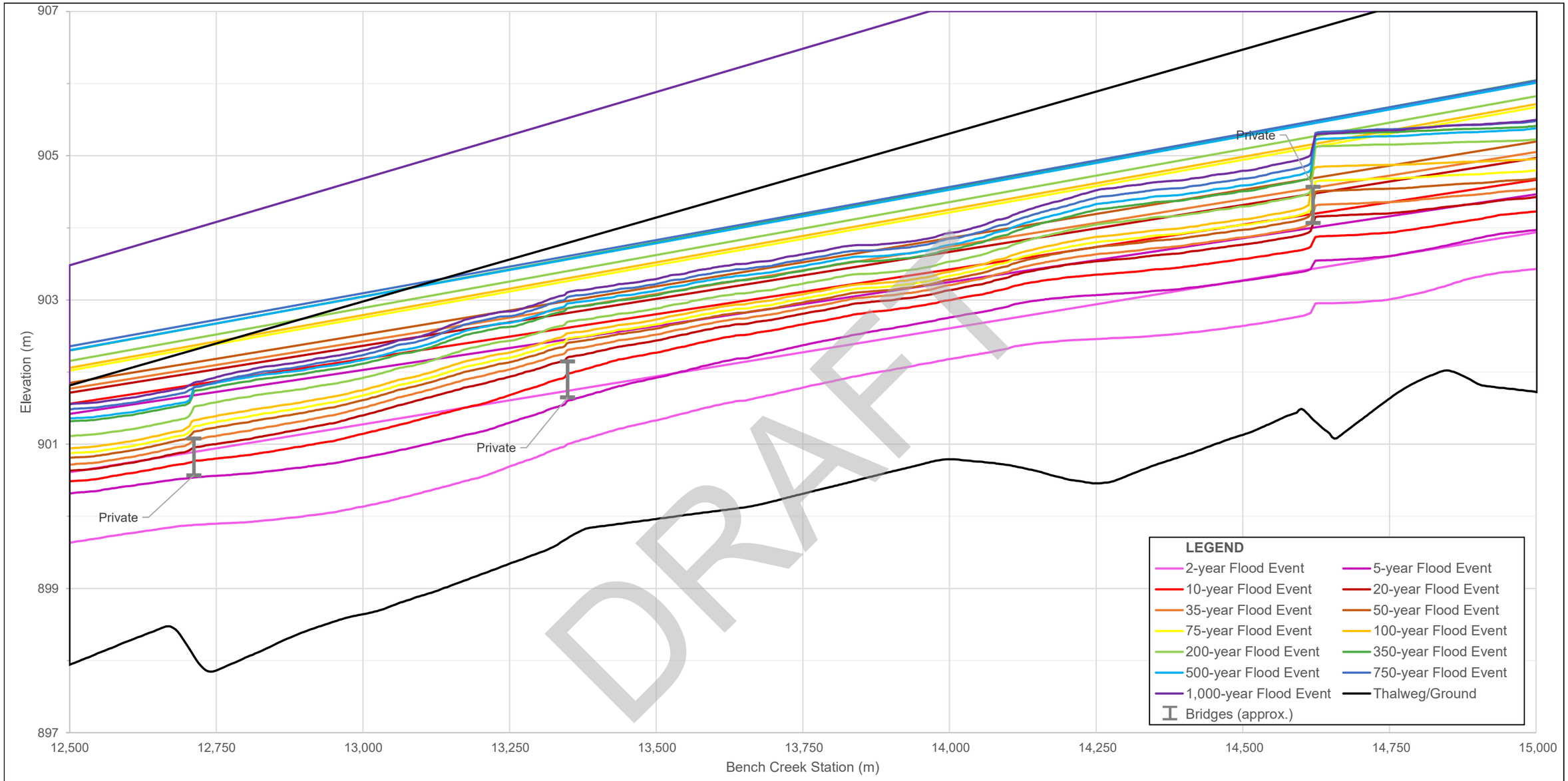
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-5
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 10,000-12,500)

Classification: Public



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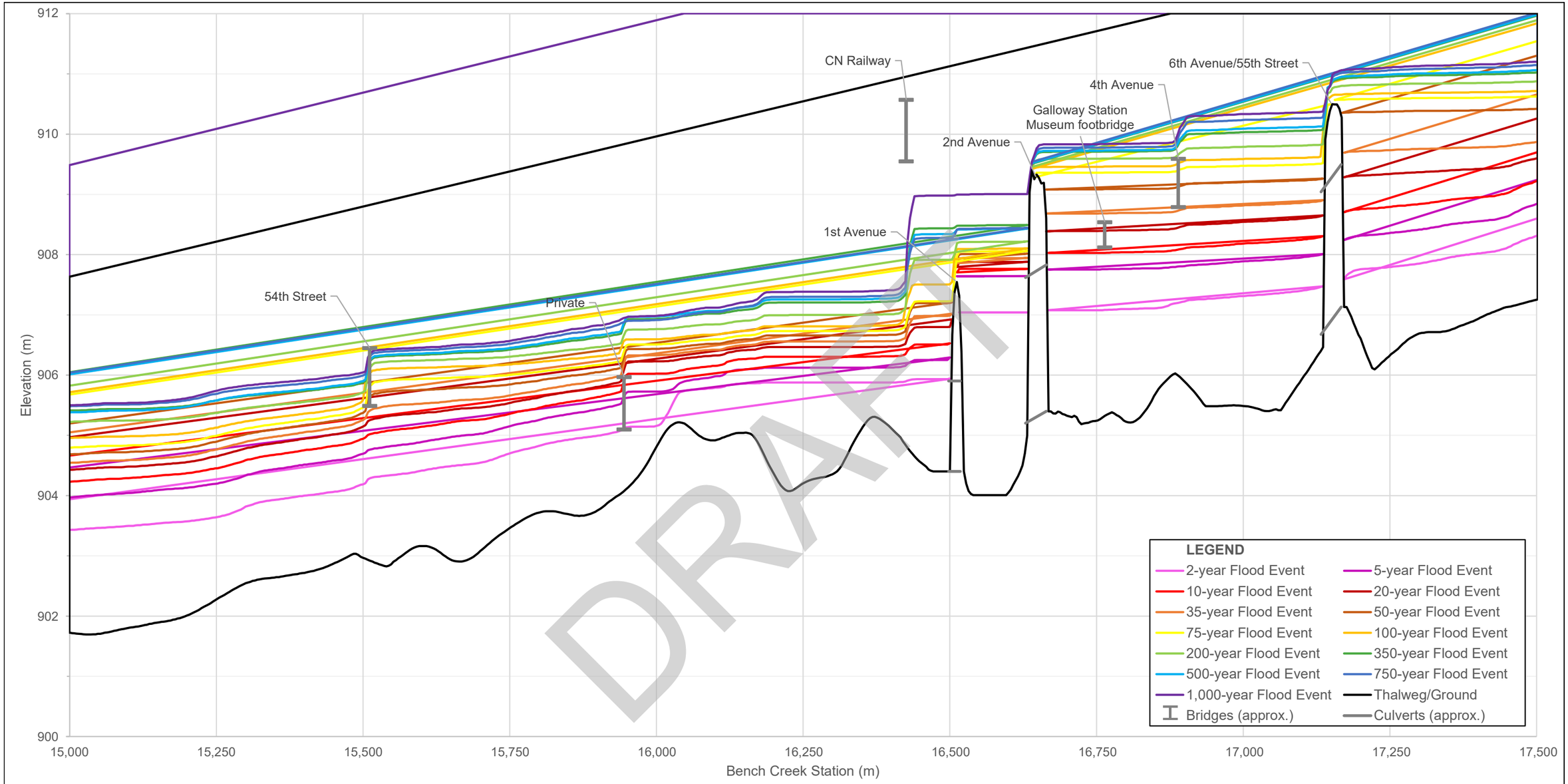
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-6
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 12,500-15,000)

Classification: Public



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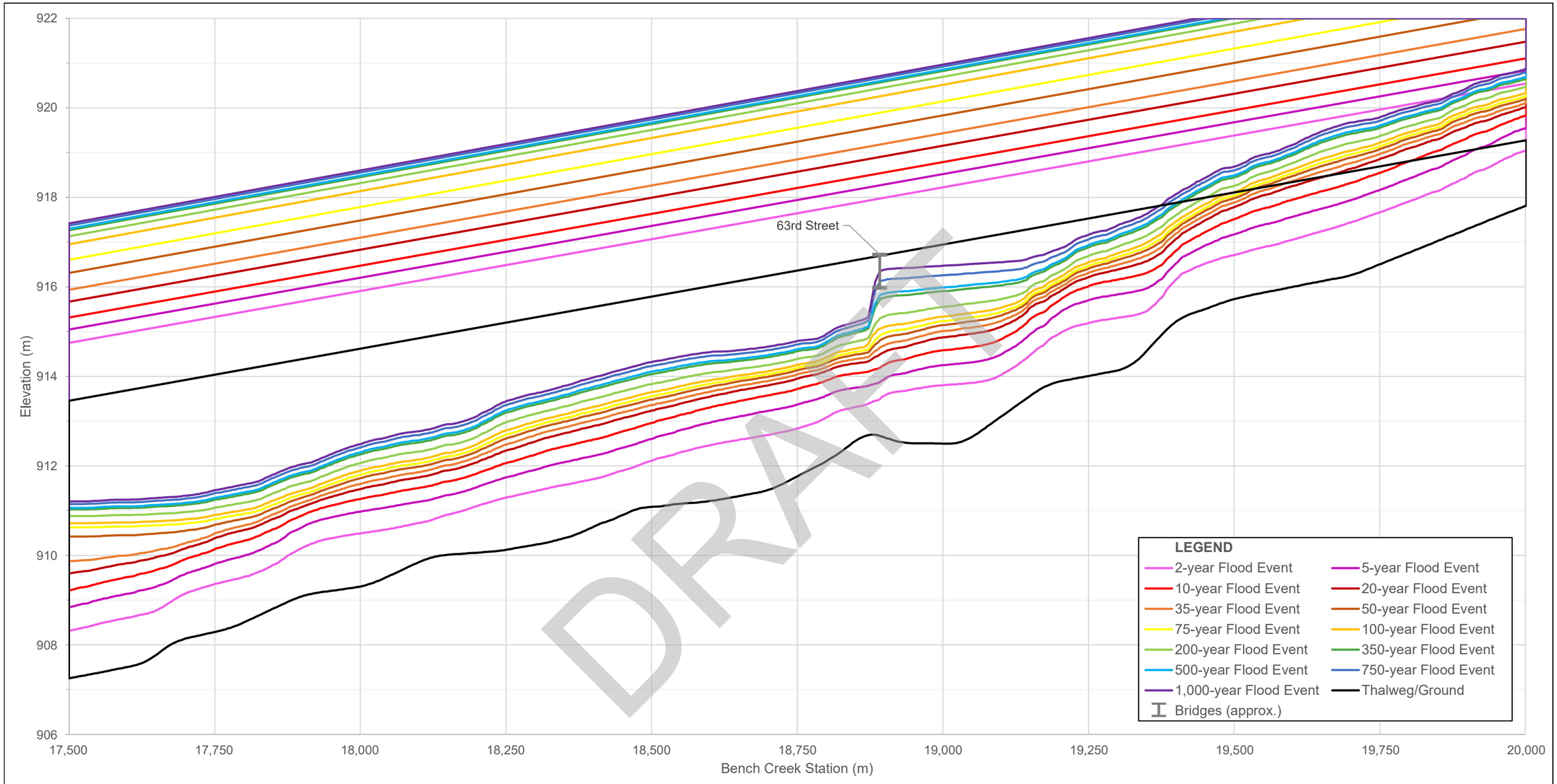
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-7
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 15,000-17,500)

Classification: Public



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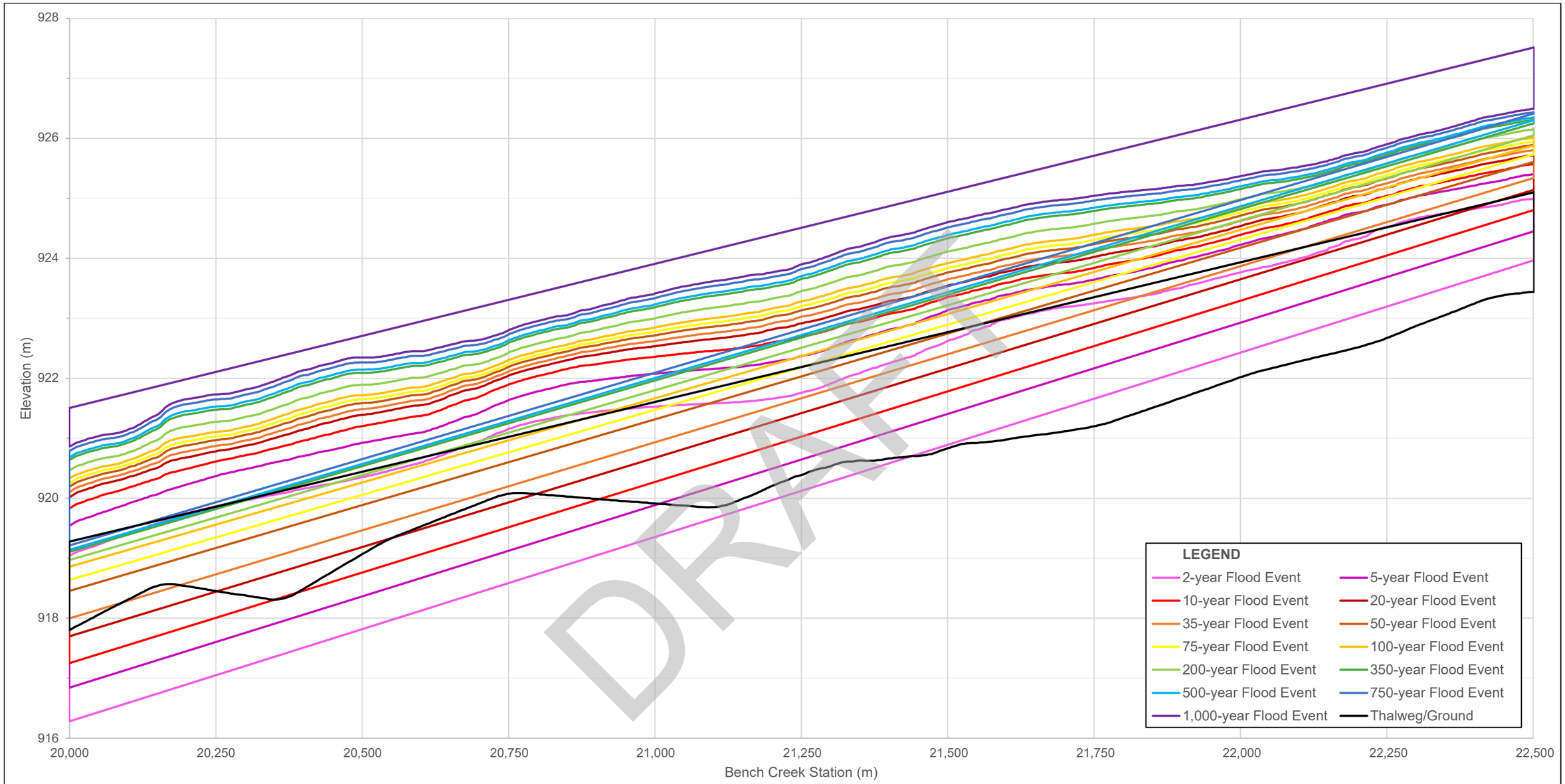
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-8
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 17,500-20,000)

Classification: Public



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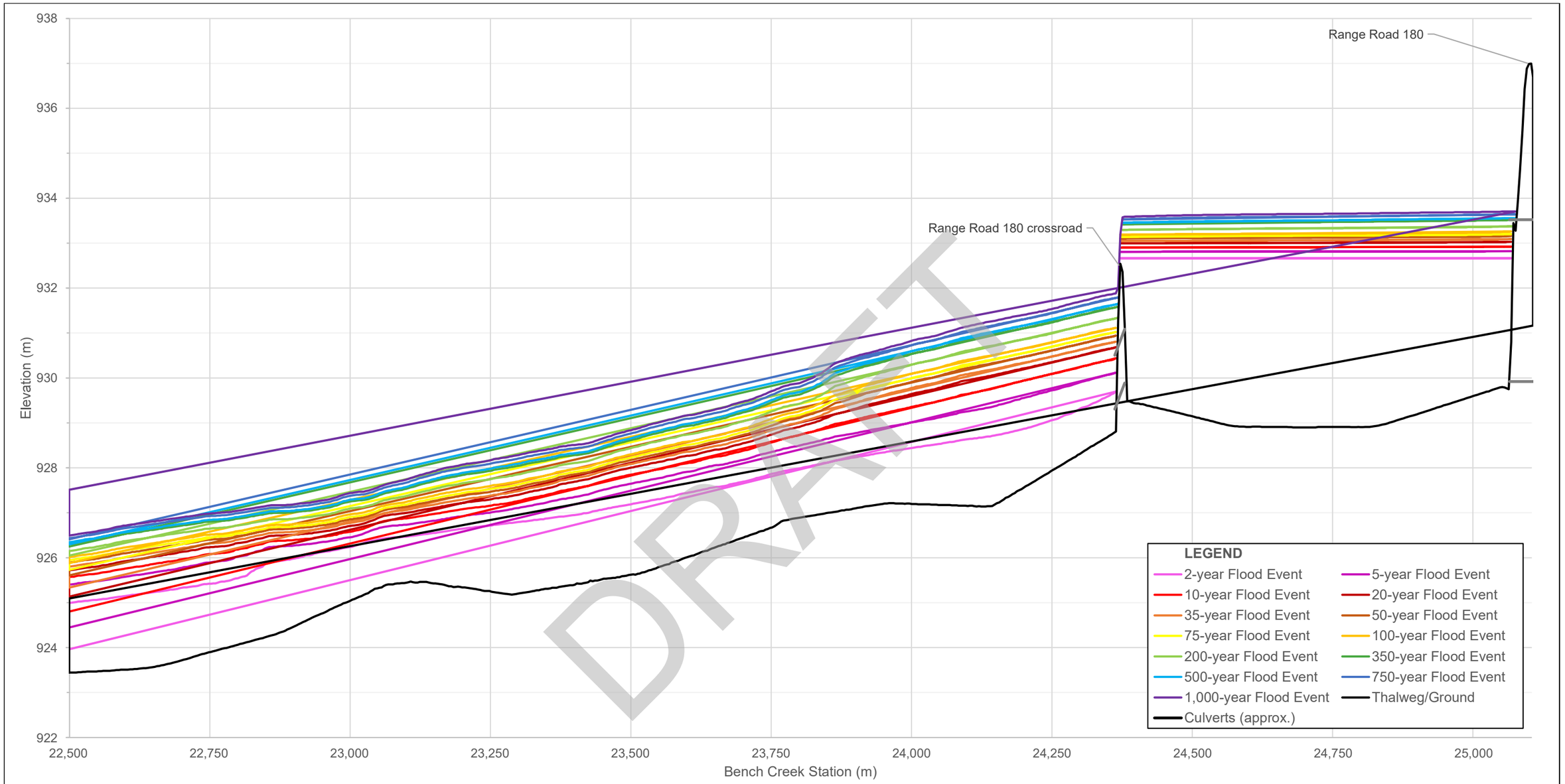
KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-9
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 20,000-22,500)

Classification: Public



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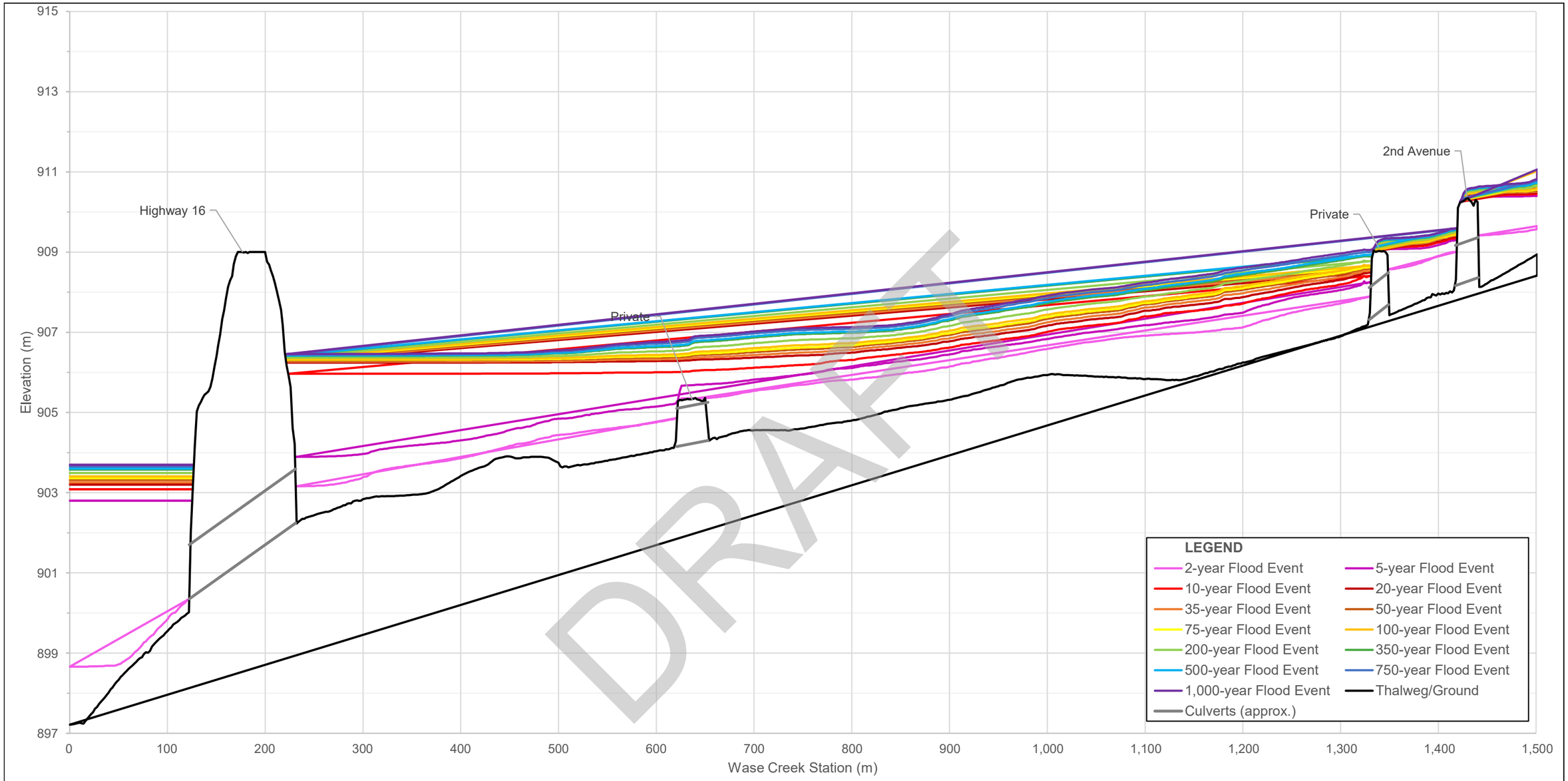
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-10
COMPUTED FLOOD FREQUENCY PROFILES — BENCH CREEK (STATION 22,500-25,105)

Classification: Public



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Alberta Canada

kwl 50 Innovation. Integrity. Employee-Owned.

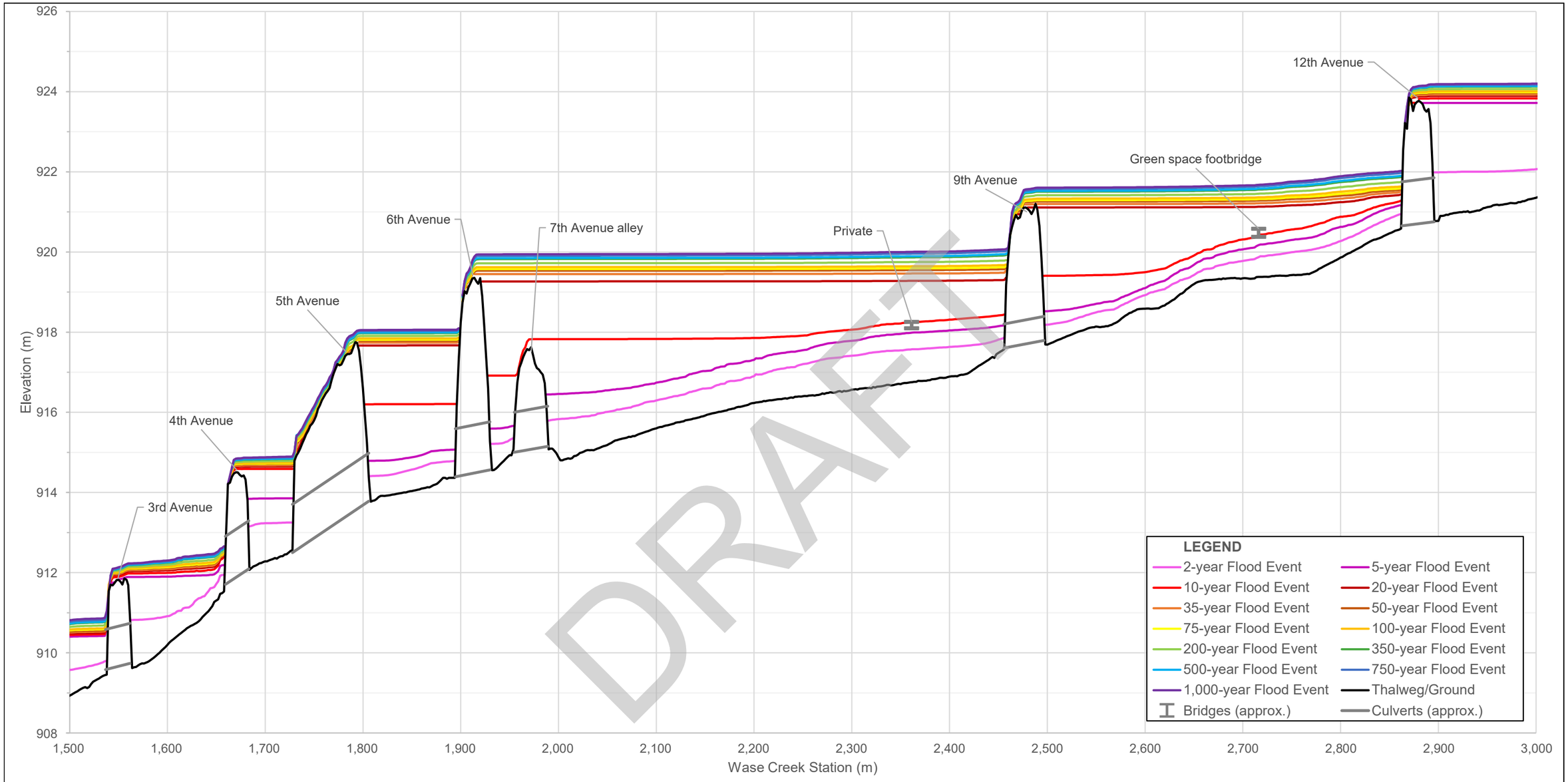
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-11
COMPUTED FLOOD FREQUENCY PROFILES — WASE CREEK (STATION 000-1,500)

Classification: Public



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Alberta Canada

kwl 50 Innovation. Integrity. Employee-Owned.

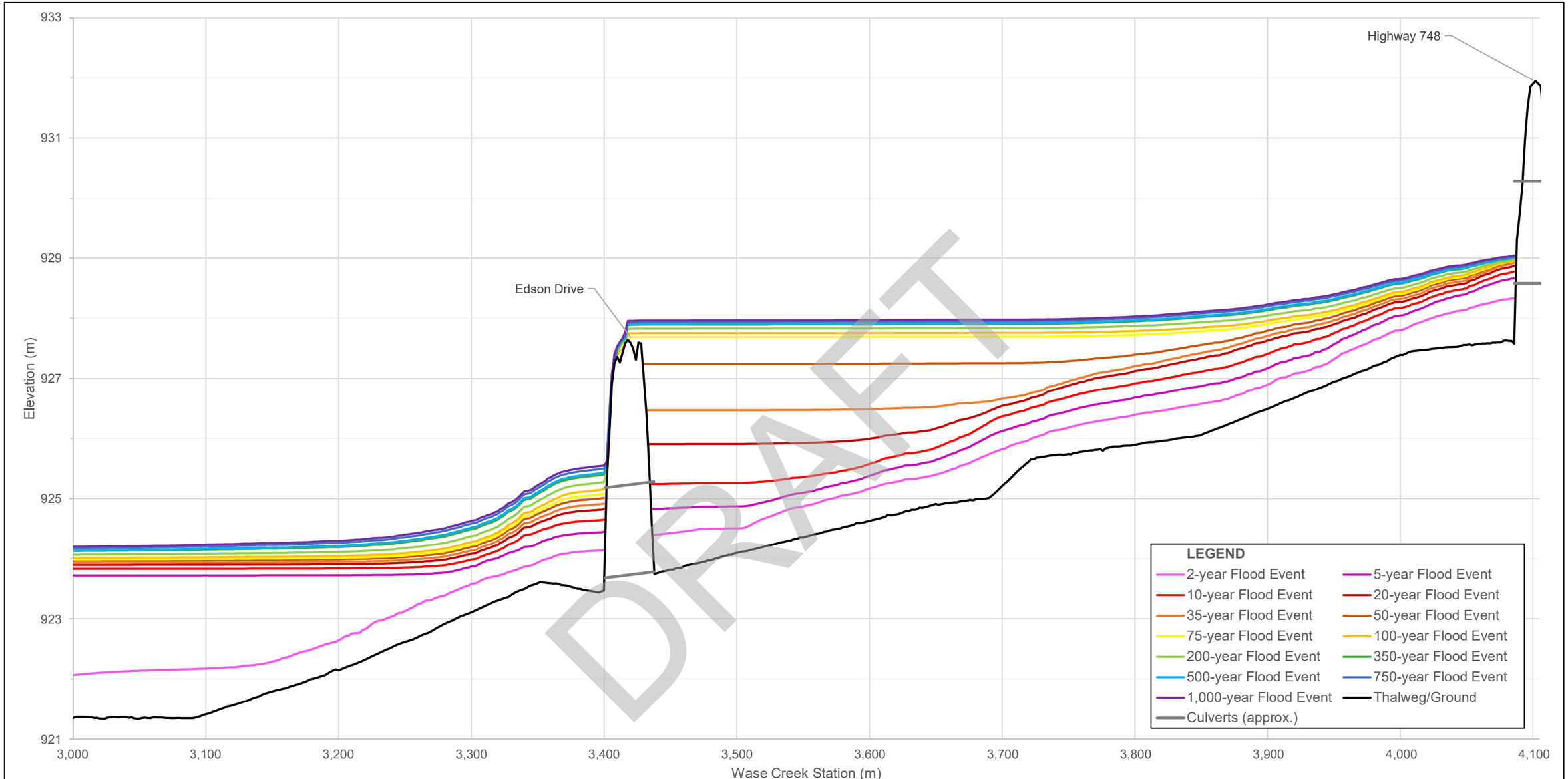
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-12
COMPUTED FLOOD FREQUENCY PROFILES — WASE CREEK (STATION 1,500-3,000)

Classification: Public



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Alberta Canada

kwl 50 Innovation. Integrity. Employee-Owned.

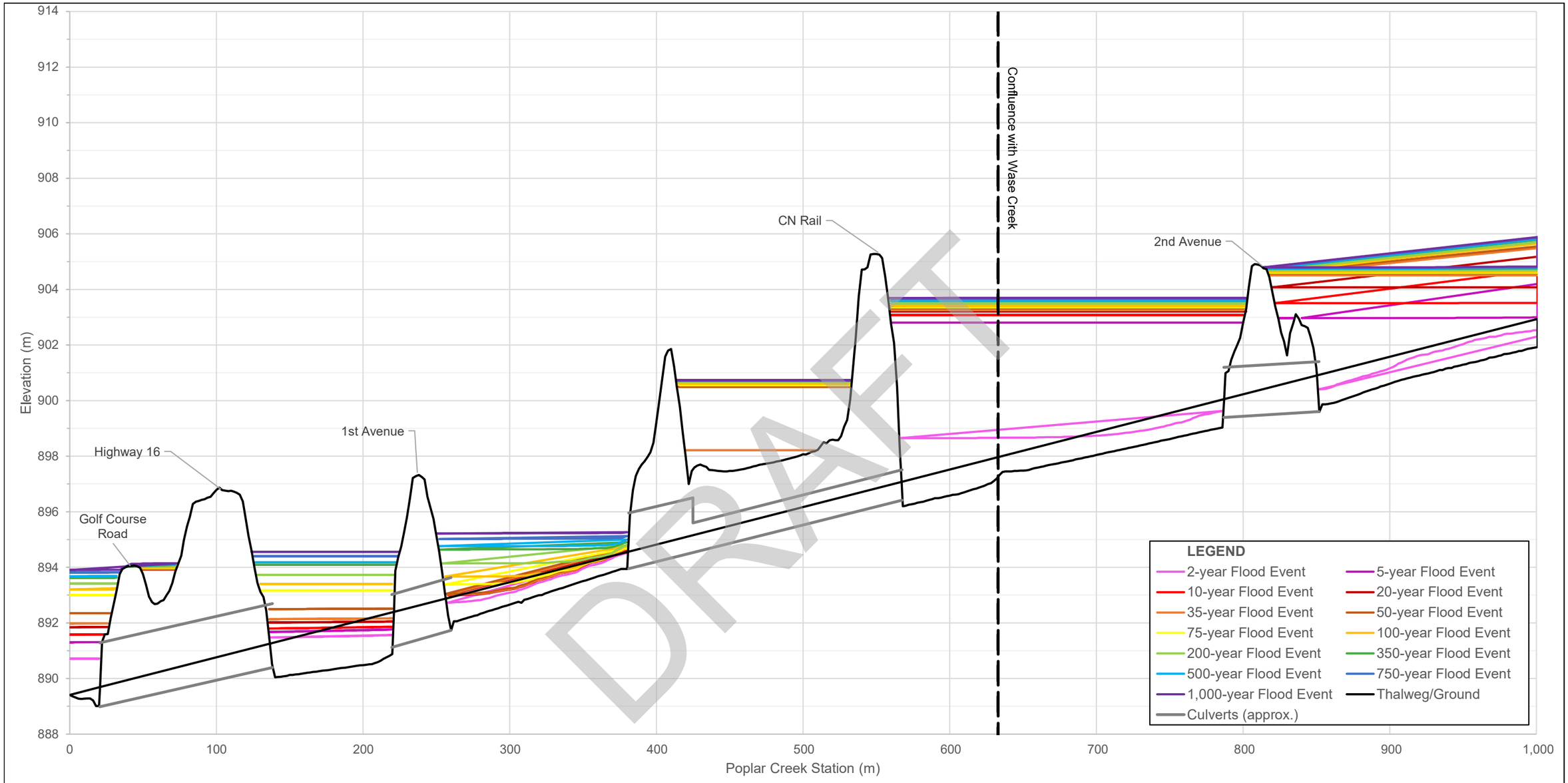
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-13
COMPUTED FLOOD FREQUENCY PROFILES — WASE CREEK (STATION 3,000-4,105)

Classification: Public



DRAFT

Alberta Canada

kwl 50 Innovation. Integrity. Employee-Owned.

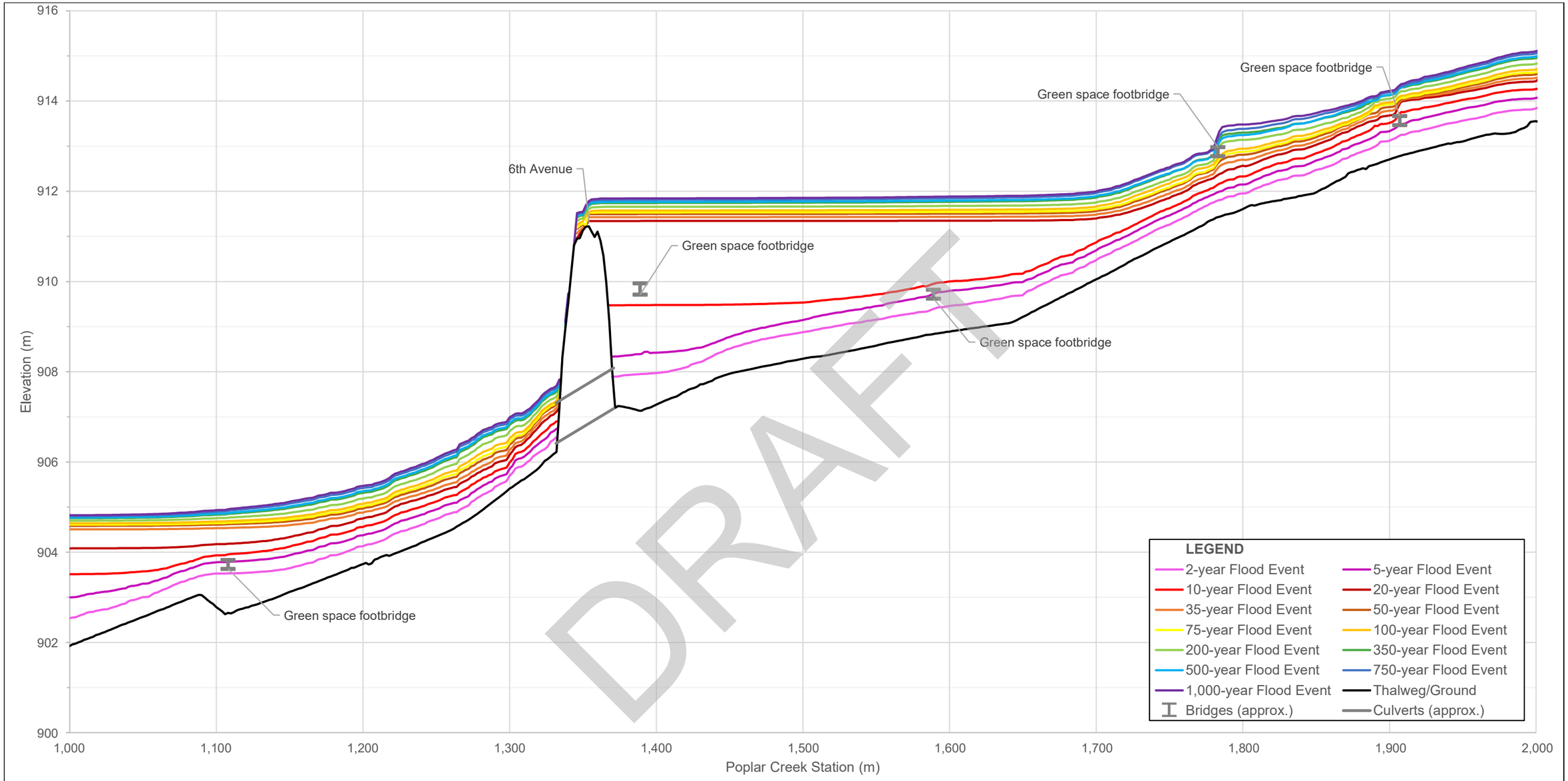
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.
2. The CN Rail culvert comprises sections of pipe of differing diameters connected by manholes.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-14
COMPUTED FLOOD FREQUENCY PROFILES — POPLAR CREEK (STATION 000-1,000)

Classification: Public



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Alberta Canada

kwl 50 Innovation. Integrity. Employee-Owned.

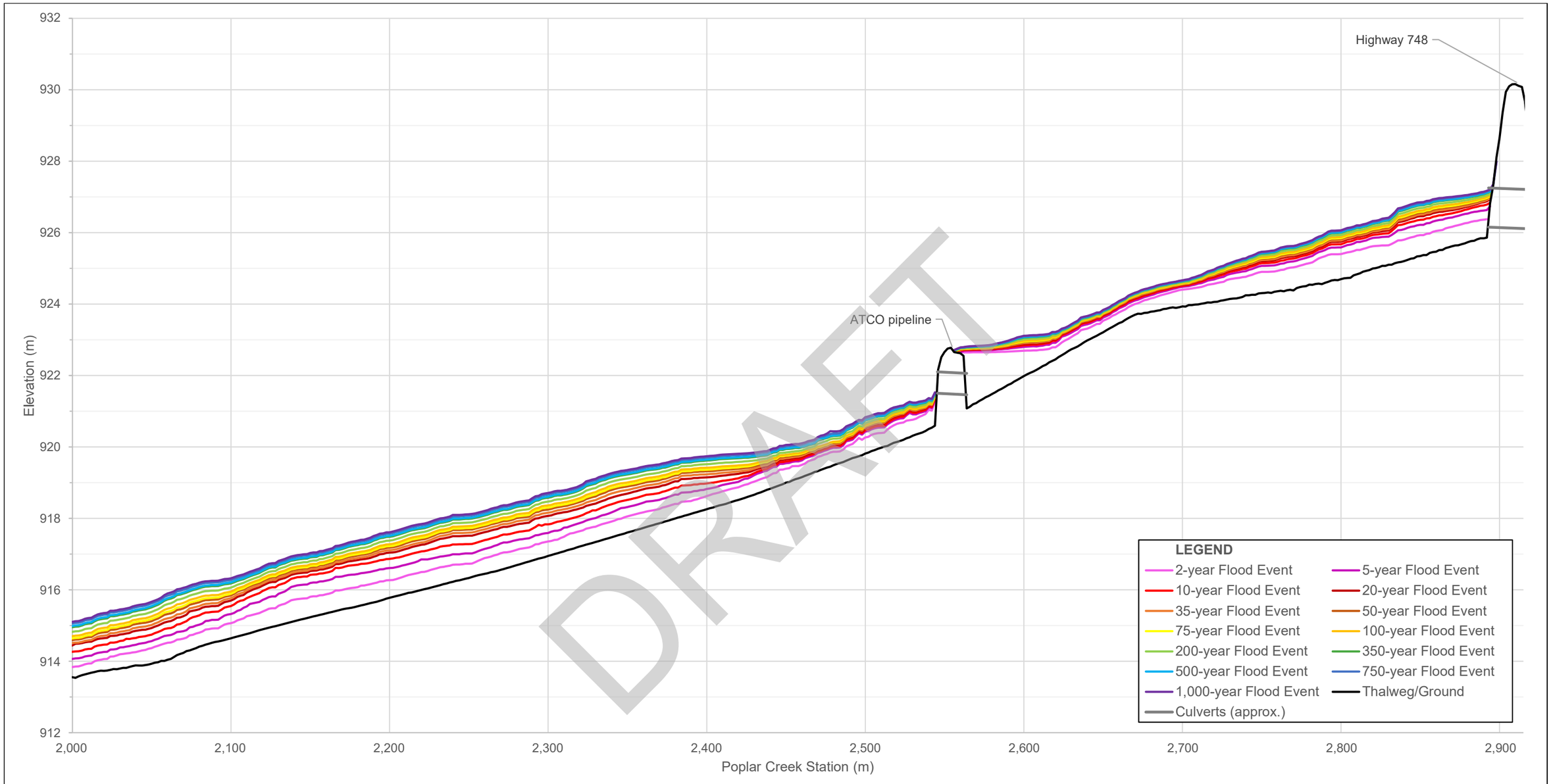
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-15
COMPUTED FLOOD FREQUENCY PROFILES — POPLAR CREEK (STATION 1,000-2,000)

Classification: Public



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Alberta Canada

kwl 50 Innovation. Integrity. Employee-Owned.

Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure C-16
COMPUTED FLOOD FREQUENCY PROFILES — POPLAR CREEK (STATION 2,000-2,915)

Classification: Public

Innovation. Integrity. Employee-Owned.

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Appendix D

Open Water Flood Frequency WSE Tables

Classification: Public

Table D-1: Upper Spirit River Open Water Flood Frequency WSE Table

Spirit River Station (m)	WSE (m)												
	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1,000-year
17,000	606.56	607.07	607.47	607.86	608.17	608.38	608.62	608.78	609.23	609.60	609.84	610.13	610.35
16,650	605.30	606.07	606.59	607.03	607.36	607.58	607.83	608.00	608.46	608.84	609.09	609.39	609.60
16,300	604.62	605.45	605.97	606.44	606.79	607.01	607.26	607.44	607.90	608.29	608.53	608.83	609.04
15,950	604.00	604.77	605.26	605.72	606.05	606.26	606.50	606.67	607.12	607.50	607.73	608.01	608.21
15,600	603.16	603.89	604.37	604.82	605.15	605.37	605.62	605.79	606.24	606.62	606.85	607.14	607.35
15,250	602.12	602.91	603.43	603.92	604.29	604.53	604.80	604.98	605.46	605.84	606.08	606.37	606.58
14,900	601.37	602.21	602.75	603.24	603.61	603.84	604.10	604.27	604.73	605.10	605.33	605.62	605.82
14,550	600.85	601.71	602.24	602.72	603.06	603.29	603.53	603.69	604.13	604.49	604.71	604.99	605.19
14,200	600.22	601.04	601.56	602.03	602.37	602.58	602.81	602.96	603.37	603.70	603.92	604.18	604.37
13,850	599.68	600.47	600.96	601.42	601.77	601.98	602.21	602.37	602.79	603.13	603.35	603.61	603.80
13,500	599.02	599.75	600.23	600.69	601.01	601.22	601.46	601.62	602.05	602.41	602.64	602.92	603.11
13,150	598.13	598.85	599.36	599.87	600.25	600.49	600.75	600.94	601.40	601.78	602.02	602.31	602.52
12,800	597.03	597.81	598.30	598.77	599.11	599.33	599.58	599.75	600.19	600.56	600.80	601.08	601.28
12,450	596.77	597.44	597.88	598.29	598.60	598.81	599.03	599.19	599.61	599.95	600.17	600.43	600.62
12,100	596.55	597.11	597.48	597.83	598.09	598.27	598.47	598.61	598.98	599.28	599.48	599.71	599.88
11,750	596.47	596.94	597.26	597.55	597.77	597.93	598.09	598.22	598.54	598.81	598.98	599.18	599.33
11,400	592.80	593.43	593.86	594.29	594.62	594.86	595.13	595.32	595.83	596.26	596.51	596.79	596.99
11,050	591.39	592.09	592.56	593.03	593.39	593.65	593.94	594.14	594.66	595.08	595.33	595.64	595.86

Table D-2: Middle Spirit River Open Water Flood Frequency WSE Table

Spirit River Station (m)	WSE (m)												
	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1,000-year
10,700	590.50	591.22	591.70	592.19	592.56	592.82	593.11	593.32	593.86	594.29	594.56	594.88	595.10
10,350	589.56	590.33	590.83	591.32	591.70	591.97	592.27	592.48	593.03	593.46	593.72	594.04	594.27
10,000	588.56	589.35	589.86	590.36	590.75	591.02	591.32	591.54	592.07	592.49	592.76	593.07	593.30
9,650	587.94	588.70	589.20	589.68	590.06	590.32	590.61	590.82	591.34	591.75	592.00	592.31	592.53

Table D-3: Lower Spirit River Open Water Flood Frequency WSE Table

Spirit River Station (m)	WSE (m)												
	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1,000-year
9,300	587.11	587.87	588.35	588.83	589.20	589.46	589.75	589.96	590.49	590.90	591.16	591.47	591.69
8,950	586.16	586.90	587.39	587.86	588.23	588.49	588.78	588.99	589.51	589.93	590.18	590.48	590.69
8,600	585.20	585.95	586.45	586.93	587.31	587.57	587.86	588.07	588.60	589.01	589.27	589.57	589.79
8,250	584.48	585.22	585.69	586.15	586.52	586.77	587.05	587.26	587.77	588.17	588.42	588.72	588.92
7,900	583.60	584.33	584.80	585.25	585.61	585.86	586.14	586.35	586.87	587.28	587.53	587.82	588.03
7,550	582.75	583.39	583.83	584.27	584.62	584.87	585.14	585.36	585.91	586.33	586.57	586.87	587.08
7,200	581.22	582.08	582.61	583.12	583.51	583.78	584.07	584.28	584.79	585.19	585.44	585.74	585.96
6,850	580.58	581.42	581.92	582.40	582.77	583.03	583.30	583.50	583.98	584.37	584.61	584.90	585.10
6,500	579.80	580.61	581.12	581.60	581.98	582.23	582.50	582.69	583.16	583.54	583.78	584.08	584.29
6,150	579.29	580.03	580.50	580.96	581.32	581.55	581.80	581.98	582.41	582.76	582.99	583.27	583.46
5,800	578.50	579.23	579.71	580.16	580.51	580.74	580.99	581.17	581.61	581.98	582.21	582.49	582.69
5,450	577.60	578.40	578.91	579.37	579.71	579.93	580.16	580.34	580.77	581.13	581.35	581.63	581.82
5,100	577.12	577.91	578.39	578.82	579.14	579.34	579.57	579.74	580.16	580.51	580.73	581.00	581.19
4,750	576.49	577.25	577.71	578.12	578.43	578.63	578.84	579.02	579.44	579.78	579.99	580.26	580.44
4,400	576.01	576.70	577.11	577.48	577.76	577.92	578.09	578.27	578.65	578.95	579.15	579.38	579.53
4,050	571.64	572.07	572.42	572.82	573.15	573.45	573.68	573.85	574.37	574.82	575.10	575.46	575.71
3,700	569.89	570.62	571.10	571.58	571.96	572.22	572.52	572.73	573.27	573.74	574.03	574.40	574.66
3,350	568.92	569.64	570.10	570.56	570.94	571.19	571.47	571.67	572.21	572.67	572.97	573.33	573.59
3,000	567.88	568.57	569.03	569.49	569.85	570.11	570.39	570.60	571.13	571.59	571.89	572.25	572.51
2,650	566.69	567.43	567.90	568.36	568.74	568.99	569.28	569.49	570.03	570.49	570.79	571.15	571.41
2,300	565.66	566.37	566.83	567.29	567.65	567.91	568.19	568.39	568.94	569.40	569.69	570.06	570.31
1,950	564.67	565.36	565.81	566.27	566.64	566.89	567.17	567.38	567.93	568.39	568.69	569.05	569.31
1,600	563.70	564.35	564.79	565.24	565.60	565.85	566.13	566.33	566.87	567.34	567.63	568.00	568.26
1,250	562.44	563.16	563.64	564.11	564.49	564.75	565.05	565.26	565.81	566.28	566.58	566.95	567.22
900	561.58	562.31	562.79	563.26	563.63	563.89	564.18	564.39	564.94	565.40	565.70	566.07	566.34
550	560.63	561.37	561.85	562.32	562.70	562.95	563.24	563.44	563.98	564.44	564.74	565.10	565.37
200	559.89	560.62	561.10	561.55	561.90	562.14	562.41	562.60	563.12	563.57	563.86	564.22	564.48
0	559.69	560.37	560.82	561.24	561.56	561.80	562.05	562.23	562.73	563.16	563.44	563.80	564.06

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Table D-4: Unnamed Tributary Open Water Flood Frequency WSE Table

Unnamed Tributary Station (m)	WSE (m)												
	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1,000-year
2,450	611.23	611.26	611.28	611.30	611.31	611.32	611.32	611.33	611.34	611.35	611.35	611.36	611.36
2,300	610.28	610.31	610.32	610.34	610.35	610.35	610.36	610.37	610.38	610.38	610.39	610.39	610.40
2,150	609.65	609.70	609.73	609.75	609.77	609.78	609.79	609.80	609.82	609.83	609.84	609.85	609.85
2,000	609.23	609.27	609.30	609.32	609.33	609.34	609.35	609.35	609.36	609.38	609.38	609.39	609.39
1,850	608.28	608.32	608.34	608.36	608.38	608.38	608.39	608.40	608.42	608.43	608.44	608.45	608.46
1,700	607.56	607.61	607.64	607.67	607.81	607.93	608.05	608.12	608.24	608.28	608.30	608.31	608.32
1,550	607.08	607.18	607.31	607.52	607.79	607.92	608.05	608.11	608.24	608.28	608.30	608.31	608.32
1,400	606.59	606.78	606.97	607.26	607.43	607.50	607.54	607.55	607.57	607.59	607.60	607.61	607.62
1,250	606.40	606.49	606.56	606.64	606.70	606.80	606.86	606.88	606.91	606.92	606.94	606.96	606.97
1,100	605.24	605.36	605.44	605.51	605.55	605.58	605.62	605.65	605.68	605.71	605.74	605.78	605.81
950	604.27	604.37	604.46	604.61	604.83	605.00	605.15	605.18	605.20	605.21	605.22	605.23	605.24
850	603.75	603.97	604.19	604.51	604.79	604.98	605.14	605.17	605.19	605.20	605.21	605.21	605.22
700	602.57	602.73	602.83	602.92	602.96	602.99	603.01	603.08	603.13	603.15	603.16	603.17	603.17
550	602.26	602.40	602.49	602.56	602.60	602.62	602.64	602.70	602.74	602.75	602.76	602.77	602.77
400	601.31	601.39	601.47	601.53	601.57	601.59	601.61	601.68	601.73	601.75	601.75	601.76	601.76
250	597.72	598.02	598.19	598.33	598.40	598.43	598.47	598.56	598.64	598.66	598.68	598.68	598.69
100	593.90	594.06	594.15	594.22	594.26	594.29	594.31	594.37	594.44	594.57	594.73	594.98	595.19
0	590.58	591.29	591.77	592.25	592.62	592.88	593.17	593.38	593.92	594.35	594.61	594.93	595.16

Table D-5: West Ditch of Highway 2 Open Water Flood Frequency WSE Table

West Ditch of Highway 2 Station (m)	WSE (m)												
	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1,000-year
3,200	611.77	611.80	611.82	611.83	611.84	611.85	611.86	611.86	611.87	611.88	611.88	611.89	611.89
3,050	610.91	610.94	610.96	610.97	610.98	610.98	610.99	611.00	611.00	611.01	611.02	611.02	611.02
2,900	610.54	610.61	610.66	610.69	610.71	610.72	610.73	610.74	610.75	610.77	610.77	610.78	610.78
2,750	610.01	610.10	610.16	610.21	610.23	610.24	610.25	610.26	610.28	610.29	610.30	610.31	610.32
2,600	609.59	609.68	609.74	609.78	609.81	609.82	609.84	609.85	609.87	609.87	609.88	609.88	609.88
2,450	608.96	609.05	609.10	609.14	609.16	609.18	609.19	609.20	609.20	609.20	609.20	609.20	609.20
2,300	608.40	608.50	608.55	608.60	608.62	608.64	608.66	608.67	608.69	608.70	608.71	608.72	608.72
2,150	607.70	607.79	608.06	608.18	608.21	608.22	608.24	608.25	608.27	608.29	608.30	608.31	608.31
2,000	606.52	606.58	606.62	606.62	606.63	606.63	606.63	606.63	606.63	606.63	606.63	606.63	606.63
1,850	604.94	605.03	605.04	605.04	605.05	605.06	605.15	605.18	605.19	605.20	605.21	605.21	605.22
1,650	603.78	604.01	604.20	604.35	604.49	604.59	604.72	604.81	604.86	604.87	604.88	604.89	604.89
1,500	602.97	603.10	603.40	603.51	603.52	603.53	603.53	603.54	603.55	603.57	603.58	603.58	603.59
1,350	602.71	603.03	603.39	603.50	603.51	603.52	603.53	603.53	603.54	603.55	603.56	603.56	603.57
1,200	602.33	602.45	602.51	602.54	602.57	602.58	602.59	602.61	602.65	602.69	602.71	602.73	602.74
1,050	602.10	602.21	602.26	602.29	602.32	602.33	602.34	602.35	602.40	602.43	602.45	602.47	602.49
900	601.73	601.81	601.85	601.88	601.90	601.92	601.93	601.95	602.07	602.12	602.14	602.15	602.16
750	601.36	601.48	601.56	601.63	601.67	601.70	601.74	601.79	602.00	602.05	602.07	602.08	602.09
600	600.94	601.05	601.10	601.14	601.16	601.18	601.19	601.20	601.24	601.24	601.25	601.25	601.25
450	600.72	600.82	600.87	600.90	600.92	600.93	600.94	600.96	600.98	600.99	600.99	600.99	601.00
300	600.32	600.37	600.39	600.41	600.42	600.43	600.43	600.44	600.46	600.46	600.46	600.46	600.46
150	599.38	599.48	599.53	599.58	599.60	599.61	599.62	599.63	599.66	599.67	599.67	599.67	599.67
0	587.42	588.19	588.69	589.16	589.54	589.79	590.09	590.30	590.82	591.24	591.49	591.80	592.02

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Appendix E

Hydraulic Model Sensitivity Analysis Inundation Width Tables

Classification: Public

Table E-1: Upper Spirit River Sensitivity Analysis Inundation Width Summary

Spirit River Station (m)	Base Case	Manning's Roughness (Channel)				Manning's Roughness (Overbank)			
		-20%		+20%		-20%		+20%	
		Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)
17,000	34.1	33.0	-1.1	34.1	0.0	33.4	-0.7	34.1	0.0
16,500	29.4	28.8	-0.6	29.8	0.4	29.4	-0.1	29.6	0.1
16,000	54.2	53.4	-0.8	55.3	1.0	54.2	0.0	55.0	0.8
15,500	36.1	35.4	-0.7	36.8	0.7	36.1	0.0	36.1	0.0
15,000	40.0	38.9	-1.1	40.0	0.0	40.0	0.0	40.0	0.0
14,500	49.6	49.6	0.0	51.0	1.4	49.6	0.0	49.6	0.0
14,000	74.0	73.3	-0.7	74.0	0.0	74.0	0.0	74.0	0.0
13,500	57.5	56.7	-0.8	58.3	0.8	57.5	0.0	57.5	0.0
13,000	43.5	42.0	-1.5	46.4	2.9	43.5	0.0	44.4	0.9
12,500	82.5	82.5	0.0	83.3	0.8	82.5	0.0	83.3	0.8
12,000	57.2	56.7	-0.5	58.8	1.5	56.7	-0.5	57.3	0.1
11,500	53.6	53.6	0.0	53.6	0.0	53.6	0.0	53.6	0.0
11,000	59.8	59.3	-0.6	61.0	1.2	59.8	0.0	60.1	0.3

Table E-2: Middle Spirit River Sensitivity Analysis Inundation Width Summary

Spirit River Station (m)	Base Case	Manning's Roughness (Channel)				Manning's Roughness (Overbank)			
		-20%		+20%		-20%		+20%	
		Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)
10,500	32.9	31.2	-1.7	34.4	1.5	32.0	-0.8	33.7	0.8
10,000	30.1	28.2	-1.9	32.8	2.6	30.1	0.0	30.8	0.7
9,500	33.8	32.9	-0.9	37.0	3.2	33.8	0.0	33.8	0.0

Table E-3: Lower Spirit River Sensitivity Analysis Inundation Width Summary

Spirit River Station (m)	Base Case	Normal Depth Slope (Downstream Boundary Condition)				Manning's Roughness (Channel)				Manning's Roughness (Overbank)			
		-20% (s = 0.0008)		+20% (s = 0.00012)		-20%		+20%		-20%		+20%	
		Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)
9,000	25.3	25.3	0.0	25.3	0.0	24.4	-0.8	25.3	0.0	25.3	0.0	25.3	0.0
8,500	40.4	40.4	0.0	40.4	0.0	38.9	-1.5	41.1	0.8	39.8	-0.5	40.4	0.0
8,000	43.4	43.4	0.0	43.4	0.0	40.5	-2.8	45.1	1.7	42.4	-0.9	44.2	0.9
7,500	53.9	53.9	0.0	53.9	0.0	51.7	-2.1	56.5	2.6	53.9	0.0	54.8	0.9
7,000	41.9	41.9	0.0	41.9	0.0	38.8	-3.1	43.5	1.6	41.1	-0.8	41.9	0.0
6,500	41.1	41.1	0.0	41.1	0.0	38.7	-2.4	43.5	2.4	40.4	-0.7	41.1	0.0
6,000	62.6	62.6	0.0	62.6	0.0	61.1	-1.5	64.2	1.6	62.6	0.0	63.4	0.8
5,500	63.6	63.6	0.0	63.6	0.0	62.5	-1.1	65.6	2.1	63.6	0.0	64.6	1.1
5,000	50.6	50.6	0.0	50.6	0.0	49.6	-1.0	52.1	1.5	50.6	0.0	52.1	1.5
4,500	55.0	55.0	0.0	55.0	0.0	52.7	-2.3	56.0	1.0	54.0	-1.0	56.0	1.0
4,000	22.2	22.2	0.0	22.2	0.0	22.2	0.0	23.1	0.9	22.2	0.0	22.2	0.0
3,500	20.1	20.1	0.0	20.1	0.0	19.3	-0.8	20.8	0.7	20.1	0.0	20.1	0.0
3,000	25.6	25.6	0.0	25.6	0.0	25.6	0.0	30.2	4.6	25.6	0.0	29.6	4.0
2,500	20.2	20.2	0.0	20.2	0.0	19.0	-1.2	20.7	0.5	20.2	0.0	20.2	0.0
2,000	29.8	29.8	0.0	29.8	0.0	29.1	-0.7	30.8	1.0	29.8	0.0	30.8	1.0
1,500	20.6	20.6	0.0	20.6	0.0	20.0	-0.6	22.2	1.7	20.6	0.0	21.1	0.5
1,000	34.7	34.7	0.0	34.7	0.0	33.7	-1.0	34.7	0.0	34.7	0.0	34.7	0.0
500	27.2	27.2	0.0	26.5	-0.6	26.5	-0.6	27.2	0.0	26.5	-0.6	27.2	0.0
0	33.8	33.8	0.0	33.4	-0.4	33.8	0.0	33.8	0.0	33.4	-0.4	33.8	0.0

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Table E-4: Unnamed Tributary Sensitivity Analysis Inundation Width Summary

Unnamed Tributary Station (m)	Base Case	Manning's Roughness (Channel)				Manning's Roughness (Overbank)			
		-20%		+20%		-20%		+20%	
		Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)
2,600	23.9	23.9	0.0	23.9	0.0	22.2	-1.7	24.9	1.0
2,400	24.9	24.2	-0.7	24.9	0.0	24.9	0.0	24.9	0.0
2,200	20.0	19.0	-1.0	20.9	0.9	20.0	0.0	20.0	0.0
2,000	26.9	26.4	-0.6	26.9	0.0	26.9	0.0	26.9	0.0
1,800	16.1	16.1	0.0	16.1	0.0	16.1	0.0	16.1	0.0
1,600	32.2	32.2	0.0	32.2	0.0	32.2	0.0	32.2	0.0
1,400	37.2	37.2	0.0	37.2	0.0	37.2	0.0	37.2	0.0
1,200	5.4	5.4	0.0	5.4	0.0	5.4	0.0	5.4	0.0
1,000	7.1	7.1	0.0	7.1	0.0	7.1	0.0	7.1	0.0
800	25.4	25.4	0.0	25.4	0.0	24.8	-0.6	25.4	0.0
600	5.1	5.1	0.0	5.1	0.0	5.1	0.0	5.1	0.0
400	8.8	8.8	0.0	9.9	1.2	8.8	0.0	8.8	0.0
200	3.0	2.8	-0.2	3.4	0.4	3.0	0.0	2.9	-0.1
0	18.0	17.0	-0.9	20.7	2.7	18.0	0.0	18.6	0.7

Table E-5: West Ditch of Highway 2 Sensitivity Analysis Inundation Width Summary

West Ditch of Highway 2 Station (m)	Base Case	Manning's Roughness (Channel)				Manning's Roughness (Overbank)			
		-20%		+20%		-20%		+20%	
		Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)	Inundation Width (m)	Difference in Inundation Width (m)
3,200	97.7	97.7	0.0	97.7	0.0	97.7	0.0	98.4	0.7
3,000	173.1	173.1	0.0	173.1	0.0	172.6	-0.5	173.1	0.0
2,800	87.2	87.2	0.0	87.2	0.0	87.2	0.0	96.8	9.6
2,600	20.2	20.2	0.0	24.9	4.7	20.2	0.0	20.2	0.0
2,400	70.4	70.4	0.0	72.7	2.3	70.4	0.0	70.4	0.0
2,200	14.2	14.2	0.0	14.2	0.0	14.2	0.0	14.2	0.0
2,000	73.2	73.2	0.0	74.0	0.8	70.7	-2.5	73.2	0.0
1,800	52.0	52.0	0.0	52.0	0.0	52.0	0.0	52.0	0.0
1,600	18.2	18.2	0.0	18.2	0.0	15.3	-3.0	18.4	0.2
1,400	36.0	36.0	0.0	36.0	0.0	35.8	-0.2	36.0	0.0
1,200	129.1	129.1	0.0	129.4	0.3	129.1	0.0	129.4	0.3
1,000	4.8	4.8	0.0	5.8	1.0	4.8	0.0	4.8	0.0
800	7.0	7.0	0.0	7.0	0.0	7.0	0.0	7.0	0.0
600	5.5	5.3	-0.2	5.6	0.2	5.5	0.0	5.5	0.0
400	6.6	6.6	0.0	6.6	0.0	6.6	0.0	6.6	0.0
200	15.3	14.4	-0.9	15.4	0.1	15.3	0.0	15.3	0.0
0	12.0	11.1	-0.8	12.5	0.5	12.0	0.0	12.0	0.0

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Appendix F

Open Water Flood Inundation Map Library

(provided under separate cover)

Classification: Public

Innovation. Integrity. Employee-Owned.

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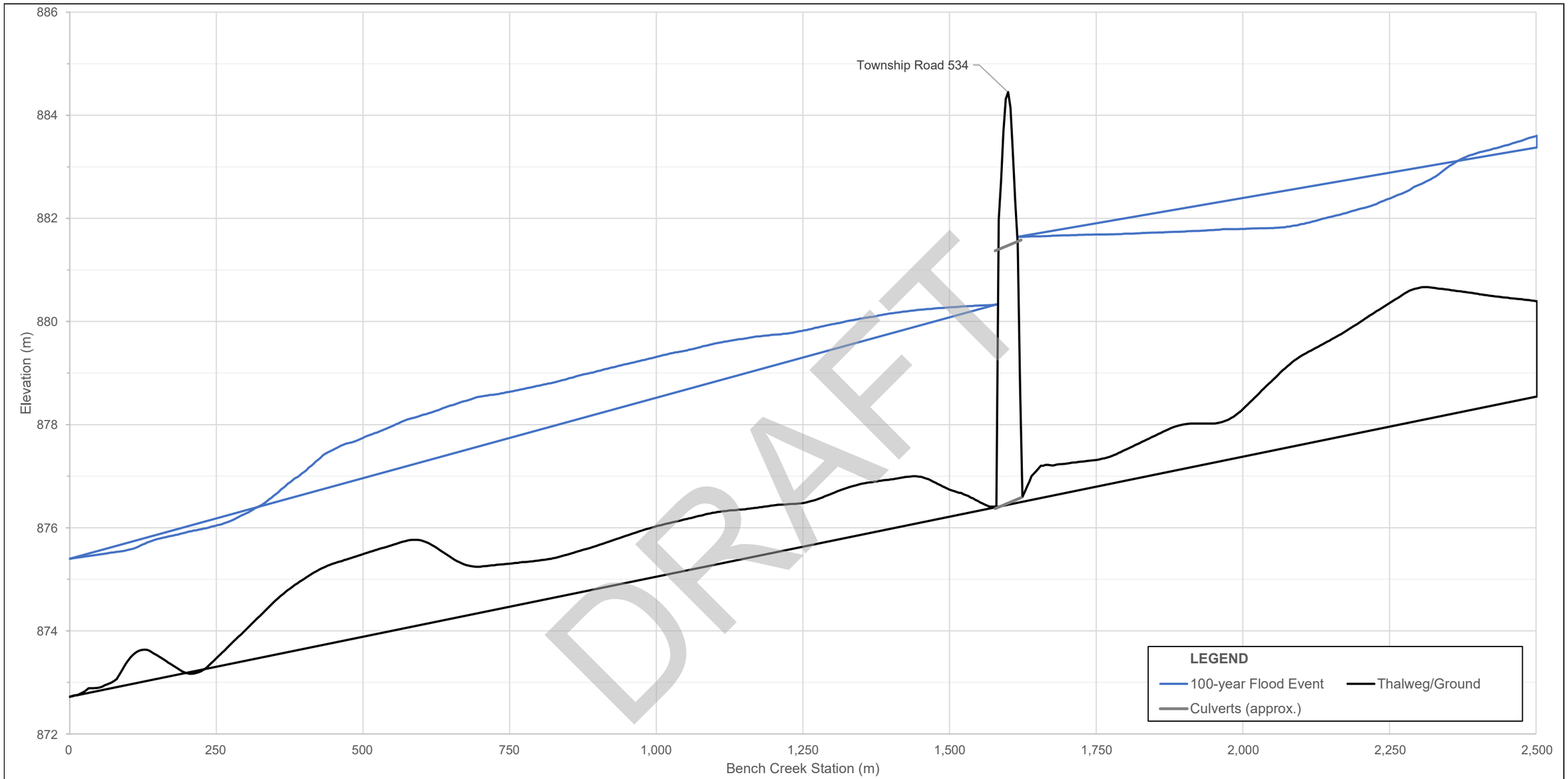
Appendix G

Open Water Design Flood Profile

Classification: Public



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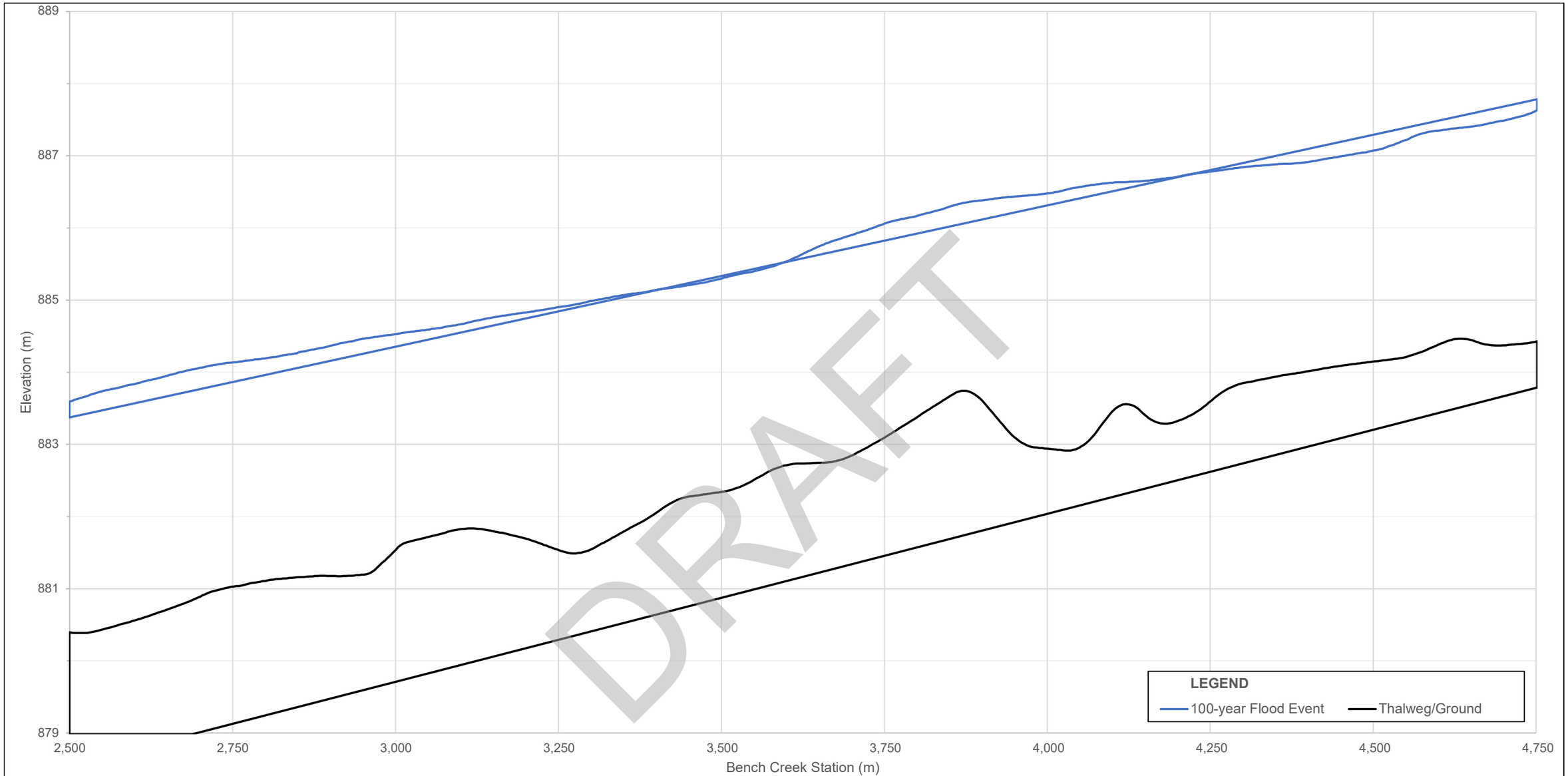
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-1
DESIGN FLOOD PROFILE — BENCH CREEK
(STATION 000-2,500)

Classification: Public



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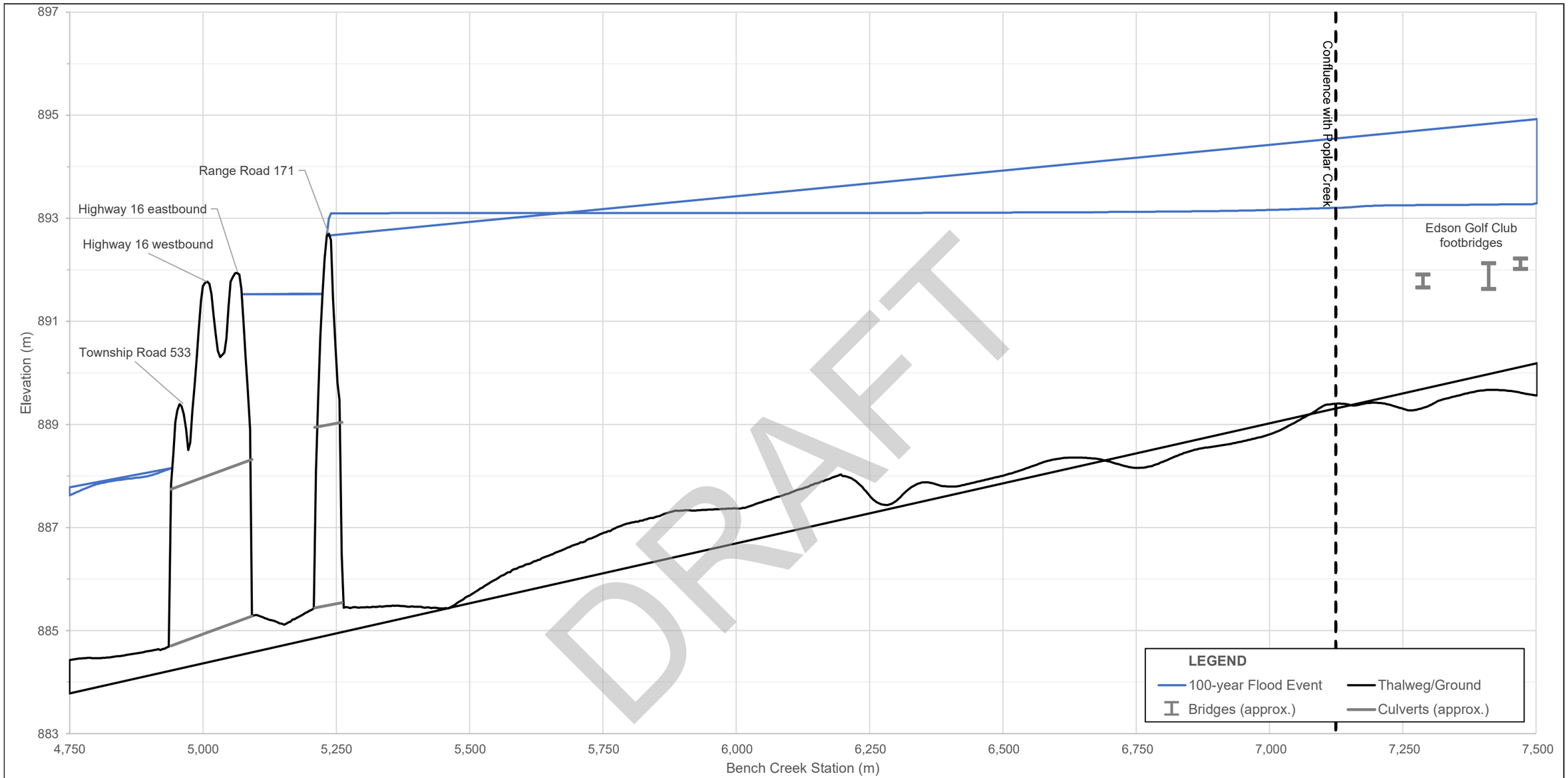
KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-2
DESIGN FLOOD PROFILE — BENCH CREEK (STATION 2,500-4,750)

Classification: Public



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Alberta Canada

kwl 50 Innovation. Integrity. Employee-Owned.

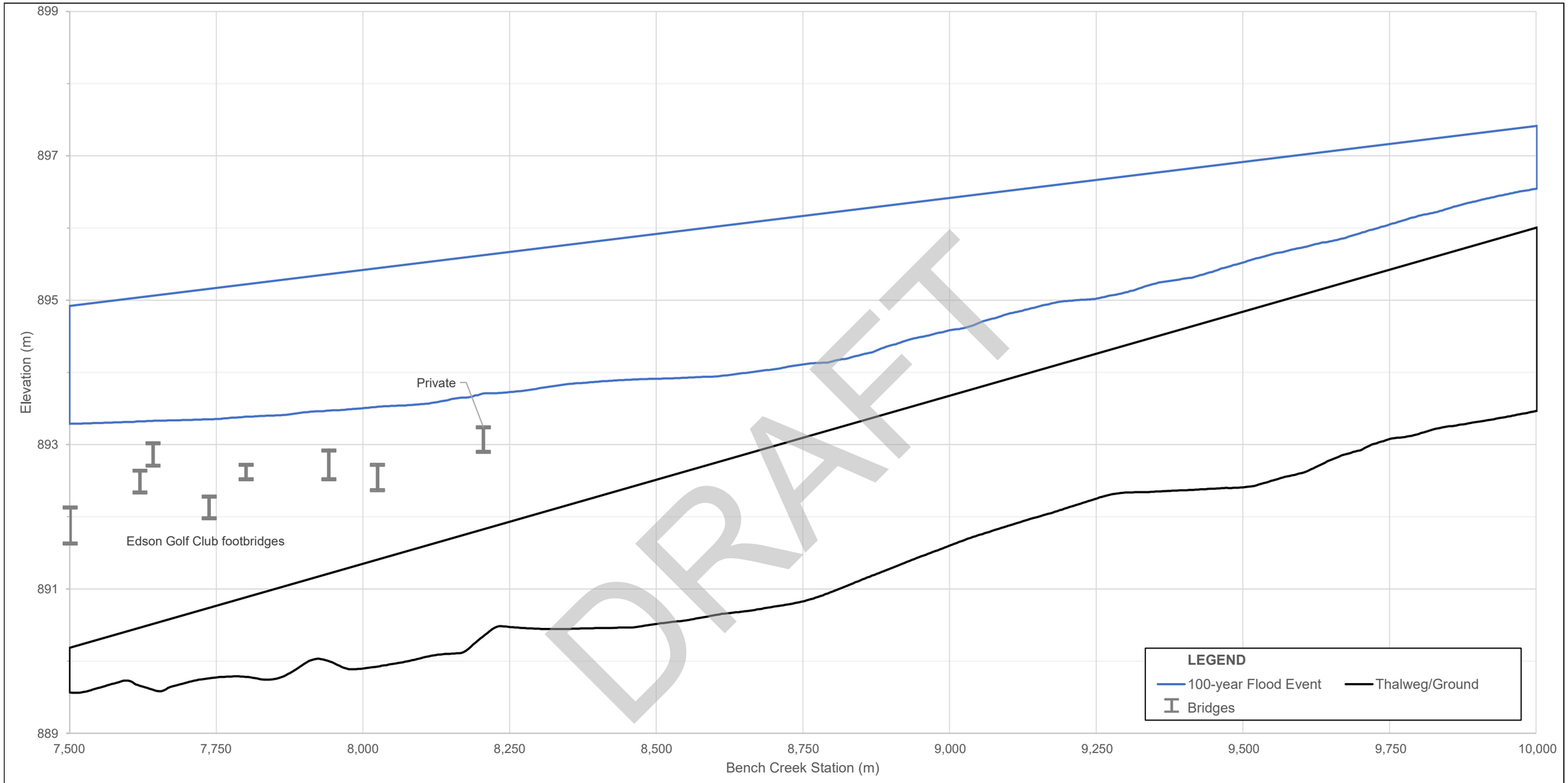
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-3
DESIGN FLOOD PROFILE — BENCH CREEK
(STATION 4,750-7,500)

Classification: Public



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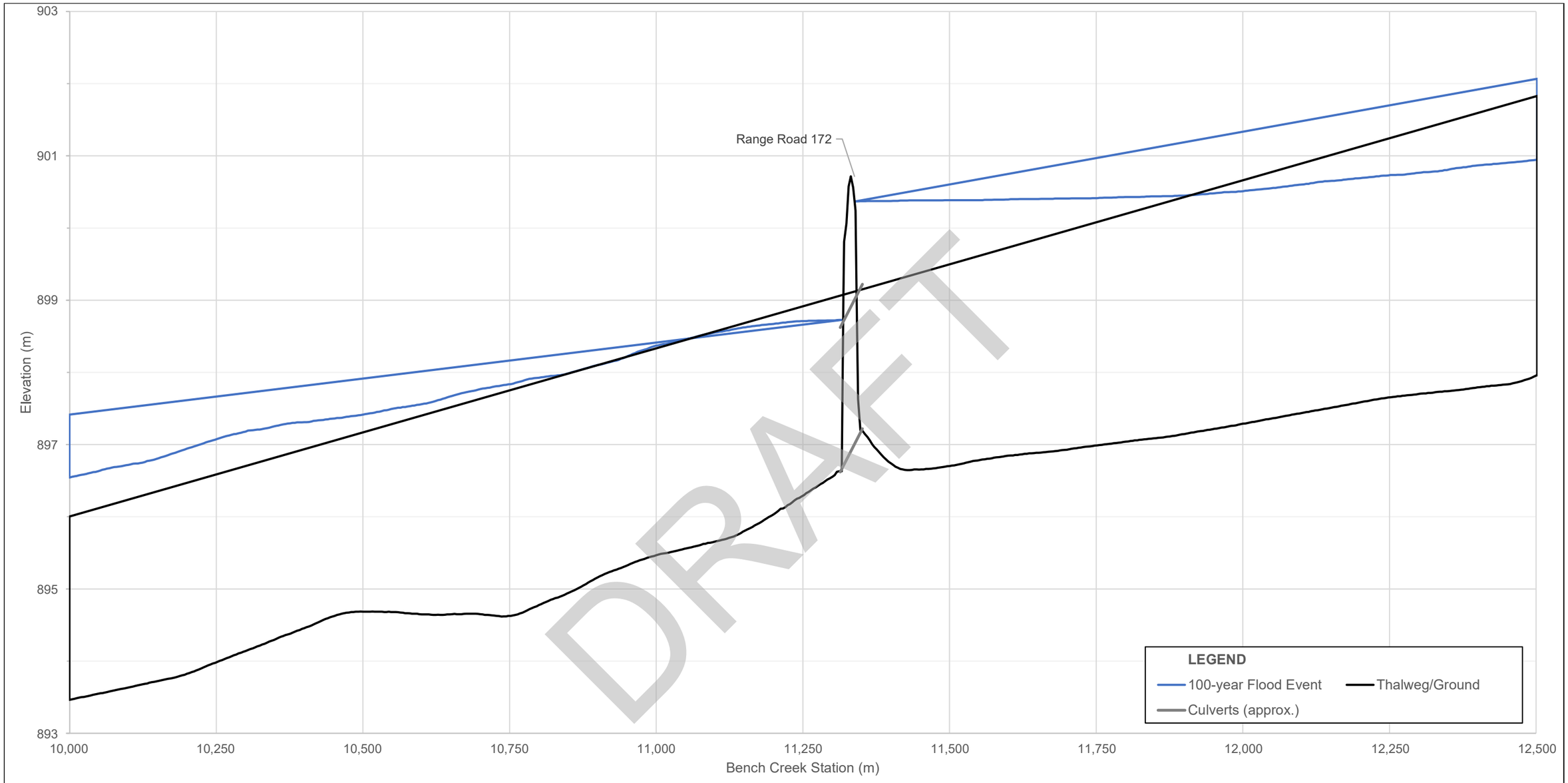
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-4
DESIGN FLOOD PROFILE — BENCH CREEK
(STATION 7,500-10,000)

Classification: Public



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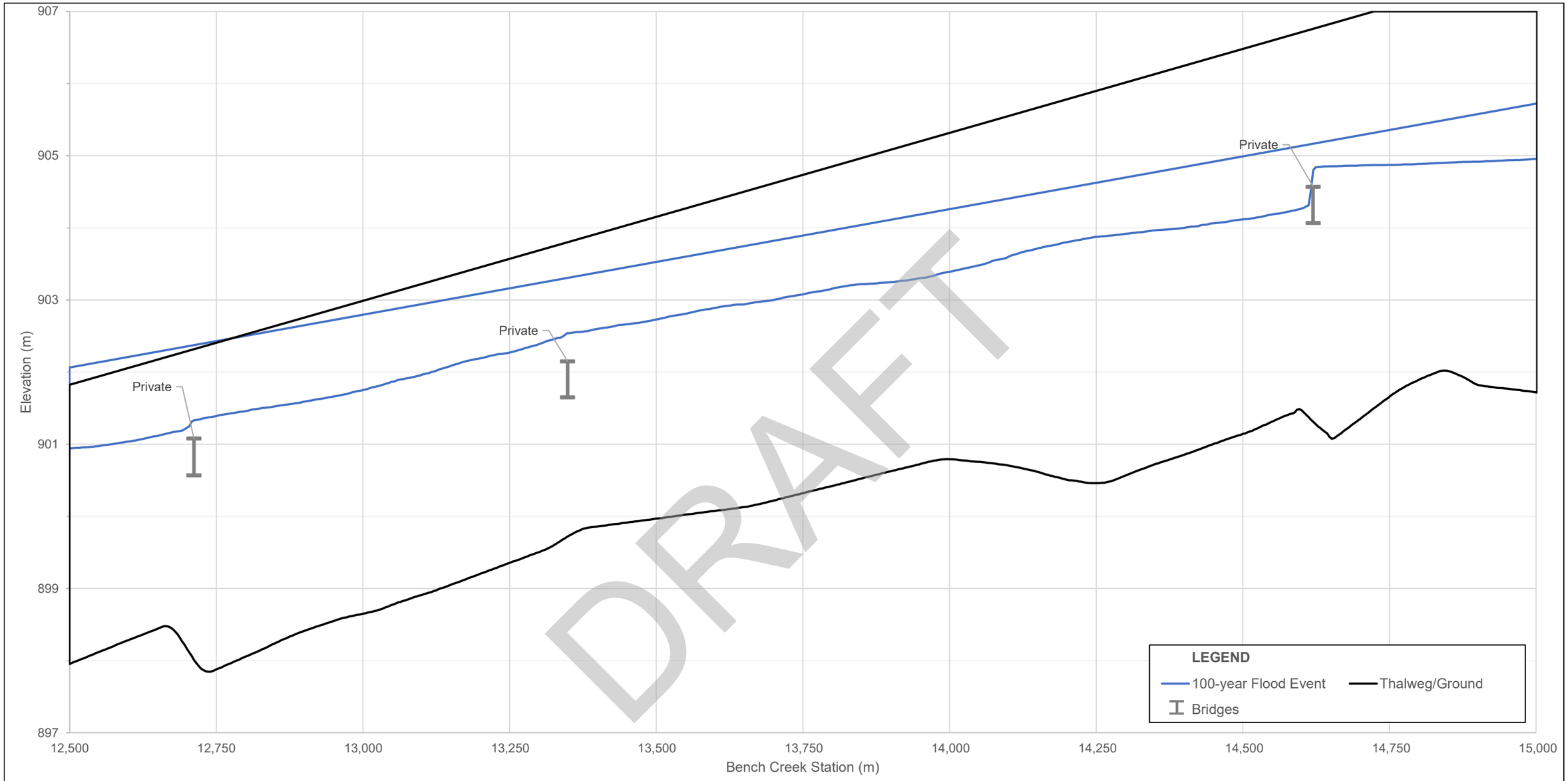
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-5
DESIGN FLOOD PROFILE — BENCH CREEK
(STATION 10,000-12,500)

Classification: Public



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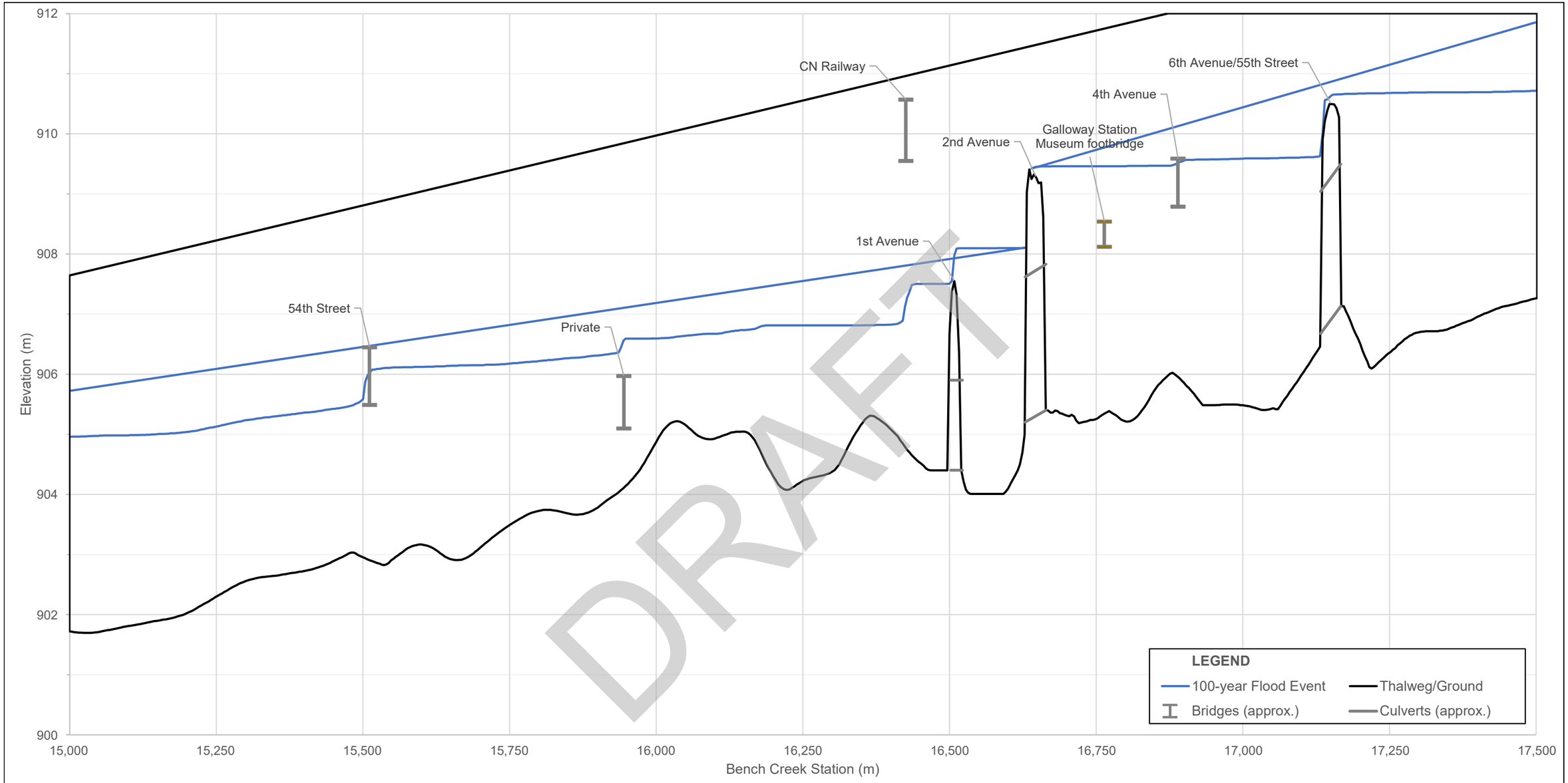
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-6
DESIGN FLOOD PROFILE — BENCH CREEK (STATION 12,500-15,000)

Classification: Public



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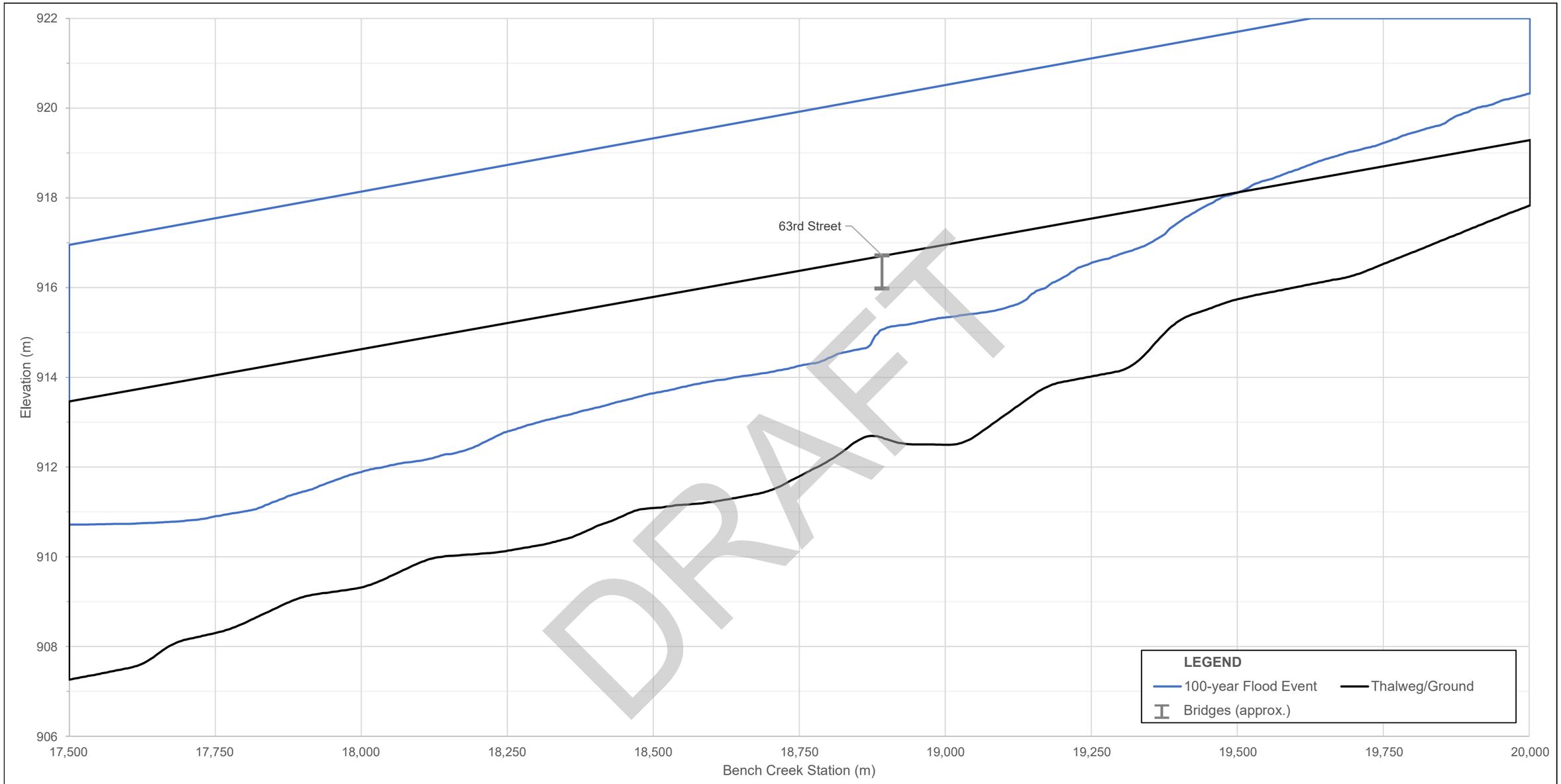
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-7
DESIGN FLOOD PROFILE — BENCH CREEK
(STATION 15,000-17,500)

Classification: Public



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Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.

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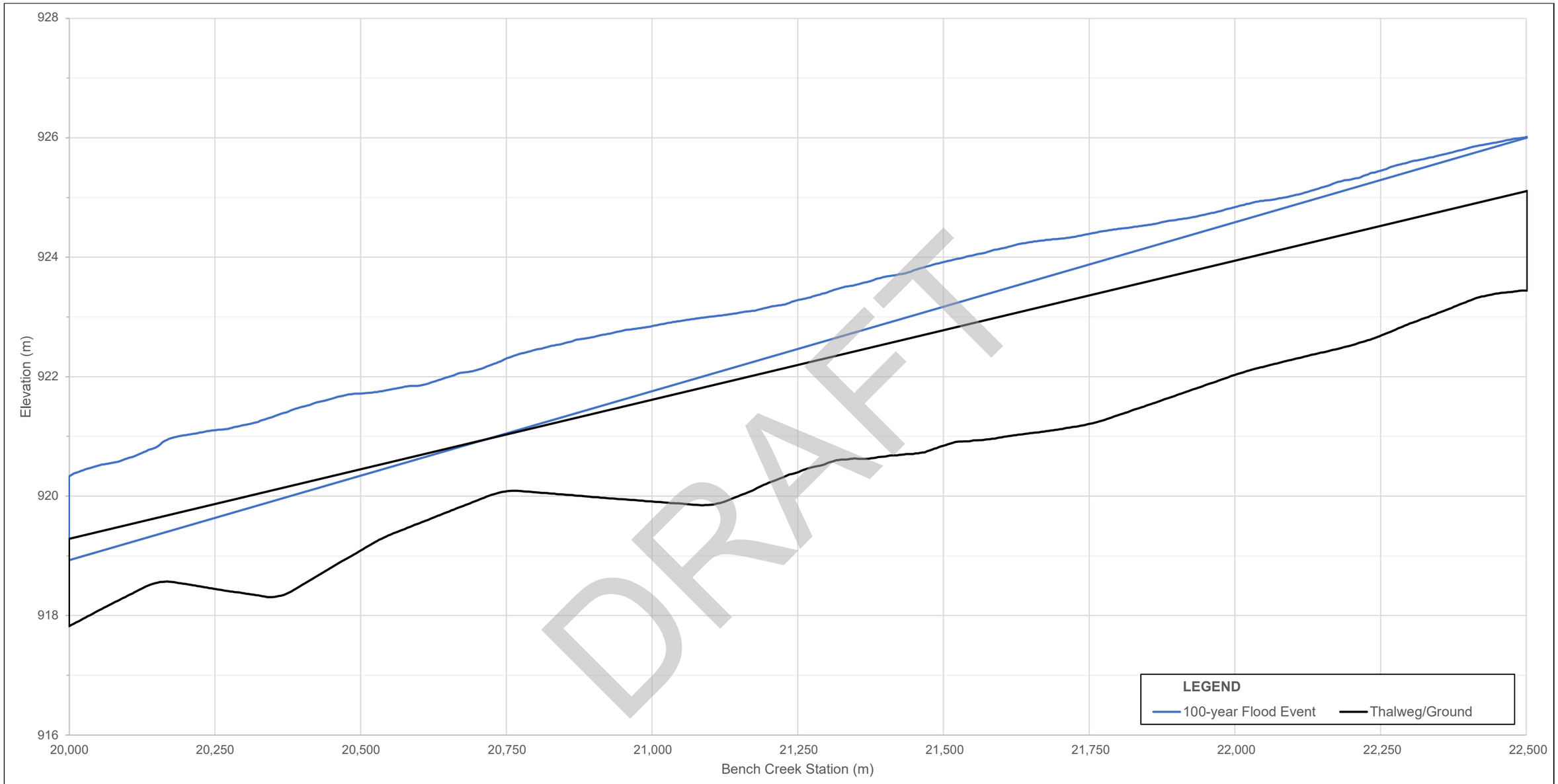
Date: 2025-10

EDSON FLOOD STUDY

Figure G-8
DESIGN FLOOD PROFILE — BENCH CREEK
(STATION 17,500-20,000)

Classification: Public



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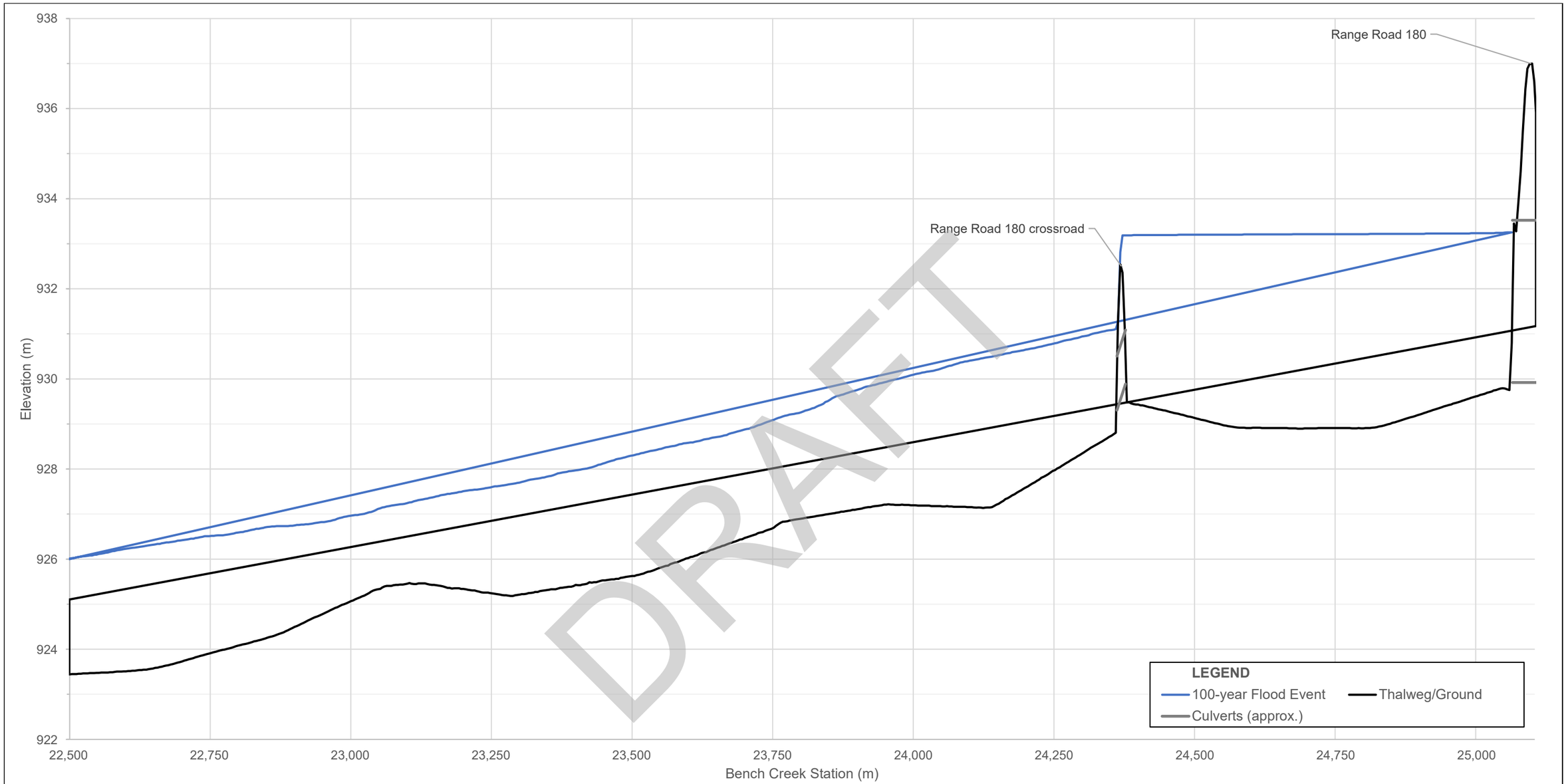
Date: 2025-10

EDSON FLOOD STUDY

Figure G-9
DESIGN FLOOD PROFILE — BENCH CREEK
(STATION 20,000-22,500)

Classification: Public



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Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

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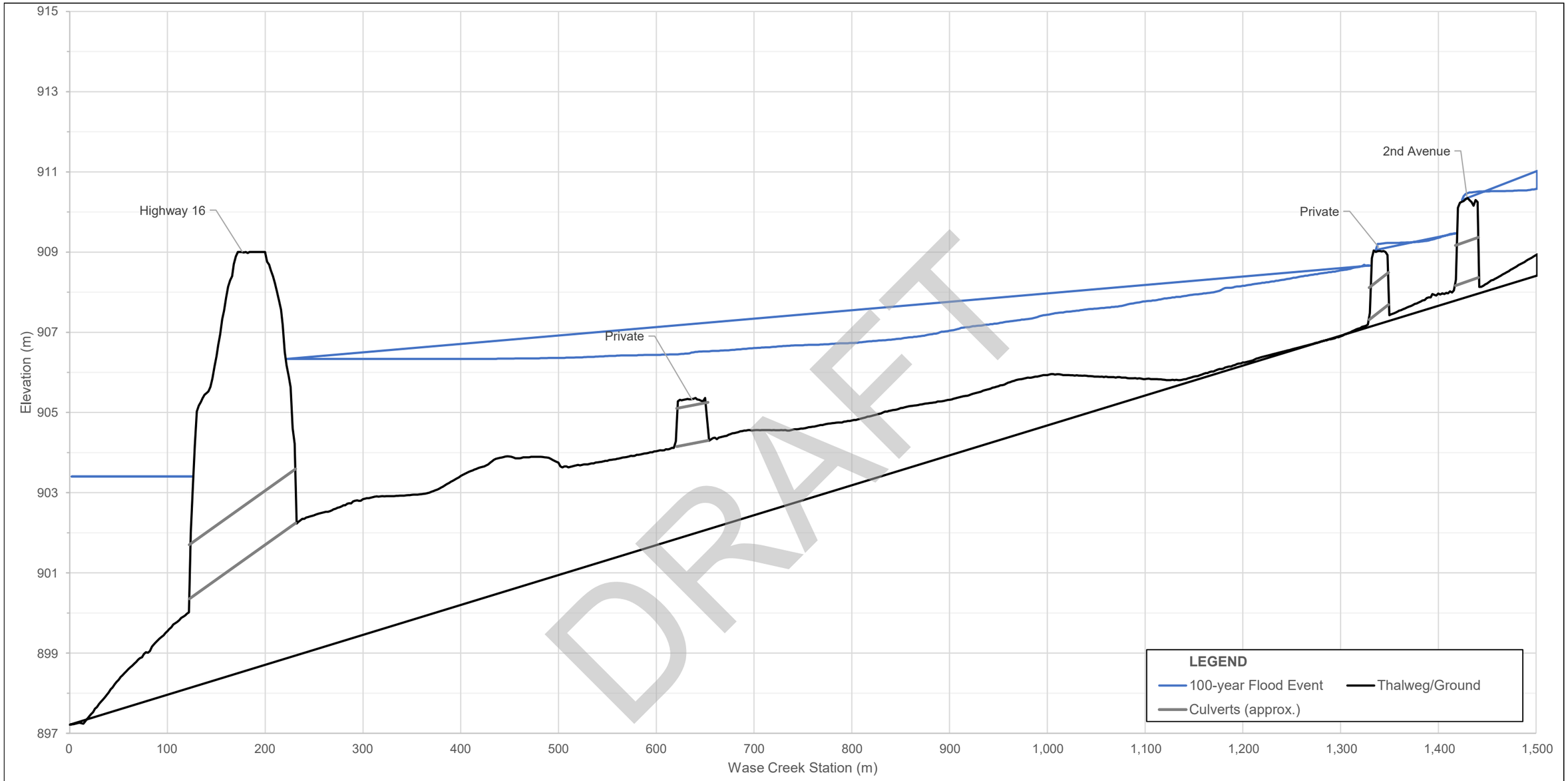
Date: 2025-10

EDSON FLOOD STUDY

Figure G-10
DESIGN FLOOD PROFILE — BENCH CREEK
(STATION 22,500-25,105)

Classification: Public



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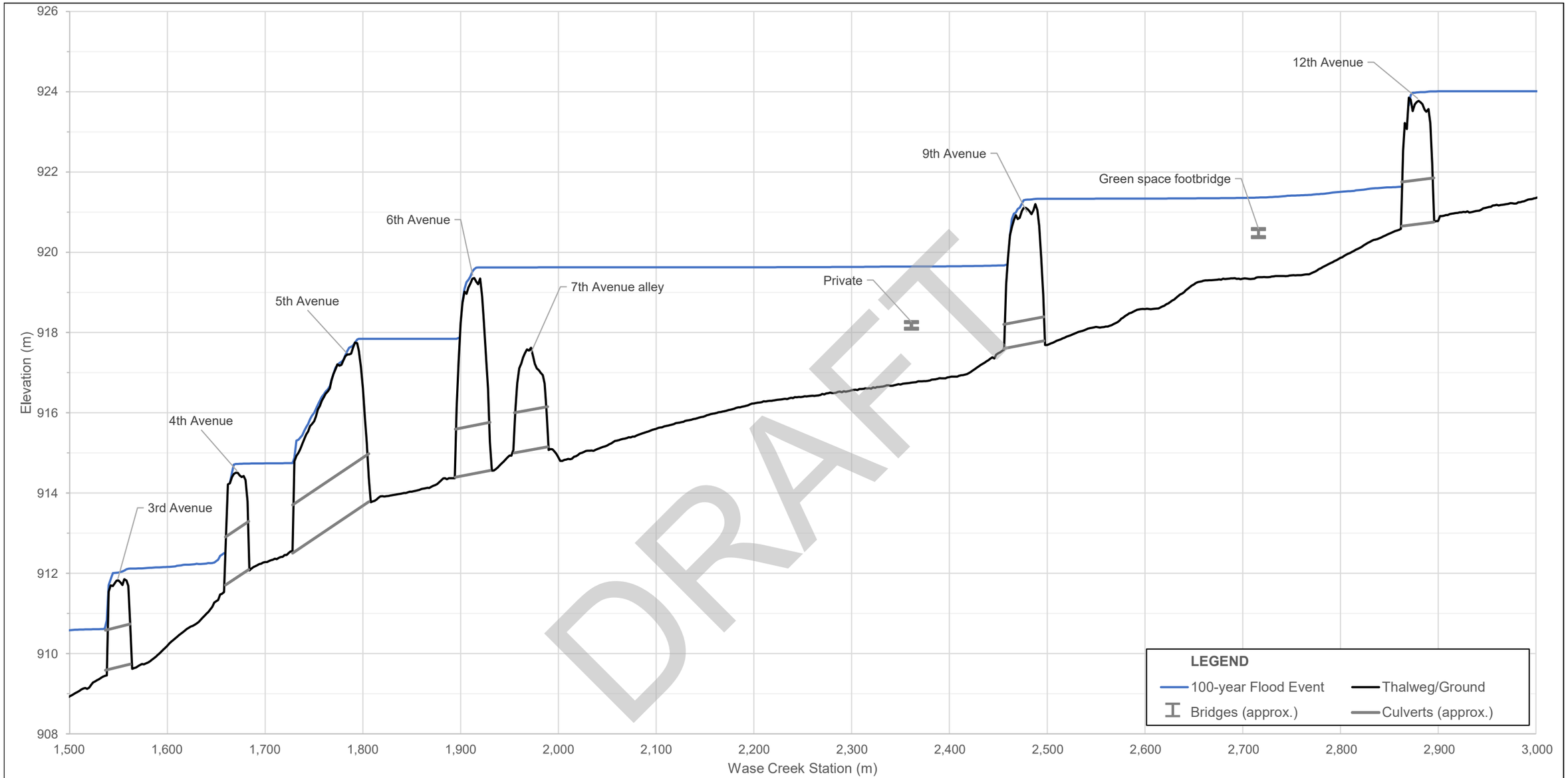
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-11
DESIGN FLOOD PROFILE — WASE CREEK
(STATION 000-1,500)

Classification: Public



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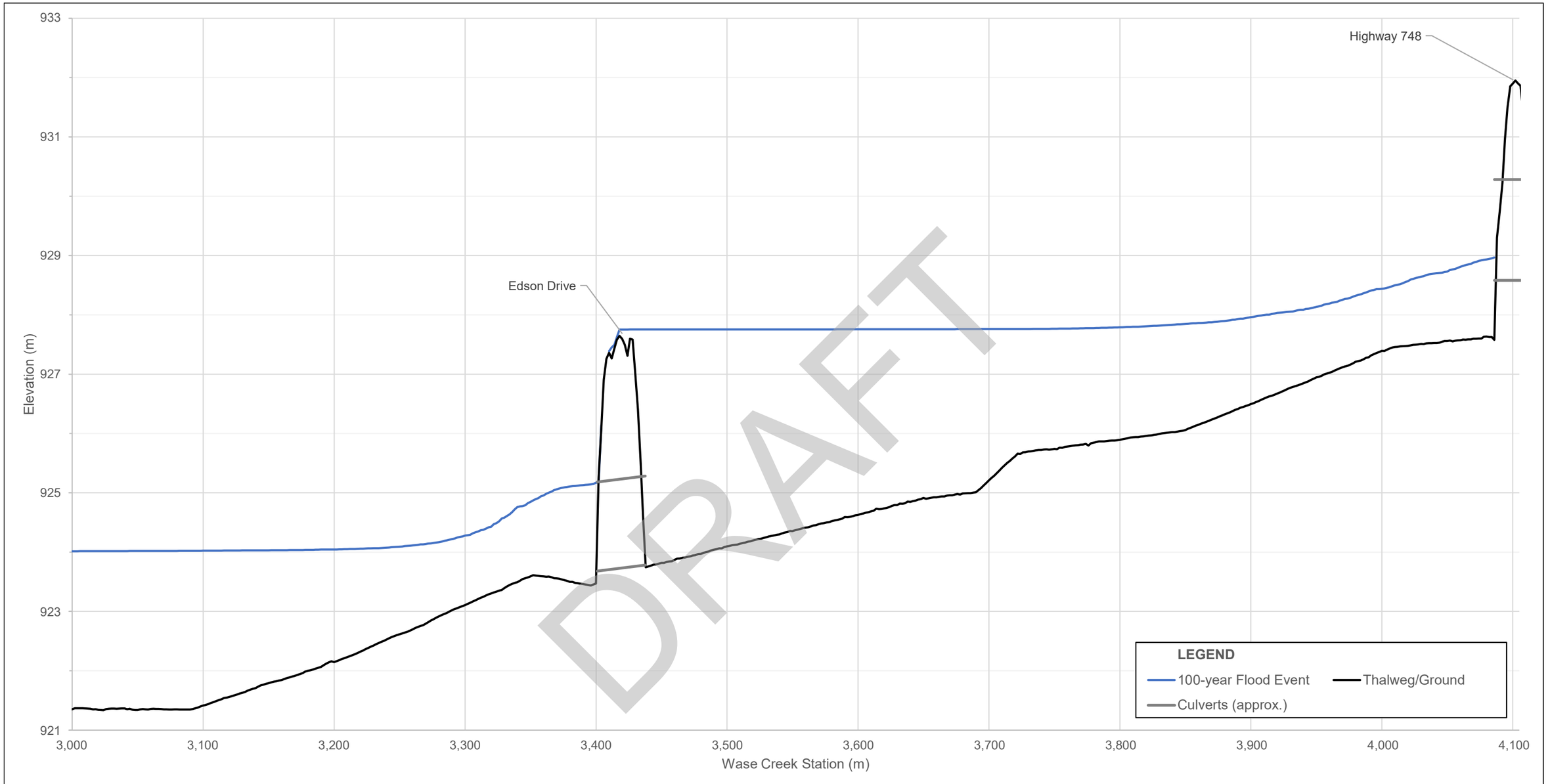
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-12
DESIGN FLOOD PROFILE — WASE CREEK
(STATION 1,500-3,000)

Classification: Public



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kwl 50 Innovation. Integrity. Employee-Owned.

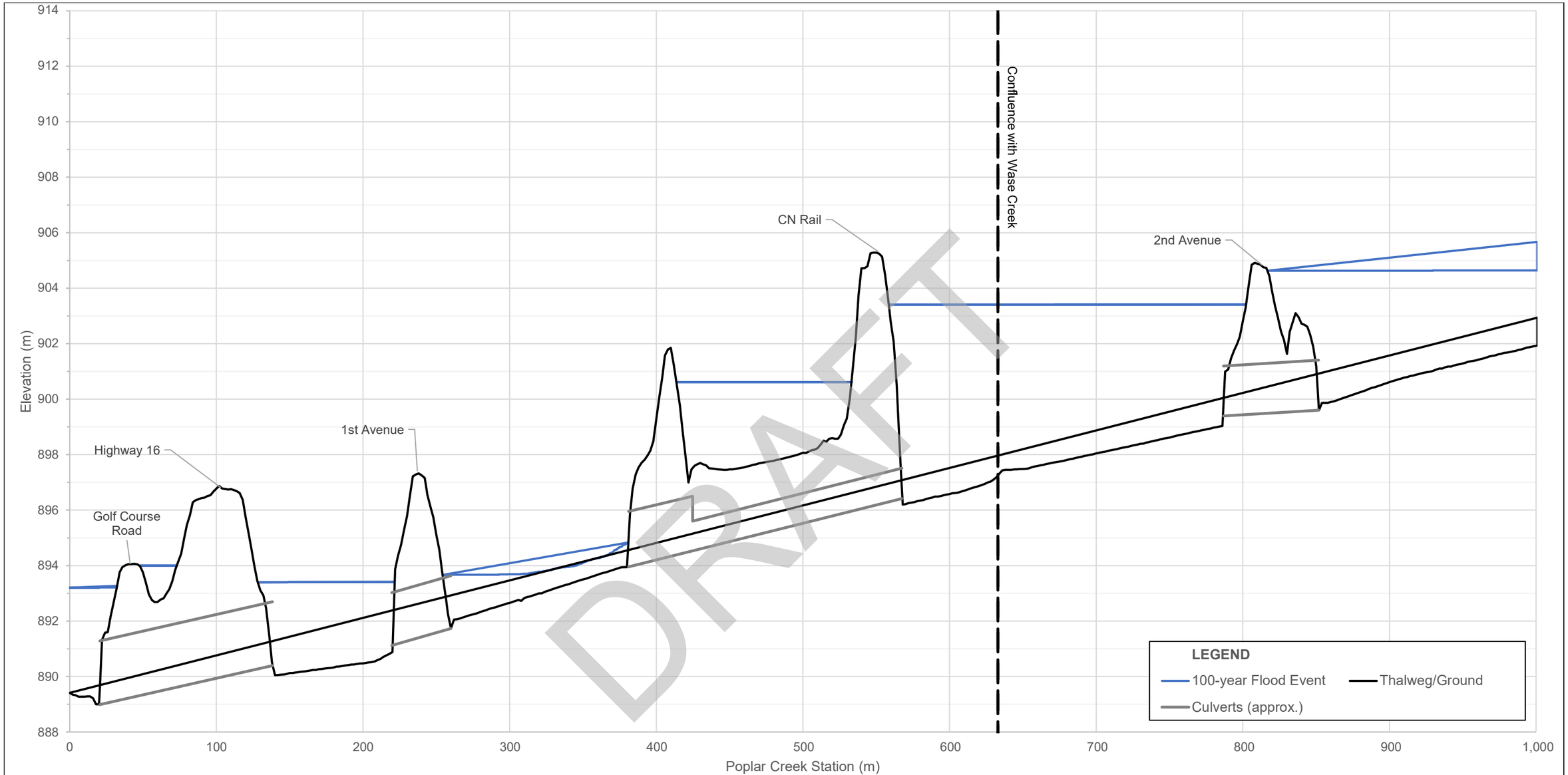
Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-13
DESIGN FLOOD PROFILE — WASE CREEK
(STATION 3,000-4,105)

Classification: Public



Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.
2. The CN Rail culvert comprises sections of pipe of differing diameters connected by manholes.

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Date: 2025-10

EDSON FLOOD STUDY

Figure G-14
DESIGN FLOOD PROFILE — POPLAR CREEK (STATION 000-1,000)

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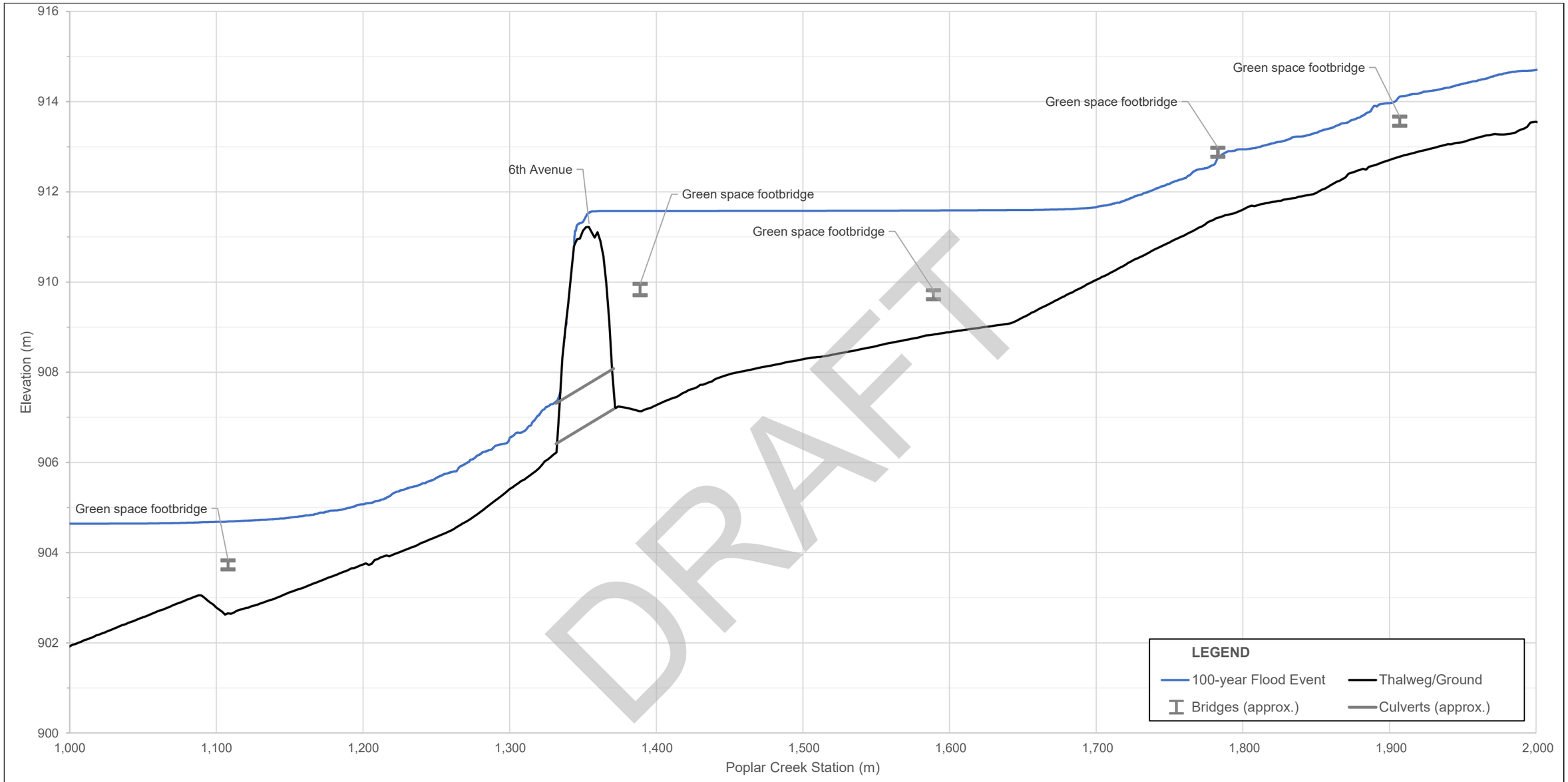
Classification: Public



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Alberta Canada

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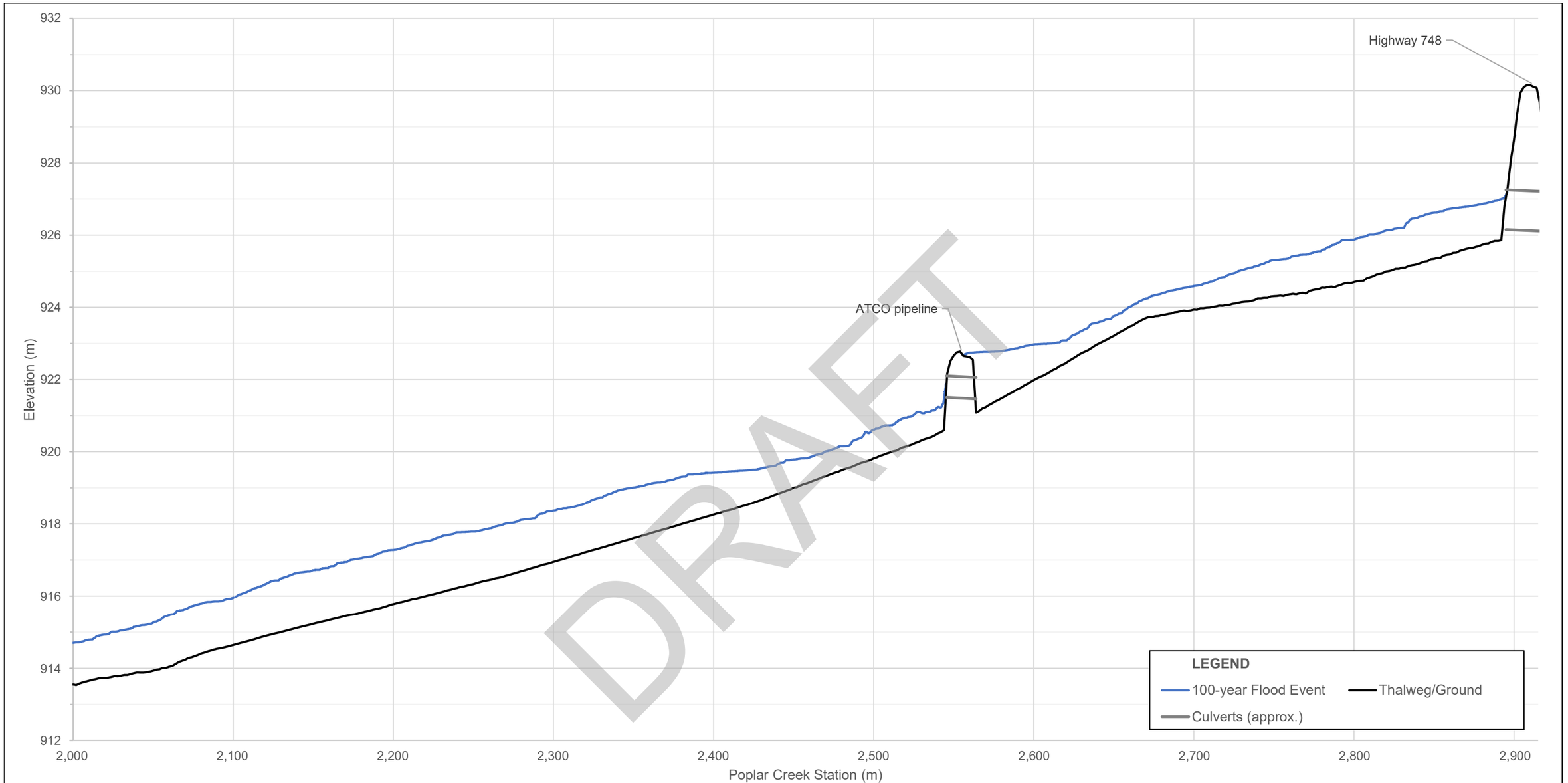
Notes
1. Bridge lines represent the roadway (maximum) and low chord (minimum) elevations.
2. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

KWL Project No.: 3052.029
Date: 2025-10

EDSON FLOOD STUDY

Figure G-15
DESIGN FLOOD PROFILE — POPLAR CREEK
(STATION 1,000-2,000)

Classification: Public



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Notes
1. Culvert lines represent the obvert (maximum) and invert (minimum) elevations.

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Date: 2025-10

EDSON FLOOD STUDY

Figure G-16
DESIGN FLOOD PROFILE — POPLAR CREEK
(STATION 2,000-2,915)

Classification: Public

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Appendix H

Floodway Determination Criteria Tables

Classification: Public

Table H-1: Upper Bench Creek Floodway Determination Criteria

Bench Creek Station (m)	Floodway Determination Criteria	
	Left Bank	Right Bank
25,000	≥1 m depth	≥1 m depth
24,500		
24,000		
23,500		
23,000		
22,500		
22,000		
21,500		
21,000		
20,500		
20,000		
19,500	Main Channel	Main Channel
19,000	≥1 m depth	≥1 m depth
18,500		
18,000		
17,500		
17,000		
16,500		
16,000		
15,500		
15,000		
14,500		
14,000		
13,500		
13,000		
12,500		
12,000		
11,500		
11,000	≥1 m depth and ≥1 m/s velocity	
10,500	≥1 m depth	
10,000		
9,500		
9,000		
8,500		
8,000		
7,500		

Table H-2: Lower Bench Creek Floodway Determination Criteria

Bench Creek Station (m)	Floodway Determination Criteria	
	Left Bank	Right Bank
7,000	≥1 m depth	≥1 m depth
6,500		
6,000		
5,500		
5,000		
4,500		
4,000		
3,500	Main Channel	Main Channel
3,000	≥1 m depth	≥1 m depth
2,500		
2,000		
1,500		
1,000		
500		
0		

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Table H-3: Wase Creek Floodway Determination Criteria

Wase Creek Station (m)	Floodway Determination Criteria	
	Left Bank	Right Bank
4,000	Main Channel	Main Channel
3,800		
3,600	≥1 m depth	≥1 m depth
3,400		
3,200	Main Channel	Main Channel
3,000	≥1 m depth	≥1 m depth
2,800		
2,600		
2,400		
2,200		
2,000		
1,800		
1,600	≥1 m/s velocity	≥1 m/s velocity
1,400		Main Channel
1,200	≥1 m depth and ≥1 m/s velocity	≥1 m depth and ≥1 m/s velocity
1,000		
800		
600		
400	≥1 m depth	≥1 m depth
200		
0		

Table H-4: Upper Poplar Creek Floodway Determination Criteria

Poplar Creek Station (m)	Floodway Determination Criteria	
	Left Bank	Right Bank
2,800	≥1 m depth and ≥1 m/s velocity	≥1 m depth and ≥1 m/s velocity
2,600	Main Channel	Main Channel
2,400		
2,200	≥1 m/s velocity	≥1 m/s velocity
2,000		
1,800	≥1 m depth and ≥1 m/s velocity	≥1 m depth and ≥1 m/s velocity
1,600	≥1 m depth	≥1 m depth
1,400		
1,200	≥1 m/s velocity	≥1 m/s velocity
1,000	≥1 m depth	≥1 m depth
800		

Table H-5: Lower Poplar Creek Floodway Determination Criteria

Poplar Creek Station (m)	Floodway Determination Criteria	
	Left Bank	Right Bank
600	≥1 m depth	≥1 m depth
400		
200	Main Channel	Main Channel
0	≥1 m depth	≥1 m depth

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Appendix I

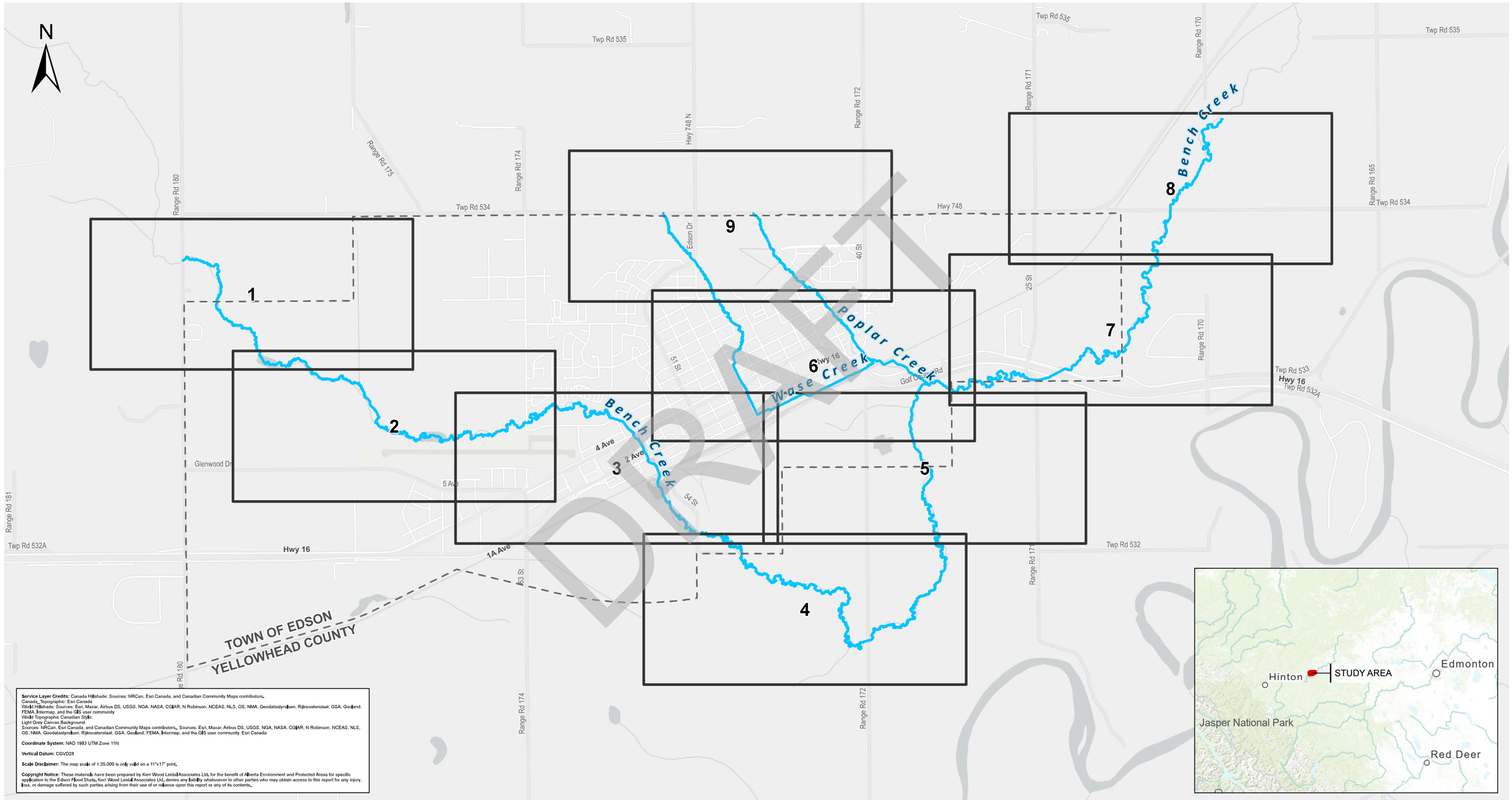
Floodway Criteria Maps

Classification: Public

Path: P:\3000-3099\3052-029\430-GIS\Pro Projects\3052029_FloodWayCriteriaMaps\3052029_FloodWayCriteriaMaps.aprx\3052029_FloodwayCriteria_Overview | Date Saved: 2025-10-23 9:24 AM | Author: tromans

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.



Service Layer Credits: Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors.
Canada_Topographic: Esri Canada
World Hillshade: Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community
World Topographic Canadian Style:
Light Grey Canvas Background:
Sources: NRCan, Esri Canada, and Canadian Community Maps contributors,, Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community, Esri Canada

Coordinate System: NAD 1983 UTM Zone 11N

Vertical Datum: CGVD28

Scale Disclaimer: The map scale of 1:35,000 is only valid on a 11"x17" print.

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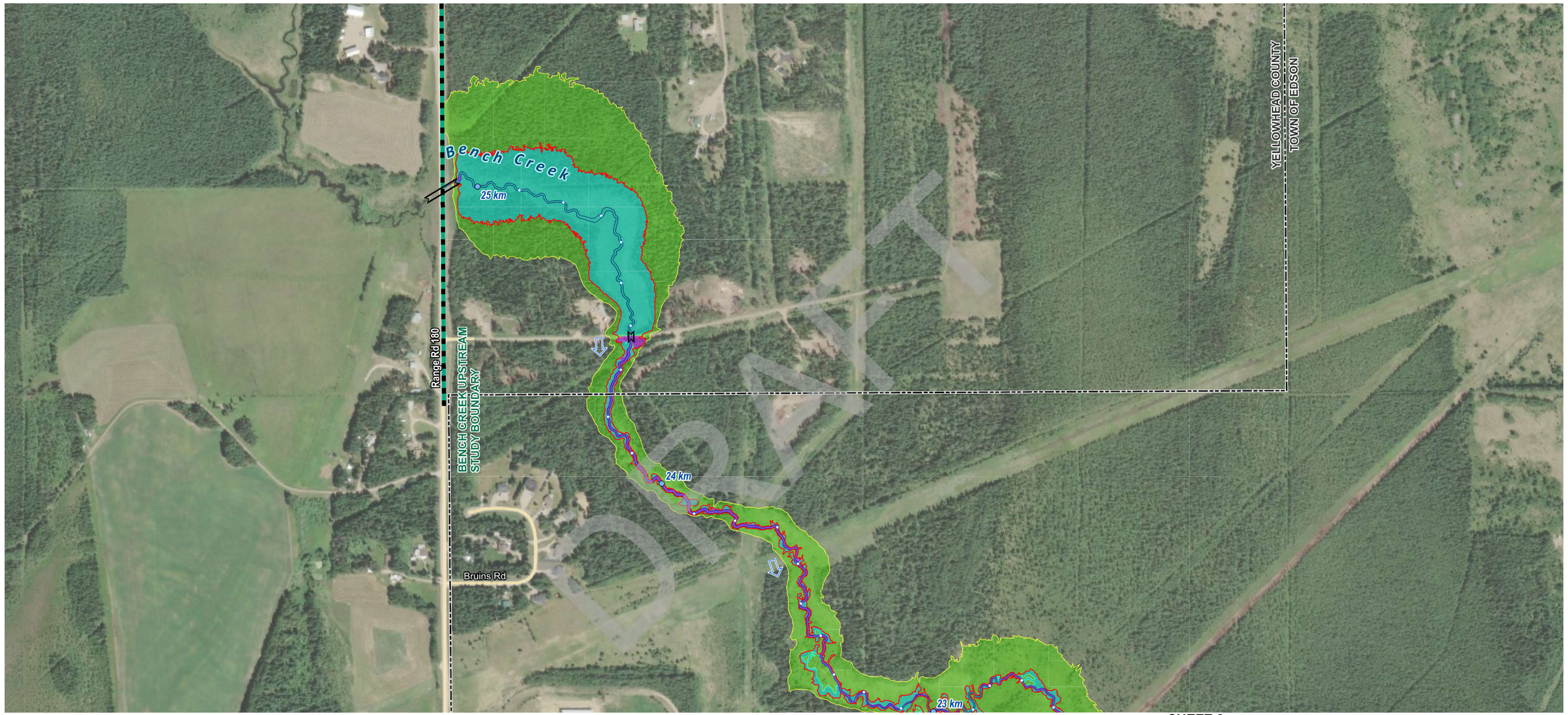
Project No. 3052.029
Date October 2025
Scale 1:35,000
0 0.25 0.5 1 Km

Edson Flood Study
Floodway Criteria Map

Overview

Classification: Public

Alberta Environment and Protected Areas



▼ SHEET 2

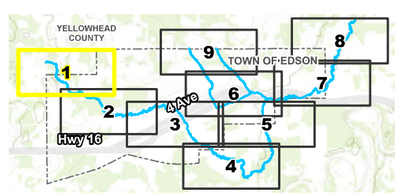
N

Legend

- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s



Project No.	3052.029
Date	October 2025
Scale	1:7,500

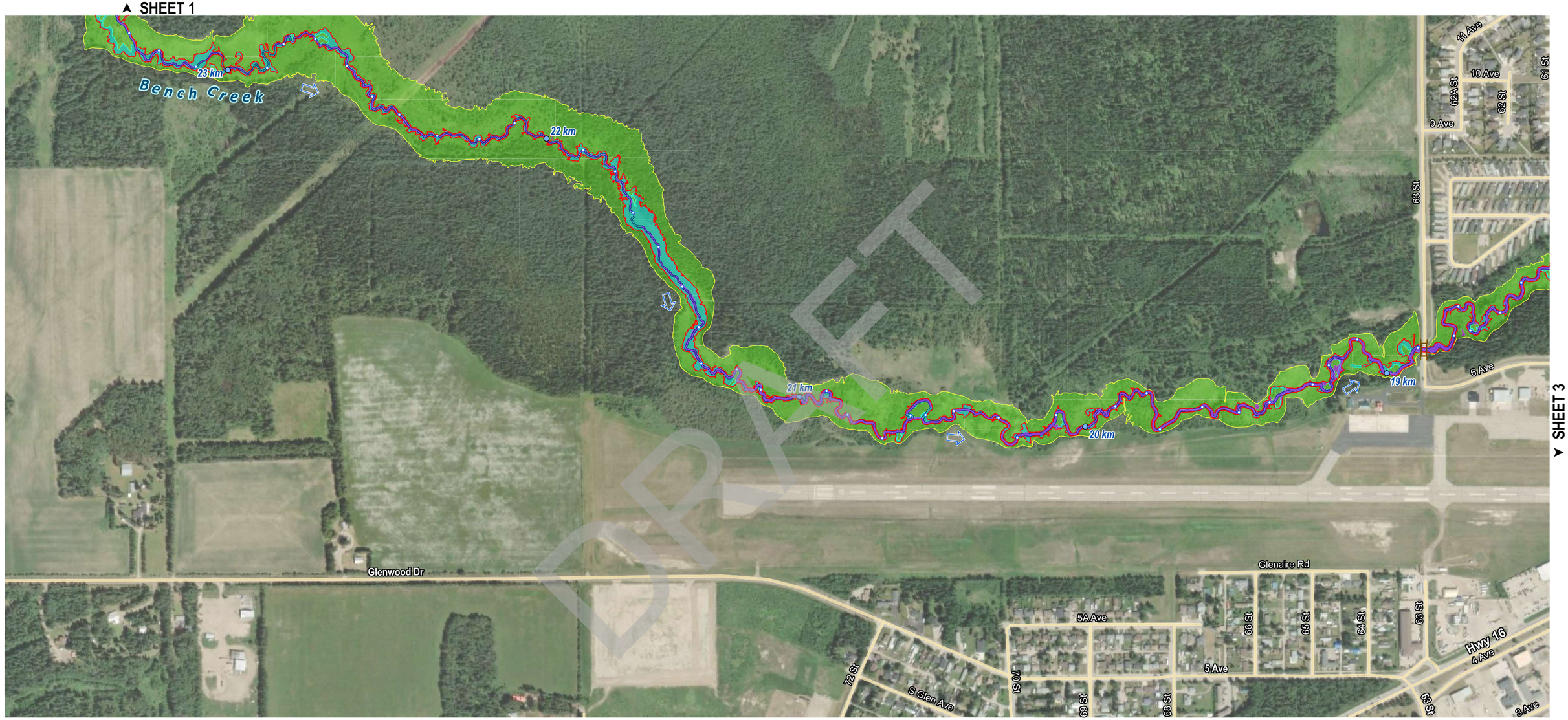
0 50 100 200 Metres

Edson Flood Study
Floodway Criteria Map

Sheet 1 of 9

Classification: Public

▲ SHEET 1



SHEET 3 ➤

DRAFT

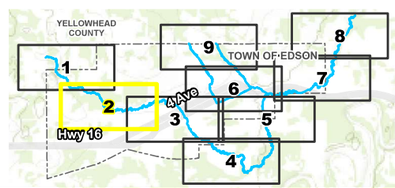
N

Legend

- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s



Project No.	3052.029
Date	October 2025
Scale	1:7,500

0 50 100 200 Metres

Edson Flood Study
Floodway Criteria Map

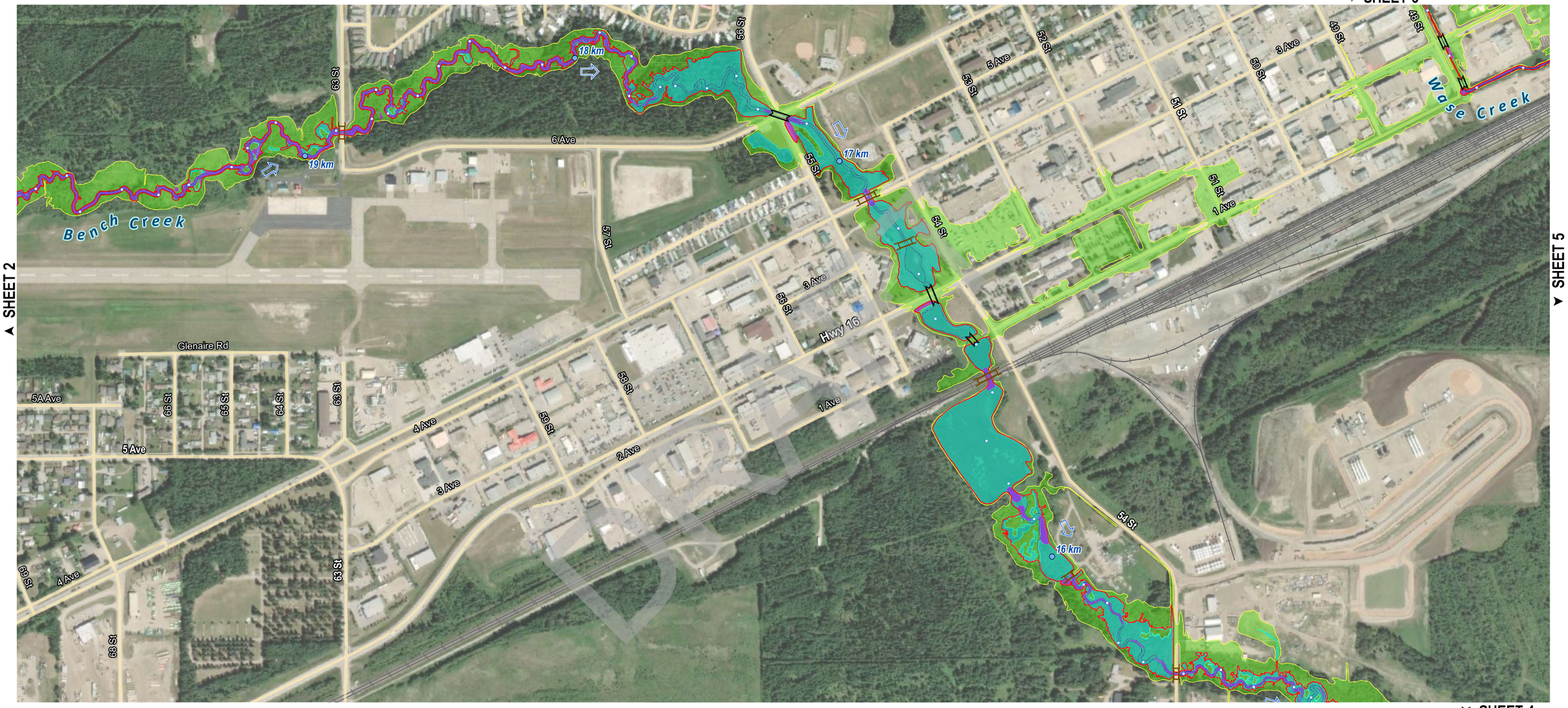
Classification: Public

Alberta Environment and Protected Areas

◄ SHEET 2

► SHEET 6

► SHEET 5



▼ SHEET 4

N

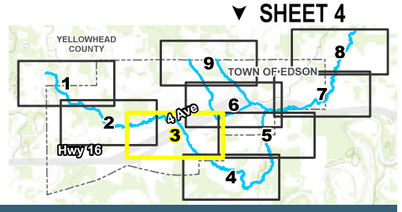
Legend

- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s

Wase Creek - 11.8 m^3/s



Project No. 3052.029
Date October 2025
Scale 1:7,500
0 50 100 200 Metres

Edson Flood Study
Floodway Criteria Map

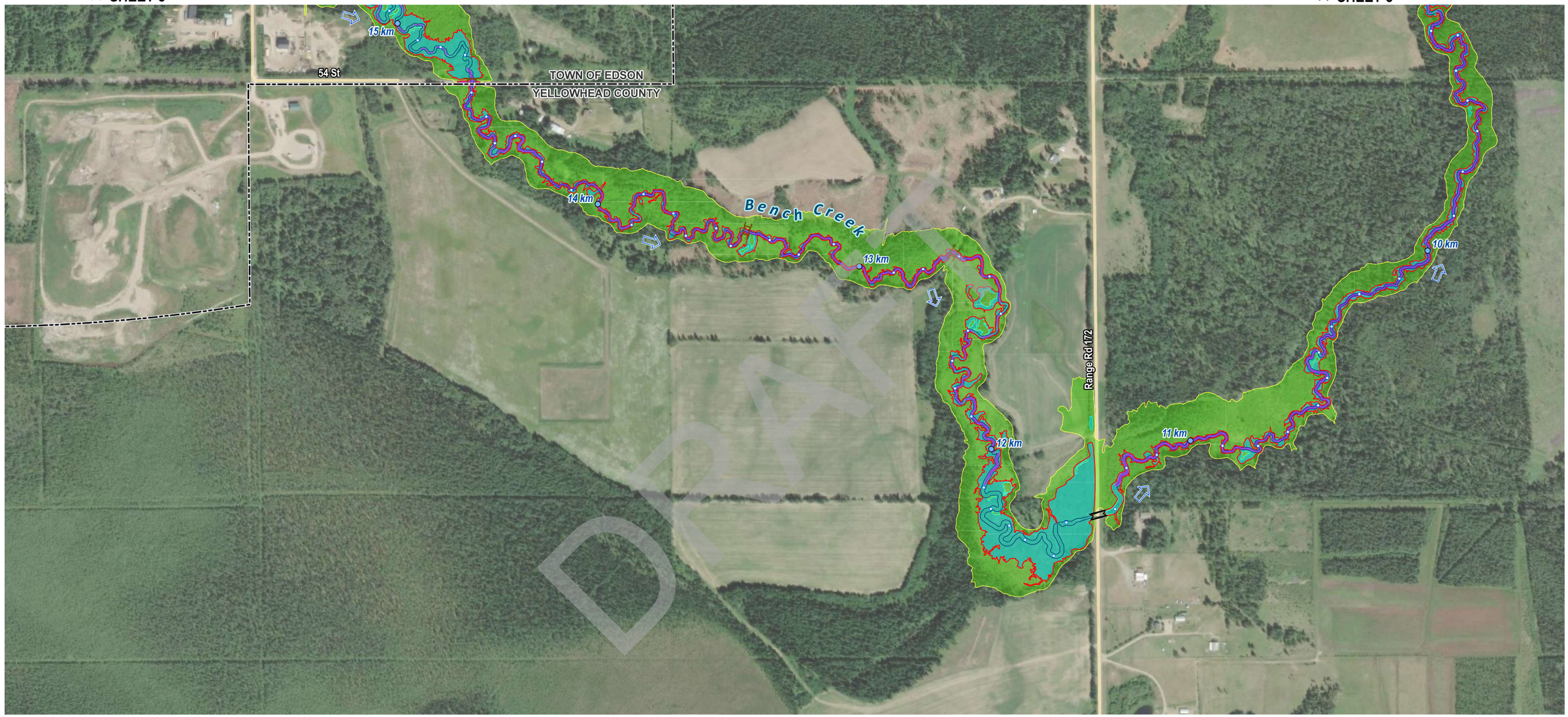
Sheet 3 of 9

Classification: Public

Alberta Environment and Protected Areas

▲ SHEET 3

▲ SHEET 5



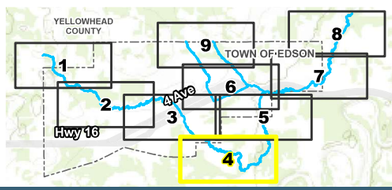
N

Legend

- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s



Project No.	3052.029
Date	October 2025
Scale	1:7,500

0 50 100 200 Metres

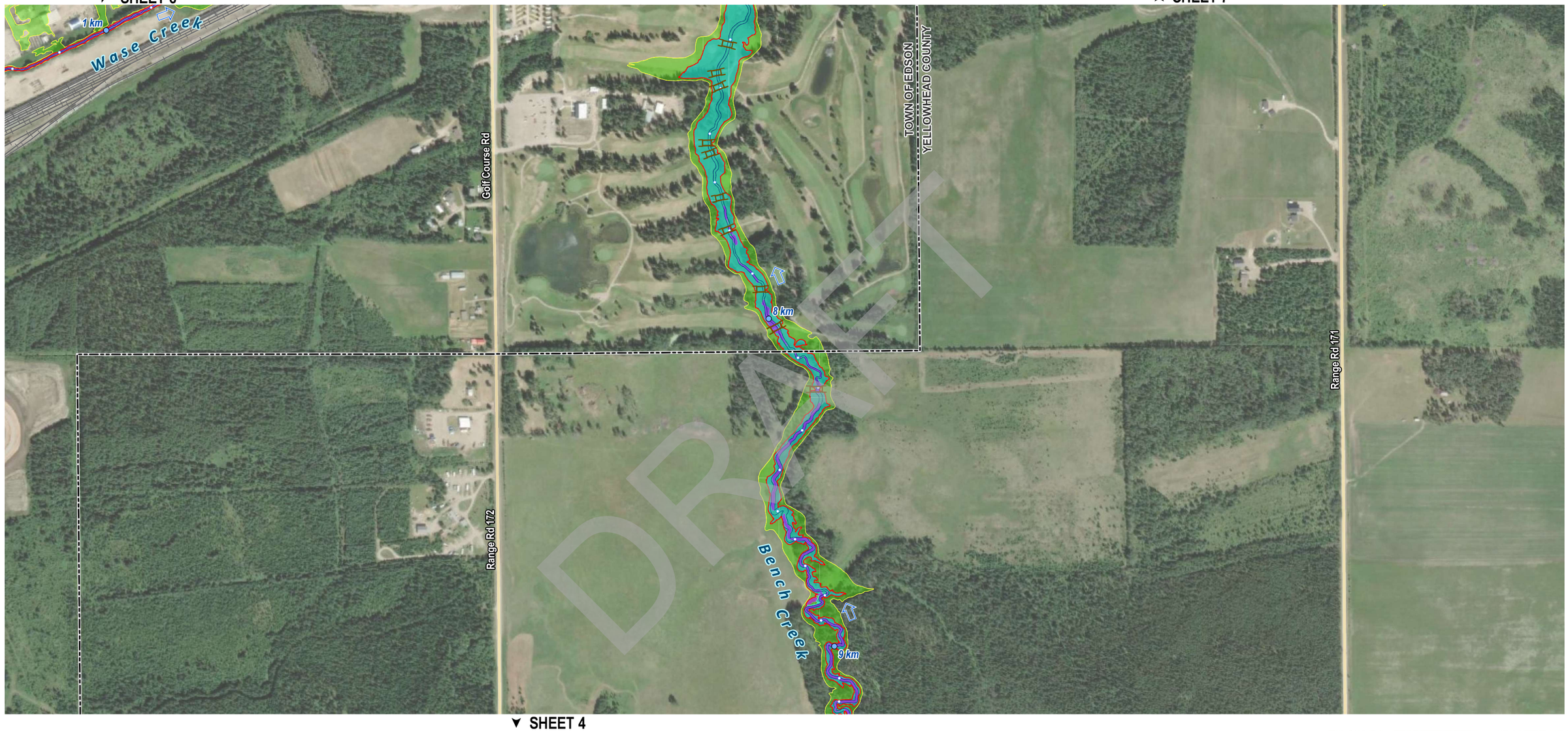
Edson Flood Study
Floodway Criteria Map

Classification: Public

Alberta Environment and Protected Areas

▶ SHEET 6

▲ SHEET 7



▼ SHEET 4

N

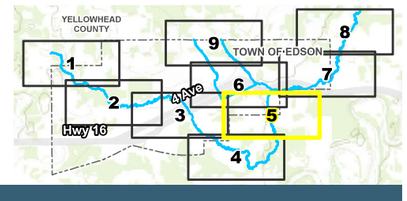
Legend

- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s

Wase Creek - 11.8 m^3/s



Project No. 3052.029
Date October 2025
Scale 1:7,500
0 50 100 200 Metres

Edson Flood Study
Floodway Criteria Map

Sheet 5 of 9

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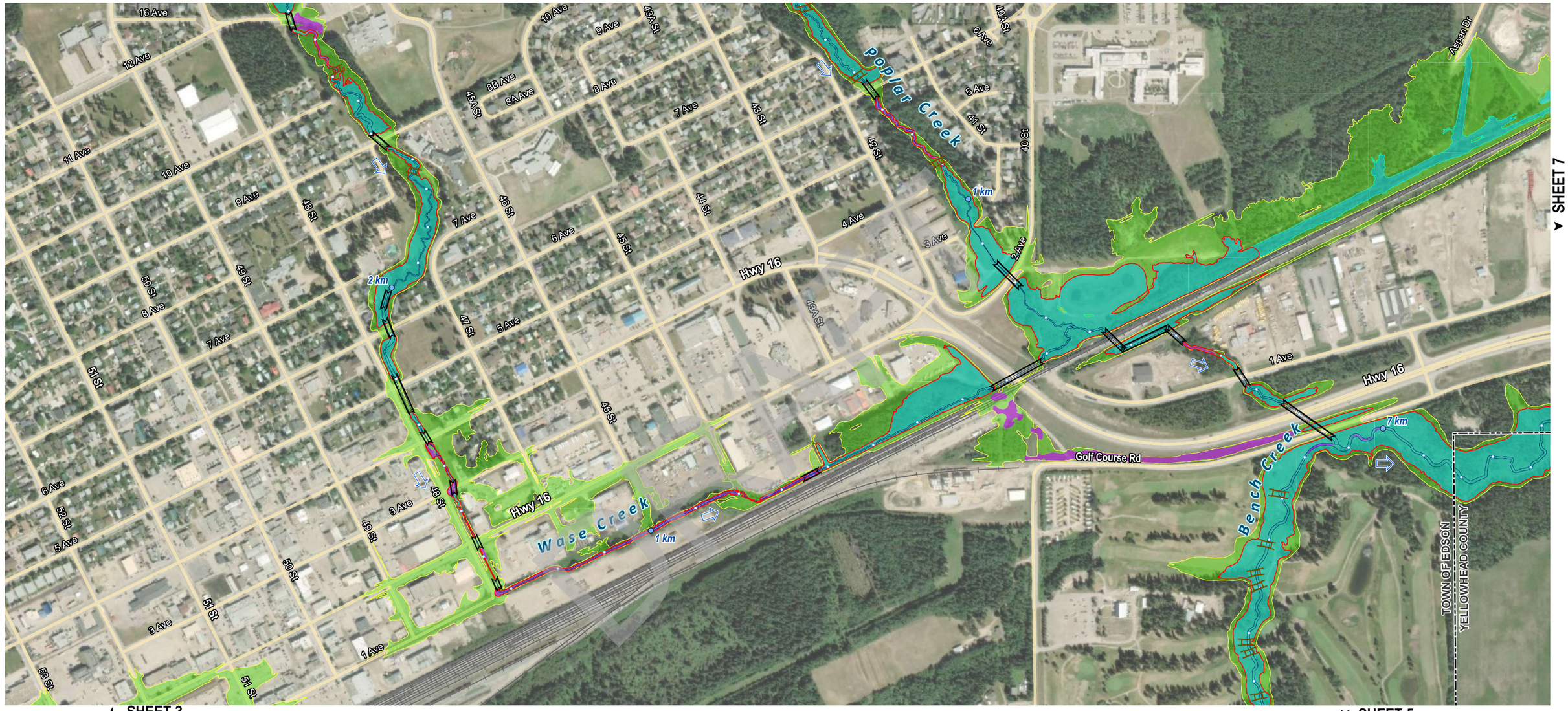
Classification: Public

▲ SHEET 9



▼ SHEET 7

▲ SHEET 3

▼ SHEET 5

N

Legend

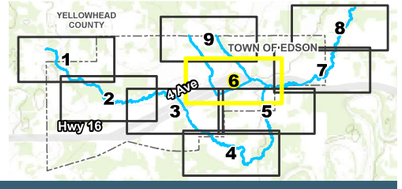
- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s

Poplar Creek - 10.5 m^3/s

Wase Creek - 11.8 m^3/s



Project No. 3052.029

Date October 2025

Scale 1:7,500

0 50 100 200 Metres

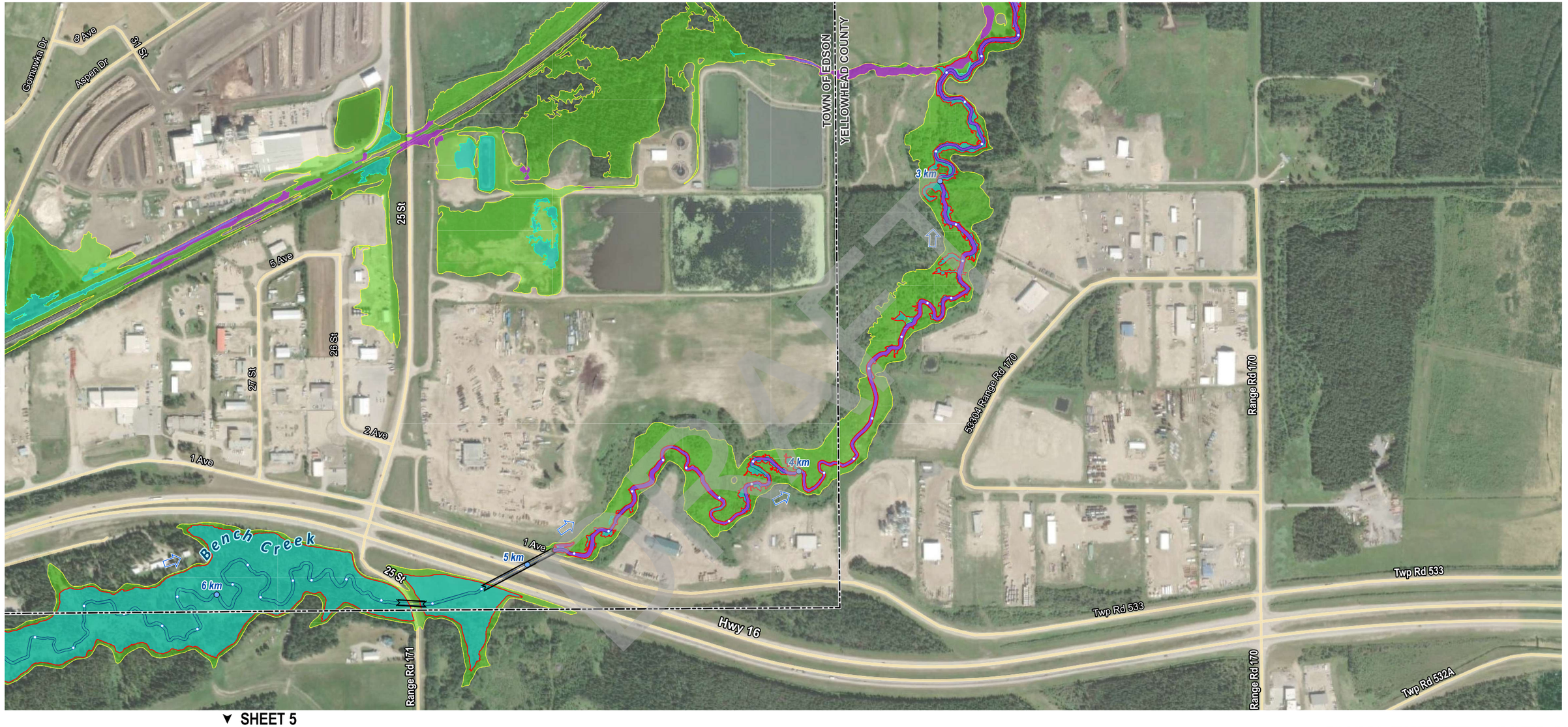
Edson Flood Study
Floodway Criteria Map

Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.

▲ SHEET 8



▼ SHEET 5

◄ SHEET 6

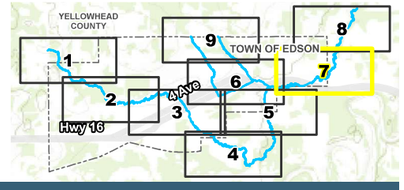
N

Legend

- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 65.5 m^3/s



Project No.	3052.029
Date	October 2025
Scale	1:7,500

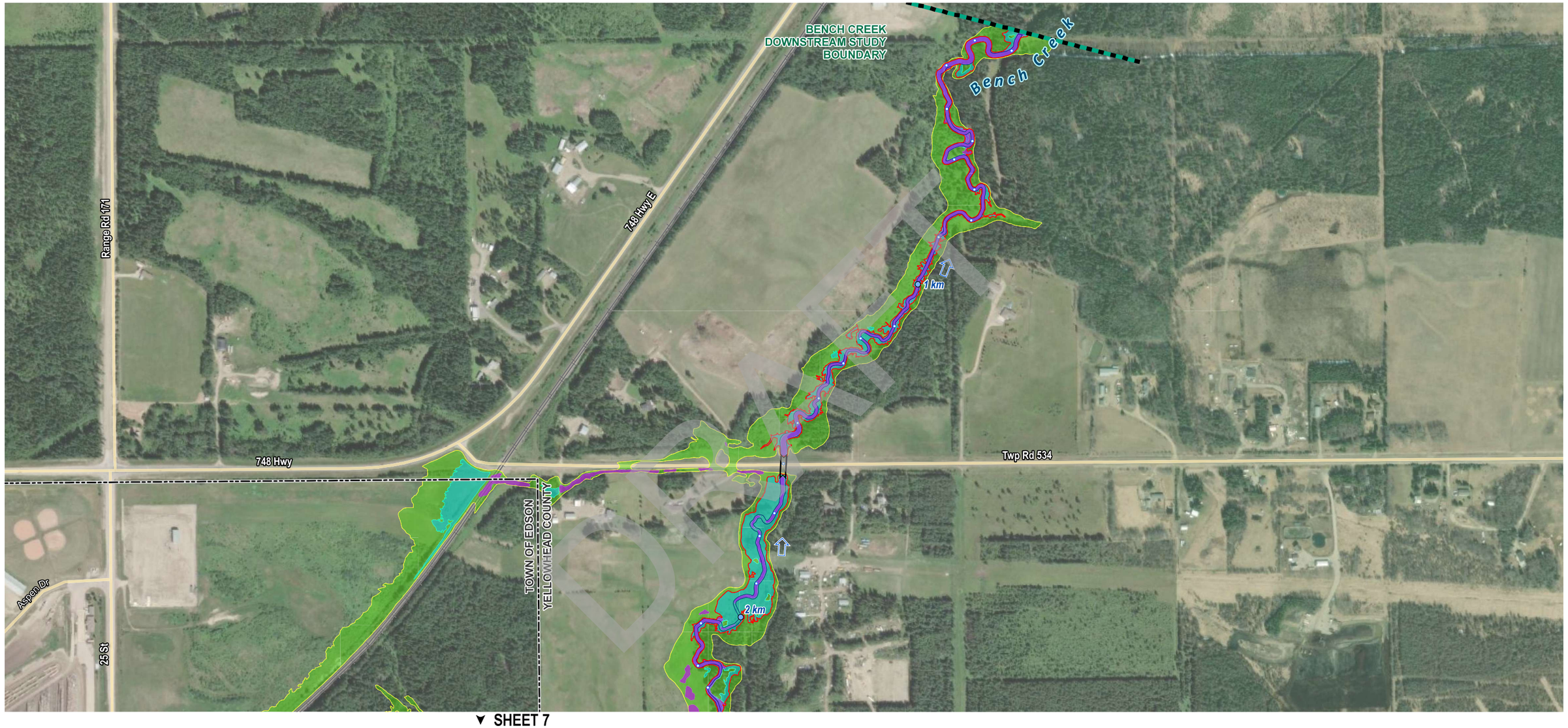
0 50 100 200 Metres

Edson Flood Study
Floodway Criteria Map

Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.



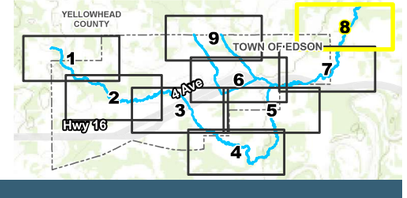
N

Legend

- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 65.5 m^3/s



Project No.	3052.029
Date	October 2025
Scale	1:7,500

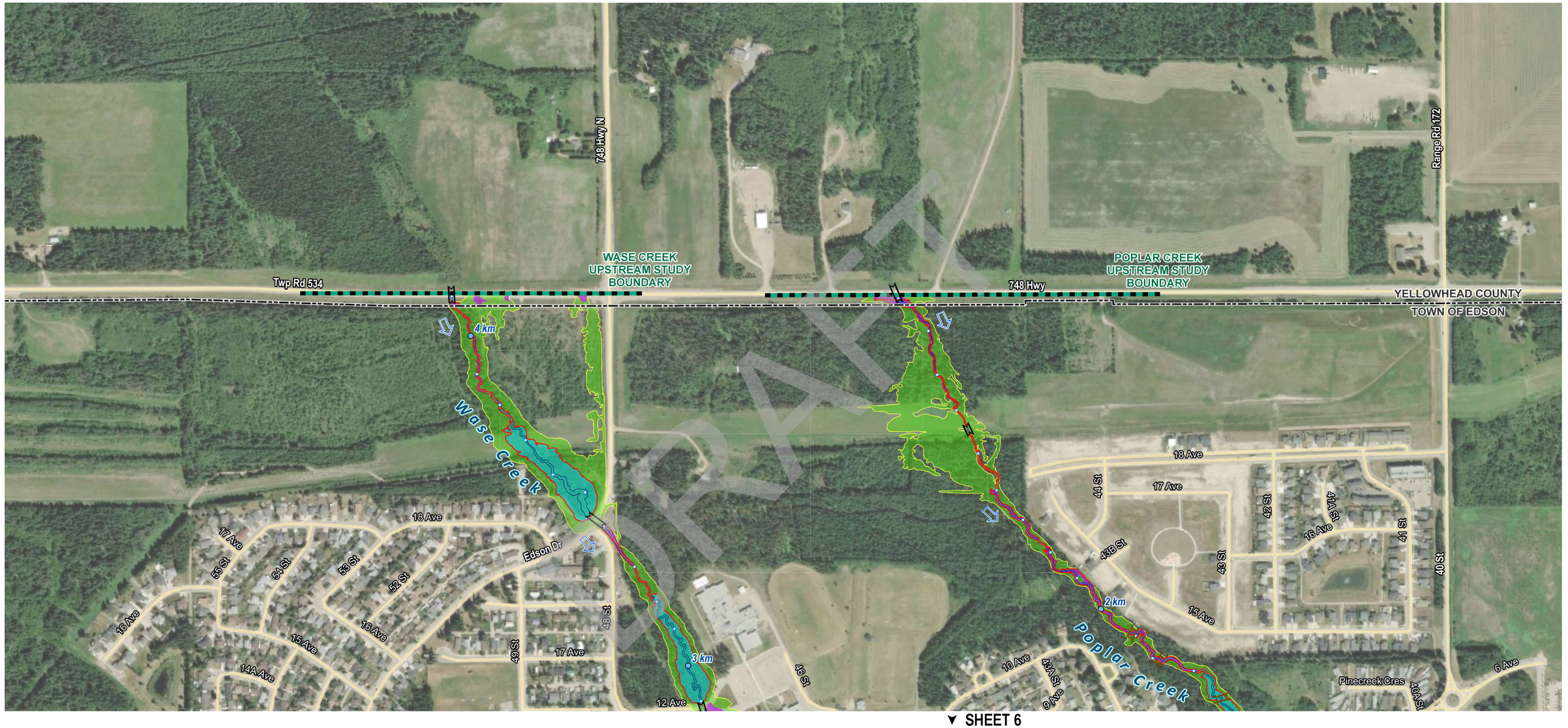
0 50 100 200 Metres

Edson Flood Study
Floodway Criteria Map

Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.



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▼ SHEET 6

N

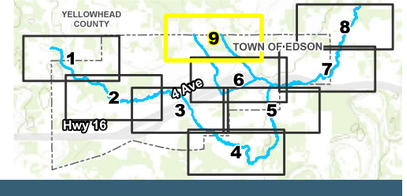
Legend

- Municipal Boundary
- Floodway
- Creek Extent
- Velocity ≥ 1 m/s
- Depth ≥ 1 m
- 100-Year Design Flood Extent
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Poplar Creek - 10.5 m^3/s

Wase Creek - 11.8 m^3/s



Project No.	3052.029
Date	October 2025
Scale	1:7,500

0 50 100 200 Metres

Edson Flood Study
Floodway Criteria Map

Sheet 9 of 9

Classification: Public

Innovation. Integrity. Employee-Owned.

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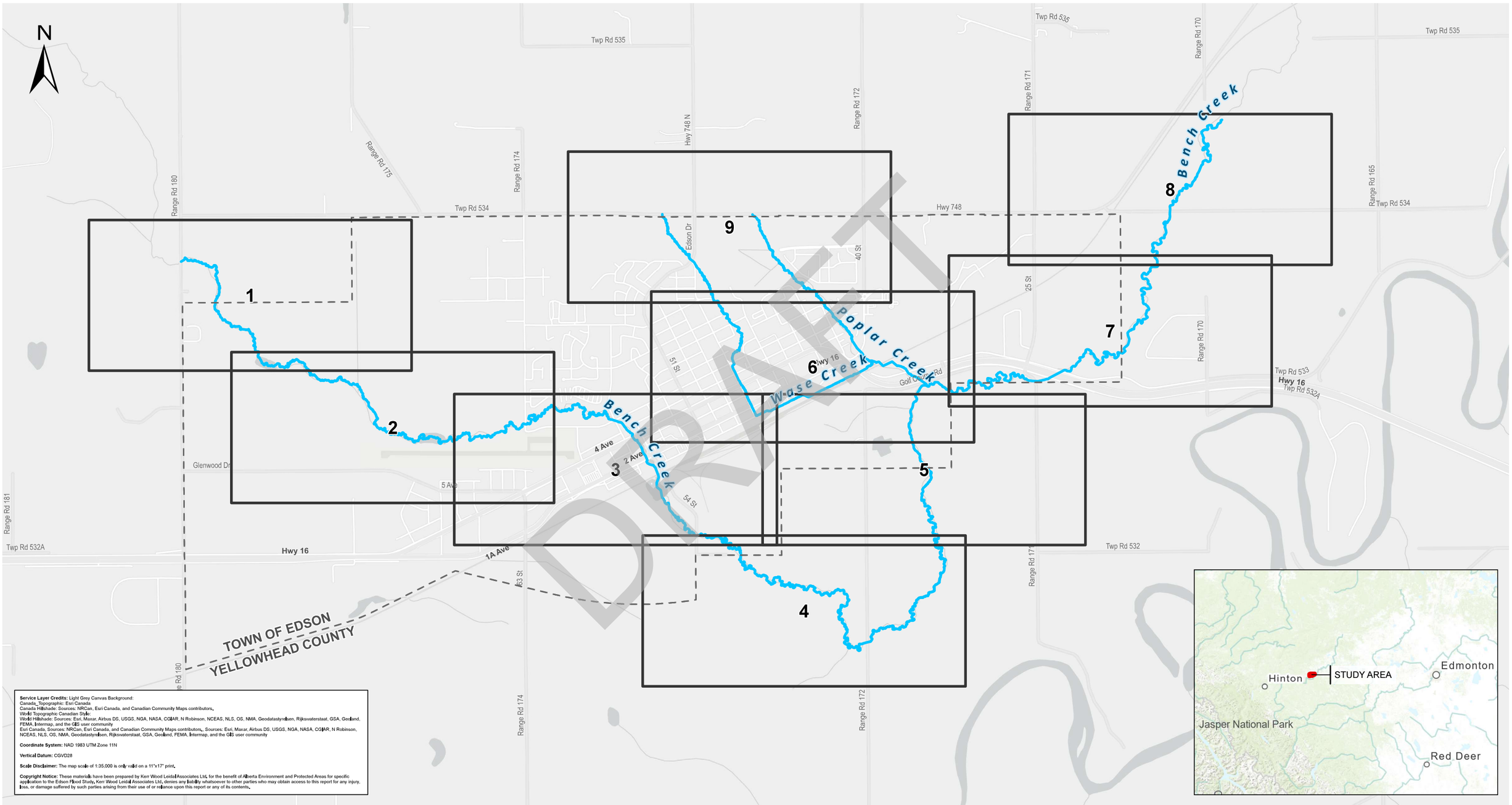
Appendix J

Flood Hazard Maps

Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.



Service Layer Credits: Light Grey Canvas Background:
Canada_Topographic: Esri Canada
Canada Hillshade: Sources: NRCan, Esri Canada, and Canadian Community Maps contributors,
World Topographic Canadian Style:
World Hillshade: Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community
Esri Canada, Sources: NRCan, Esri Canada, and Canadian Community Maps contributors,, Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community

Coordinate System: NAD 1983 UTM Zone 11N

Vertical Datum: CGVD28

Scale Disclaimer: The map scale of 1:35,000 is only valid on a 11"x17" print.

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Project No.	3052.029
Date	April 2026
Scale	1:35,000

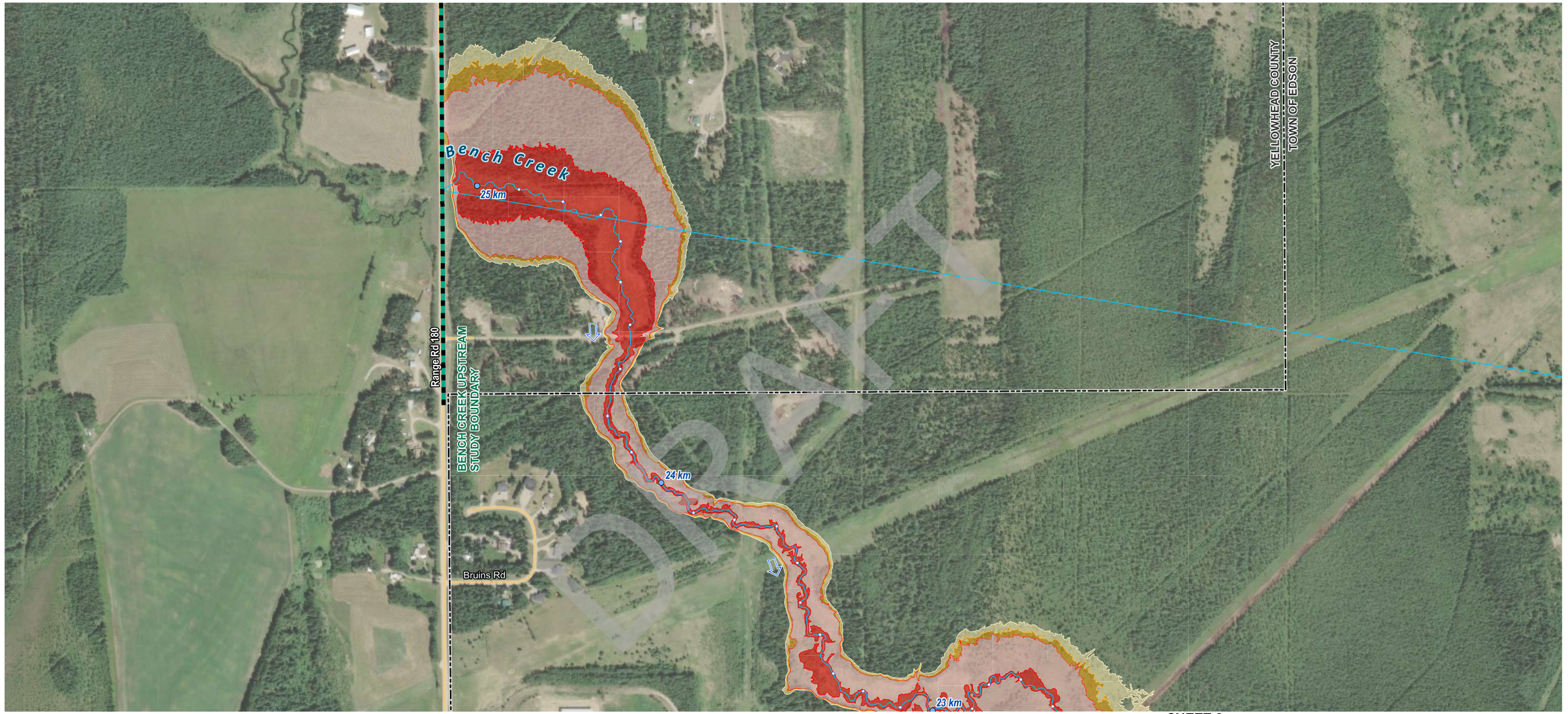
0 0.25 0.5 1 Km

Edson Flood Study
Flood Hazard Map

Overview

Classification: Public

Alberta Environment and Protected Areas



▼ SHEET 2

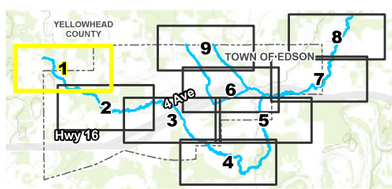
N

Legend

- Municipal Boundary
- Creek Centreline
- Floodway
- High Hazard Flood Fringe
- Flood Fringe
- 1:200 Flood
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s



Project No.	3052.029
Date	April 2026
Scale	1:7,500

0 50 100 200 Metres

Edson Flood Study
Flood Hazard Map

Sheet 1 of 9

Classification: Public

Alberta Environment and Protected Areas

▲ SHEET 1



▶ SHEET 3

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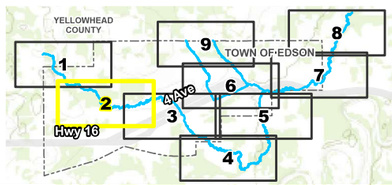
N

Legend

- Municipal Boundary
- Creek Centreline
- Floodway
- High Hazard Flood Fringe
- Flood Fringe
- 1:200 Flood
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s



Project No.	3052.029
Date	April 2026
Scale	1:7,500

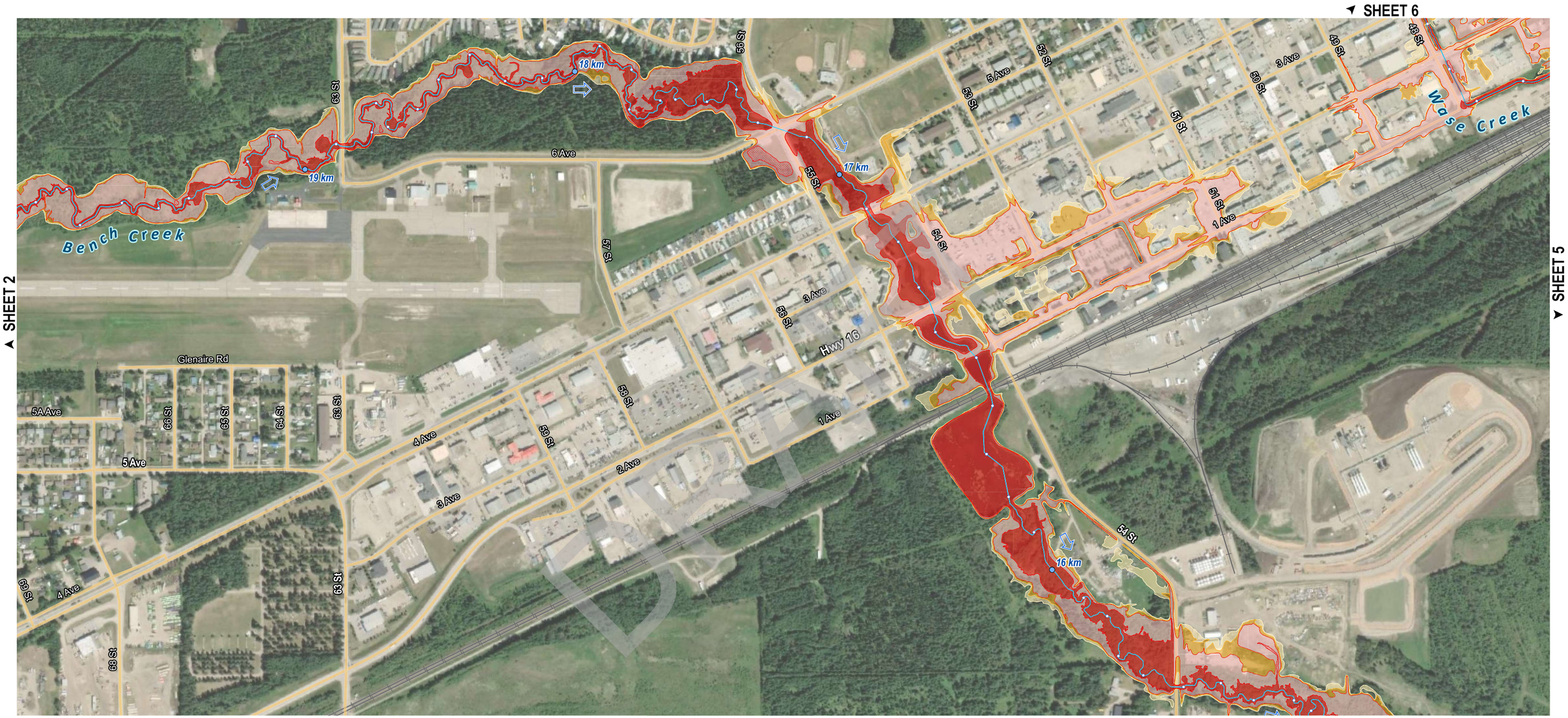
0 50 100 200 Metres

Edson Flood Study
Flood Hazard Map

Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.



Legend

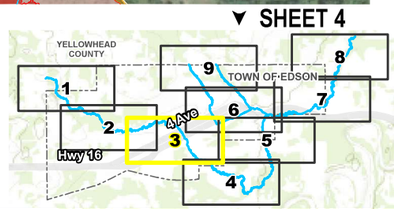
- Municipal Boundary
- Creek Centreline
- Floodway
- High Hazard Flood Fringe
- Flood Fringe
- 1:200 Flood
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

N

Creek Discharge

Bench Creek - 43.2 m^3/s

Wase Creek - 11.8 m^3/s



Project No.	3052.029
Date	April 2026
Scale	1:7,500

0 50 100 200 Metres

Edson Flood Study
Flood Hazard Map

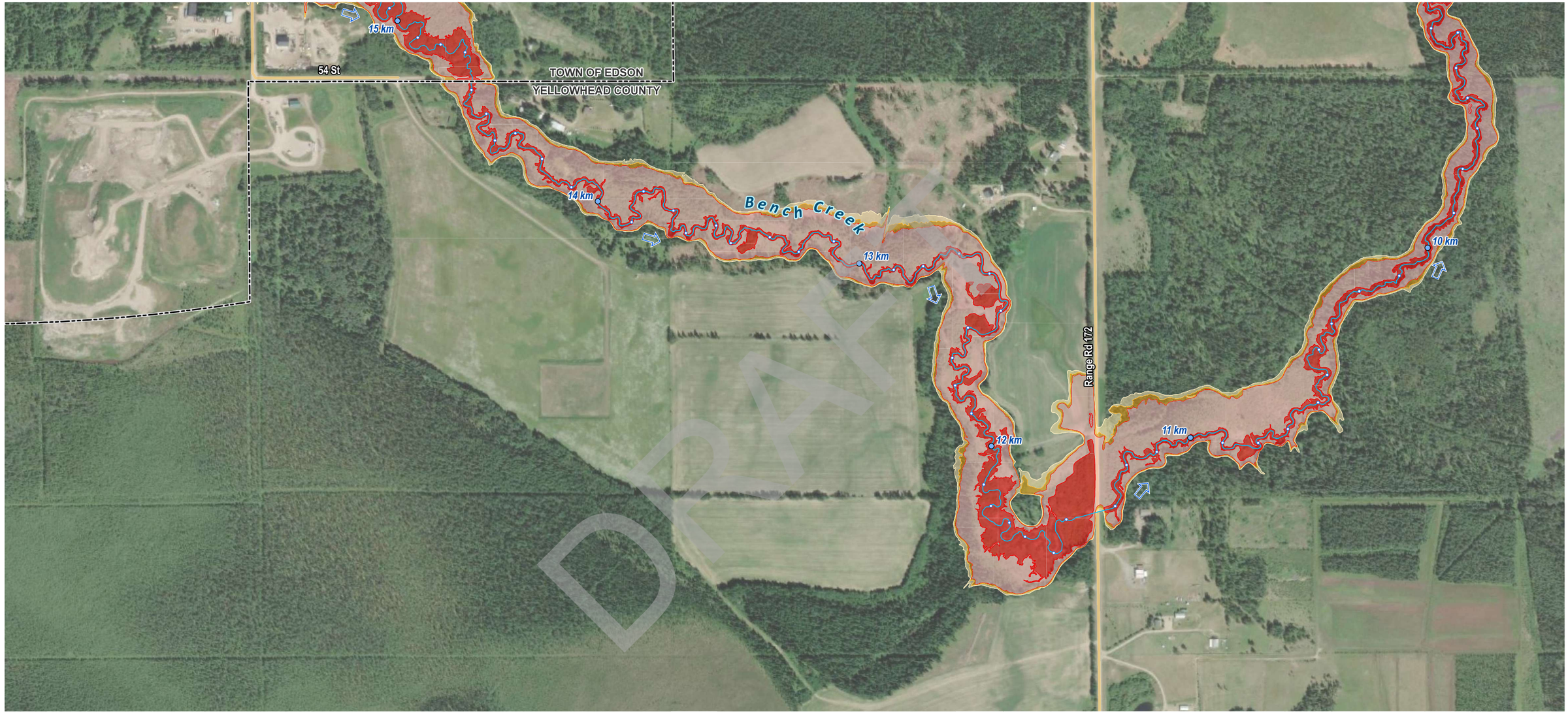
Sheet 3 of 9

Classification: Public

Alberta Environment and Protected Areas

▲ SHEET 3

▲ SHEET 5



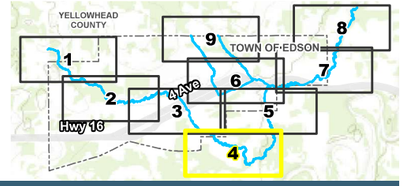
N

Legend

- Municipal Boundary
- Creek Centreline
- Floodway
- High Hazard Flood Fringe
- Flood Fringe
- 1:200 Flood
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43,2 m^3/s



Project No.	3052.029
Date	April 2026
Scale	1:7,500

0 50 100 200 Metres

Edson Flood Study
Flood Hazard Map

Sheet 4 of 9

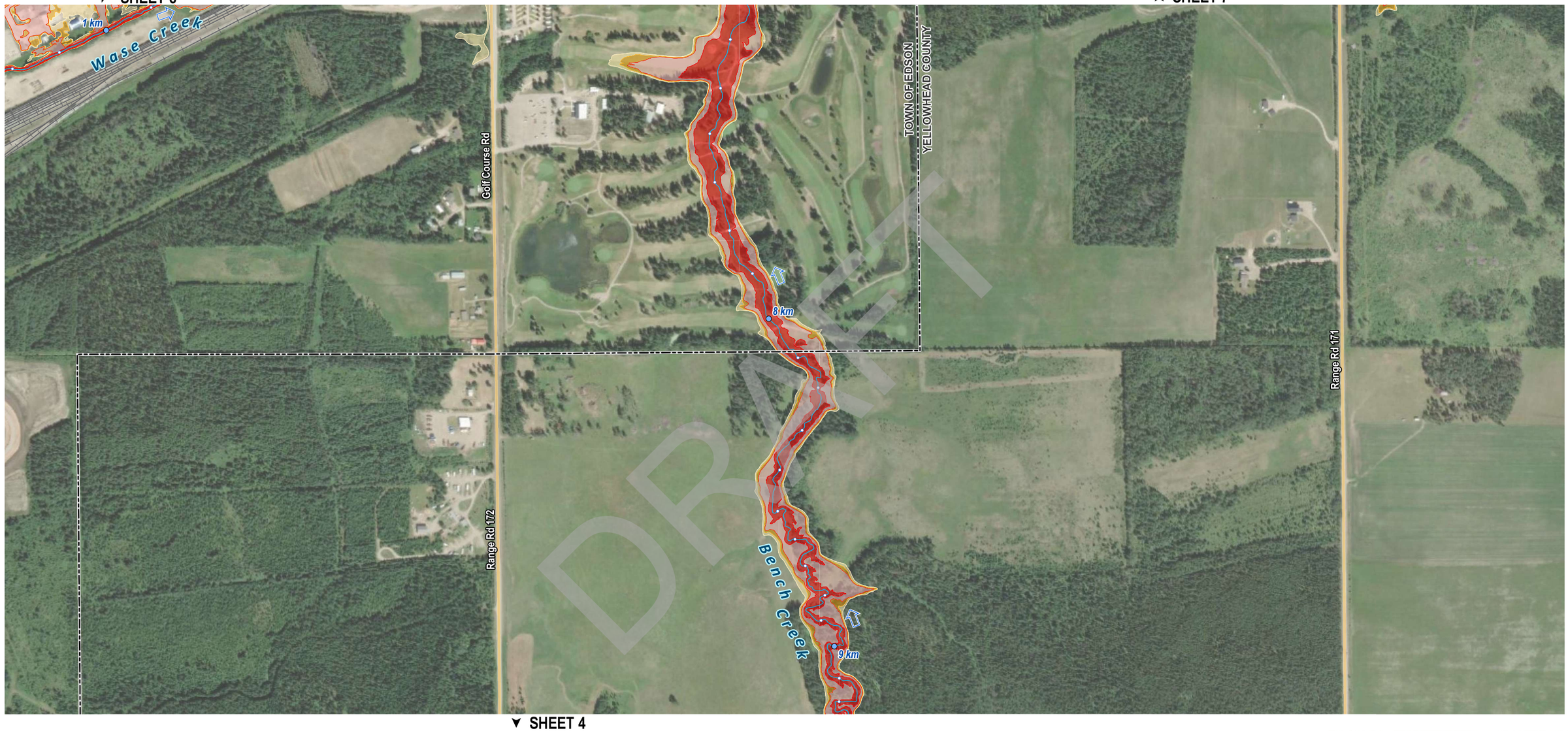
Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.

▶ SHEET 6

▲ SHEET 7



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▼ SHEET 4

N

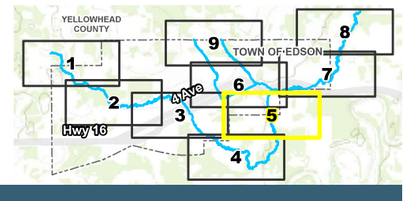
Legend

- Municipal Boundary
- Creek Centreline
- Floodway
- High Hazard Flood Fringe
- Flood Fringe
- 1:200 Flood
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s

Wase Creek - 11.8 m^3/s



Project No.	3052.029
Date	April 2026
Scale	1:7,500

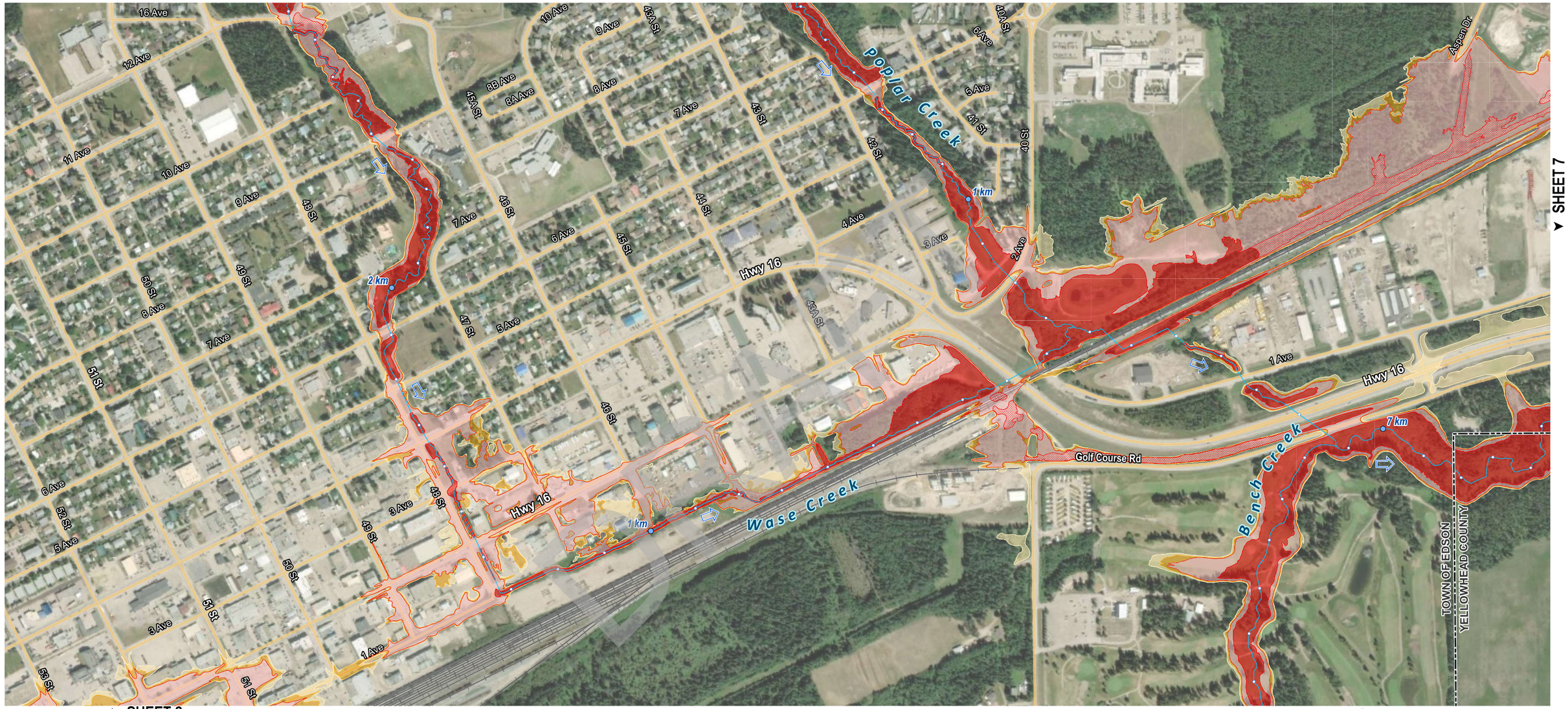
0 50 100 200 Metres

Edson Flood Study
Flood Hazard Map

Classification: Public

Alberta Environment and Protected Areas

▲ SHEET 9



▼ SHEET 7

▲ SHEET 3

▼ SHEET 5

N

Legend

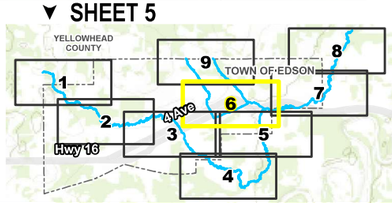
- Municipal Boundary
- Creek Centreline
- Floodway
- High Hazard Flood Fringe
- Flood Fringe
- 1:200 Flood
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 43.2 m^3/s

Poplar Creek - 10.5 m^3/s

Wase Creek - 11.8 m^3/s



Project No.	3052.029
Date	April 2026
Scale	1:7,500

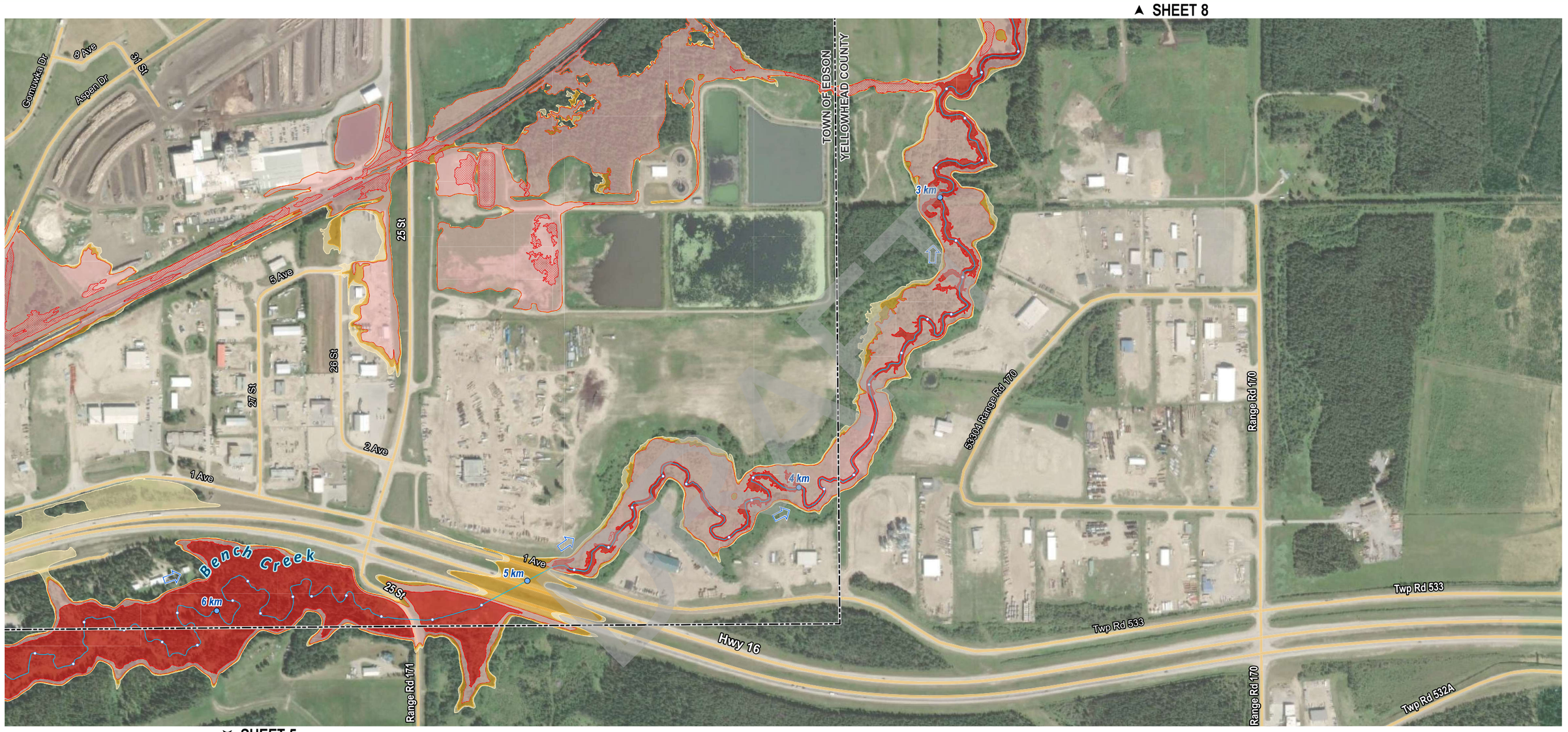
0 50 100 200 Metres

Edson Flood Study
Flood Hazard Map

Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.

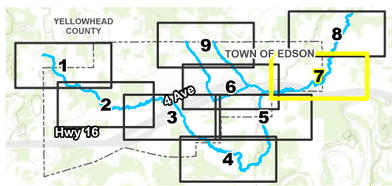


Legend

- Municipal Boundary
- Creek Centreline
- Floodway
- High Hazard Flood Fringe
- Flood Fringe
- 1:200 Flood
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 65.5 m^3/s



Project No.	3052.029
Date	April 2026
Scale	1:7,500

0 50 100 200 Metres

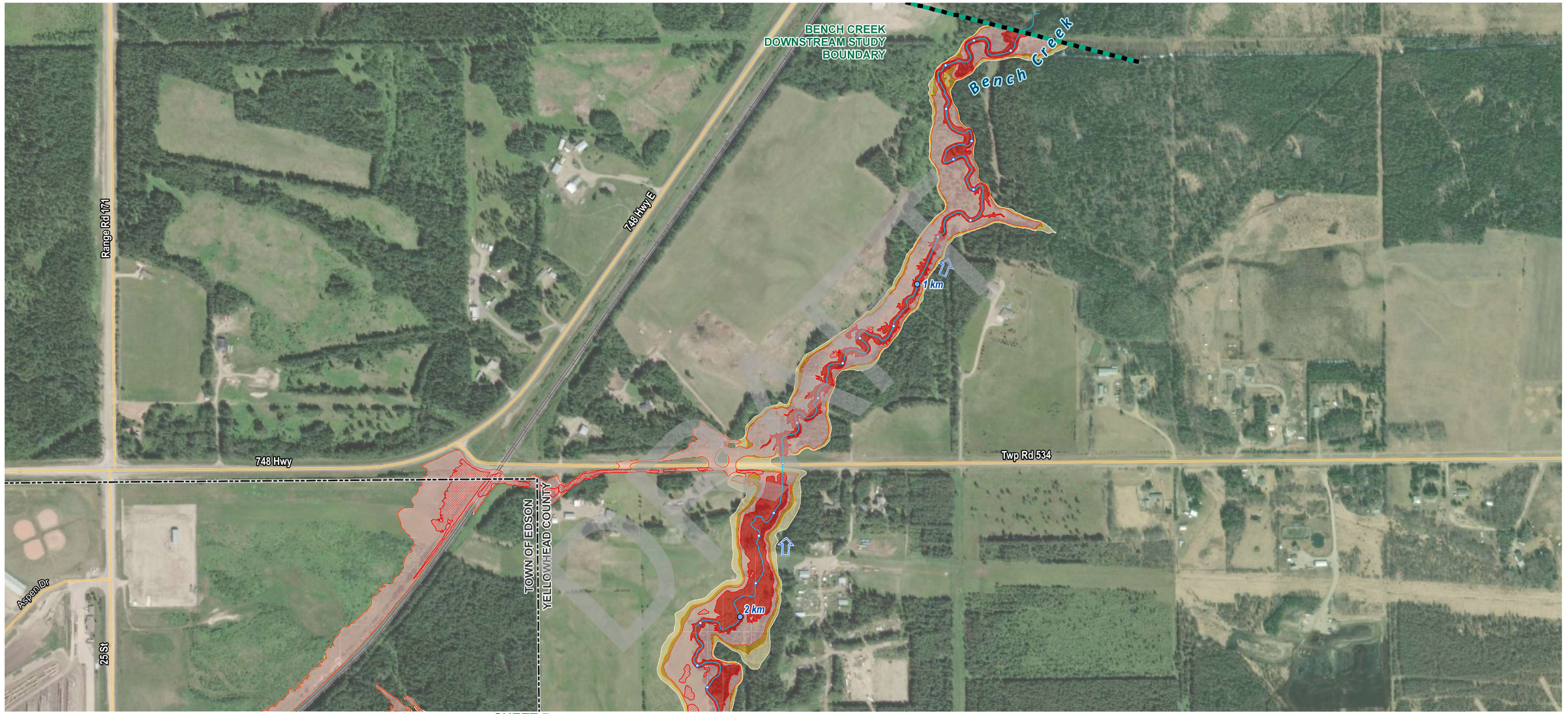
Edson Flood Study
Flood Hazard Map

Sheet 7 of 9

Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.



N

Legend

- Municipal Boundary
- Creek Centreline
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- Flood Fringe
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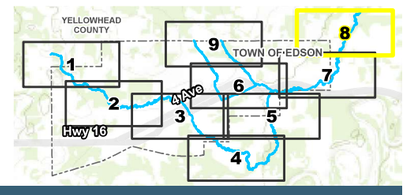
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Bench Creek - 65.5 m^3/s



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Date	April 2026
Scale	1:7,500

0 50 100 200 Metres

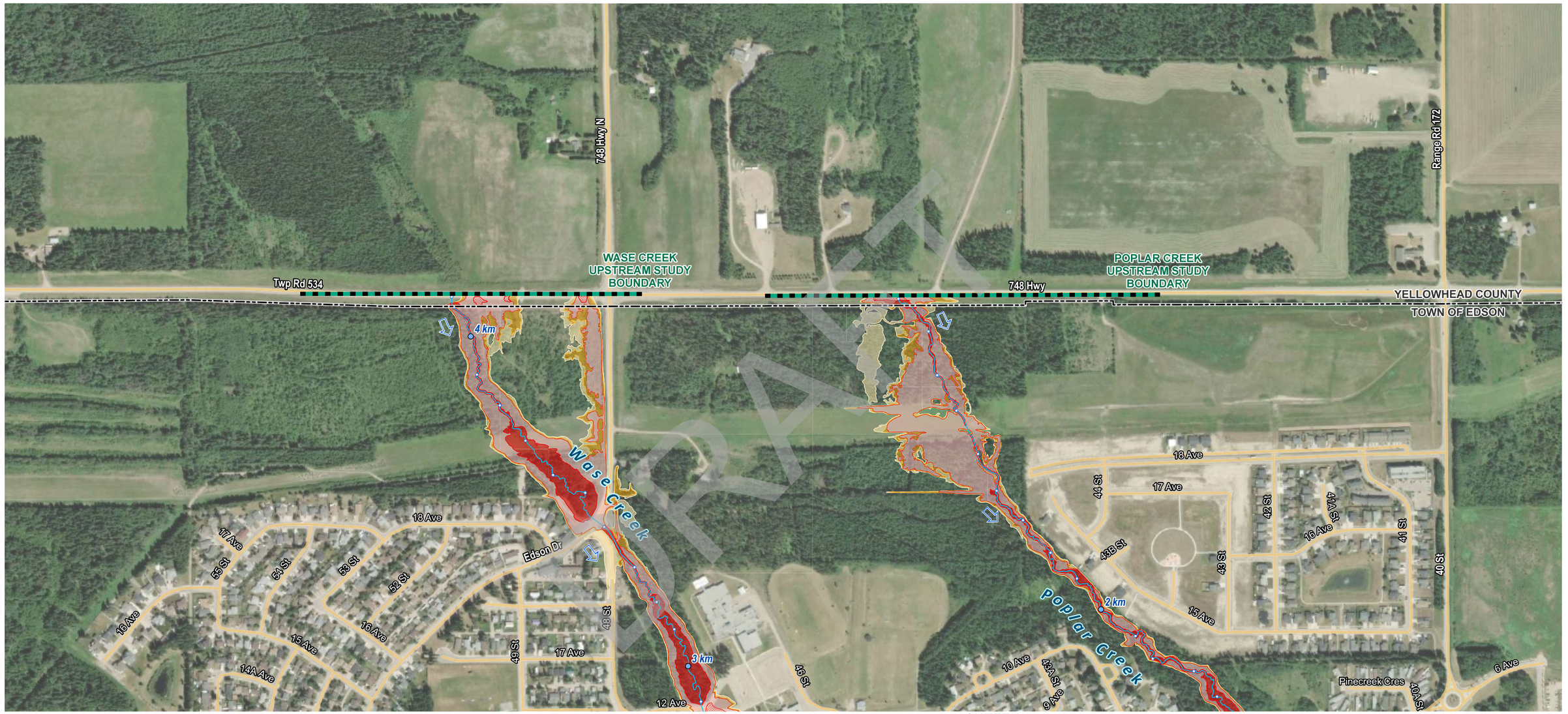
Edson Flood Study
Flood Hazard Map

Sheet 8 of 9

Classification: Public

Alberta Environment and Protected Areas

Canada Alberta 50 km Innovation. Integrity. Employee-Owned.



N

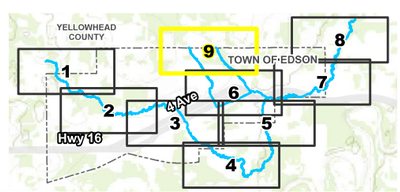
Legend

- Municipal Boundary
- Creek Centreline
- Floodway
- High Hazard Flood Fringe
- Flood Fringe
- 1:200 Flood
- 1:500 Flood
- 100 m Creek Station
- 1 km Creek Station
- Flow Direction
- Bridge
- Culvert
- Road
- Railway

Creek Discharge

Poplar Creek - 10.5 m^3/s

Wase Creek - 11.8 m^3/s



Project No.	3052.029
Date	April 2026
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0 50 100 200 Metres

Edson Flood Study
Flood Hazard Map

Classification: Public