MACKENZIE COUNTY

COMMITTEE OF THE WHOLE MEETING

JANUARY 15, 2019
10:00 AM

FORT VERMILION COUNCIL CHAMBERS

780.927.3718

www.mackenziecounty.com

4511-46 Avenue, Fort Vermilion

office@mackenziecounty.com

Mackenzie County

MACKENZIE COUNTY
COMMITTEE OF THE WHOLE MEETING

Tuesday, January 15, 2019
10:00 a.m.

Fort Vermilion Council Chambers
Fort Vermilion, Alberta

AGENDA

REQUEST FOR DIRECTION

Meeting:	**Committee of the Whole Meeting**
Meeting Date:	**January 15, 2019**
Presented By:	**Byron Peters, Deputy Chief Administrative Officer**
Title:	**DELEGATION** **CCI Wireless Proposed Micro-Towers Locations in the Hamlet of La Crete and Wi-Fibre Deployment**

BACKGROUND / PROPOSAL:

CCI Wireless has been in contact with Mackenzie County since July, 2018. CCI Wireless would like to place four (4) separate micro-towers throughout the hamlet of La Crete to increase wireless internet speeds.

Graham Fleet, CCI Wireless will present their plans.

OPTIONS & BENEFITS:

COSTS & SOURCE OF FUNDING:

No cost to the County.

SUSTAINABILITY PLAN:

Goal E21 That County residents and businesses have access to the most current telecommunication technologies to permit them to participate in global opportunities.

Strategy E21.1 Encourage the existing internet service providers in the region to continue to upgrade their systems, both in terms of reliability and speed.

Strategy E21.5 Explore the possibility of other businesses such as Shaw, CCI, SIS, NorthwesTel, Axia, etc. expanding their service in the region to serve the hamlets within the County.

Author: _____ **Reviewed by:** _____ **CAO:** _____

COMMUNICATION / PUBLIC PARTICIPATION:

No communication required according to the ADM056 Public Participation Policy. It is recommended that the public be informed before implementation.

POLICY REFERENCES:

ADM056 Public Participation Policy

RECOMMENDED ACTION:

☑ Simple Majority ☐ Requires 2/3 ☐ Requires Unanimous

For information.

Author: _____ **Reviewed by:** _____ **CAO:** _____

cci wireless
perfecting rural connectivity

Mackenzie County Council Presentation
La Crete Wi-Fibre Deployment

January 15, 2019

Agenda

1. Who is CCI Wireless
2. What is Wi-Fibre
3. The Caroline Test Case
4. Proposed La Crete Deployment
5. Pictures of Equipment
6. Questions

Who is CCI?

CCI WIRELESS IS AN INNOVATIVE COMMUNICATIONS TECHNOLOGY COMPANY that delivers custom connectivity solutions to the underserved and under-connected—made possible by Canadian ingenuity and a customer-first attitude

cci wireless
perfecting rural connectivity

10th anniversary since incorporation in October 2017

Now serving over 20,000 customers

Prides itself on unlimited data offering and excellent customer care

Internet Service Provider (ISP) and home phone service specializing in bringing high speed to rural Alberta

cci wired

Fully Alberta-owned and operated by gas co-ops, Rural Electrification Associations, and several municipalities

CCI's Purpose and Values

PASSION—we are passionate about service for our customers, our community, and our people

INNOVATION—we are dedicated to enabling and empowering underserved communities by providing innovative solutions not yet defined by current rules or norms

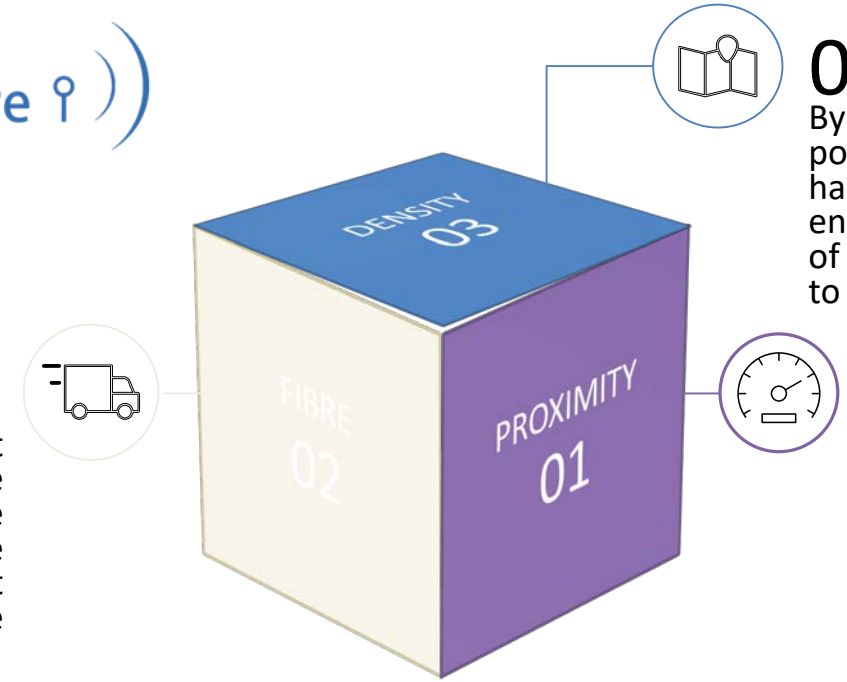
CCI POWERS UNDERSERVED COMMUNITIES TO THEIR POTENTIAL—by connecting them to the world via the Internet and enabling their long-term sustainability and viability

ENTREPRENEURSHIP—we are entrepreneurs at heart

COMMUNITY—we uphold togetherness, in the way our communities relate, grow, behave and govern themselves

What is Wi-Fibre?

Wi Fibre



03

By having multiple access points throughout the hamlet, we are able to ensure that the majority of households will be able to connect to our system

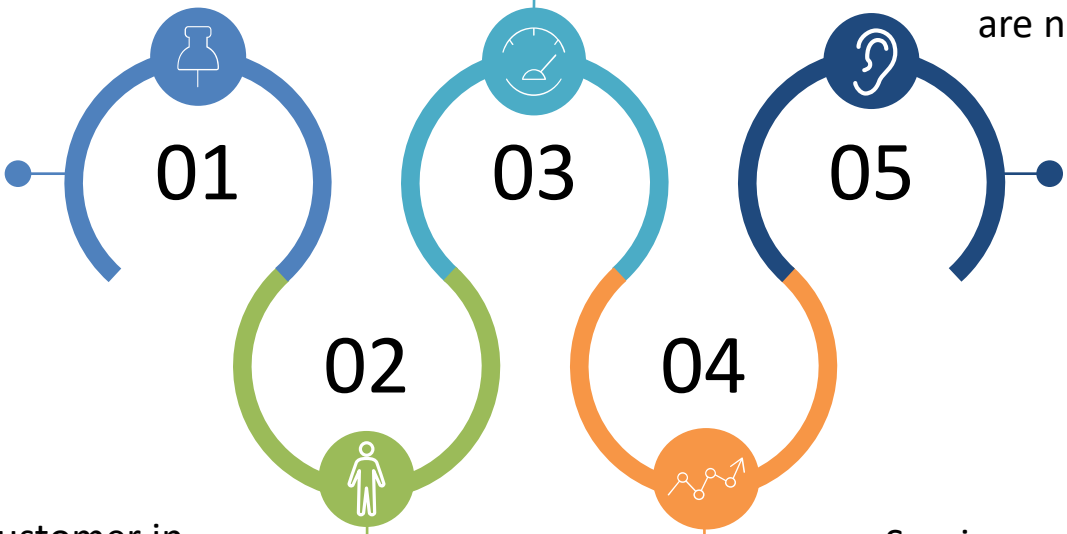
02

Data is offloaded almost immediately from the towers onto a fibre backhaul located at the CCI Wireless tower just east of La Crete

01

by deploying smaller sites with the access points (antennae) closer to the customer we are able to provide a faster service

Caroline Test Case



Service went live in spring of 2017

Monitoring of our test case has indicated that there are not any capacity issues

VOIP Service also available

The average customer in Caroline is using almost 350 GB of data per month which is 2.5* the national average

Service can scale and grow as the town grows and adds both industrial and residential areas

The Caroline Plans

Thanks to Wi-Fibre, every single building in Caroline can get our best plans.

Basic
$45
for the first 6 months*
30 Mbps Download / 5 Mbps Upload
$64.99 starting in 7th month

Ultra
$48
for the first 6 months*
50 Mbps Download / 5 Mbps Upload
$79.99 starting in 7th month

Supreme
$50
for the first 6 months*
100 Mbps Download / 10 Mbps Upload
$94.99 starting in 7th month

Save up to $420

with promotional pricing for the first 6 months & FREE installation!**

*Sign Up Bonus pricing ends after 6th month of service.

** "Free Install" offer valid on new 2-year contracts until December 31, 2018. Cannot be combined with other offers.

The Proposed La Crete Deployment

01 Community Engagement – Summer 2018

02 Detailed Site Study – Fall 2018

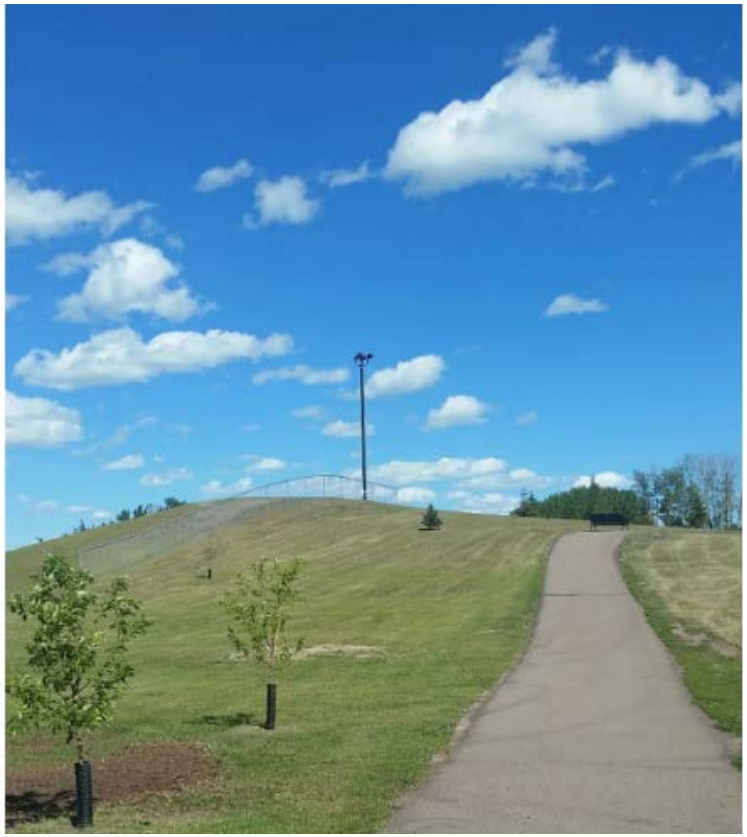
03 Fastest Service of 100/10 Available – Spring 2019

The 4 Proposed Tower Locations

Park – Reinland Location

Ball Diamond Location - Original

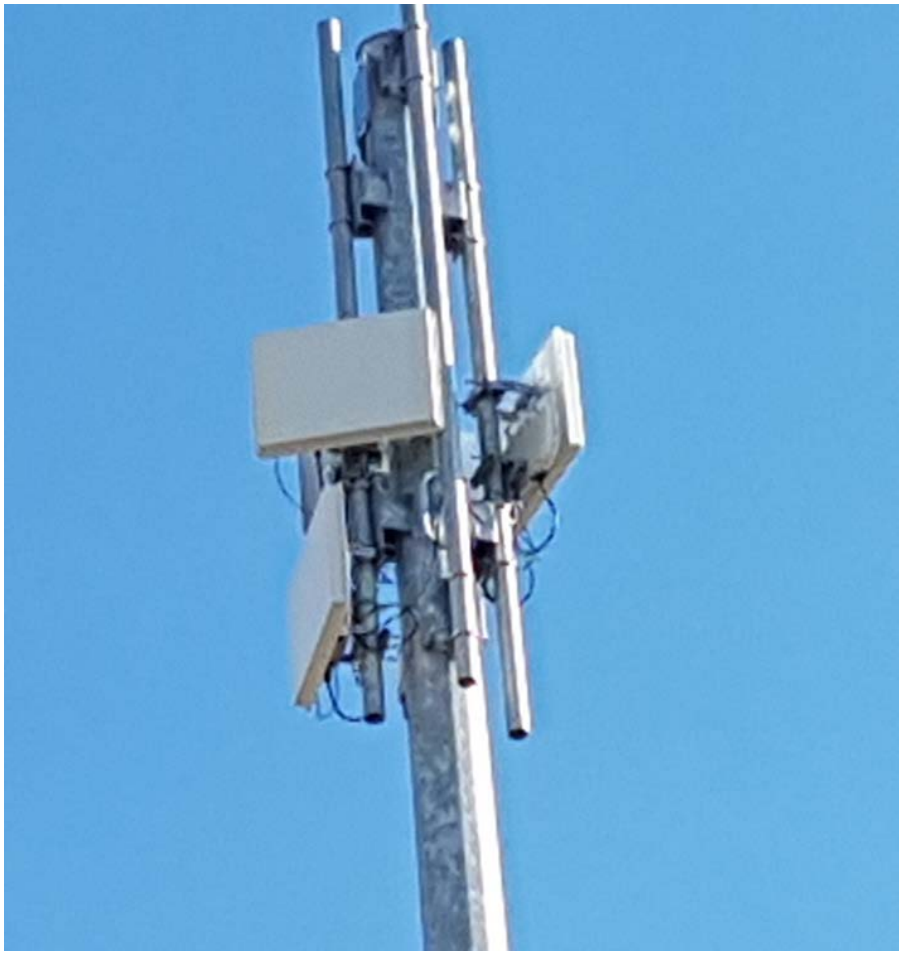
The 4 Proposed Tower Locations



Park – Hill

Water Fill

Equipment Pictures



Equipment Pictures

Questions

Graham Fleet / Director of Outside Sales and Business Development
403 250 9324 / grahamf@corp.cciwireless.ca

CCI Wireless / #137 - 465 Aviation Road, Calgary T2E 7H8
1-888-240-2224 / cciwireless.ca

cci wireless

cci wired

Wi Fibre

REQUEST FOR DIRECTION

Meeting:	**Committee of the Whole Meeting**
Meeting Date:	**January 15, 2019**
Presented By:	**Dave Fehr, Director of Operations**
Title:	**Review of Dispositions**

BACKGROUND / PROPOSAL:

Council approved 'LC & FV - Road Dispositions – Survey Work for $50,000' as a Non TCA Project in 2014. Administration has experienced some changes since the initial approval of this project, which make it difficult to pinpoint the status of the project. Administration is in possession of a very large document containing more than 150 dispositions held by Mackenzie County.

To be clear, many of these dispositions were 'given' to Mackenzie County through status changes within the Alberta government. Since many of the dispositions were not at the County's request we do not have any information on them. See attached list of dispositions and location map. Detailed map will be projected on screen.

Once we establish what each lease is for, we will require Council's decision on retention, renewal and reclamation. This will be an ongoing project as there are many leases requiring attention. Administration has requested more information from Dispositions Department with Alberta Environment and Parks. If this information is available at the time of Council meeting, a hand out will be presented.

As many of these dispositions require more investigation and likely more funds, we present the following step process rather than options:

OPTIONS & BENEFITS:

Step 1:
Proceed with certain time sensitive leases at once. If current allocated funds are not sufficient, Administration will request additional funds at a future Council meeting.

Author: S Wheeler **Reviewed by:** D Fehr **CAO:** _____

Step 2:
Carry forward the project to 2019 and request additional funds at budget preparation time.

COSTS & SOURCE OF FUNDING:

'X' number of funds may be required for 'X' number of years for ongoing 'clean up' concerning all dispositions.

SUSTAINABILITY PLAN:

COMMUNICATION / PUBLIC PARTICIPATION:

POLICY REFERENCES:

RECOMMENDED ACTION:

☑ Simple Majority ☐ Requires 2/3 ☐ Requires Unanimous

For Information and Discussion.

Author: S Wheeler **Reviewed by:** D Fehr **CAO:** _____

Disposition: Page	Disposition: Page	Disposition: Page	Disposition: Page	Disposition: Page	Disposition: Page	
EZE100178: 18 EZE100227: 19 EZE870153: 24 EZE870243: 14 EZE890266: 13 EZE890267: 19 EZE900291: 31 EZE910232: 31 EZE910387: 9 EZE930336: 82 EZE940342: 33 EZE940343: 33, 34 EZE940346: 19, 25 EZE940349: 18, 24, 25 EZE950003: 19 FRD570011: 56, 61, 62 FRD620033: 54 FRD630012: 1, 2, 87, 88, 89	LOC040171: 49, 50 LOC040593: 81, 82 LOC090308: 82 LOC090670: 30 LOC091324: 61 LOC100182: 81, 82 LOC750355: 15 LOC780462: 22 LOC781197: 30 LOC800345: 24 LOC800782: 21 LOC810435: 50 LOC830342: 50 LOC830524: 23 LOC830701: 23 LOC860453: 4 LOC861309: 13, 14 LOC870231: 81, 82 LOC950041: 30 LOC950843: 15, 16, 21, 22 LOC951512: 17 LOC961475: 19 LOC962982: 21 MLL040062: 22 MLL050113: 22 MLL050118: 81 MLL090011: 82 MLL090052: 11 MLL3066: 82 MLL840021: 86 MLL870044: 81 MLL890071: 82 MLL890072: 70 MLL890073: 85 MLL930081: 82 MLL940010: 51 MLL950043: 48 MLL950045: 34 MLL960060: 48 MLL960123: 11	PLS060030: 81, 82 PLS080023: 81, 82 RDS020010: 9 RDS020033: 25, 26 RDS040021: 40 RDS050004: 57 RDS060010: 39 RDS080056: 71 RDS800060: 53, 59, 60 RDS800061: 76, 77 RDS870061: 44 REC030012: 7 REC090007: 61 REC100003: 61 REC100008: 21 REC2621: 31 REC820035: 21 REC880027: 3	RRD0224981: 30 RRD1178PX: 10 RRD1189PX: 9 RRD1508PX: 31, 40 RRD1522PX: 10 RRD2102EU: 41 RRD2141PX: 44 RRD2160EU: 41 RRD2437PX: 34, 43 RRD2653PX: 20 RRD2901PX: 31 RRD2905PX: 21 RRD3248PX: 83, 84 RRD3389PX: 26 RRD3677LZ: 42 RRD3871LZ: 15 RRD3884PX: 31 RRD3885PX: 32 RRD4000LZ: 26, 27 RRD4210PX: 30 RRD4418PX: 32 RRD4498PX: 39 RRD4727PX: 44 RRD4793PX: 31 RRD4969PX: 20, 26 RRD5709LZ: 11, 12 RRD7621130: 30 RRD7720558: 26 RRD7920193: 52, 57, 58 RRD8020178: 44 RRD8021388: 44 RRD8022999: 21 RRD8220836: 11 RRD8221687: 36 RRD8222077: 34, 35 RRD8223190: 32 RRD8420074: 15 RRD8420866: 12 RRD8420974: 47 RRD8421233: 21 RRD8421279: 30 RRD8421370: 41 RRD8421764: 49 RRD8421896: 49 RRD8521571: 36 RRD8521604: 21 RRD8620566: 38, 45, 46 RRD8620893: 43, 44 RRD8621394: 3, 5 RRD8622407: 18 RRD8622408: 18	RRD8622898: 18, 19 RRD8720360: 18, 19 RRD880PX: 11 RRD8920420: 9, 10 RRD8923305: 29, 37, 38 RRD8923319: 55 RRD9020811: 41 RRD9023296: 67, 68 RRD9120208: 65, 66, 67 RRD9120227: 57, 63 RRD9120371: 65 RRD9120580: 28 RRD9120581: 28 RRD9121446: 6 RRD9121447: 6 RRD9121448: 28 RRD9121451: 29 RRD9121452: 28, 29 RRD9123740: 19 RRD9221174: 21 RRD9221436: 11, 12 RRD9320416: 15, 16 RRD9322564: 11 RRD9421144: 19 RRD9421767: 31 RRD9824906: 71, 72 RRD9824907: 71, 72, 77, 78 RRD9824908: 77, 78 RRD9922485: 75, 79 RRD9922498: 69, 72, 75 RRD9922512: 81, 82 RRD9922514: 73, 79, 80 RRD9922516: 73, 74, 81	SML950026: 22 SML950057: 17	

Mackenzie County Dispositions

Disposition

1 Page Number

6th M.

5th M.

N

Steen River

Lutose

Slavey Creek

Meander River

Tugate Settlement

Chateh

Rainbow Lake

Footner Lake

High Level

John D'or Prairie

North Vermilion Settlement

Fox Lake

Little Red River

Adams Landing

Big Slough

Garden Creek

Little Fishery

Fifth Meridian

Metis

La Crete

Wilson Prairie

Savage Prairie

Tall Cree North

Tall Cree South

Paddle Prairie

Keg River

Keg River

Carcajou

Kemp River

REQUEST FOR DIRECTION

Meeting:	**Committee of the Whole Meeting**
Meeting Date:	**January 15, 2019**
Presented By:	**Byron Peters, Deputy Chief Administrative Officer**
Title:	**Strategic Plan 2018-2021**

BACKGROUND / PROPOSAL:

A strategic planning workshop was held on April 9, 2018 with Council and Management. A draft copy of the plan was presented at the April 24, 2018 Committee of the Whole Meeting for review and discussion. Copies of the Plan were available at the annual Ratepayer Meetings.

The Strategic Plan has been formatted into a condensed, reader friendly document for review by Council.

OPTIONS & BENEFITS:

COSTS & SOURCE OF FUNDING:

SUSTAINABILITY PLAN:

COMMUNICATION / PUBLIC PARTICIPATION:

Copies of the draft Plan were available at the 2018 Annual Ratepayer Meetings.

Author: C. Gabriel **Reviewed by:** _____ **CAO:** _____

POLICY REFERENCES:

Policy ADM050 Council-Administration Protocol – states that the annual business planning process which outlines the strategic direction set by Council will be an organizational tool used to contribute to a successful working relationship. (s. 8. (i))

Policy ADM056 Public Participation – requires the municipality to inform the public regarding the Strategic Plan.

RECOMMENDED ACTION:

☐ Simple Majority ☐ Requires 2/3 ☐ Requires Unanimous

For review and discussion.

Author: _____ **Reviewed by:** _____ **CAO:** _____

STRATEGIC PLAN

2018-21

Mackenzie County

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CONTENTS

INTRODUCTION

Mackenzie County is dedicated to their ratepayers and meeting the unique needs of each community within our region.

The purpose of Mackenzie County's Strategic Plan is to establish critical priorities and activities of the County for the four year period between 2018-2021.

The Strategic Plan will be utilized by Administration, Council, as well as all stakeholders for follow-up review, information, and direction.

Mackenzie County's Strategic Plan has four primary categories addressed below, each with unique guiding principles, key objectives, and desired outcomes.

Governance & Leadership

Quality of Life

Economic Development

Infrastructure & Environment

VISION

An enhanced quality of life and opportunity in the community, and a healthy economic climate.

MISSION

To provide a reasonable and equitable level of service and create a sustainable economic climate through the effective use of resources.

CORE VALUES

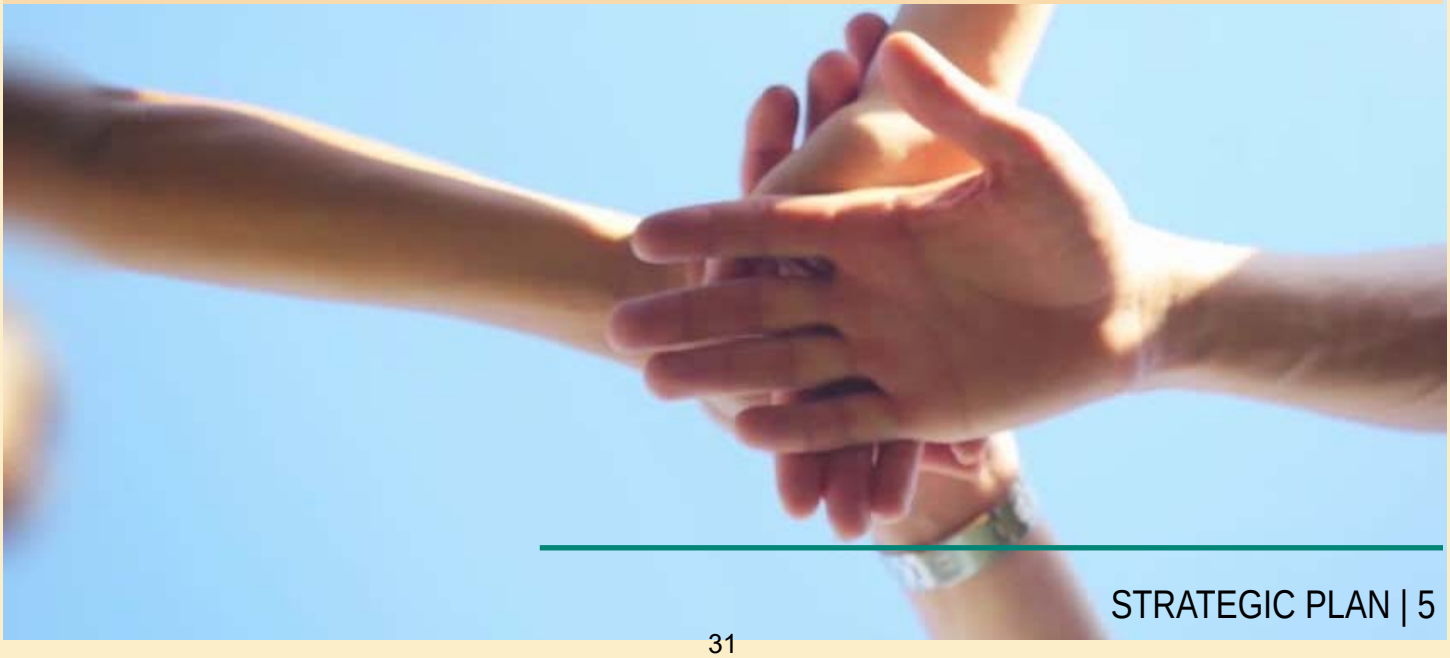
To be an efficient, fiscally responsible organization, being sincere, approachable, and maintaining a high degree of integrity.

GOVERNANCE & LEADERSHIP

Guiding Principle

To improve relationship and communication with our stakeholders, including First Nations and Metis groups, and neighbouring municipalities.

Key Objectives	Outcomes
Collaborate with neighbouring municipalities in municipal planning objectives	Completion of ICFs and IDPs
Build regular contact with First Nations & Metis groups	Collaboration in community events and provincial Consultation Policy Development
Review non-profit service delivery and develop regular contact	Support streamlining of service delivery
Build regular contact with provincial government	Establish clear and concise agenda items for Ministerial briefings
Increase education, awareness, and social capital of the hamlets	Increase opportunities for public participation at meetings/events



QUALITY OF LIFE

Guiding Principle

To improve service quality and opportunity for education, employment, health, and recreation.

Key Objectives	Outcomes
Ensure education is accessible to all residents at every level	Grade K-12 availability for all residents; Continuing Education between Fort Vermilion School Division and Northern Lakes College
Increase basic health services and personnel to deliver such services	Discuss with Alberta Health Services; Increase maternity services at Fort Vermilion Hospital and La Crete Health Centre; Partner with community health groups to fill gaps in services; Incentive programs for physicians/specialists
Address needs and services for seniors	Addition of SL3/SL4 beds and better food quality at seniors centres
Increase job opportunities and economic development to support the high cost of living in the North	Increase Northern Living Allowance and carbon levy rebates to Northern residents
Increase community involvement and recreational opportunities	Develop a La Crete Health & Fitness Facility Plan and Mackenzie County Regional Recreation Masterplan; Continue development of Blue Hills Ski Hill; Development of recreational options at Blue Hills Public School; Provincial library system node; Continued campground expansion

ECONOMIC DEVELOPMENT

Guiding Principle

To focus on local production and sustainable use of resources, and continue initiatives to develop our tourism sector.

Key Objectives	Outcomes
Increase local/regional trade	Investigate marketing strategies for our regional craftsmen; Partner with local organizations for agricultural development; Conduct feasibility study for cannabis processing facility; Partner with neighbouring provinces on value added opportunities
Increase farmland and local production	Lobby for additional Crown land sales in our region
Make efforts to support a sustainable environment	Investigate tire recycling opportunities; Ensure oil and gas resources are utilized prior to well abandonment; Encourage use of existing facilities for development
Encourage tourism and draw visitors to the region	Continue initiatives with MFTS & REDI; Develop the hamlets' appearance working with Streetscape Committees; Host events and support other community groups with their events/activities; Increase advertising efforts; Continued campground expansion

INFRASTRUCTURE & ENVIRONMENT

Guiding Principle

To ensure equity of crucial necessities for life in the North, including transportation and utilities such as water, gas, and cell service.

Key Objectives	Outcomes
Improve key regional corridors	Construction of roads and bridges; Conduct cost analyses of road pavement; Expand P5 to access southern markets
Increase access and opportunity to surrounding markets	Investigate rail options to transport goods; Collaborate with neighbouring municipalities and provinces
Increase accessibility to potable water	Collaborate with First Nations; Increase rural potable water truck-fill stations
Expand gas supply to meet community needs	Continue efforts with Atlas Gas; Collaborate with Northern Gas Co-op and Tallcree First Nation to construct additional gas line; Continue lobbying efforts to the province
Improve cell service throughout the North	Continue lobbying efforts to Telus

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Fort Vermilion, AB, T0H 1N0

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Mackenzie County

Mackenzie County

REQUEST FOR DIRECTION

Meeting:	**Committee of the Whole Meeting**
Meeting Date:	**January 15, 2019**
Presented By:	**Byron Peters, Deputy Chief Administrative Officer**
Title:	**Fort Vermilion Peace River Flood Risk Assessment**

BACKGROUND / PROPOSAL:

Mackenzie County received federal and provincial funding to conduct a Flood Risk Assessment for the Peace River in Fort Vermilion in late 2017. The project was awarded to Northwest Hydraulic Consultants (NHC) on April 25, 2018.

The project is to conduct a Flood Risk Assessment (FRA) that will identify the following:

- potential hazards present within the Peace River – Fort Vermilion geographical area;
- an assessment of their likelihoods of occurrence;
- potential impact(s) to people, economy, structures and networks, the natural environment, etc.; and
- the community vulnerabilities with respect to each of the aforementioned elements.

Main objectives of the National Disaster Mitigation Program is to reduce the impacts of natural flooding disasters within flooding prone sites such as the Fort Vermilion area. This is performed by focusing investments on recurring flood incidences that result often in unbudgeted costs; and advancing work to facilitate the communications that will assist the public as it relates to all aspects and impacts on overland flooding.

The project commenced May 7, 2018 and will be completed by March 29, 2019.

OPTIONS & BENEFITS:

Author: C. Smith **Reviewed by:** B. Peters **CAO:** _____

COSTS & SOURCE OF FUNDING:

The County has received a grant from the National Disaster Mitigation Program (NDMP) for $50,000, the County also received grant approval from Alberta Emergency Management Agency for $40,000 and the municipality has allocated $15,000 which has been carried forward from 2017. Total budget is $105,000.

There is approximately $42,000 remaining in the budget.

SUSTAINABILITY PLAN:

Strategy N1.3 Develop municipal policy to ensure that sound environmental protection, maintenance and utilization practices serve to preserve the health and safety of valleys (especially sound practices to guide the development of any future roadways that must be built over a river).

Strategy N2.1 Identify and maintain an up-to-date inventory of Mackenzie County's environmentally sensitive land areas or ones that are at risk of becoming environmentally sensitive.

COMMUNICATION / PUBLIC PARTICIPATION:

There are no requirements to notify or involve the public as this is simply a report.

Before final approval, the County has an opportunity to present the findings within the report to the public and/or get additional feedback.

POLICY REFERENCES:

N/A

RECOMMENDED ACTION:

☑ Simple Majority ☐ Requires 2/3 ☐ Requires Unanimous

For discussion.

Author: C. Smith **Reviewed by:** B. Peters **CAO:** _____

FORT VERMILION – PEACE RIVER FLOOD RISK ASSESSMENT

DRAFT REPORT

Prepared for:

Mackenzie County

17 December 2018

NHC Ref. No. 1003834

nhc
northwest hydraulic consultants
water resource specialists

FORT VERMILION – PEACE RIVER
FLOOD RISK ASSESSMENT

DRAFT REPORT

Prepared for:

Mackenzie County
Fort Vermilion, Alberta

Prepared by:

Northwest Hydraulic Consultants Ltd.
Edmonton, Alberta

17 December 2018

NHC Ref No. 1003834

APEGA Permit to Practice - P654

Prepared by:

Robyn Andrishak, MSc, PEng
Principal

Md Makamum Mahmood, M.Eng., P. Eng.
Project Engineer

Reviewed by:

Vivien Reske, M.Eng., P.Eng.
Senior Water Resources Engineer

DISCLAIMER

This report has been prepared by Northwest Hydraulic Consultants Ltd. in accordance with generally accepted engineering practices, for the benefit of Mackenzie County for specific application to the Fort Vermilion – Peace River Flood Risk Assessment in Alberta. The information and data contained herein represent Northwest Hydraulic Consultants Ltd.'s best professional judgment based on the knowledge and information available to Northwest Hydraulic Consultants Ltd. at the time of preparation.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by Mackenzie County, its officers and employees. Northwest Hydraulic Consultants Ltd. denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents.

EXECUTIVE SUMMARY

Northwest Hydraulic Consultants Ltd. (NHC) was retained by Mackenzie County to conduct a flood risk assessment for Fort Vermilion Townsite and North Vermilion Settlement, which are situated along the Peace River in northern Alberta. The community has flooded several times; the most recent event occurred in 2018 as a result of a breakup ice jam. A much larger ice jam event occurred in 1934, resulting in extensive flooding of the North Vermilion Settlement and Fort Vermilion.

This project is funded as part of a National Disaster Mitigation Program (NDMP) Stream 1 Risk Assessment. The objective of the project is to identify flood risks and develop potential flood mitigation strategies for flood prone areas. The scope of the project included a review of local flood history, hydrology assessment, modelling and mapping inundation extents, identification and assessment of flood risks, and development of mitigation alternatives. A key component of this project was to complete the NDMP Risk Assessment Information Template (RAIT).

Four flood scenarios were mapped and analysed: 100-year open water flood, open water flood with potential climate change effects, 2018 ice jam flood, and 1934 ice jam flood. The results of the flood risk assessment demonstrate that the North Vermilion Settlement and Fort Vermilion Airport lands are the most susceptible to flooding in the Community, followed by areas behind River Road between 50 Street and the airport. For a recurrence of the 1934 ice jam flood event, nearly 400 people and 180 buildings could be flooded in Fort Vermilion and the North Vermilion Settlement combined, resulting in damages up to $40,000,000 based on present development within the flood prone areas. Open water floods would impact the North Vermilion Settlement and the Fort Vermilion Airport lands the most, since the anticipated flood levels are lower for open water events relative to floods caused by ice jams.

Based on the flood vulnerabilities identified, potential flood mitigation alternatives for Fort Vermilion include construction of flood barriers around critical buildings and assets (e.g. the school), relocation of the airport to a new location on higher ground, restricting new development in low-lying areas, flood proofing existing structures, raising roads to provide flood protection, and retreat from flood prone areas. At the North Vermilion Settlement, the mitigation alternatives include a 4.5 km flood dike to protect the entire area, flood proofing individual structures, or buying-out existing properties immediately or over time. Other non-structural measures that apply to both portions of the study area include updating the existing regulatory floodway maps and boundaries, improving breakup forecasting and warning systems, and educating the public on flood risks to the community.

Specific recommendations and priorities for flood mitigation will be provided following additional stakeholder consultation in early 2019.

CREDITS AND ACKNOWLEDGEMENTS

The work described in this report was undertaken by Northwest Hydraulic Consultants Ltd. (NHC) for Mackenzie County. Special thanks are expressed to Byron Peters and Caitlin Smith for providing overall study management, background information, technical guidance, and valuable comments on this report. We would also like to express appreciation to the Fort Vermilion Heritage Centre for sharing historical flood documentation and local knowledge with the study team.

The study team from NHC consisted of:

- Robyn Andrishak, M.Sc., P.Eng. – Project Manager and Technical Lead
- Md Makamum Mahmood, M.Eng., P.Eng. – Project Engineer
- Vivien Reske, M.Eng., P.Eng. – Project Engineer
- James Snyder, P.Eng. – Project Engineer

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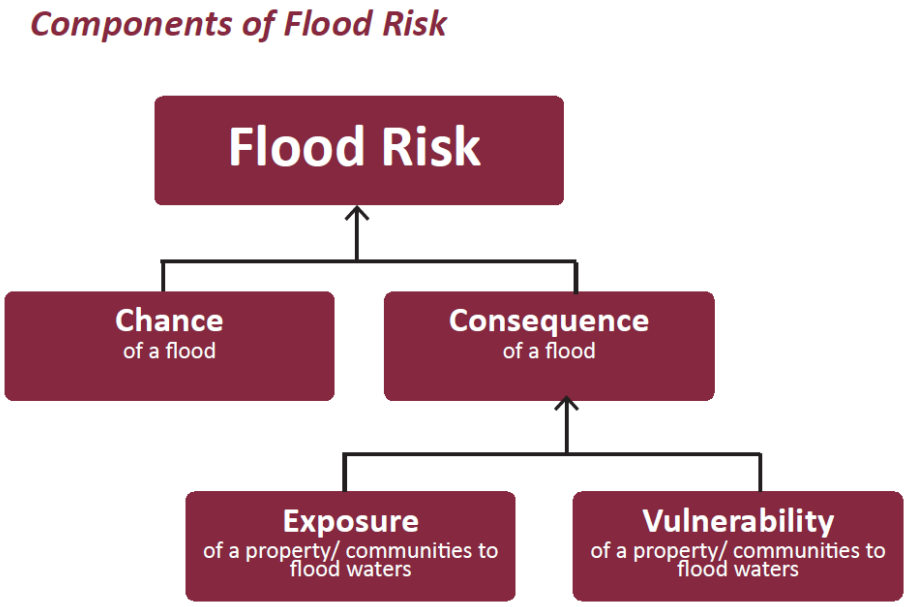
1 INTRODUCTION

1.1 Background

Northwest Hydraulic Consultants Ltd. (NHC) was retained by Mackenzie County (the County) to conduct a Flood Risk Assessment for Peace River at Fort Vermilion. The project is funded as part of a National Disaster Mitigation Program (NDMP) Stream 1 Risk Assessment.

Floods along the lower Peace River have occurred during both open water and ice affected periods. However, breakup ice jam events have been found to cause the most extreme flood levels based on previous study (Alberta Environment, 2000) and historical accounts. Therefore, both open water and ice jam events were carefully considered in this study.

Flood risk assessment involves not only characterizing the flood hazard but also assessing the consequences of an event. In this context, "risk" is defined as the combination of the likelihood (or chance) of the event occurring and the resulting consequences of the event (De Wrachien, 2008); the latter being a function of the exposure and vulnerability of the community and its infrastructure. These components of flood risk are illustrated below.



Source: Queensland Reconstruction Authority (2013).

Exposure can be represented as the sum of the elements potentially impacted by the flood event, including: people; dwellings, hospitals, schools, commercial or industrial businesses, government buildings, and various types of infrastructure. Vulnerability is the degree to which exposed elements are susceptible to the adverse effects of flooding.

1.2 Project Area

The Hamlet of Fort Vermilion is located in northern Alberta, approximately 77 km southeast of the Town of High Level and 250 km north of the Town of Peace River (**Figure 1**). The project area shown in **Figure 2** includes the Fort Vermilion townsite and the North Vermilion Settlement located along the banks of the Peace River. The North Vermilion Settlement is also known locally as Buttertown. A Water Survey of Canada (WSC) gauging station (07HF001 Peace River at Fort Vermilion) is located near the northwest boundary of the Fort Vermilion Townsite. Highway 88 crosses the Peace River just a few kilometres upstream of the project area.

1.3 Study Objective

The objective of this study is to assist the County in identifying flood risks within the Hamlet of Fort Vermilion and potential flood mitigation strategies for flood prone areas. A key component of this work is to complete the NDMP Risk Assessment Information Template (RAIT) with inputs from the County and the results of this study. The RAIT tool supports future activities such as more intensive data collection and detailed analysis, including preparing floodplain mapping, detailed vulnerability and risk assessments, and mitigation planning.

2 STUDY APPROACH

2.1 Data Collection and Review

The following provides a summary of the data collected and reviewed for this study.

Previous Reports and Studies

A flood mapping study for the Peace River at Fort Vermilion was previously completed by Alberta Environment (2000). The report and associated numerical hydraulic model were obtained from Alberta Environment and Parks (AEP). The flood mapping report is a key document to understand the local flood risks.

Other available reports and studies relevant to the present flood risk assessment include:

- Fort Vermilion Highwater Marks and Water Levels (Alberta Environment, 1990).
- Provincial Flood Damage Assessment Study (IBI Group, 2015).
- Peace River Basin Flood Mitigation Feasibility Study (AECOM, 2015).

Flood Documents and Photographs

Historical and recent flood documents and photographs were collected from various sources. The documents collected and reviewed include: Alberta Transportation (AT) records for the Highway 88 Bridge (BF7422) as well as photographs and related local flood history collected from the Fort Vermilion Heritage Centre. Additional photographs were also supplied by the County for the April/May 2018 ice jam flood event affecting the community.

Flow and Water Level Data

WSC operates a streamflow gauging station on Peace River at Fort Vermilion (07HF001). The watershed area upstream of the gauge location is 227,000 km^2 covering portions of northwestern Alberta and northeastern British Columbia. Historical flow (discharge) data are available for the periods 1915-1922, 1961-1978 and 2006-present; water level data is available for the period of 1979-1993 and 2012-present.

Spatial Data and Base Mapping Features

High resolution LiDAR-derived digital elevation model data for this study was provided by the County as a point elevation cloud. Aerial imagery (10 cm resolution) acquired in 2016 was also provided by the County. Additional imagery from ArcGIS base map was used to extend coverage over the North Vermilion Townsite.

Cadastral (land parcel) information was provided by the County; road and railway alignments were obtained from Natural Resources Canada; census boundaries and population values were obtained from Statistics Canada (2016).

2.2 Site Inspection and Survey

A site inspection and survey was completed by NHC personnel 27 and 28 June 2018. Photos taken during the site inspection are provided in Appendix A. The elevation of highwater marks, ice scars on trees, low points on River Road, WSC benchmarks, and the main floor of key structures was surveyed, using Trimble R10 Real Time Kinematic (RTK) Global Navigation Satellite Systems (GNSS) receivers, to support the flood risk assessment.

2.3 Stakeholder Engagement

Stakeholder engagement included initial discussions with representatives of Mackenzie County, some local residents, and the Fort Vermilion Heritage Centre to better understand the local flood history. Since a significant flood had occurred very recently, in April 2018, much of the input from stakeholders was provided in the context of that event. Some longtime residents of the North Vermilion Settlement were also available to provide accounts of the 1934 ice jam flood and its impacts on the community.

Additional stakeholder engagement as part of the review of this flood risk assessment and prioritization of mitigation alternatives will be completed in early 2019.

2.4 Flood Hydrology

Previous flood frequency estimates for the Peace River at Fort Vermilion were reviewed and updated for this study using available information from WSC and AEP. Open water and ice jam flood mechanisms were considered separately in this analysis.

For open water events, the most recent 18 years of peak annual discharge recorded at Fort Vermilion (Station 07HF001) were used to update the flood frequency estimates. Peak instantaneous values were estimated based on a linear relationship between peak daily and instantaneous values where gaps in the record exist. In total, 29 years of data were available for the updated flood frequency analysis.

Severe ice jams with the potential to cause flooding at Fort Vermilion are most likely to occur during spring breakup. Unfortunately, there is limited availability (approximately eight years) of peak water levels recorded at the WSC gauge during breakup to support a typical ice jam flood frequency analysis. However, qualitative and some limited quantitative information does exist for ice jam floods that occurred in 1888, 1934, 1950, and 1963. In addition, the most recent 2018 ice jam event was well-documented, including a highwater mark profile surveyed by NHC for this study along the study reach. The largest recorded event (1934) and most recent (2018) ice jam events were used in this study to assess the ice jam flood risks to the community, as it is expected that these events are representative of

the 100-year ice jam flood magnitude that could be obtained through more comprehensive statistical analysis and modelling.

2.5 Vulnerability and Risk Assessment

Flood vulnerabilities in the community were identified using the flood hydrology and hydraulic modelling techniques to map areas of inundation and associated flood depths for open water and ice jam floods. Since an existing HEC-RAS numerical model complete with cross section geometry for the study reach was available from a previous flood risk mapping study, it was possible to estimate flood levels for specified risk events (e.g. the 100-year flood) and compare modelled and observed inundation extents for past floods (e.g. the 2018 ice jam). However, detailed flood mapping and hazard identification was not within the scope of this study and requires additional field data collection and engineering analysis.

Results of the modelling and mapping were then used to estimate impacts to populations, structures, and critical assets in the community. Census dissemination blocks from Statistics Canada (2016) were used to identify the total population at risk under different flood scenarios. Buildings in flood prone areas were classified as residential and non-residential buildings based on aerial imagery, cadastral data, and information obtained during the site inspection. In some cases, the 2018 flood photos provided by the County were referenced to help identify the type of structure when it was not apparent from other sources.

All land parcels, structures, and roads falling all or partially within the flood inundation extents for a given scenario (i.e. open water or ice jam flood) were deemed to be at risk and inventoried. Population at risk of flooding was estimated based on the census data and number of buildings at risk of flooding. Flood depth was used to further define the risks to structures and populations as follows:

- 50 cm or less: most buildings dry, walking in moving water or driving is potentially dangerous, basements and underground facilities may be flooded.
- 50 to 100 cm: water on ground floor, basements and underground parking flooded, potentially causing evacuation, electricity failed, vehicles are commonly swept off the road.
- 100 to 200 cm: ground floor flooded, residents evacuated.
- 200 to 500 cm: first floor and often roof covered by water; residents evacuated.
- More than 500 cm: first floor and often roof covered by water; residents evacuated.

Roads at risk were calculated by determining the total length of roadway inundated. Other identified historical or environmentally sensitive sites impacted were also identified.

The risk assessment inventory was used to estimate potential flood damages to structures, in monetary terms, based on flood damage curves developed for the Province of Alberta (IBI Group, 2015). Both structural and contents damages are incorporated in the flood damage curves. Flood damages were assessed based on the size and type of each affected primary structure or building and the depth of

flooding at their locations. Secondary structures such as garages and other out-buildings were not included in the damage estimates. Published adjustment factors for damage values in the Fort Vermilion region were applied. Other potential costs associated with emergency response, infrastructure repairs, and environmental remediation were not estimated due to a variety of uncertainties.

2.6 Development of Mitigation Alternatives

Flood mitigation concepts were developed to address vulnerabilities identified in the flood risk assessment. For this risk assessment stage, mitigation alternatives provide planning-level detail that can be discussed with stakeholders to determine which alternatives should be advanced to detailed design or given further consideration. Both structural and non structural measures were considered in the development of mitigation alternatives. Structural measures include flood control dikes (berms) and raising roads and other structures in flood prone areas. Non structural measures include changes to land use policies, flood forecasting and warning systems, updated emergency response plans, capital asset management strategies, flood risk education for local residents, and stakeholder outreach.

3 HISTORY OF FLOODING

Fort Vermilion has experienced both open water and ice jam floods in the past, with the most recent event occurring as a result of a breakup ice jam on the Peace River in April/May 2018. The most devasting flood observed at Fort Vermilion occurred in 1934, also as the result of a breakup ice jam. Fewer (severe) open water floods have been experienced at Fort Vermilion and upstream communities along the Peace River, including the Town of Peace River. However, such open water floods can be severe enough to pose risks similar to ice jam floods. The history of flooding at Fort Vermilion is described below; available photographs documenting these floods are provided in Appendix B.

3.1 2018 Ice Jam Flood

Colder than average spring temperatures and above average late-season snowpack in the Peace River basin resulted in a series of ice jams forming on the lower Peace River in late April of 2018. During the course of breakup, a significant ice jam formed at Fort Vermilion that caused emergency evacuations, temporary closure of Highway 88 near the Peace River Bridge, flooded nine homes in the North Vermilion Settlement, and inundated low lying areas near the airport. Flood depths on the order of 1.5 m (five feet) were recorded at the North Vermilion Settlement and flood levels came within 0.15 m (six inches) of overtopping River Road in the main townsite. The peak water level recorded at the WSC gauge during this event was 255.79 m.

3.2 2011 Open Water Flood

WSC recorded a discharge of 12,900 m^3/s on 13 July 2011. The maximum water level recorded at the gauge during that time was 252.89 m. The primary concern during this event was that the water would overtop the Highway 88 near the south approach to the Peace River Bridge.

3.3 1990 Open Water Flood

On 16 June 1990, WSC recorded an instantaneous water level of 253.403 m and a peak discharge of 12,640 m^3/s at Fort Vermilion. This flood was the result of concurrent highwater events in the middle and upper portions of the Peace and Smoky river basins. Floodwaters peaked at the Town of Peace River three days earlier on 13 June as a result of this same event, but the town's dikes were not overtopped. Flooding at Fort Vermilion was minimal during this event.

3.4 Earlier Floods

Although WSC's earliest records at Fort Vermilion date back to 1915, there are significant gaps in the record between 1922 and 1961 and between 1978 and 2006. Notwithstanding these gaps, the historical records from local observers provide key details about the severity of floods that occurred in 1888, 1934, 1950, 1963, and 1964. Table 1 provides a summary of those details.

Table 1 Summary of flood events at Fort Vermilion prior to 1990

Date	Type of Flood	Description
7-9 May 1888	Ice jam	The flood was believed to be caused by ice jam 25 miles (40 km) downstream at Big Island. The 1888 flood reached approximately same height as 1934 flood, some even believed that 1888 flood reached a higher level. Estimated flood level is not available.[1]
22 April 1934	Ice jam	Worst historical flood reported by long term residents in Fort Vermilion. The flood was caused by an ice jam located 3.2 km (2 miles) below the town. It was estimated by the residents that there was 0.6 m of water in the area of the Hudson Bay company store and 1.8 m deep where the present airport is located. Previous reports have established the flood level of 256.95 m.[2]
7 May 1950	Ice jam	Not much information is available about the 1950 flood, except for a few photos of ice breakup.[3] It is believed that this event did not have impacts as significant as the 1888 or 1934 floods.
23 May 1963	Ice jam	The 1963 ice jam caused a number of areas to become inundated. The estimated peak flood level was around 254.2 m.[4] The airport road had up to 0.6 m of water over it. [2]
1964	Unspecified	The river reached bank full in 1964. The water elevation at airport area is reported as 255.7 m.[5]

Sources:

1. The Emperor of Peace River 1886-1952 from Eugenie Louise Myles (Collected from Alberta Transportation Bridge File 74227-1888 flood documentation).
2. AENV (2000). Flood Risk Mapping Study-Peace River at Fort Vermilion. Alberta Environment, July 2000.
3. Alberta Transportation, Bridge File 74227-1950 flood documentation.
4. Alberta Transportation, Bridge File 74227-1963 flood documentation.
5. Alberta Transportation, Bridge File 74227-1934 flood documentation.

4 MODELLING AND MAPPING

4.1 Flood Frequency Analysis

Updated open water flood frequency discharge estimates based on available data from WSC Station 07HF001 are provided in **Table 2**. The Log-Pearson Type III distribution shown in **Figure 3** was used to obtain the present estimates.

Table 2 Open water flood frequency discharge estimates for the Peace River at Fort Vermilion

Return Period (years)	Probability of Exceedance in Any Given Year (%)	Peak Instantaneous Discharge (m^3/s)
500	0.2	18,500
200	0.5	17,400
100	1	16,400
50	2	15,300
20	5	13,700
10	10	12,300
5	20	10,500
2	50	7,500

It is worth noting that the additional years of recorded peak discharge data available at the gauge since the most recent flood mapping study by Alberta Environment (2000) has resulted in a 100-year return period discharge that is approximately 30% higher than the previous estimate. The updated values in **Table 2** were found to be consistent with flood frequency analyses recently conducted by NHC for upstream locations along the Peace River.

4.2 Flood Levels and Profiles

Flood levels were simulated along the study reach using the hydraulic model obtained from Alberta Environment and Parks (refer to Section 2.1). This model was previously calibrated to the 1990 open water flood event, which had a corresponding discharge of 12,640 m^3/s. Water levels simulated for a range of discharges were compared to the WSC gauge rating curve, and the previous model calibration was further refined by varying the roughness coefficient with discharge to achieve better agreement between the simulated water levels and the WSC rating curve at the Fort Vermilion gauging station. The results of the rating curve comparison are shown in **Figure 4**.

Water surface profiles for selected open water flood frequencies are illustrated in **Figure 5**, with elevation profiles for River Road (in Fort Vermilion) and Buttertown Road (in the North Vermilion Settlement) indicated for reference. **Table 3** provides a summary of expected open water flood levels at

four key locations along the study reach: Highway 88 Bridge, WSC gauging station (near the Legion Hall), 45 Street, and the Airport. The highest recorded open water flood level at the WSC gauge is 253.68 m, during 1990 flood. This value is 0.35 m below the estimated 20-year flood level of 254.03 m.

Table 3 Open water flood levels at selected return periods and key locations

Key Location	Estimated Flood Level (m)				
	500-year	200-year	100-year	50-year	20-year
Highway 88 Bridge	256.12	255.72	255.35	254.94	254.29
WSC Gauge	255.95	255.53	255.15	254.71	254.03
45 Street	255.39	254.99	254.63	254.22	253.58
Airport	255.49	255.08	254.71	254.28	253.62

The simulated water surface profile for the 2018 breakup ice jam event is shown in **Figure 6** along with the surveyed highwater marks for comparison. The peak discharge during breakup and necessary ice jam model parameters were estimated based on the information available and NHC's experience modelling ice jam events at other locations along the Peace River. The 1934 ice jam was also simulated for comparison, although the historical record of this event provides limited details to validate model parameters. An estimate of the water surface profile associated with this event is provided in **Figure 7** with the 2018 ice jam profile and reported 1934 peak water level at Fort Vermilion shown for comparison.

4.3 Inundation Extents and Flood Depths

Inundation extents were mapped for the 100-year, 200-year, and 500-year open water floods as shown in **Figure 8**. Based on these maps, the areas most vulnerable to flooding include the North Vermilion Settlement, lands immediately east of the water treatment plant including portions of River Road, St. Luke's Anglican Cemetery, and the airport. The road to the old ferry crossing on the south side of the river, west of the Townsite is also quite vulnerable to flooding; however, there no development in this area. The 500-year open water flood corresponds to water levels that are roughly 0.8 m above the 100-year flood. The terrain beyond the floodplain is relatively steep, so the overall 500-year inundation extents are fairly similar to the 100-year extents, with the most notable exception being to the southwest of the airport. Some isolated areas of high ground above the 100-year flood levels, such as the airport runway, would become inundated for the 200-year and larger events.

The approximate inundation extents for the 2018 ice jam flood are shown in **Figure 9** and the estimated inundation extents for the 1934 ice jam flood are shown in **Figure 10**. The areas most vulnerable to flooding during an ice jam event are similar to those for open water; however, compared to open water floods, the airport may be somewhat less impacted during an ice jam if the toe of the jam forms at or upstream of the airport. The 2018 ice jam flood extents were estimated to be slightly greater than the 100-year open water flood. The 1934 flood would have been significantly larger than the 2018 event and impacted a large area downstream of 50th Street behind River Road.

Flood depths were also mapped for the 100-year open water (**Figure 11**), 2018 ice jam (**Figure 12**) and 1934 ice jam (**Figure 13**) floods. Estimated flood depths for the 100-year open water flood are on the order of 0.5 m or less at Fort Vermilion, along River Road and around the airport. Depths associated with the 2018 ice jam event were estimated to be up to 2 m along River Road. For the 1934 ice jam event, the mapping shows significantly higher depths of water compared to both 100-year open water and 2018 ice jam floods. Depths of up to 0.5 m around 50th Street, 1-2 m at 45th and 47th streets, and exceeding 2 m at 31st Street and at the airport were estimated. The estimated average flood depth at the North Vermilion Settlement is just below 1 m for 100-year open water flood, 1-2 m for the 2018 ice jam flood, and more than 2 m for the 1934 ice jam flood.

4.4 Potential Effects of Climate Change

Climate change is an important consideration in flood risk assessment, since floods are generally expected to become more frequent and severe as a result of global warming. Climate models differ in their projections, with some models predicting increases in runoff (e.g. Poitras et al., 2011) and others predicting decreases. At present, there is low confidence in global climate model predictions of changes in flood magnitudes (Jiménez et al., 2014). However, most investigations predict a trend toward earlier peak flow and breakup timing.

For this study, a simplified approach similar to the one adopted by Alberta Environment and Parks for recent flood hazard identification studies was completed. Potential effects of climate change were considered, for open water conditions, by analysing a flood with a discharge 20% larger than the current 100-year flood estimate at Fort Vermilion, or 19,700 m^3/s. A flood of this magnitude is larger than the current estimate of the 500-year flood indicated in **Table 2**. A comparison of the current and climate change flood level profiles through Fort Vermilion is presented in **Figure 14**. Based on these results, climate change effects could result in flood levels up to 1.2 m above current 100-year open water flood levels (**Table 4**).

Table 4 Estimated increase in open water flood levels at Fort Vermilion due to climate change

Key Location	Increase in Flood Level (m)
Highway 88 Bridge	1.1
WSC Gauge	1.1
45 Street	1.2
Airport	1.1

The areas at risk of flooding (i.e. incremental inundation) beyond the current 100-year open water flood extents are shown in **Figure 15**. Potential climate change effects on flooding are somewhat more significant for the Townsite than the North Vermilion Settlement, which is already completely inundated at the 100-year flood extents. Climate change could lead to open water flooding as severe as the ice jam flooding experienced in 2018; however, the 1934 ice jam flood would still be significantly larger than the

open water flood with potential climate change effects. Open water flood depths with potential climate change effects were mapped (**Figure 16**) to support the flood risk assessment and assess the potential incremental risks to populations, structures, and critical assets in the community.

Potential climate change effects on breakup severity could not be addressed quantitatively in this study because there are numerous factors (not only discharge) that affect ice-induced flooding. More detailed ice jam modelling that is beyond the scope of this study is possible to address detailed design requirements for future flood mitigation projects.

5 FLOOD RISK ASSESSMENT

A flood risk assessment was completed to identify and inventory specific components that are likely to cause disruption to the community and result in monetary and other losses. Four flood scenarios were considered:

1. Current 100-year open water flood
2. Open water flood with potential climate change
3. 2018 ice jam flood
4. 1934 ice jam flood

The results of the risk assessment are presented separately for the Fort Vermilion Townsite and North Vermilion Settlement, below. Complete Risk Assessment Information Template (RAIT) documentation is provided as Appendix C to this report.

5.1 Fort Vermilion

Overtopping of River Road can pose a significant flood risk to people and infrastructure within the Townsite. The elevation of the road drops to the east of 45 Street and could be overtopped during 50-year and higher open water floods and ice jam floods. **Table 5** summarizes the risk assessment results for the Fort Vermilion Townsite.

Table 5 Summary of flood risks at Fort Vermilion Townsite

Risk Component	Flood Scenario			
	Current 100-year open water	Open water with potential climate change	2018 ice jam	1934 ice jam
Inundated Area (ha)	92	166	74	407
Land Parcels	32	69	41	252
Residential Buildings	1	5	1	120
Non-Residential Buildings	11	14	0	46
Length of Road (km)	1.23	3.49	1.54	8.48
Population	2	14	2	363

The results above show that the 100-year open water flood and 2018 ice jam flood have similar impacts on the Townsite, except for the airport site. Potential climate change effects could increase the inundated portion of the Townsite by 80%. An ice jam flood like the 1934 event could inundate an area more than five times larger than that affected by the 2018 ice jam flood. The total number of buildings affected by a recurrence of the 1934 ice jam event would be as much as 166, based on present development conditions on the inundated lands, impacting a population of approximately 363. For comparison, the 100-year open water flood would impact one residential building and an estimated population of two.

The affected residential and non-residential buildings are further categorized in **Table 6** (below) based on depth of inundation around the structure. Approximate flood depth at locations of interest (e.g. public facilities and gathering places) are provided in **Table 7.**

Table 6 Number of buildings in Fort Vermilion at risk by building type and flood depth

Building Type	Flood Depth (m)	Flood Scenario			
		Current 100-year open water	Open water with potential climate change	2018 ice jam	1934 ice jam
Residential	< 0.5	1	4	1	13
	0.5 – 1	0	1	0	39
	1 – 2	0	0	0	67
	> 2	0	0	0	1
Non-Residential	< 0.5	11	1	0	3
	0.5 – 1	0	1	0	8
	1 – 2	0	12	0	24
	> 2	0	0	0	11

Table 7 Depth of flooding at locations of interest in Fort Vermilion

Location of Interest	Flood Scenario			
	Current 100-year open water	Open water with potential climate change	2018 ice jam	1934 ice jam
Legion	Nil	Nil	Nil	Nil
Library	Nil	Nil	Nil	Nil
St. Mary's School	Nil	0.15 m	Nil	2
Courthouse	Nil	Nil	Nil	1.6
Church	Nil	Nil	Nil	1.9
Bay House (Historical Site)	Nil	Nil	Nil	1.5
Water Treatment Plant	Nil	Nil	Nil	0.8
St. Luke's Cemetery	Nil	1.1 m	0.3	2.4
Airport Terminal	< 0.1 m	1.25 m	Nil	2
Airport Runway	0.15 m	1.2 m	Nil	2

For the open water flood event, the primary impacts would be at the airport, where the flood depths could reach 0.15 m on the runway. Potential climate change impacts could increase the depth of flooding in this area by up to 1.1 m. A recurrence of the 1934 ice jam flood would impede access to several key facilities in the Townsite, such as the school, church, library, courthouse, and water treatment plant.

Potential environmental risks associated with flooding at Fort Vermilion are considered minimal based on the type and number of structures and facilities at risk. However, a review of the airport facilities and operations is recommended to ensure that fuel stores are not exposed to flood waters and released into the river during a flood.

Estimated flood damages at Fort Vermilion are summarized in **Table 8**. These estimates include only structural and contents damages based on published residential and non-residential rates. Non-residential damages are mainly associated with the flooding at the airport and do not include repairs to the runway. The estimated total flood damages from 100-year open water and 2018 ice jam flood events is estimated to be less than a million dollars. Potential climate change impacts could increase the flood damages to between 2.2 and 4.2 million dollars, while the estimated damages associated with a recurrence of the 1934 ice jam flood are in the order of 19 to 36 million dollars.

Table 8 Estimated flood damages at Fort Vermilion (in millions of dollars)

Building Type	Flood Scenario			
	Current 100-year open water	Open water with potential climate change	2018 ice jam	1934 ice jam
Residential	< 0.01	0.2 to 0.4	< 0.01	14 to 26
Non-Residential	0.1 to 0.2	2.0 to 3.8	Nil	5 to 10

5.2 North Vermilion Settlement

The results of the flood risk assessment for North Vermilion Settlement were summarized into statistics based on the number of land parcels, number of buildings and bridges (infrastructure), length of roadway and railway (infrastructure), estimated population and key facilities at risk. The results are presented in **Table 9** below for different scenarios. Buttertown Road is at risk of overtopping at the 50-year and higher open water floods.

Table 9 Summary of flood risks at North Vermilion Settlement

Risk Component	Flood Scenario			
	Current 100-year open water	Open water with potential climate change	2018 ice jam	1934 ice jam
Inundated Area (ha)	145	176	171	252
Land Parcels	41	42	42	44
Residential Buildings	8	10	9	12
Non-Residential Buildings	0	0	0	0
Length of Road (km)	3.01	3.39	3.35	3.84
Population	20	25	23	30

These results show that all flood scenarios will have a similar impact on the North Vermilion Settlement because most of the existing structures are situated within the floodplain and the area is relatively flat. The available census information suggests that up to 30 residents in the area could be impacted.

The flood risks from different scenarios can be further assessed based on flood depths. The affected residential buildings are further categorized in **Table 10** (below) based on depth of inundation around the structure. There are no non-residential (e.g. commercial or industrial) buildings in the North Vermilion Settlement. The results show that the affected houses would be exposed to flood depths less than 1 m for the 100-year open water flood; however, this could increase to 2 m with potential climate change effects. For the 2018 ice jam flood, the flood depths were estimated to be less than 1 m at five homes and up to 2 m at four others. For a recurrence of the 1934 ice jam flood, ten of the twelve homes in the area would be exposed to flood waters exceeding 2 m in depth. Potential environmental and historical resource risks associated with flooding at the North Vermilion Settlement are minimal based on the type of structures at risk. However, the potential for damages and impacts to the resident population are significant as shown in **Table 11**.

Table 10 Number of buildings in North Vermilion Settlement at risk by building type and flood depth

Building Type	Flood Depth (m)	Flood Scenario			
		Current 100-year open water	Open water with potential climate change	2018 ice jam	1934 ice jam
Residential	< 0.5	5	2	0	1
	0.5 – 1	3	0	5	0
	1 – 2	0	8	4	1
	> 2	0	0	0	10
Non-Residential	< 0.5	Nil			
	0.5 – 1				
	1 – 2				
	> 2				

Table 11 Estimated flood damages at North Vermilion Settlement (in millions of dollars)

Building Type	Flood Scenario			
	Current 100-year open water	Open water with potential climate change	2018 ice jam	1934 ice jam
Residential	0.1 to 0.2	1.0 to 1.8	1.0 to 1.8	1.4 to 2.6
Non-Residential	Nil			

6 MITIGATION ALTERNATIVES

Structural and non-structural flood mitigation alternatives were developed for the Townsite and the North Vermilion Settlement. Structural flood mitigation measures typically include dikes, berms, diversion canals, or dams; non-structural flood mitigation measures include retreat from flood-prone areas, restricting new development in flood prone areas, improving flood forecasting and warning systems, and flood proofing buildings. Since the main objective of the present study is to provide conceptual-level flood mitigation alternatives, the 1934 ice jam flood has been used as a point of reference. However, a less severe event may ultimately be more appropriate for detailed design of mitigation measures.

Specific mitigation alternatives are discussed below. These alternatives are not necessarily listed in order of priority and a combination of alternatives may ultimately be recommended based on feedback from the County and other stakeholders.

6.1 Fort Vermilion

The following flood mitigation alternatives have been identified for Fort Vermilion. Although much of the townsite is situated above the floodplain, some development exists in areas that would be impacted if an ice jam of similar magnitude to the 1934 event were to recur. The County will need to balance a variety of priorities and factors when developing its flood mitigation strategy.

Construct Flood Barriers Around Critical Buildings and Assets

Some newer infrastructure built near the river, such as the courthouse and water treatment facilities, has been built well above ground elevation to mitigate flood impacts. However, the floor level of the school is estimated to be 2 m and the church 1 m below 1934 ice jam flood levels. Flood depths of this magnitude would result in significant damage to these critical buildings in the community. If another measure of flood mitigation is not able to provide protection, berms or flood walls around the perimeters of these sites should be considered to provide localized flood protection. Locations where onsite flood barriers should be considered are shown in **Figure 17**.

Relocate Airport

Options for relocating the Fort Vermilion Airport to higher ground should be investigated as the existing site is at significant risk of flooding during either an open water or ice jam event. The remaining service life on the runway and structures on the property should also be considered, as it may be appropriate to remain at the current location until the next major infrastructure reinvestment is required. No alternate locations have been identified under the scope of this work; however, the topography around Fort Vermilion is generally flat and sparsely developed. Therefore, it is anticipated that suitable locations exist nearby.

Restrict New Development in Low-Lying Areas

New development in low-lying areas shown in **Figure 17** should be restricted, if possible. This may involve a combination of zoning changes and flood proofing requirements for new builds. To the extent possible, servicing and new development should be encouraged outside flood prone areas that have been identified.

Flood Proof Existing Structures

Several residential and non-residential structures exist within the estimated extent of the 1934 ice jam flood. Although it may not be feasible to provide full protection for these areas with a system of dikes, individual homes and structures could be retrofitted to provide partial protection. This may include moving breaker boxes, furnaces, and hot water tanks to the upper floor of structures to minimize potential damages and impacts to residents in the event of a flood. It may also be possible to elevate the foundations of certain types of structures to bring the main floor elevation above flood levels.

Raise Roads

It may be feasible to raise some sections of River Road (**Figure 17**) to provide flood protection for existing structures; however, west of 45 Street, the road would need to be raised up to 2.5 m to provide adequate protection against a recurrence of the 1934 ice jam event. Unfortunately, there is not enough room between the river and existing structures to accommodate this. This option is more suitable along the 1.5 km segment between the boat launch and the airport (, but at the lowest point along the existing road, between 31 Street and the Anglican Cemetery, the grade change would be on the order of 4.0 m. To accommodate this, a vertical retaining wall or encroachment onto adjacent properties may need to be included as part of the road design because of the close proximity of the road to the river. Elsewhere, the grade change would be on the order of 2.5 to 3.0 m. The total length of River Road below the 1934 ice jam flood level is approximately 4.5 km. This option would be more feasible to protect against an event of the scale of the 2018 ice jam, which resulted in flood levels approximately 2 m less than the 1934 ice jam. In this case, only 1.8 km of road would need to be raised a maximum of 1.8 m above existing grade.

Retreat Immediately or Over Time

Although disruptive to existing residents, immediate or gradual property buy-outs are an alternative that may be considered to eliminate future flood damages for some properties along River Road. A gradual or staged approach involves the County acquiring these lands as they become available on the market, while immediate buy-outs are aimed towards addressing the existing risks on a short-term basis.

6.2 North Vermilion Settlement

The following flood mitigation alternatives have been identified for the North Vermilion Settlement. Since existing development is limited in this area, prioritization of mitigation measures will need to consider cost relative to the benefits that can be achieved.

Construct an Earthen Dike

In order to provide flood protection for the entire North Vermilion Settlement, a 4.5 km long earthen dike between the existing road and the river would be required. The approximate alignment of the dike is shown in **Figure 18**. The height of the dike would be approximately 3.6 m above the existing road in order to provide protection for 1934 ice jam flood levels. Construction of the dike would require removal of trees along the dike alignment; conflicts with existing utilities adjacent to the road should be minimal. The majority of the dike would also be built on public lands; however, some privately-owned land would be impacted on the eastern end of the Settlement.

Flood Proof Individual Structures

Since the number of buildings exposed to flooding in the Settlement is relatively small, there may be advantages to flood proofing existing structures in place or raising buildings above flood levels where possible. Since all works would need to be done on private lands, the County would need to develop a program or mechanism to allow individual landowners to complete such projects. This alternative would avoid the environmental impact of a large-scale dike adjacent to the river.

The preferred flood proofing approach may be different for each landowner, but may include a ring dike around the primary residences (i.e. homes), raising foundations, or relocating structures to higher ground on the same property. Other flood proofing measures that provide partial protection include moving breaker boxes, furnaces, and hot water tanks to the upper floor of structures to minimize potential damages and impacts to residents in the event of a flood.

Retreat Immediately or Over Time

Although disruptive to existing residents, immediate or gradual property buy-outs are an alternative that may be considered to eliminate future flood damages in the Settlement. A gradual or staged approach involves the County acquiring these lands as they become available on the market, while immediate buy-outs are aimed towards addressing the existing risks on a short-term basis.

If this option is feasible, the mitigation strategy should focus on this exclusive of other measures discussed above. Agriculture and other land uses not significantly impacted by occasional flooding would remain appropriate for this area.

6.3 Other Measures

Other flood mitigation measures that have value and should be discussed with stakeholders are listed below.

- Since the most recent flood hazard mapping was completed in 2000 and did not consider ice jam conditions, an updated flood hazard mapping study would be beneficial to the County. This would identify the appropriate regulatory floodway and flood fringe boundaries to guide future development decisions.

- Although breakup on the Peace River is actively monitored each year by Alberta Environment and Parks, the County may wish to further investigate improved forecasting and warning systems for the community. River breakup events may progress rapidly leaving little time to issue and enforce evacuation orders for the safety of the public. A system of automated monitoring stations similar to the one in place above Fort McMurray could be used at Fort Vermilion to provide additional information and advance warning of potential breakup floods.
- Public education can help the community better understand flood risks. Although the 2018 breakup event is presently in the minds of residents of the community, memories of earlier (and more severe) floods may not be as well-recalled. Education programs may include development of information brochures and town hall sessions to periodically review flood risks in the community and provide information residents can use to better flood proof their homes.

7 SUMMARY AND RECOMMENDATIONS

7.1 Summary

This flood risk assessment study was conducted to fulfill the requirements of the NDMP Stream 1 Risk Assessment. Flood risks associated with both open water and ice jam affected floods were assessed. The 1934 ice jam event is the largest recorded flood on the Peace River at Fort Vermilion, so the estimated impacts of a recurrence of this event were used to develop flood mitigation alternatives. The 2018 ice jam flood, although smaller than the 1934 event, was used as a point of reference as it is the most recent event for which detailed information and a highwater mark elevation profile is available for comparison with simulation results.

The results of the flood risk assessment demonstrate that the North Vermilion Settlement and Fort Vermilion Airport lands are the most susceptible to flooding in the Community, followed by areas behind River Road between 50 Street and the airport. For a recurrence of the 1934 ice jam flood event, nearly 400 people and 180 buildings could be flooded in Fort Vermilion and the North Vermilion Settlement combined. Such an event could result in damages of up to $40,000,000, based on present development. Open water floods would impact the North Vermilion Settlement and the Fort Vermilion Airport lands the most, since the anticipated flood levels are lower for open water events relative to floods caused by ice jams.

Potential flood mitigation alternatives for Fort Vermilion include construction of flood barriers around critical buildings and assets, relocation of the airport, restricting new development in low-lying areas, flood proofing existing structures, raising roads to provide flood protection, and retreat from flood prone areas. At the North Vermilion Settlement, the mitigation alternatives include a 4.5 km flood dike to protect the entire area, flood proofing individual structures, or buying-out existing properties. Other measures include updating the existing regulatory floodway maps and boundaries, improving breakup forecasting and warning systems, and educating the public on flood risks to the community.

7.2 Recommendations

Specific recommendations and priorities for flood mitigation will be provided following additional stakeholder consultation in early 2019.

8 REFERENCES

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FIGURES

500000 550000 600000

6500000

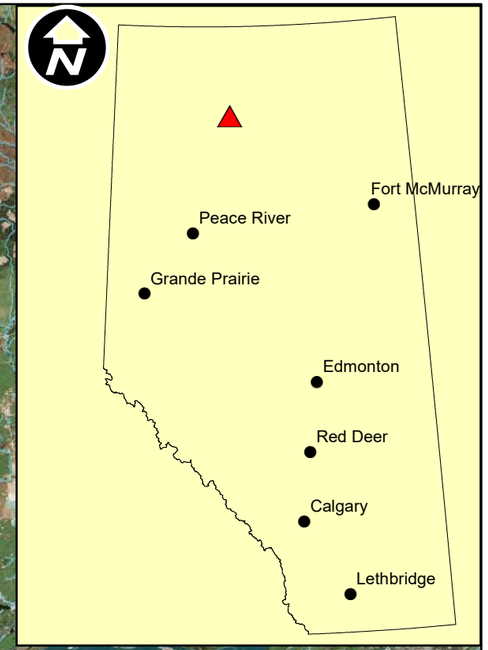
6450000

High Level

North Vermilion Settlement

Peace River

Fort Vermilion Townsite



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

500000 550000 600000

Legend

- Watercourse (National Hydro Network)
- Study Area
- Town/Settlement Boundary

Scale: 1:450,000

0 15,000 30,000 Meters

Mackenzie County

Projection: NAD 1983 UTM Zone 11N

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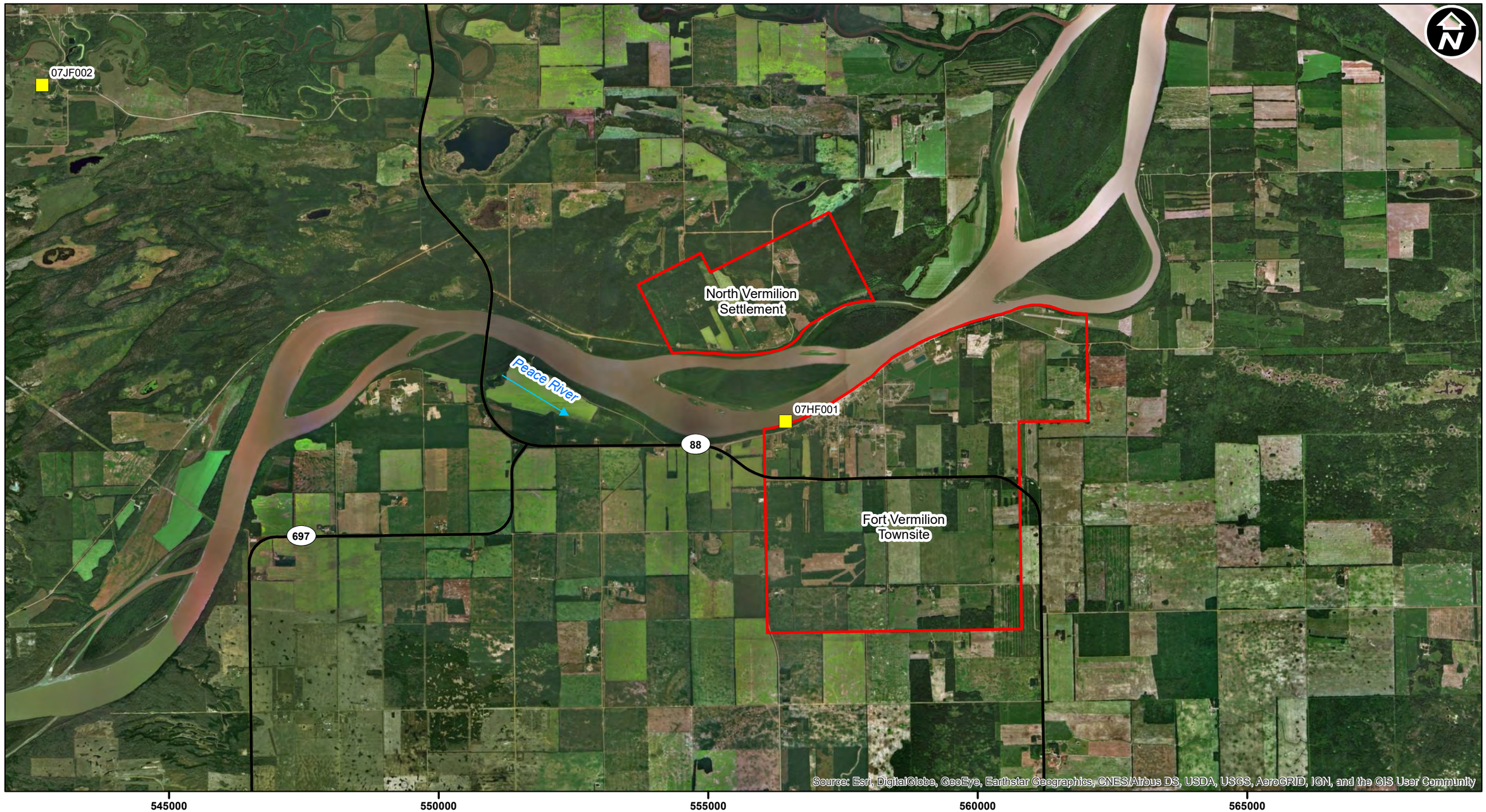
MACKENZIE COUNTY

FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT DRAFT

LOCATION MAP

1003834	SEPT 2018	Figure 1

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure1_Location_Map.mxd



Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure2_Study_Area.mxd

Legend

- WSC Gauge Station
- Highway
- Study Area

Scale: 1:70,000

0 2,500 5,000 Meters

Mackenzie County

Projection: NAD 1983 UTM Zone 11N

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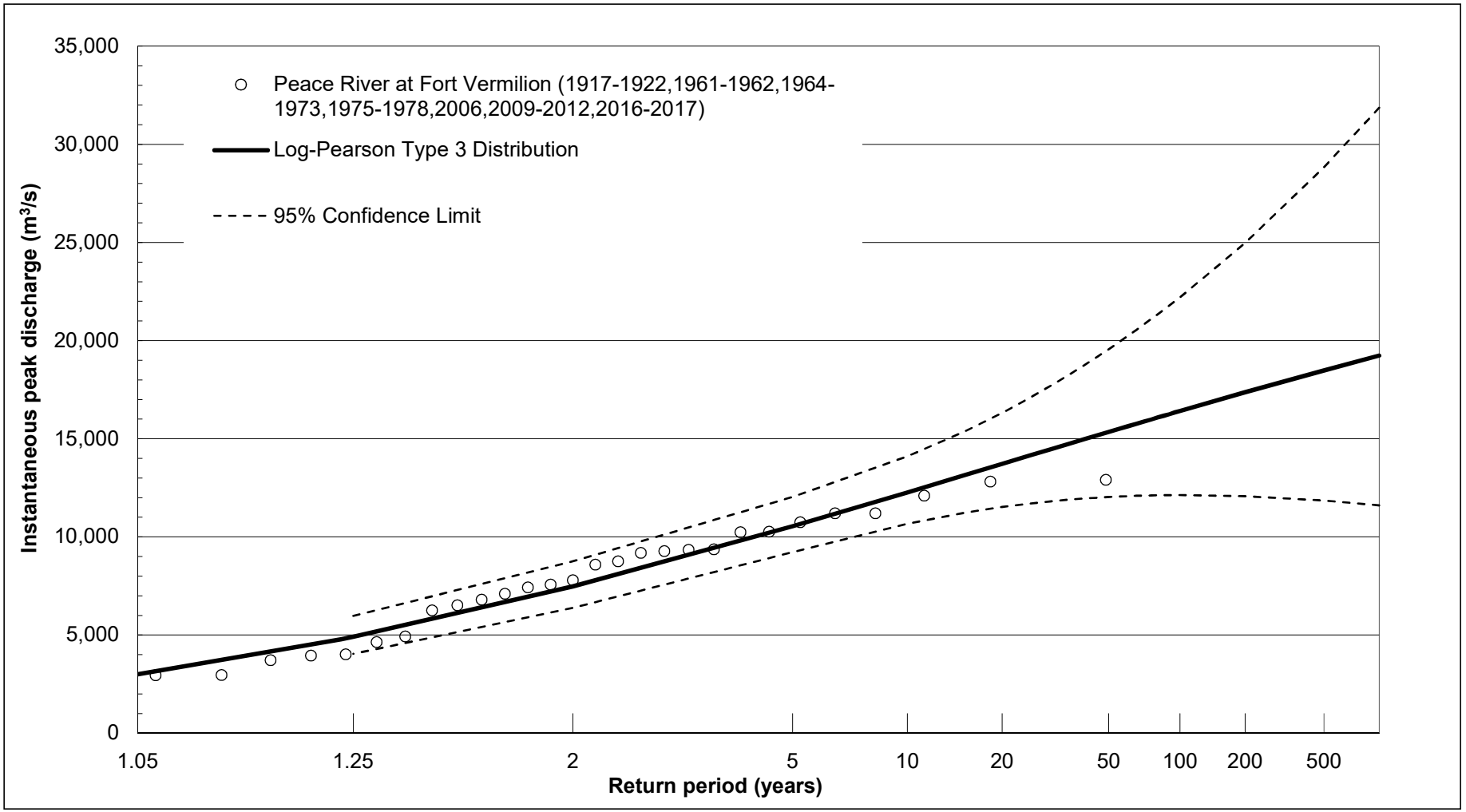
FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT DRAFT

STUDY AREA

1003834	SEPT 2018	Figure 2



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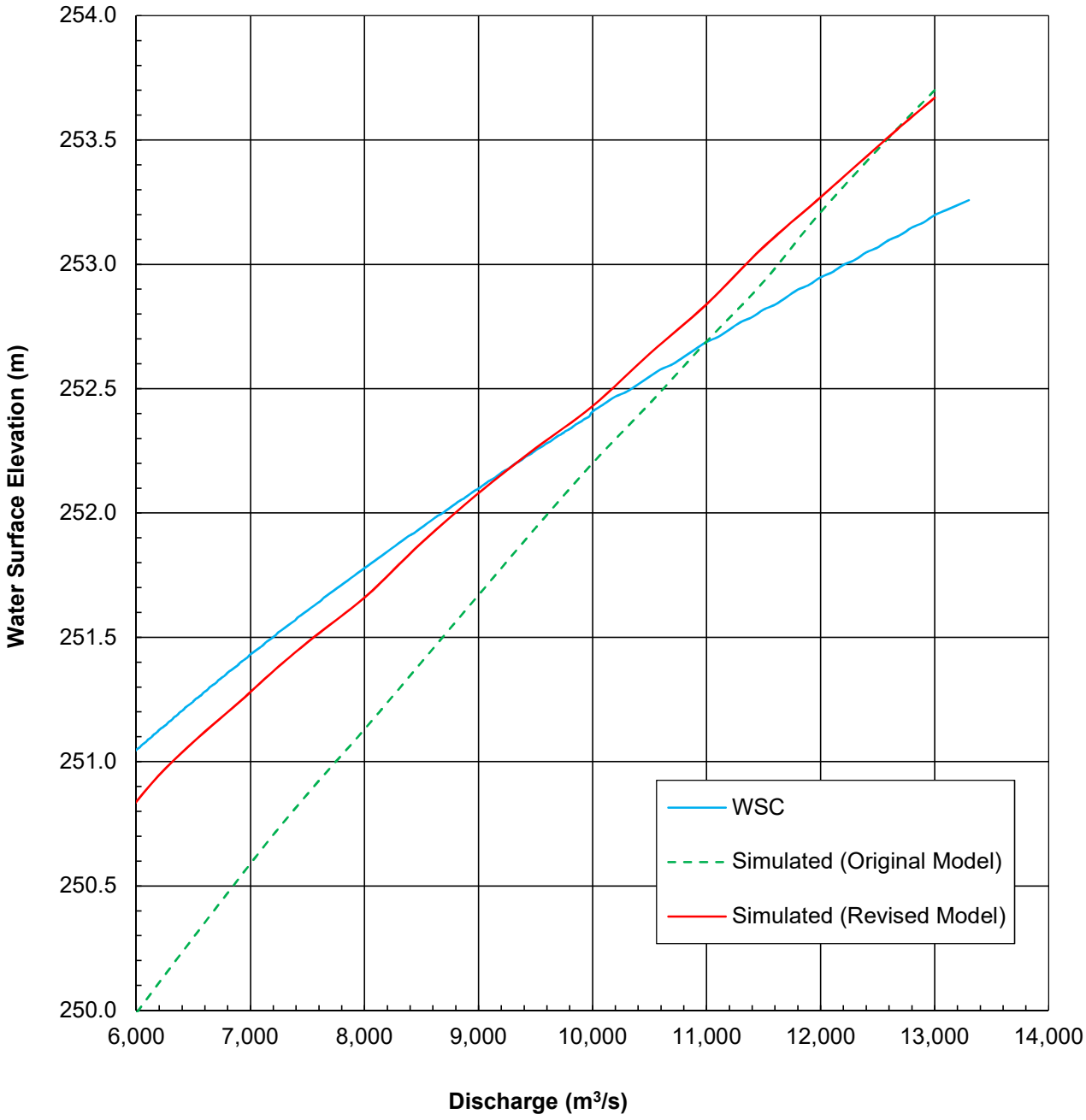
FORT VERMILION – PEACE RIVER FLOOD RISK ASSESSMENT **OPEN WATER FLOOD FREQUENCY CURVES (PEACE RIVER AT FORT VERMILION- WSC 07HF001)**		
1003834	17 DEC 2018	**FIGURE 3**



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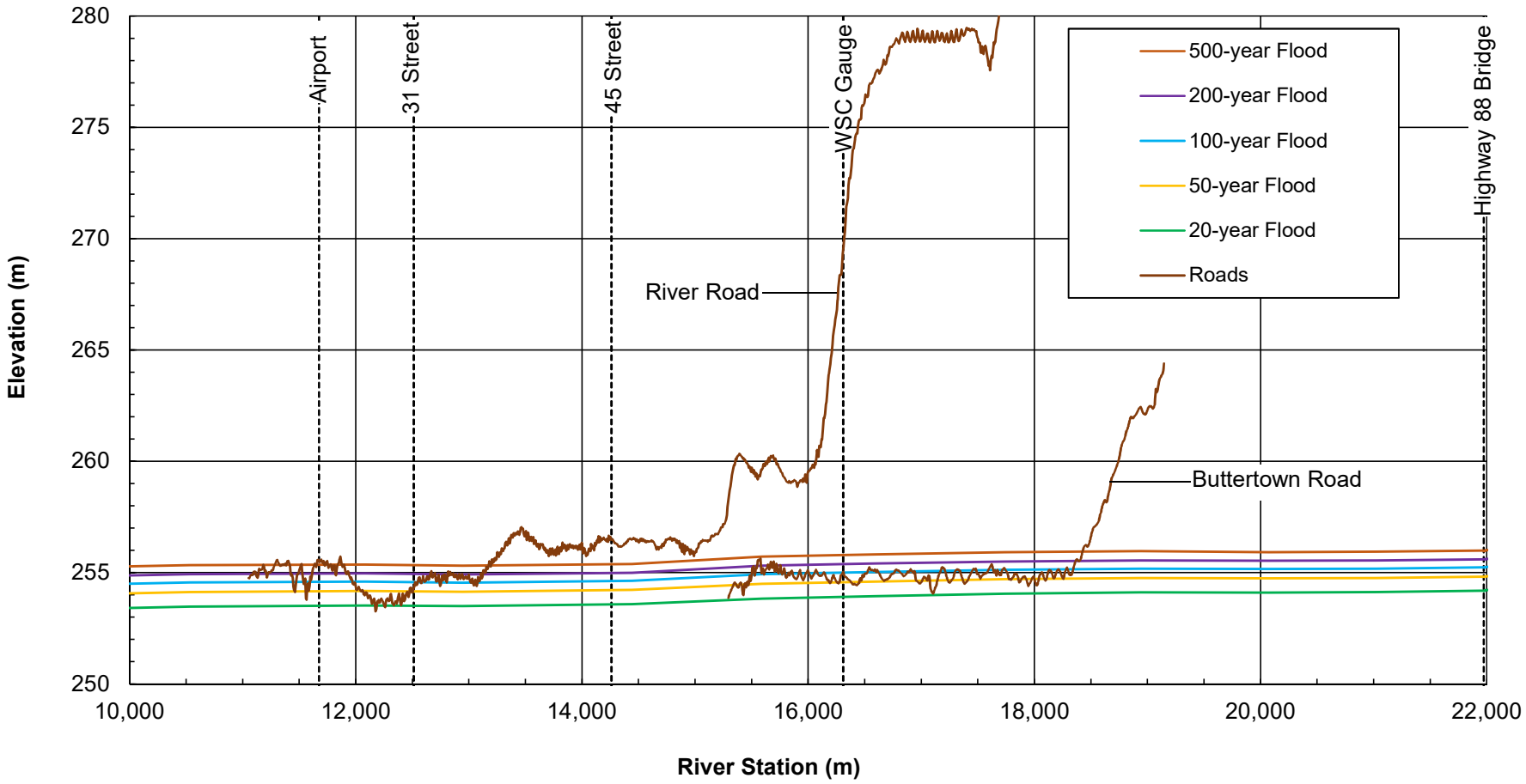
FORT VERMILION – PEACE RIVER
FLOOD RISK ASSESSMENT

RATING CURVE COMPARISION

1003834	17 DEC 2018	**FIGURE 4**



Notes: 1. Road profiles extracted from the LiDAR data provided by Mackenzie County.

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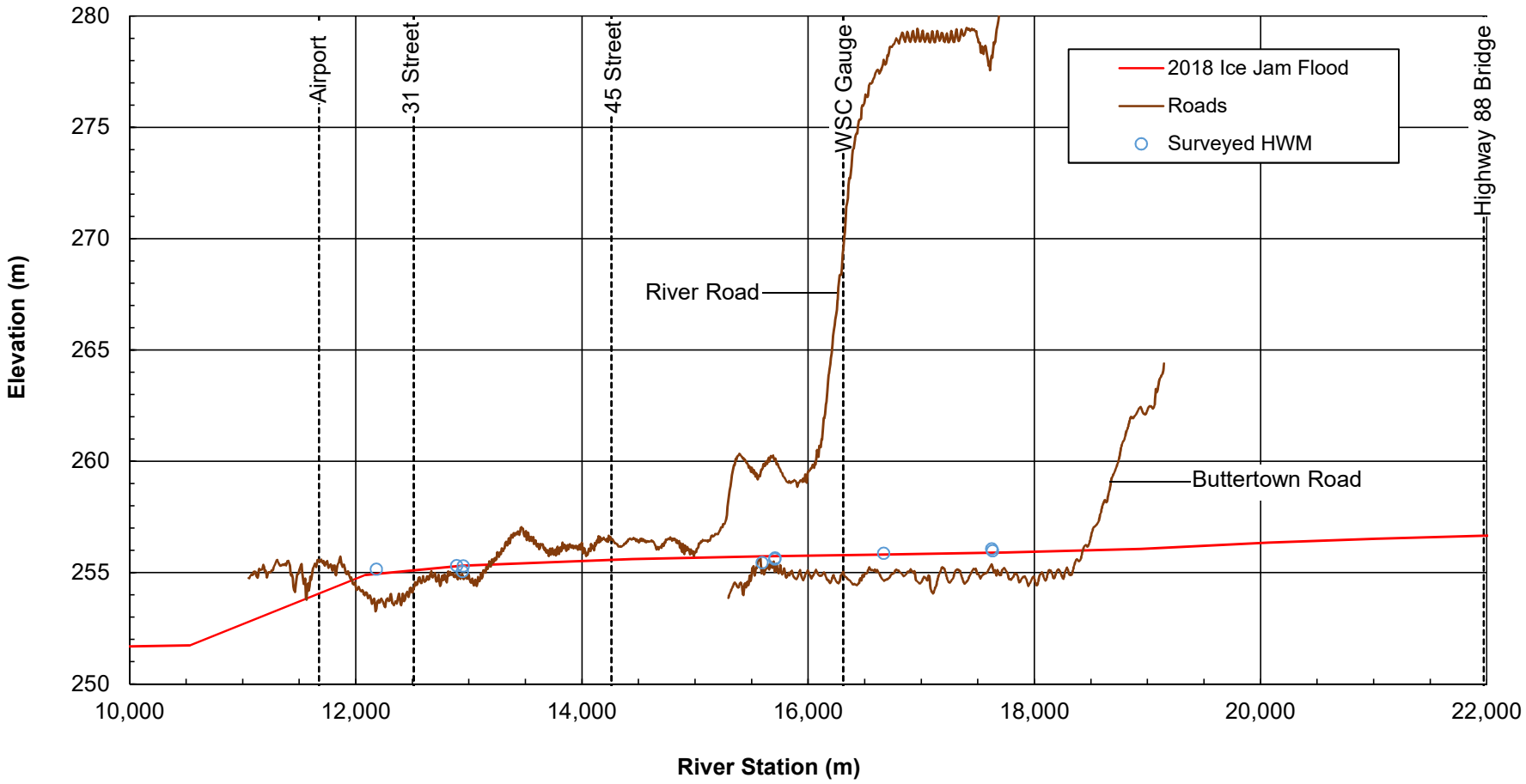
FORT VERMILION – PEACE RIVER
FLOOD RISK ASSESSMENT

OPEN WATER FLOOD FREQUENCY PROFILES

1003834	17 DEC 2018	**FIGURE 5**



Notes:
1. HWM Survey was conducted by NHC on June 27-28, 2018.
2. Road profiles extracted from the LiDAR data provided by Mackenzie County.

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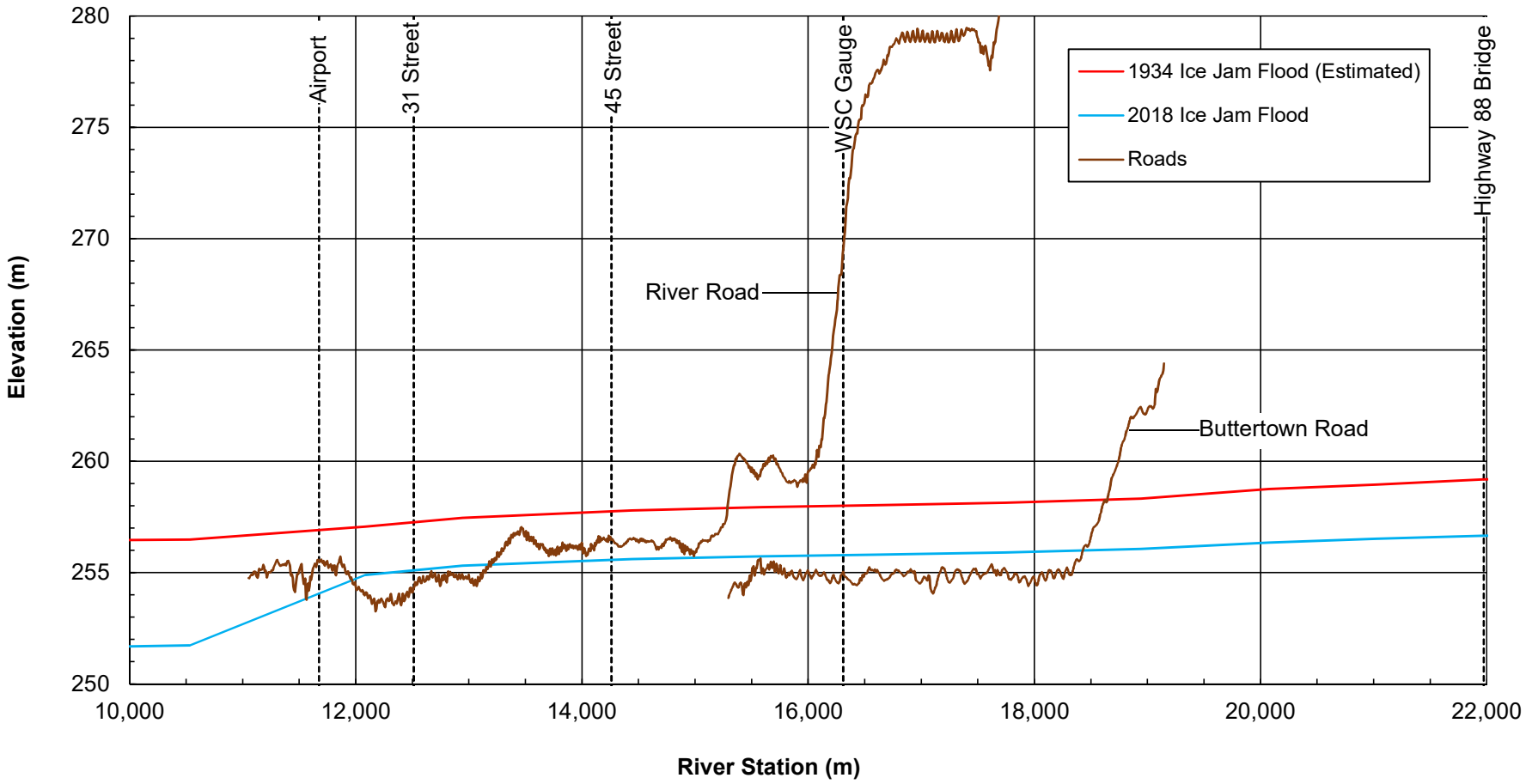
FORT VERMILION – PEACE RIVER
FLOOD RISK ASSESSMENT

2018 ICE JAM FLOOD PROFILE

1003834	17 DEC 2018	**FIGURE 6**



Notes: 1. Road profiles extracted from the LiDAR data provided by Mackenzie County.

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FORT VERMILION – PEACE RIVER
FLOOD RISK ASSESSMENT

1934 ICE JAM FLOOD PROFILE

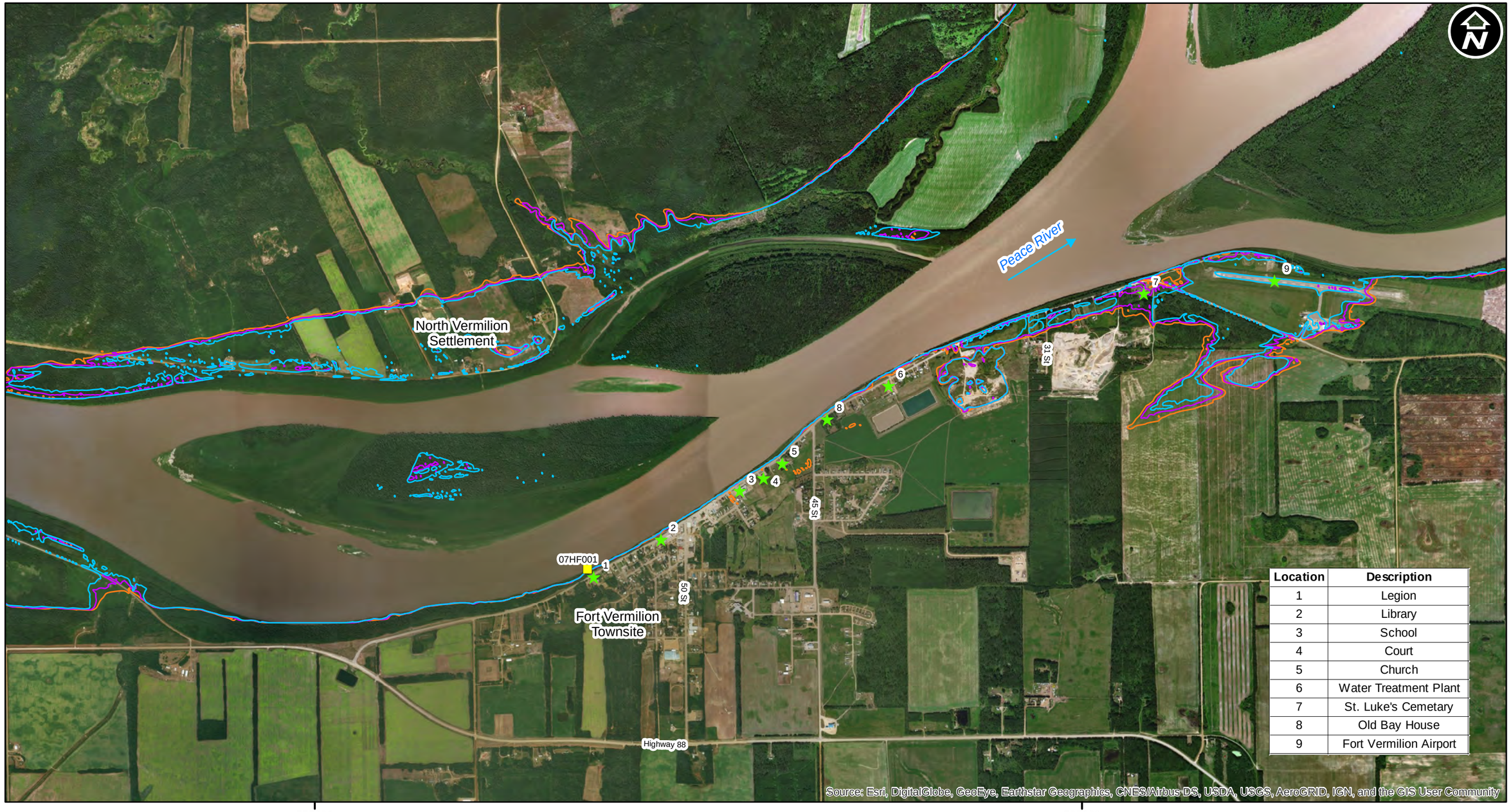
1003834	17 DEC 2018	**FIGURE 7**

555000

560000

6475000

6475000



Location	Description
1	Legion
2	Library
3	School
4	Court
5	Church
6	Water Treatment Plant
7	St. Luke's Cemetary
8	Old Bay House
9	Fort Vermilion Airport

555000

560000

Legend

- Locations of Interest
- WSC Gauge Station
- 100-year Flood
- 200-year Flood
- 500-year Flood

Scale: 1:25,000

0 800 1,600 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT

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OPEN WATER FLOOD INUNDATION EXTENTS

1003834	DEC 2018	Figure 8

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure8_Open_Water_Flood_Extent.mxd

555000

560000

6475000

6475000

Peace River

North Vermilion Settlement

Fort Vermilion Townsite

07HF001

1

2

3

4

5

6

7

8

9

31 St

45 St

50 St

Highway 88

Location	Description
1	Legion
2	Library
3	School
4	Court
5	Church
6	Water Treatment Plant
7	St. Luke's Cemetary
8	Old Bay House
9	Fort Vermilion Airport

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

555000

560000

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure9_2018_ice_jam_flood_extent.mxd

Legend

- Locations of Interest
- WSC Gauge Station
- 2018 Ice Jam Flood

Scale: 1:25,000

0 800 1,600 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT

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APPROXIMATE 2018 ICE JAM FLOOD INUNDATION EXTENT

1003834	DEC 2018	Figure 9

555000

560000

6475000

6475000

Location	Description
1	Legion
2	Library
3	School
4	Court
5	Church
6	Water Treatment Plant
7	St. Luke's Cemetary
8	Old Bay House
9	Fort Vermilion Airport

555000

560000

Legend

- Locations of Interest
- WSC Gauge Station
- 1934 Ice Jam Flood

Scale: 1:25,000

0 800 1,600 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT

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ESTIMATED 1934 ICE JAM FLOOD INUNDATION EXTENT

1003834	DEC 2018	Figure 10

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure10_1934_ice_jam_flood_extent.mxd

554500 555000 555500 556000 556500 557000 557500 558000 558500 559000

6474500 6474000 6473500 6473000 6472500

North Vermilion Settlement

Buttertown Road

Peace River

River Road

45 St

47 St

50 St

Fort Vermilion Townsite

07HF001

Legend

WSC Gauge Station

100-year Flood Depth (m)

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- >5

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure11A_100_Yr_Open_Water_Flood_Depth (1 of 2).mxd

Scale: 1:12,500

0 400 800 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT DRAFT

APPROXIMATE 100-YEAR OPEN WATER FLOOD DEPTHS (SHEET 1 OF 2)

1003834	DEC 2018	Figure 11A

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure11B_100_Yr_Open_Water_Flood_Depth (2 of 2).mxd

559000 559500 560000 560500 561000 561500 562000

6474500

6474000

6473500

Legend

100-year Flood Depth (m)

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- >5

Peace River

River Road

31 St

Range Road 124A

Township Road 1084A

Airport

Fort Vermilion Townsite

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Scale: 1:9,000

0 250 500 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER
FLOOD RISK ASSESSMENT

APPROXIMATE 100-YEAR OPEN WATER FLOOD DEPTHS (SHEET 2 OF 2)

1003834	DEC 2018	Figure 11B

554500 555000 555500 556000 556500 557000 557500 558000 558500 559000

6474500 6474000 6473500 6473000 6472500

North Vermilion Settlement

Buttertown Road

Peace River

River Road

45 St

47 St

50 St

Fort Vermilion Townsite

07HF001

Legend

WSC Gauge Station

2018 Ice Jam Flood Depth (m)

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- >5

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

554500 555000 555500 556000 556500 557000 557500 558000 558500 559000

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure12A_2018_Ice_Flood_Depth (1 of 2).mxd

Scale: 1:12,500

0 400 800 Meters

Projection: NAD 1983 UTM Zone 11N

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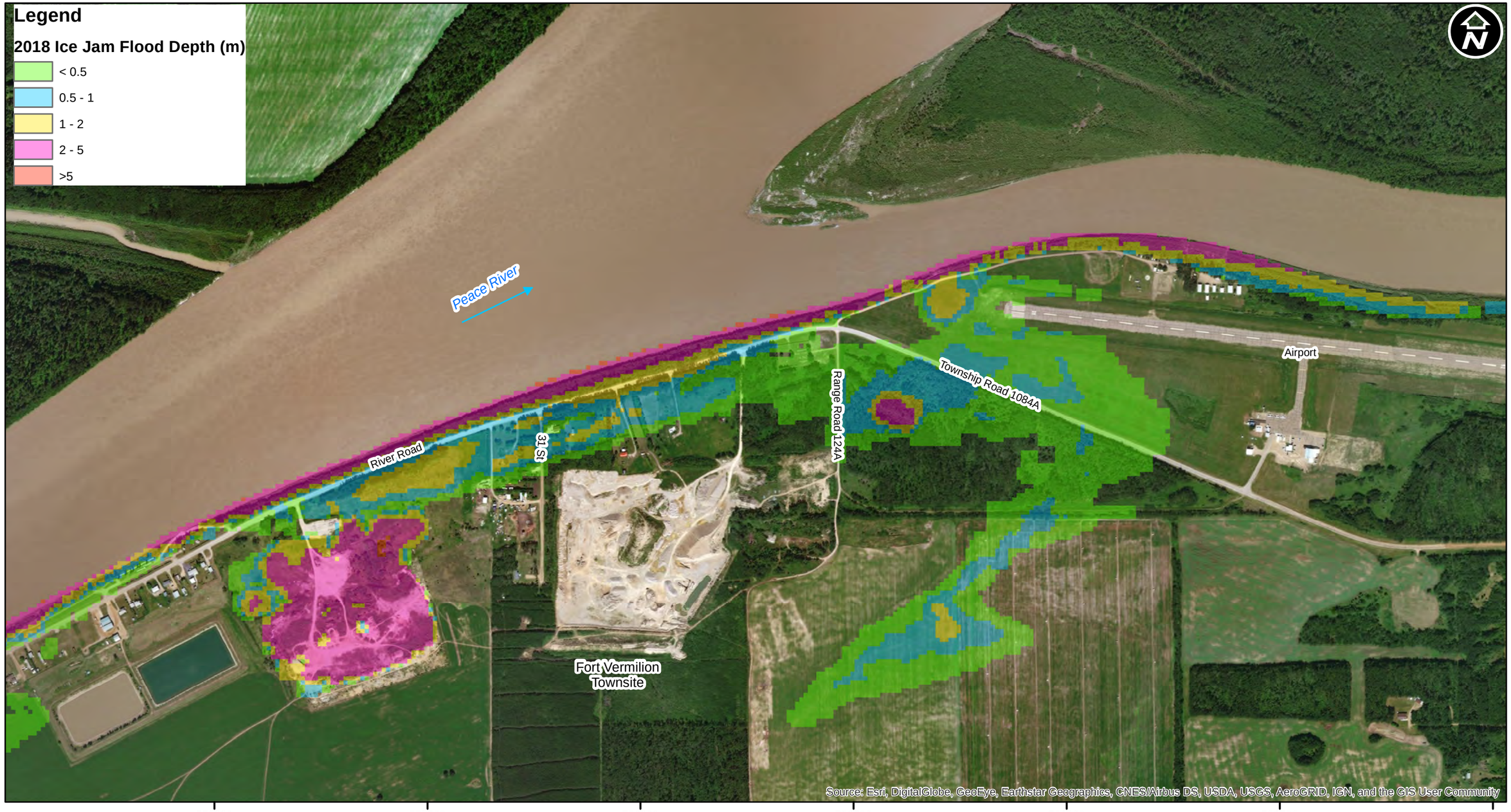
FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT DRAFT

APPROXIMATE 2018 ICE JAM FLOOD DEPTHS (SHEET 1 OF 2)

1003834	DEC 2018	Figure 12A



Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure12B_2018_Ice_Flood_Depth (2 of 2).mxd

Scale: 1:9,000

0 250 500 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT

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APPROXIMATE 2018 ICE JAM FLOOD DEPTHS (SHEET 2 OF 2)

1003834	DEC 2018	Figure 12B

554500 555000 555500 556000 556500 557000 557500 558000 558500 559000

6474500 6474000 6473500 6473000 6472500

North Vermilion Settlement

Buttertown Road

Peace River

River Road

45 St

47 St

50 St

Fort Vermilion Townsite

07HF001

Legend

WSC Gauge Station

1934 Ice Jam Flood Depth (m)

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- >5

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure13A_1934_Ice_Flood_Depth (1 of 2).mxd

Scale: 1:12,500

0 400 800 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT

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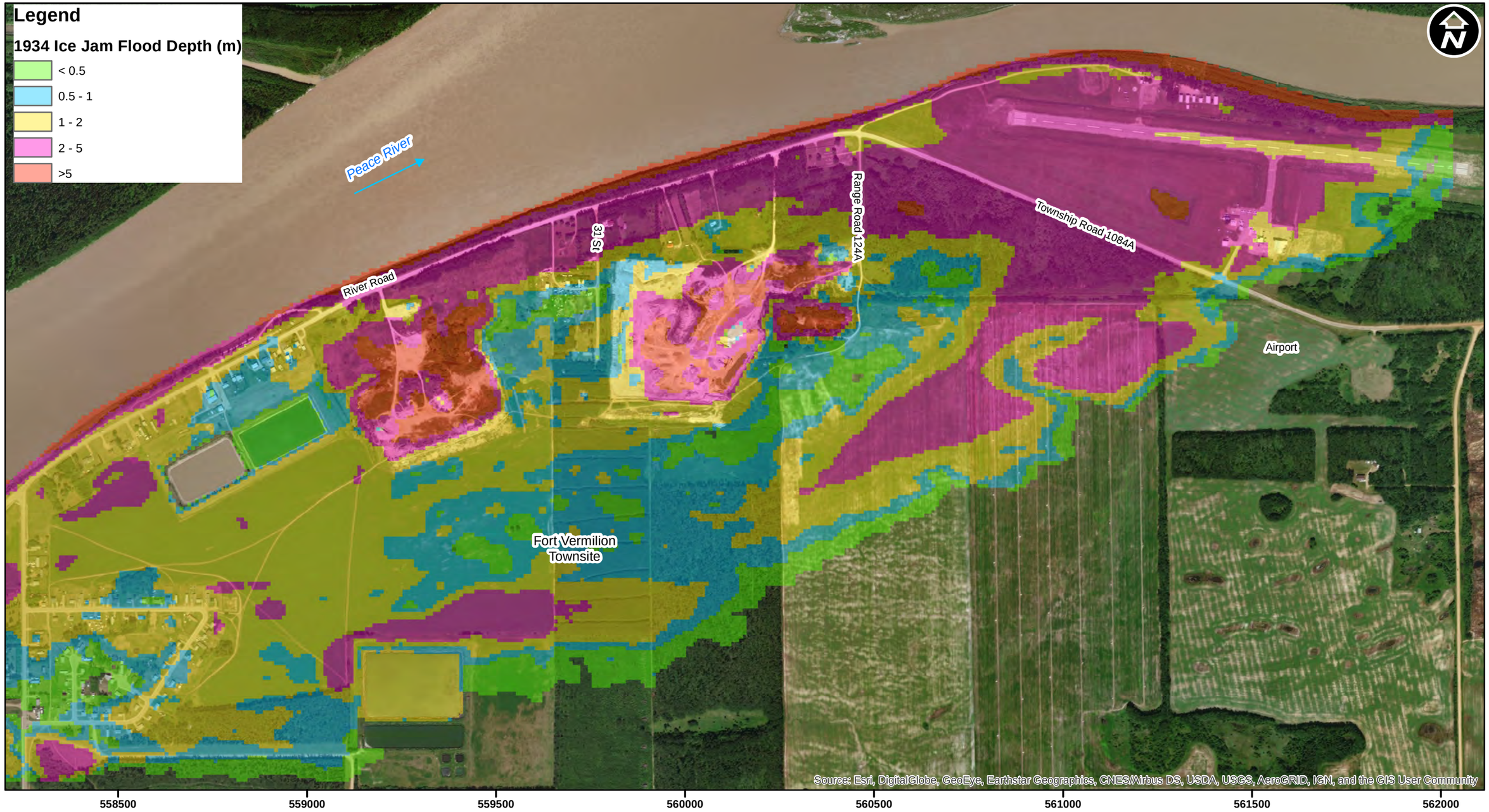
Estimated 1934 ICE JAM FLOOD DEPTHS (SHEET 1 OF 2)

1003834	DEC 2018	Figure 13A



Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure13B_1934_Ice_Flood_Depth (2 of 2).mxd

Scale: 1:10,000

0 250 500 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT

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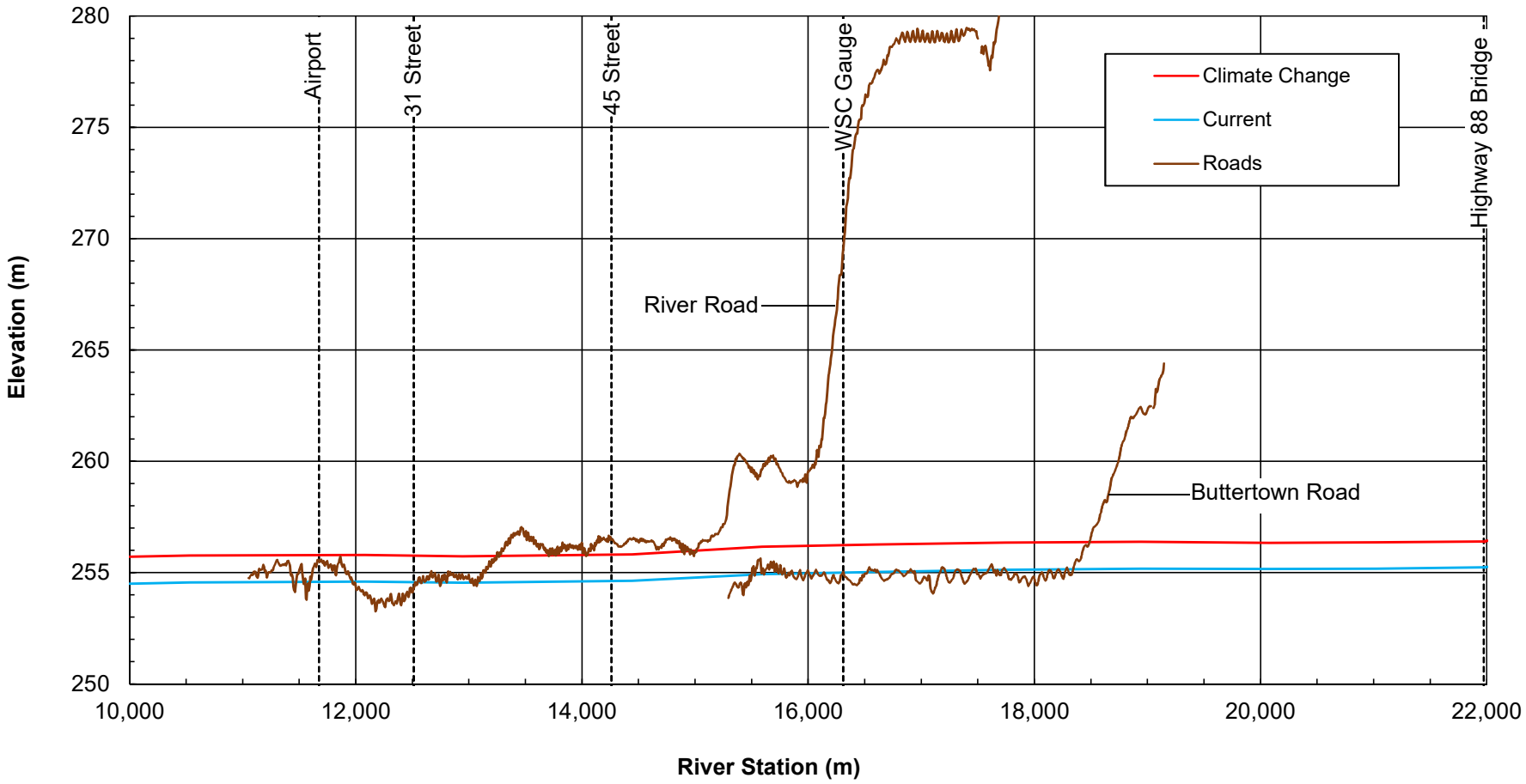
ESTIMATED 1934 ICE JAM FLOOD DEPTHS (SHEET 2 OF 2)

1003834	DEC 2018	Figure 13B



Notes:
1. Climate change flood level profile based on 20% increase over current 100-year discharge.
2. Road profiles extracted from the LiDAR data provided by Mackenzie County.

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FORT VERMILION – PEACE RIVER
FLOOD RISK ASSESSMENT

POTENTIAL EFFECTS OF CLIMATE CHANGE ON OPEN WATER FLOOD LEVELS

1003834	17 DEC 2018	**FIGURE 14**

Location	Description
1	Legion
2	Library
3	School
4	Court
5	Church
6	Water Treatment Plant
7	St. Luke's Cemetary
8	Old Bay House
9	Fort Vermilion Airport

Legend

- Locations of Interest
- WSC Gauge Station
- Incremental Inundation
- 100-year Flood

Scale: 1:25,000

0 800 1,600 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER
FLOOD RISK ASSESSMENT

INCREMENTAL OPEN WATER FLOODING DUE TO POTENTIAL CLIMATE CHANGE EFFECTS

1003834	DEC 2018	Figure 15

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure15_100_Year_Open_Water_Climate_Change_Flood_Extent.mxd

554500 555000 555500 556000 556500 557000 557500 558000 558500 559000

6474500 6474000 6473500 6473000 6472500

North Vermilion Settlement

Buttertown Road

Peace River

River Road

45 St

47 St

50 St

Fort Vermilion Townsite

07HF001

Legend

WSC Gauge Station

100-year Flood Depth (m)

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- >5

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure16A_100_Yr_Open_Water_Flood_Depth_CC (1 of 2).mxd

Scale: 1:12,500

0 400 800 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT

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APPROXIMATE OPEN WATER FLOOD DEPTHS WITH POTENTIAL CLIMATE CHANGE EFFECTS (SHEET 1 OF 2)

1003834	DEC 2018	Figure 16A

559000 559500 560000 560500 561000 561500 562000

6474500

6474000

6473500

Legend

100-year Flood Depth (m)

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- >5

Peace River

River Road

31 St

Range Road 124A

Township Road 1084A

Airport

Fort Vermilion Townsite

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure16B_100_Yr_Open_Water_Flood_Depth_CC (2 of 2).mxd

Scale: 1:9,000

0 250 500 Meters

Projection: NAD 1983 UTM Zone 11N

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MACKENZIE COUNTY

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FORT VERMILION - PEACE RIVER
FLOOD RISK ASSESSMENT

APPROXIMATE OPEN WATER FLOOD DEPTHS WITH POTENTIAL CLIMATE CHANGE EFFECTS (SHEET 2 OF 2)

1003834	DEC 2018	Figure 16B

557000 558000 559000 560000 561000 562000

6474000

6473000

6472000

Peace River

31 St

50 St

45 St

07HF001

A B C D E F G F G

Site	Location	Mitigation Measure
A	School	Construct flood barrier
B	Church	Construct flood barrier
C	Old Bay House	Construct flood barrier
D	St. Luke's Cemetery	Construct flood barrier
E	Airport	Relocate airport
F	River Road	Raise Road (to 2018 ice jam level)
G	River Road	Raise Road (to 1934 ice jam level)

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- WSC Gauge Station
- Mitigation Measures
- Potential Restricted Development/Flood Proofing

Scale: 1:15,000

0 500 1,000 Meters

Projection: NAD 1983 UTM Zone 11N

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FORT VERMILION - PEACE RIVER FLOOD RISK ASSESSMENT DRAFT

FLOOD MITIGATION ALTERNATIVES FORT VERMILION

1003834	DEC 2018	Figure 17

Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure17_Flood mitigation alternatives - Fort Vermilion.mxd

554000 555000 556000 557000

6475000

6474000

Buttertown Road

Peace River

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Flood Protection Dike
- Potential Restricted Development/Flood Proofing

Scale: 1:12,000

0 400 800 Meters

Projection: NAD 1983 UTM Zone 11N

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MACKENZIE COUNTY

DRAFT

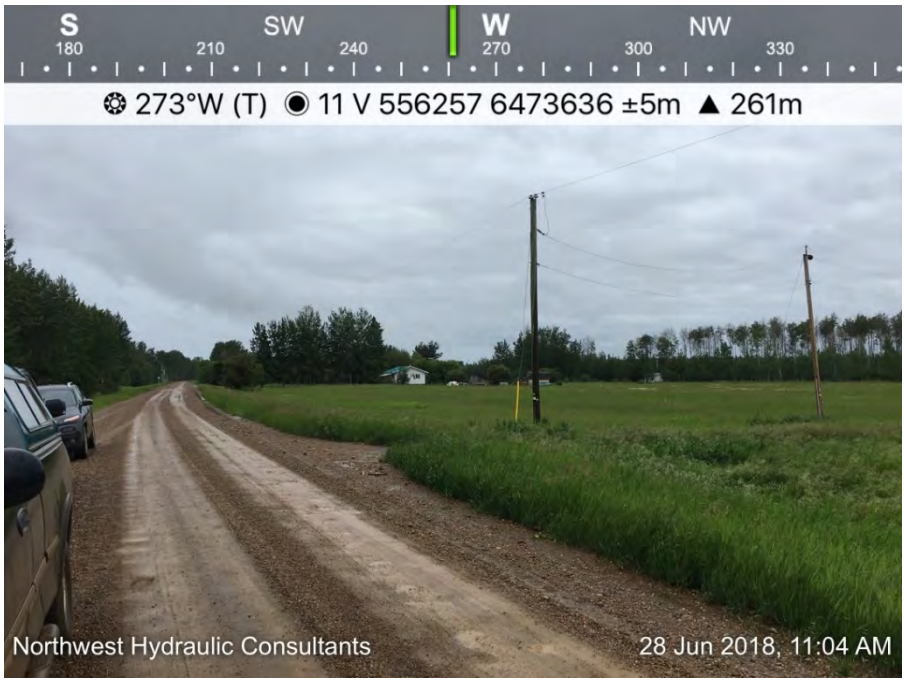
FORT VERMILION - PEACE RIVER
FLOOD RISK ASSESSMENT

**FLOOD MITIGATION ALTERNATIVES
NORTH VERMILION SETTLEMENT**

1003834	DEC 2018	Figure 18

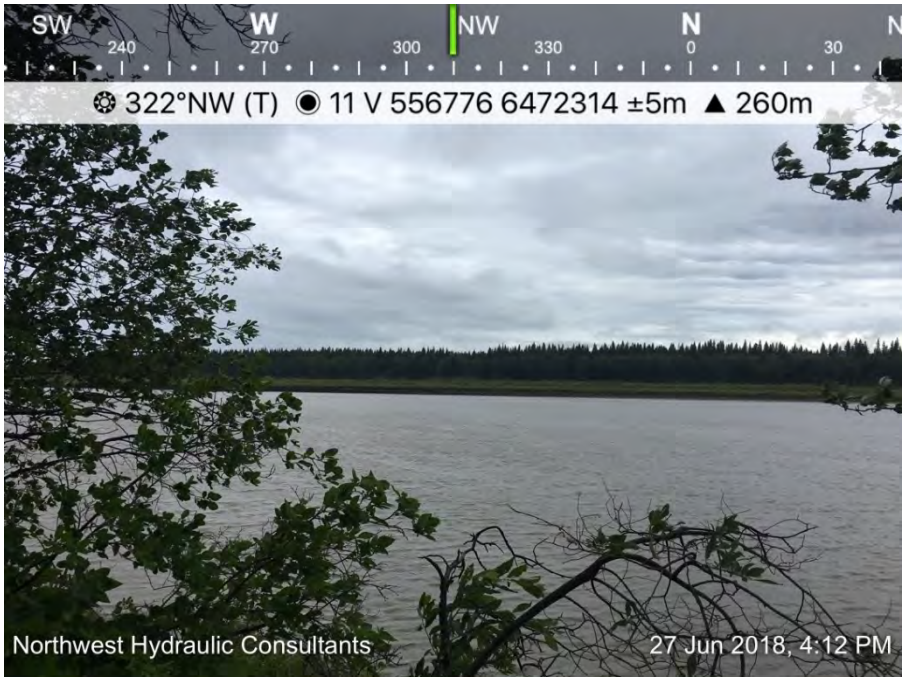
Path: P:_Projects (Active)\1003834 Fort Vermilion Flood Risk Assessment\03 Calculations\GIS\Figure18_Flood mitigation alternatives - North Vermilion.mxd

APPENDIX A
Site Inspection Photographs

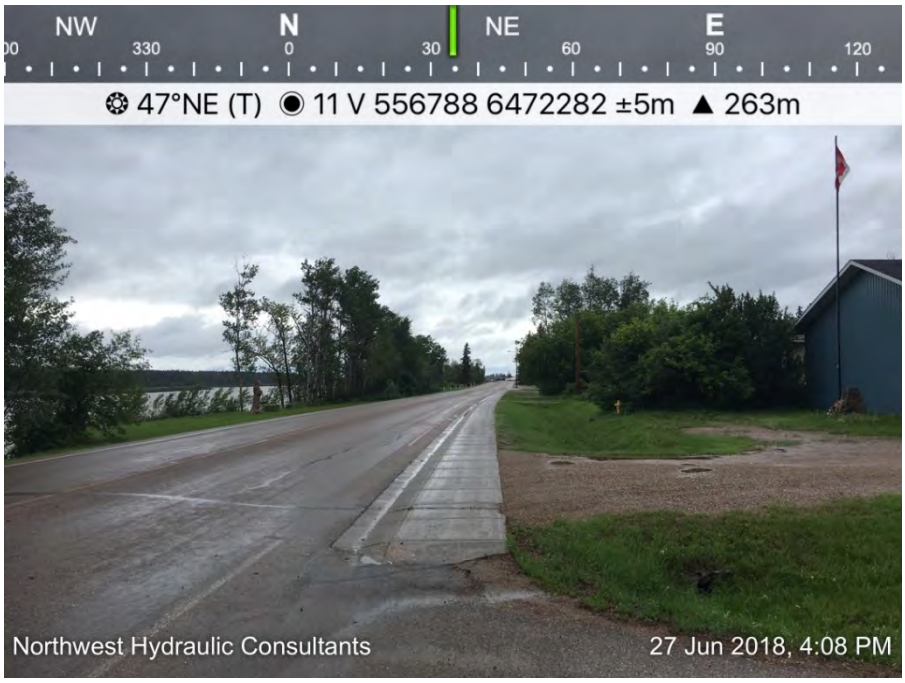


View looking west (upstream) along Buttertown Road (North Vermilion Settlement)

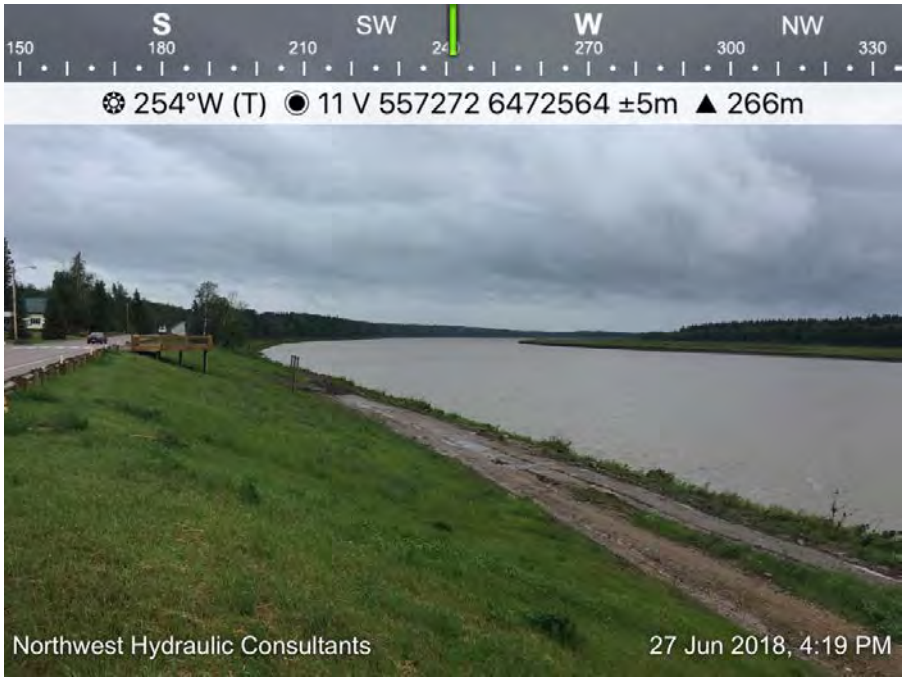
Water Survey of Canada gauging station – Peace River at Fort Vermilion (07HF001)



View looking north across the Peace River at the
Water Survey of Canada gauging station (near the Legion)

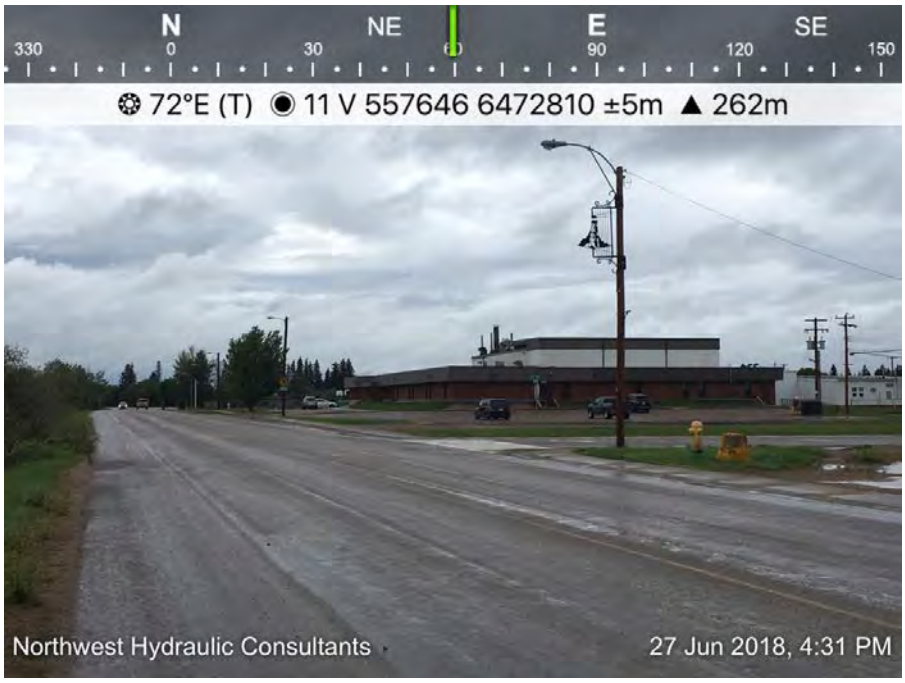


View looking downstream along River Road at the
Water Survey of Canada gauging station (the Legion building is on the far right)

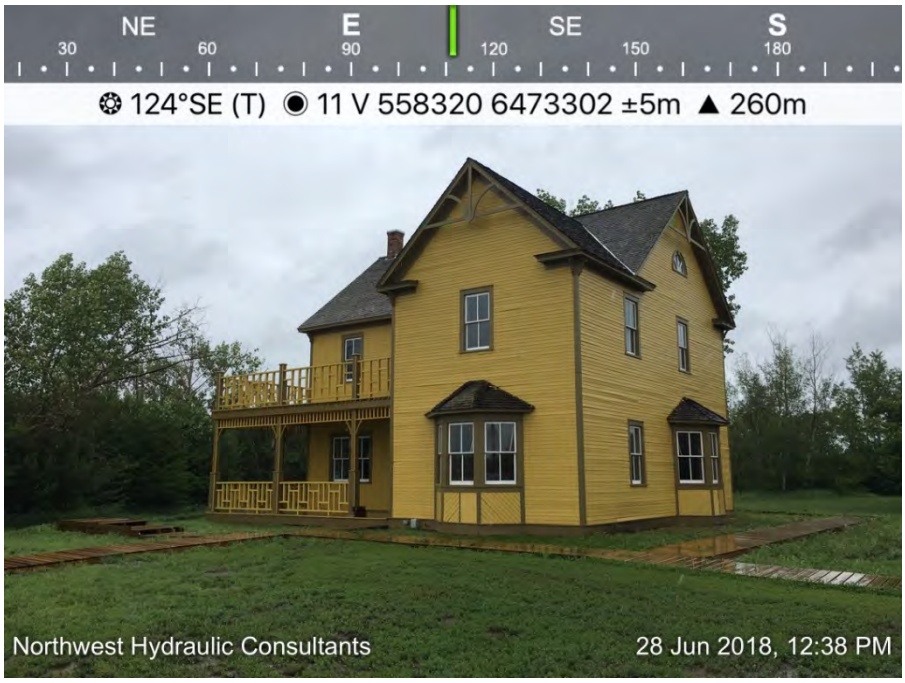


View looking upstream (west) on the Peace River near the viewpoint on River Road

View looking downstream along River Road near the hardware store (the school is located in the background on the right hand side)

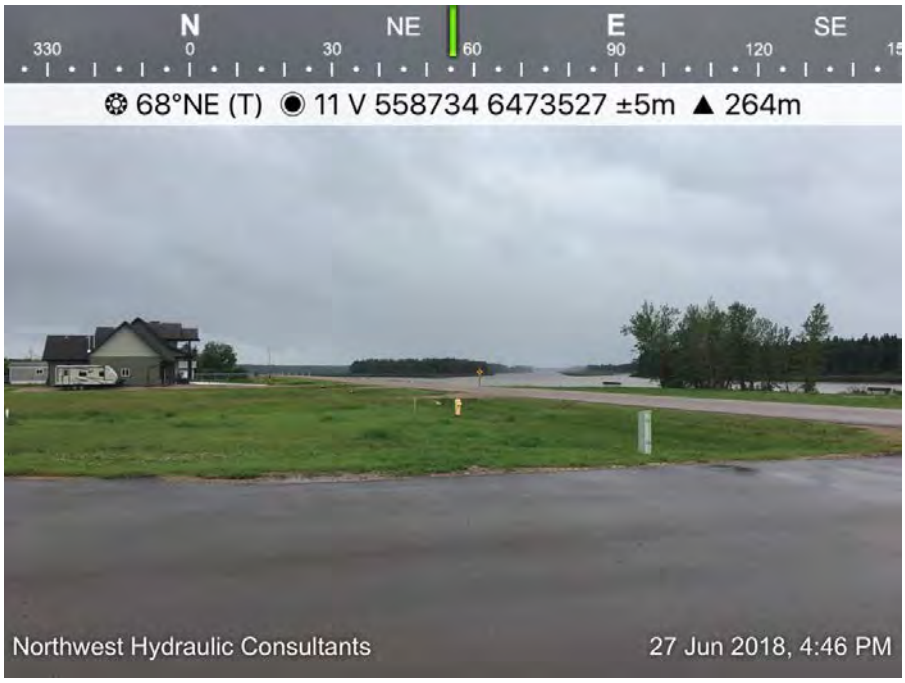


View looking east toward St. Mary's School



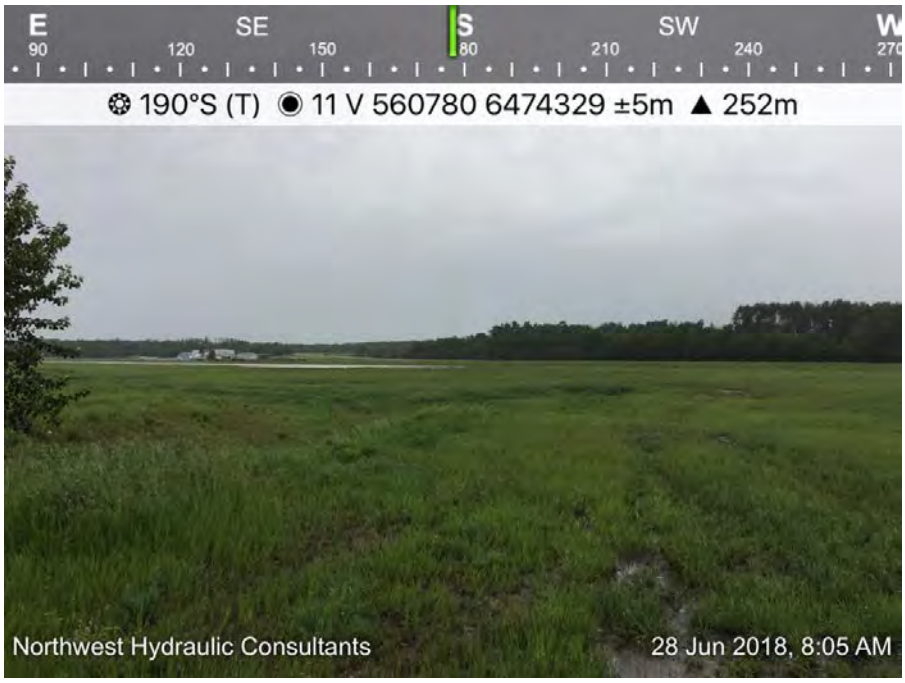
The Old Bay House on River Road

Water Treatment Plant on River Road



Fort Vermilion looking upstream toward River Road and the Peace River at the water treatment plant

Tree scar near the boat launch representing highwater mark from 2018 breakup ice jam



View of the Fort Vermilion Airport from the west end of the airstrip

Access road to north end of airstrip, looking west towards Fort Vermilion

Access road to north end of airstrip, looking north towards the Peace River

APPENDIX B
Flood History Documentation

Notes:

1. (Left) View of Hudson Bay Company (April 22, 1934)
2. (Right) Old Sheridan Lawrence Ranch (April 22,1934).

[Image from AT Bridge File 74227-1934 Flood Documentation]

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MACKENZIE COUNTY		
FORT VERMILION PEACE RIVER FLOOD RISK ASSESSMENT Flood Hazard Imagery **1934 ICE JAM AFFECTED FLOOD**		
1003834	17 DEC 2018	**FIGURE B-1**

Notes:

1. (Left) Breakup of Peace River opposite experimental farm (May 7, 1950).
2. (Right) Ice left on river banks after breakup (May 7,1950).

[Image from AT Bridge File 74227-1950 Flood Documentation]

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MACKENZIE COUNTY		
FORT VERMILION PEACE RIVER FLOOD RISK ASSESSMENT Flood Hazard Imagery **1950 ICE JAM AFFECTED FLOOD**		
1003834	17 DEC 2018	**FIGURE B-2**

Notes:

1. (Top left) Looking upstream from east of town (May 23, 1963).
2. (Top right) Fort Vermilion Ice Breakup.
3. (Bottom left) Looking west on new approach to south side of ferry crossing (westerly). Water elevation estimated as 834 ft.
4. (Bottom right) Prairie Point Fields Flooded.

[Image from AT Bridge File 74227-1963 Flood Documentation]

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FORT VERMILION PEACE RIVER FLOOD RISK ASSESSMENT Flood Hazard Imagery **1963 ICE JAM AFFECTED FLOOD**		
1003834	17 DEC 2018	**FIGURE B-3**

Notes:
1. (Top Left) Looking upstream from the peace river bridge (June 16, 1990).
2. (Top Right) Upstream end of the culvert in overflow channel (June 16, 1990).
3. (Bottom Left) Downstream end of the culvert in overflow channel (June 16, 1990).
4. (Bottom Right) Drift at upstream side of 3rd pier from south (June 16, 1990)

[Image from AT Bridge File 74227-1990 Flood Documentation]

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MACKENZIE COUNTY

FORT VERMILION PEACE RIVER FLOOD RISK ASSESSMENT
Flood Hazard Imagery

1990 OPEN WATER FLOOD

1003834	17 DEC 2018	**FIGURE B-4**

Notes:

1. (Left) Flow under the peace river bridge. (July, 2011).
2. (Right) Photo of BF77452 which is the culvert on the old cut off channel about 650 m south of the bridge.

[Image from AT Bridge File 74227-2011 Flood Documentation]

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MACKENZIE COUNTY		
FORT VERMILION PEACE RIVER FLOOD RISK ASSESSMENT Flood Hazard Imagery **2011 OPEN WATER EVENT**		
1003834	17 DEC 2018	**FIGURE B-5**

Notes:

1. (Left) Aerial View of Ice Jammed River (April, 2018).
2. (Right) Jammed Ice over the River bank (April, 2018).

[Image provided by Mackenzie County]

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MACKENZIE COUNTY		
FORT VERMILION PEACE RIVER FLOOD RISK ASSESSMENT Flood Hazard Imagery **2018 ICE JAM AFFECTED EVENT**		
1003834	17 DEC 2018	**FIGURE B-6**

Notes:

1. (Left) Flooding at Buttertown Road, North Fort Vermilion (April, 2018).
2. (Top Right) DA Thomas Park (April, 2018).
3. (Bottom Right) Damages to trees by Traper Shack on River Road (April, 2018).

[Image provided by Mackenzie County]

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MACKENZIE COUNTY		
FORT VERMILION PEACE RIVER FLOOD RISK ASSESSMENT Flood Hazard Imagery **2018 ICE JAM AFFECTED EVENT**		
1003834	17 DEC 2018	**FIGURE B-7**

APPENDIX C
Risk Assessment Information Template (RAIT)

National Disaster Mitigation Program (NDMP)
Risk Assessment Information Template

Risk Event Details			
Start and End Date	Provide the start and end dates of the selected event, based on historical data.	Start Date: 27-April-2018	End Date: 02-May-2018
Severity of the Risk Event	Provide details about the risk, including: • Speed of onset and duration of event; • Level and type of damaged caused; • Insurable and non-insurable losses; and • Other details, as appropriate.	An ice jam flood that occurred on 27 April 2018 is the most recent event to impact the community. The jam produced water depths up to 1.5 m on roads and around homes. Nine homes in the North Vermilion Settlement were flooded and several homes in Fort Vermilion narrowly avoided significant damage. The duration of the event was around a week. The County was forced to issue a state of local emergency and the evacuation of around 100 people from their homes. Flood waters also surrounded the western portion of the airport runway and came close to inundating it. The total insurable damage from the flood is $ X [Input from Mackenzie County].	
Response During the Risk Event	Provide details on how the defined geographic area continued its essential operations while responding to the event.	During the risk event, a mandatory evacuation and road closures were in place. A reception center was opened at the Fort Vermilion Public School (4401-50 Street). According to Fort Vermilion RCMP, Highway 88 near the junction of Highway 697 was impassable as a result of overland flooding resulting in the only access to Fort Vermilion through Red Earth Creek (240 kilometers south).	
Recovery Method for the Risk Event	Provide details on how the defined geographic area recovered.	The water level in the Peace River started to increase on 29 April 2018 and the emergency evacuation came into effect for the low lying area. On 30 April 2018 the water levels had dropped overnight in Fort Vermilion. On 2 May 2018 the mandatory evacuation of North Vermilion was also lifted. Recovery from the risk event would require cleaning debris, rebuilding roads, installing temporary housing, repairing/rebuilding buildings and replacing building contents. Some shorelines lost to erosion were unrecoverable.	
Recovery Costs Related to the Risk Event	Provide details on the costs, in dollars, associated with implementing recovery strategies following the event.	The cost of structural damage and content damage in 2018 flood was estimated at $1,000,000-$1,800,000. The recovery cost to Mackenzie County was $X. [Input from Mackenzie County]	

Recovery Time Related to the Risk Event	Provide details on the recovery time needed to return to normal operations following the event.	The mandatory emergency evacuations lasted one day for Fort Vermilion and four days for the North Vermilion Settlement. Clean-up of the area and installation of temporary housing would take up to 12 months, and re-building and repairing structures could take as long as 3 years. Fort Vermilion airport was inundated from the flooding. [Input from the County on Fort Vermilion Airport operational impacts.]

National Disaster Mitigation Program
Risk Assessment Information Template

Risk Event Identification and Overview	
Provide a qualitative description of the defined geographic area, including: • Watershed/community/region name(s); • Province/Territory; • Area type (i.e., city, township, watershed, organization, etc.); • Population size; • Population variances (e.g., significant change in population between summer and winter months); • Main economic areas of interest; • Special consideration areas (e.g., historical, cultural and natural resource areas); and an • Estimate of the annual operating budget of the area.	Community: Fort Vermilion Townsite and North Vermilion Settlement Watershed: Peace River Location: Province of Alberta Area Type: Hamlet of Fort Vermilion and surrounding rural settlement on the north side of the river Population: According to the 2011 census, the population for Fort Vermilion and North Vermilion Settlement is 1065. Population Variance: Most of the people are assumed permanent resident. Main economic area of interest: The main economic areas of interest includes the Fort Vermilion townsite, located on the south shore of the Peace River. A number of commercial buildings, critical infrastructure, and some homes are situated along River Road. Special consideration areas: The Old Bay House is an historical site located east of 45 Street on River Road. The Water Treatment Plant is another major capital asset located adjacent to the River Road and in between 45th and 31st streets. Annual Operating Budget: $X [Input from Mackenzie County]
Methodolgies, processes and analyses	
Provide the year in which the following processes/analyses were last completed and state the methodology(ies) used: • Hazard identification; • Vulnerability analysis; • Likelihood assessment; • Impact assessment; • Risk assessment; • Resiliency assessment; and/or • Climate change impact and/or adaptation assessment. *Note:* It is recognized that many of the processes/analyses mentioned above may be included within one methodology.	The risk assessment for Fort Vermilion Townsite and North Vermilion Settlement was carried out in 2018-2019. The 2018 flood hazards were identified based on field level highwater mark surveys, hydraulic modelling, and flood risk mapping. Flood depth maps were also created to understand the impact of floods in/around different affected buildings or facilities. Due to limited availability of data, the statistical probability of the 2018 and 1934 ice jam events was not performed, but an updated open water flood frequency analysis was completed. An inventory of flood risks was created based on cadastral and census data, buildings at risks, and capital assets (including transportation infrastructure). Damages (structural and contents) were estimated using provincial flood damage assessment curves. Potential climate change impacts were assessed for the open water flood by increasing the estimated 100-year open water peak flood by 20% (which is the current practice for flood hazard mapping studies in Alberta).

National Disaster Mitigation Program
Risk Assessment Information Template

Hazard Mapping	
To complete this section: • Obtain a map of the area that clearly indicates general land uses, neighbourhoods, landmarks, etc. For clarity throughout this exercise, it may be beneficial to omit any non-essential information from the map intended for use. Controlled photographs (e.g. aerial photography) can be used in place of or in addition to existing maps to avoid the cost of producing new maps. • Place a grid over the maps/photographs of the area and assign row and column identifiers. This will help identify the specific area(s) that may be impacted, as well as additional information on the characteristics within and affecting the area. • Identify where and how flood hazards may affect the defined geographic area. • Identify the mapped areas that are most likely to be impacted by the identified flood hazard. Map(s)/photograph(s) can also be used, where appropriate, to visually represent the information/prioritization being provided as part of this template.	
Hazard identification and prioritization	
List known or likely flood hazards to the defined geographic area in order of proposed priority. For example: (1) dyke breach overland flooding; (2) urban storm surge flooding ; and so on.	Identified flood hazards listed from highest to lowest priority are: 1. Ice jam flood hazard from the Peace River 2. Open water flood hazard from the Peace River
Provide a rationale for each prioritization and the key information sources supporting this rationale.	Both ice affected flooding and open water flooding was selected as the potential hazard based on the review of historical and recorded floods at Fort Vermilion Townsite and North Vermilion Settlement. The key information sources for determining type of potential flood hazard and prioritization are: previous flood hazard study and hydraulic model (Alberta Environment, 1990), WSC flow and water level data at Peace River at Fort Vermilion gauge, historical and recorded flood data, historical highwater mark survey data and highwater mark survey of 2018 ice affected flood.
Risk Event Title	
Identify the name/title of the risk. An example of a risk event name or title is: "A one-in-one hundred year flood following an extreme rain event."	Flood due to ice jam formation in Peace River at Fort Vermilion. The 1934 and 2018 ice jam flood events have been used to develop flood risk assessment statistics and flood mitigation concepts.
Type of Flood Hazard	

National Disaster Mitigation Program
Risk Assessment Information Template

Identify the type of flood hazard being described (e.g., riverine flooding, coastal inundation, urban run-off, etc.)	Riverine flooding due to ice jam events (predominantly spring breakup). The most recent 2018 flood at Fort Vermilion was caused by an ice jam. The largest flood at Fort Vermilion occurred in1934 as a result of a similar, but more severe ice jam.

Secondary hazards	
Describe any secondary effects resulting from the risk event (e.g., flooding that occurs following a hurricane).	A 1 in 100-year (or larger) open water flood with potential climate change impacts can also pose significant risks to low-lying portions of the community susceptible to ice jam flooding.
Primary and secondary organizations for response	
Identify the primary organization(s) with a mandate related to a key element of a natural disaster emergency, and any supporting organization(s) that provide general or specialized assistance in response to a natural disaster emergency.	Primary: Mackenzie County Secondary: Government of Alberta, RCMP, Fire Department [Input from Mackenzie County]

Risk Event Description	
Description of risk event, including risk statement and cause(s) of the event	
Provide a baseline description of the risk event, including: • Risk statement; • Context of the risk event; • Nature and scale of the risk event; • Lead-up to the risk event, including underlying cause and trigger/stimulus of the risk event; and • Any factors that could affect future events. *Note:* The description entered here must be plausible in that factual information would support such a risk event.	Floods in Fort Vermilion and the North Vermilion Settlement can be caused by both open water and ice jam events. Significant disruption to commercial activity, public safety, and residences are probable during such events. Ice jams are likely to produce more severe flood levels than open water events, and thus selected as the risk event for this study. Nearly 245 ha area was flooded in 2018 flood (selected risk event) and 660 ha area could be flooded if the 1934 ice jam flood were to recur. Both residential and non-residential buildings including the airport buildings and runway are susceptible to flooding. In the North Vermilion Settlement, only residential buildings exist, but the majority of them would be affected. Flooding in both Fort Vermilion and the North Vermilion Settlement would result in emergency evacuations, property losses, and (in extreme cases) potential loss of life.

National Disaster Mitigation Program
Risk Assessment Information Template

Location	
Provide details regarding the area impacted by the risk event such as: • Province(s)/territory(ies); • Region(s) or watershed(s); • Municipality(ies); • Community(ies); and so on.	The spring 2018 floods in Northern Alberta along the Peace River were caused by a 17 kilometre long ice jam. The jam initially formed near Tompkins Landing (river ferry crossing). Some other areas on Peace River including Beaver Ranch area and Garden River First Nation were also affected by this flood and faced evacuations.
Natural environment considerations	
Document relevant physical or environmental characteristics of the defined geographic area.	Fort Vermilion and the North Vermilion Settlement are located along the Peace River. The upstream watershed area at Fort Vermilion is approximately 227,000 sq. km, covering portions of northwestern Alberta and northeastern British Columbia. Flooding on the Peace River is often dominated by ice jams, although open water flooding has been also occurred.
Meteorological conditions	
Identify the relevant meteorological conditions that may influence the outcome of the risk event.	The most extreme flood events on the Peace River occur when ice jams form and release. Formation of ice jams are very unpredictable. Colder than average spring temperatures and high basin snowpack, followed by rapid warming and occasionally spring rainfall events in the basin, tend to increase the risk of ice jams. Key factors: formation of ice jam, duration of ice jam, ice jam breakup, precipitation, volume of snow melt.

National Disaster Mitigation Program
Risk Assessment Information Template

Seasonal conditions	
Identify the relevant seasonal changes that may influence the outcome of the risk assessment of a particular risk event.	Ice jams are most likely to occur along this reach in late March through early May.
Nature and vulnerability	
Document key elements related to the affected population, including: • Population density; • Vulnerable populations (identify these on the hazard map from step 7); • Degree of urbanization; • Key local infrastructure in the defined geographic area; • Economic and political considerations; and • Other elements, as deemed pertinent to the defined geographic area.	Population density: The report from 2011 statistics Canada shows that in total 1065 people are living at Fort Vermilion and the North Vermilion Settlement. Fort Vermilion has a higher density of population living on or adjacent to River Road. Vulnerable Populations: From the assessment, approximately 245 ha of land and 25 number of people were affected by the 2018 ice jam affected flood, while approximately 660 ha area and 400 number of people could be affected if the 1934 flood were to recur. Urbanization: Forth Vermilion Townsite is a blend of both rural and urban development. North Vermilion Settlement is rural residential only. Economic and political consideration: The Highway 88 bridge located west of Fort Vermilion could be impacted by flooding. Closure of this bridge can have significant impacts for Fort Vermilion and the North Vermilion Settlement. The affected portion of River Road and Buttertown Road can also cause problems. Key Local Infrastructure: Fort Vermilion Airport, Water Treatment Plant, Old Bay House historical site, Church, Provincial Courthouse, St. Mary's School, and Library.

National Disaster Mitigation Program
Risk Assessment Information Template

Asset inventory	
Identify the asset inventory of the defined geographic area, including: • Critical assets; • Cultural or historical assets; • Commercial assets; and • Other area assets, as applicable to the defined geographic area. Key asset-related information should also be provided, including: • Location on the hazard map (from step 7); • Size; • Structure replacement cost; • Content value; • Displacement costs; • Importance rating and rationale; • Vulnerability rating and reason; and • Average daily cost to operate. A total estimated value of physical assets in the area should also be provided.	The affected critical facilities have been identified on the hazard map. Critical infrastructure located in the flood zone includes the Fort Vermilion Airport, St. Mary's School, Provincial Courthouse, and water treatment plant. A number of residential buildings will be affected in both Fort Vermilion and the North Vermilion Settlement. Flood waters may impede access to other infrastructure. Fort Vermilion airport runway and terminal building were not inundated during the 2018 flood, but airport operations were affected due to the uncertain risk of greater ice jam flooding during the event. The other affected infrastructure in Fort Vermilion during 2018 flood includes one residential building and 1.5 km of roadway. The structural and content damage estimated cost is approximately $10,000. Nine residential buildings affected in the North Vermilion Settlement during the 2018 flood. The total assessed structural and content damage value is $1,000,000 to $1,800,000. The total damage value estimated by the Mackenzie County was $X. [Input from County]
Other assumptions, variability and/or relevant information	
Identify any assumptions made in describing the risk event; define details regarding any areas of uncertainty or unpredictability around the risk event; and supply any supplemental information, as applicable.	The effect of climate change on future ice affected flood was unable to determined. The discharge from 100-year open water flood has been increased by 20% to capture the potential adverse effect of climate change. This is the current approach used for provincial flood hazard mapping studies in Alberta.
Existing Risk Treatment Measures	
Identify existing risk treatment measures that are currently in place within the defined geographic area to mitigate the risk event, and describe the sufficiency of these risk treatment measures.	There are no existing flood control structures in the community. Some newer infrastructure, such as the Provincial Courthouse, has been constructed well above surrounding ground elevations to address flooding risks.

National Disaster Mitigation Program
Risk Assessment Information Template

Likelihood Assessment	
Return Period	
Identify the time period during which the risk event might occur. For example, the risk event described is expected to occur once every X number of years. Applicants are asked to provide the X value for the risk event.	The probability for major ice jam flooding (2018 and 1934) was not assessed, but both of these significant events have occurred within last 100 years. The 1934 event is estimated to be comparable to the 100-year ice jam event based on experience at other locations on the Peace River where more data is available.
Period of interest	
Applicants are asked to determine and identify the likelihood rating (i.e. period of interest) for the risk event described by using the likelihood rating scale within the table below.	

Likelihood Rating	**Definition**	
5	The event is expected and may be triggered by conditions expected over a 30 year period.	4
4	The event is expected and may be triggered by conditions expected over a 30 - 50 year period.	
3	The event is expected and may be triggered by conditions expected over a 50 - 500 year period.	
2	The event is expected and may be triggered by conditions expected over a 500 - 5000 year period.	
1	The event is possible and may be triggered by conditions exceeding a period of 5000 years.	

Provide any other relevant information, notes or comments relating to the likelihood assessment, as applicable.	Since two major floods (1934 and 2018) and some relatively small ice jam floods (1950 and 1963) have occurred in last 100 years, it is reasonable to expect that the risk event is likely to recur within 30 to 50 years.

National Disaster Mitigation Program
Risk Assessment Information Template

Impacts/Consequences Assessment

There are 12 impacts categories within 5 impact classes rated on a scale of 1 (least impacts) to 5 (greatest impact). Conduct an assessment of the impacts associated with the risk event, and assign one risk rating for each category. Additional information may be provided for each of the categories in the supplemental fields provided.

A) People and societal impacts

	Risk Rating	Definition	Assigned risk rating
Fatalities	5	Could result in more than 50 fatalities	2
	4	Could result in 10 - 49 fatalities	
	3	Could result in 5 - 9 fatalities	
	2	Could result in 1 - 4 fatalities	
	1	Not likely to result in fatalities	
Supplemental information (optional)	Although there were no fatalities during the 2018 flood event, the unpredictability of ice jams may not provide sufficient warning for evacuation.		
Injuries	5	Injuries, illness and/or psychological disablements cannot be addressed by local, regional, or provincial/territorial healthcare resources; federal support or intervention is required	2
	4	Injuries, illnesses and/or psychological disablements cannot be addressed by local or regional healthcare resources; provincial/territorial healthcare support or intervention is required.	
	3	Injuries, illnesses and/or psychological disablements cannot be addressed by local or regional healthcare resources additional healthcare support or intervention is required from other regions, and supplementary support could be required from the province/territory	
	2	Injuries, illnesses and/or psychological disablements cannot be addressed by local resources through local facilities; healthcare support is required from other areas such as an adjacent area(ies)/municipality(ies) within the region	
	1	Any injuries, illnesses, and/or psychological disablements can be addressed by local resources through local facilities; available resources can meet the demand for care	
Supplemental information (optional)	Severe health concerns may require support from the nearest regional health centre in High Level, Alberta.		

National Disaster Mitigation Program
Risk Assessment Information Template

		Risk Rating	Definition	Assigned risk rating
Displacement	Percentage of displaced individuals	5	> 15% of total local population	2
		4	10 - 14.9% of total local population	
		3	5 - 9.9% of total local population	
		2	2 - 4.9% of total local population	
		1	0 - 1.9% of total local population	
	Duration of displacement	5	> 26 weeks (6 months)	3
		4	4 weeks - 26 weeks (6 months)	
		3	1 week - 4 weeks	
		2	72 hours - 168 hours (1 week)	
		1	Less than 72 hours	
Supplemental information (optional)				
B) Environmental impacts				
		5	> 75% of flora or fauna impacted or 1 or more ecosystems significantly impaired; Air quality has significantly deteriorated; Water quality is significantly lower than normal or water level is > 3 meters above highest natural level; Soil quality or quantity is significantly lower (i.e., significant soil loss, evidence of lethal soil contamination) than normal; > 15% of local area is affected	3
		4	40 - 74.9% of flora or fauna impacted or 1 or more ecosystems considerably impaired; Air quality has considerably deteriorated; Water quality is considerably lower than normal or water level is 2 - 2.9 meters above highest natural level; Soil quality or quantity is moderately lower than normal; 10 - 14.9% of local area is affected	
		3	10 - 39.9% of flora or fauna impacted or 1 1 or more ecosystems moderately impaired; Air quality has moderately deteriorated; Water quality is moderately lower than normal or water level is 1 - 2 meters above highest natural level; Soil quality is moderately lower than normal; 6 - 9.9 % of area affected	

National Disaster Mitigation Program
Risk Assessment Information Template

	2	< 10 % of flora or fauna impacted or little or no impact to any ecosystems; Little to no impact to air quality and/or soil quality or quantity; Water quality is slightly lower than normal, or water level is less than 0.9 meters above highest natural level and increased for less than 24 hours; 3 - 5.9 % of local area is affected	
	1	Little to no impact to flora or fauna, any ecosystems, air quality, water quality or quantity, or to soil quality or quantity; 0 - 2.9 % of local area is affected	
Supplemental information (optional)			

C) Local economic impacts

	Risk Rating	**Definition**	**Assigned risk rating**
	5	> 15 % of local economy impacted	3
	4	10 - 14.9 % of local economy impacted	
	3	6 - 9.9 % of local economy impacted	
	2	3 - 5.9 % of local economy impacted	
	1	0 - 2.9 % of local economy impacted	
Supplemental information (optional)	[Input from Mackenzie County]		

National Disaster Mitigation Program
Risk Assessment Information Template

D) Local infrastructure impacts			
	Risk Rating	**Definition**	**Assigned risk rating**
Transportation	5	Local activity stopped for more than 72 hours; > 20% of local population affected; lost access to local area and/or delivery of crucial service or product; or having an international level impact	4
	4	Local activity stopped for 48 - 71 hours; 10 - 19.9% of local population affected; significantly reduced access to local area and/or delivery of crucial service or product; or having a national level impact	
	3	Local activity stopped for 25 - 47 hours; 5 - 9.9% of local population affected; moderately reduced access to local area and/or delivery of crucial service or product; or having a provincial/territorial level impact	
	2	Local activity stopped for 13 - 24 hours; 2 - 4.9% of local population affected; minor reduction in access to local area and/or delivery of crucial service or product; or having a regional level impact	
	1	Local activity stopped for 0 - 12 hours; 0 - 1.9% of local population affected; little to no reduction in access to local area and/or delivery of crucial service or product	
Supplemental information (optional)	The main concern is the flooding of the Highway 88 Bridge over the Peace River. Road closure can cause significant disruption to Fort Vermilion and the North Vermilion Settlement.		
Energy and Utilities	5	Duration of impacts > 72 hours; > 20% of local population without service or product; or having an international level impact	3
	4	Duration of impact 48 - 71 hours; 10 - 19.9% of local population without service or product; or having a national impact	
	3	Duration of impact 25 - 47 hours; 5 - 9.9% of local population without service or product; or having a provincial/territorial level impact	
	2	Duration of impact 13 - 24 hours; 2 - 4.9% of local population without service or product; or having a regional level impact	
	1	Local activity stopped for 0 - 12 hours; 0 - 1.9% of local population affected; little to no reduction in access to local area and/or delivery of crucial service or product	

National Disaster Mitigation Program
Risk Assessment Information Template

Supplemental information (optional)			
Information and Communications Technology	5	Service unavailable for > 72 hours; > 20 % of local population without service; or having an international level impact	3
	4	Service unavailable for 48 - 71 hours; 10 - 19.9 % of local population without service; or having a national level impact	
	3	Service unavailable for 25 - 47 hours; 5 - 9.9 % of local population without service; or having a provincial/territorial level impact	
	2	Service unavailable for 13 - 24 hours; 2 - 4.9 % of local population without service; or having a regional level impact	
	1	Service unavailable for 0 - 12 hours; 0 - 1.9 % of local population without service	
Supplemental information (optional)			
Health, Food, and Water	5	Inability to access potable water, food, sanitation services, or healthcare services for > 72 hours; non-essential services cancelled; > 20 % of local population impacted; or having an international level impact	3
	4	Inability to access potable water, food, sanitation services, or healthcare services for 48-72 hours; major delays for nonessential services; 10 - 19.9 % of local population impacted; or having a national level impact	
	3	Inability to access potable water, food, sanitation services, or healthcare services for 25-48 hours; moderate delays for nonessential services; 5 - 9.9 % of local population impacted; or having a provincial/territorial level impact	
	2	Inability to access potable water, food, sanitation services, or healthcare services for 13-24 hours; minor delays for nonessential; 2 - 4.9 % of local population impacted; or having a regional level impact	
	1	Inability to access potable water, food, sanitation services, or healthcare services for 0-12 hours; 0 - 1.9 % of local population impacted	

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Supplemental information (optional)	The water treatment plant is located to adjacent to the River Road. The facility was not flooded in 2018 ice affected flood, but flooding of the water treatment plant could disrupt the local water supply. [Input from Mackenzie County]		
Safety and Security	5	> 20 % of local population impacted; loss of intelligence or defence assets or systems for > 72 hours; or having an international level impact	3
	4	10 - 19.9 % of local population impacted; loss of intelligence or defence assets or systems for 48 – 71 hours; or having a national level impact	
	3	5 - 9.9 % of local population impacted; loss of intelligence or defence assets or systems for 25 – 47 hours; or having a provincial/territorial level impact	
	2	2 - 4.9 % of local population impacted; loss of intelligence or defence assets or systems for 13 – 24 hours; or having a regional level impact	
	1	0 - 1.9 % of local population impacted; loss of intelligence or defence assets or systems for 0 – 12 hours	
Supplemental information (optional)	Highway 88 connects Fort vermilion Townsite and North Vermilion Settlement, as well as with other surrounding populations. A flood event like 2018 could limit the use of Highway 88 and impede access for emergency services. [Input from Mackenzie County]		

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E) Public sensitivity impacts			
	Risk Rating	**Definition**	**Assigned risk rating**
	5	Sustained, long term loss in reputation/public perception of public institutions and/or sustained, long term loss of trust and confidence in public institutions; or having an international level impact	3
	4	Significant loss in reputation/public perception of public institutions and/or significant loss of trust and confidence in public institutions; significant resistance; or having a national level impact	
	3	Some loss in reputation/public perception of public institutions and/or some loss of trust and confidence in public institutions; escalating resistance	
	2	Isolated/minor, recoverable set-back in reputation, public perception, trust, and/or confidence of public institutions	
	1	No impact on reputation, public perception, trust, and/or confidence of public institutions	
Supplemental information (optional)	[Input from Mackenzie County]		

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Confidence Assessment

Based on the table below, indicate the level of confidence regarding the information entered in the risk assessment information template in the "Confidence Level Assigned" column.
Confidence levels are language-based and range from A to E (A=most confident to E=least confident).

Confidence Level	Definition	Confidence Level Assigned
A	Very high degree of confidence Risk assessment used to inform the risk assessment information template was evidence-based on a thorough knowledge of the natural hazard risk event; leveraged a significant quantity of high-quality data that was quantitative and qualitative in nature; leveraged a wide variety of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a multidisciplinary team with subject matter experts (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a significant number of existing/known mitigation measures	
B	High degree of confidence Risk assessment used to inform the risk assessment information template was evidence-based on a thorough knowledge of the natural hazard risk event; leveraged a significant quantity of data that was quantitative and qualitative in nature; leveraged a wide variety of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a multidisciplinary team with some subject matter expertise (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a significant number of potential mitigation measures	

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C	Moderate confidence Risk assessment used to inform the risk assessment information template was moderately evidence-based from a considerable amount of knowledge of the natural hazard risk event; leveraged a considerable quantity of data that was quantitative and/or qualitative in nature; leveraged a considerable amount of data and information including from historical records, geospatial and other information sources; and the risk assessment and analysis processes were completed by a moderately sized multidisciplinary team, incorporating some subject matter experts (i.e., a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences) Assessment of impacts considered a large number of potential mitigation measures	B
D	Low confidence Risk assessment used to inform the risk assessment information template was based on a relatively small amount of knowledge of the natural hazard risk event; leveraged a relatively small quantity of quantitative and/or qualitative data that was largely historical in nature; may have leveraged some geospatial information or information from other sources (i.e., databases, key risk and resilience methodologies); and the risk assessment and analysis processes were completed by a small team that may or may not have incorporated subject matter experts (i.e., did not include a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences). Assessment of impacts considered a relatively small number of potential mitigation measures	
E	Very low confidence Risk assessment used to inform the risk assessment information template was not evidence-based; leveraged a small quantity of information and/or data relating to the natural risk hazard and risk event; primary qualitative information used with little to no quantitative data or information; and the risk assessment and analysis processes were completed by an individual or small group of individuals little subject matter expertise (i.e., did not include a wide array of experts and knowledgeable individuals on the specific natural hazard and its consequences). Assessment of impacts did not consider existing or potential mitigation measures	

Rationale for level of confidence

Provide the rationale for the selected confidence level, including any references or sources to support the level assigned.	The study was carried out by flood specialists with experience in ice jams and was informed by available flood history documentation of previous severe flood events. Four scenarios were analysed to cover a wide variety of possible flood risks and the 2018 ice jam was selected as the risk event as it was the most recent flood for which detailed information is available to validate numerical modelling and flood risk mapping results. The confidence in this risk assessment could be increased by conducting river cross-section surveys and development of a new hydraulic model, detailed analysis on ice jam and estimate the probability of a ice jam event to happen.

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Key Information Sources	
Identify all supporting documentation and information sources for qualitative and quantitative data used to identify risk events, develop the risk event description, and assess impacts and likelihood. This ensures credibility and validity of risk information presented as well as enables referencing back to decision points at any point in time. Clearly identify unclassified and classified information.	The following informations have been used in the risk assessment 1. Alberta Environment Flood Hazard Mapping report and hydraulic model (2000). 2. Alberta Transportation flood documentation for Highway 88 (BF7422) bridge. 3. Flow and water level data from WSC gauge station 07HF001 (Peace River at Fort Vermilion) 4. High resolution Lidar elevation data from Mackenzie County. 5. Cadastral maps from Mackenzie County. 6. Railway and Roadway data from Natural Resources Canada. 7. Bridge information from Alberta Transportation 8. 2016 census data from Statistics Canada. 9. Aerial Imagery from Mackenzie County and Arc GIS Base Map.
Description of the risk analysis team	
List and describe the type and level of experience of each individual who was involved with the completion of the risk assessment and risk analysis used to inform the information contained within this risk assessment information template.	Team: 1. Robyn Andrishak, M.Sc., P. Eng.- Mr. Andrishak has 15 years of experience as a hydrotechnical engineer on diverse water resources and civil engineering projects across Alberta, Saskatchewan, British Columbia and the northern territories. He played active role as project manager and technical lead in numerous flood mitigation, flood hazard, dam safety, and river engineering projects. His expertise also includes river ice engineering and numerical modeling derived from his post-graduate research activities and continued involvement in the Committee on River Ice Processes and the Environment (CRIPE). 2. Md Makamum Mahmood, M. Eng., P. Eng. - Makamum has more than 7 years' (6 years North American Consulting) experience in surface water management, water resources and flood mitigation, mathematical modelling, hydrology and hydraulics, GIS analysis and flood mapping. 3. Vivien Reske, M. Eng., P. Eng. - Vivien Reske has 19 years of professioanal experience in the consulting industry focusing on project management and site development. She has led complex multi-disciplinary projects through conceptual and detailed design and managed construction aspects of various engineering works. Vivien is very capable of coming up with different flood mitigation options. 4. James Snyder, P. Eng. - Mr. Snyder has experience in hydrologic surveys data collection, hydrometric monitoring, data analysis, river engineering and field planning and coordination.