



Photo source: R. Andrishak (2018)

Aklavik Flood Hazard Mapping Study

Prepared by:

Northwest Hydraulic Consultants Ltd.

9819 - 12 Avenue SW
Edmonton, AB T6X 0E3
Tel: (780) 436-5868
www.nhcweb.com

NHC Project Contact:

Dan Healy, Ph.D., P.Eng.
Principal

April 22, 2025

Final Report

NHC Reference 1008469.300

Prepared for:

Government of the Northwest Territories

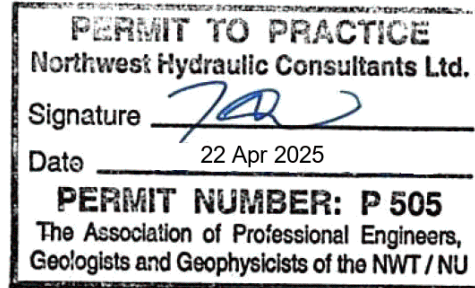
Department of Environment and Climate Change
Water Resources Division
300, 5102 – 50th Avenue
P.O. Box 1320
Yellowknife, NT X1A 2L9

Report prepared by:



22 Apr 2025

Robyn Andrishak, M.Sc., P.Eng.
Principal



Report reviewed by:

Dan Healy, Ph.D., P.Eng.
Principal

DISCLAIMER

This report has been prepared by Northwest Hydraulic Consultants Ltd. for the benefit of Government of the Northwest Territories for specific application to the Aklavik Flood Hazard Mapping Study. The information and data contained herein represent Northwest Hydraulic Consultants Ltd. best professional judgment in light of the knowledge and information available to Northwest Hydraulic Consultants Ltd. at the time of preparation and was prepared in accordance with generally accepted engineering and geoscience practices.

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 Government of the Northwest Territories, 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.

CREDITS AND ACKNOWLEDGEMENTS

The authors gratefully acknowledge the funding for this project provided by Government of Northwest Territories and Natural Resources Canada. Input from project technical committee throughout the project was also of great value. Members of the project technical committee included: Anna Coles (GNWT), Shawne Kokelj (GNWT), Jad Saade (GNWT), Ryan Connon (GNWT), Michele Culhane (GNWT), Brian Perry (NRCan), Sara Karam (NRCan), and Josh Wiebe (ECCC).

EXECUTIVE SUMMARY

Northwest Hydraulic Consultants Ltd. was retained by the Government of Northwest Territories to develop flood hazard maps for the hamlet of Aklavik in the Mackenzie Delta region. Aklavik has experienced numerous flood events in the past, occurring typically in May or June during spring breakup in the Mackenzie Delta. The largest recorded floods occurred in 1961 and 1982, with peak water levels similar to the current 200-year return period ice affected flood estimate for Aklavik.

Ice affected floods produce water levels in the Mackenzie Delta that are much greater than open water floods that occur in response to rainfall events. Therefore, the flood frequency analysis and design flood estimates in this study were based on peak water levels recorded during spring breakup. Flood hazard maps for the 100- and 200-year design floods were produced. The floodway extents follow the 1 m depth along the main river channel and are similar for both design floods. Most of the developed areas of Aklavik are situated outside of the floodway, except for some low-lying areas near the banks of the Peel Channel. Inundated areas outside of the floodway are mapped as flood fringe.

The 200-year design flood is on average 0.18 m higher than the 100-year design flood at Aklavik. As a result, the major difference between the two flood hazard maps is the extent of the flood fringe. Notably, much more of the airport runway is inundated and included in the flood fringe for the 200-year design flood, along with a reduction in the size of other isolated areas of high ground throughout the hamlet.

TABLE OF CONTENTS

DISCLAIMER	III
CREDITS AND ACKNOWLEDGEMENTS	IV
EXECUTIVE SUMMARY	V
1 INTRODUCTION	1
1.1 Project Overview.....	1
1.2 Study Area.....	1
1.3 Study Reach.....	4
2 AVAILABLE DATA	6
2.1 Previous Studies.....	6
2.2 Hydrometric Data.....	6
2.3 Geospatial Data.....	6
2.4 HEC-RAS Model.....	7
3 FLOOD HYDROLOGY	9
3.1 Flood History.....	9
3.2 Ice Regime.....	9
3.3 Flood Frequency Analysis.....	11
4 HYDRAULIC MODELLING	14
4.1 Methodology.....	14
4.2 Flood Profiles	14
5 FLOOD HAZARD MAPPING	16
6 CLIMATE CHANGE CONSIDERATIONS	16
7 SUMMARY.....	17
8 REFERENCES	18

LIST OF TABLES

Table 2.1	List of hydrometric gauges in the Mackenzie Delta area	6
Table 3.1	Documented flood events and estimated flood levels at Aklavik during breakup (1933 to present)	10
Table 3.2	Recorded annual peak water level during breakup at WSC Station 10MC003, Mackenzie River (Peel Channel) above Aklavik	11
Table 3.3	Ice affected flood frequency analysis for Aklavik	12

Table 4.1 Ice-affected flood water surface profiles for Aklavik..... 15

LIST OF FIGURES

Figure 1.1 Location Map 3
Figure 1.2 Study area 5
Figure 2.1 Cross Section Locations and Model Extents 8
Figure 3.1 Ice affected flood frequency curve – Peel Channel above Aklavik (10MC003) 13

APPENDICES

Appendix A Flood Hazard Maps
Appendix B Flood Inundation Maps

1 INTRODUCTION

1.1 Project Overview

Northwest Hydraulic Consultants Ltd. (NHC) was retained by the Government of the Northwest Territories (GNWT) Department of Environment and Climate Change to update the flood hazard maps for the hamlet of Aklavik. This project was funded in part under the Flood Hazard Identification and Mapping Program (FHIMP) with additional support from the GNWT. The intended use of these flood hazard maps is for community infrastructure planning and other flood mitigation measures, and emergency preparedness.

This report provides the results of the flood hazard mapping study for Aklavik and includes the following: a summary of the available data; ice-affected flood history and hydrology; hydraulic modelling; and the development of flood hazard maps. Potential impacts of climate change are also discussed.

1.2 Study Area

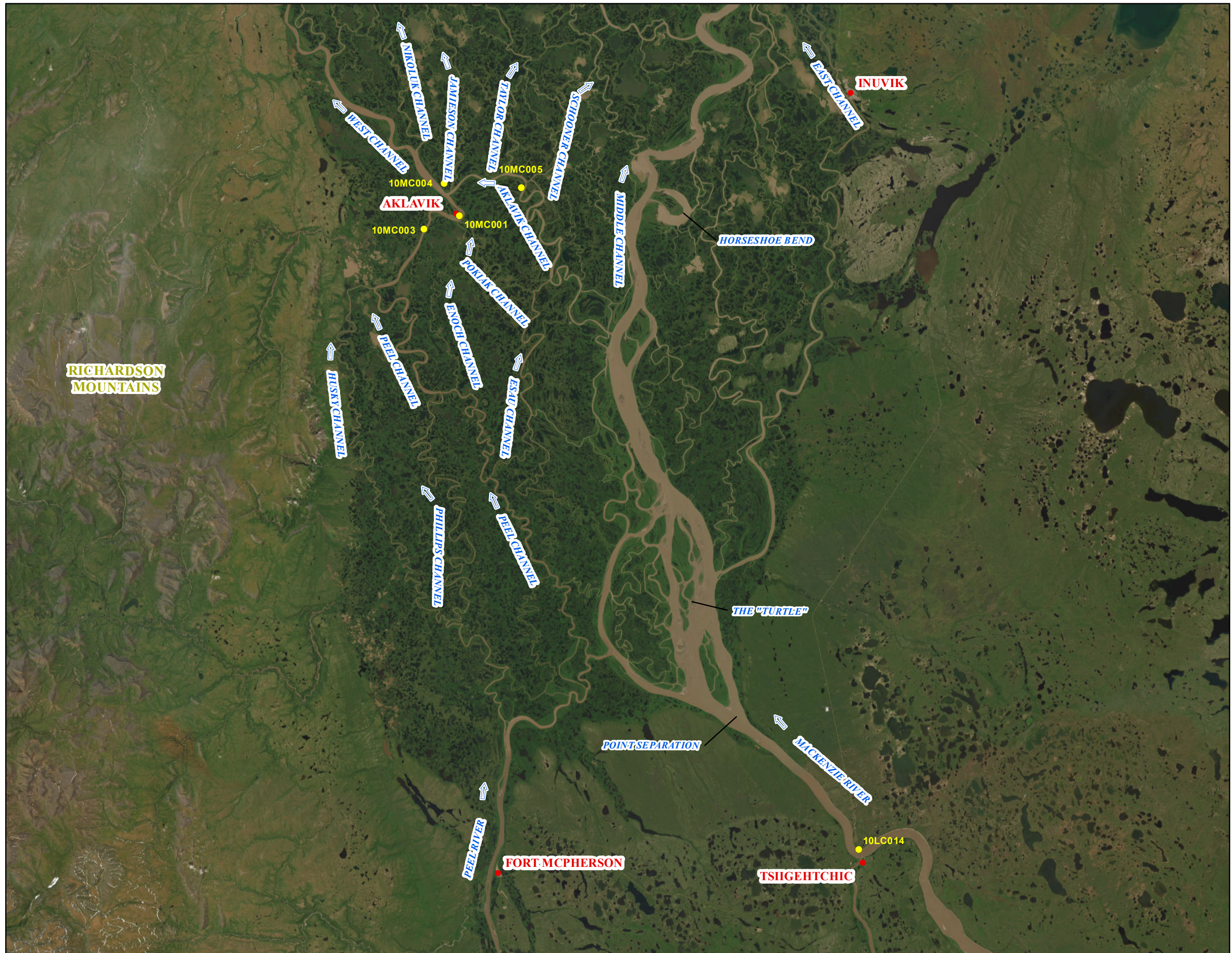
Aklavik is located in the Mackenzie Delta (the delta) about 55 km west of Inuvik, Northwest Territories (**Figure 1.1**). The delta is a highly complex hydrodynamic system consisting of many interconnected river channels and lakes (Blackburn et al., 2015). The delta begins at Point Separation, which is 25 km downstream of Tsiigehtchic, and conveys water from Mackenzie and Peel rivers into the Beaufort Sea. The nominal east-west width of the delta is about 60 km; it is bordered by the Richardson Mountains to the west and the Caribou Hills to the east.




At Point Separation, the Mackenzie River splits into several channels; this area is referred to as the “Turtle” (Beltaos et al., 2012). The west-most channel of the Turtle connects the Mackenzie River with the Peel River. Downstream of the Turtle is the Middle Channel, which is the largest in the delta. The Peel Channel originates from the Peel River about 60 km south of Aklavik and carries flow through the western half of the delta. The East Channel carries flow from the Middle Channel through the eastern half of the delta past Inuvik.

The Aklavik Channel connects the Peel/West Channel at Aklavik to the Middle Channel about 27 km southeast of Aklavik. Downstream of Aklavik Channel, the Peel Channel is referred to as the West Channel. The Enoch and Pokiak channels also connect to the Peel Channel near Aklavik. The Enoch Channel transports water from the Peel Channel about 24 km south of Aklavik while the Pokiak Channel transports water from the Aklavik Channel about 15 km southeast of Aklavik.

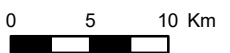
Aklavik is situated on the left bank of the Peel Channel immediately upstream of the confluence of the Peel and Aklavik Channels. Six Mile Creek drains into the West Channel approximately 5 km downstream of the confluence of the Peel and Aklavik Channels. The area surrounding Aklavik is relatively flat, and much of the hamlet can become inundated during highwater events.

Breakup in the delta occurs in the spring as the discharge increases on the Mackenzie and Peel rivers (Beltaos and Carter, 2009). The increasing flows mobilize the ice on these rivers and within the delta often resulting in the formation of ice jams, which typically form in the Middle Channel between Point Separation and Horseshoe Bend. These ice jams divert large volumes of water from the Middle Channel into the Aklavik and Peel channels, which can result in flooding at Aklavik. Goulding (2009) provides a comprehensive review of the processes and previous studies. Intact ice covers or ice jams in the West Channel downstream of Aklavik can further increase flood levels under these conditions.



-  FLOW DIRECTION
-  COMMUNITIES
-  HYDROMETRIC GAUGE

SCALE - 1:480,000



Coordinate System: NAD 1983 CSRS UTM ZONE 8N; Vertical Datum: CGVD2013; Units: Metres

Job: 1008469 | Date: 14-MAR-2025

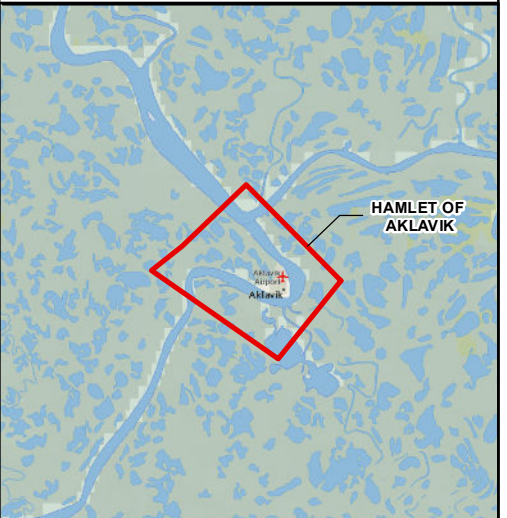
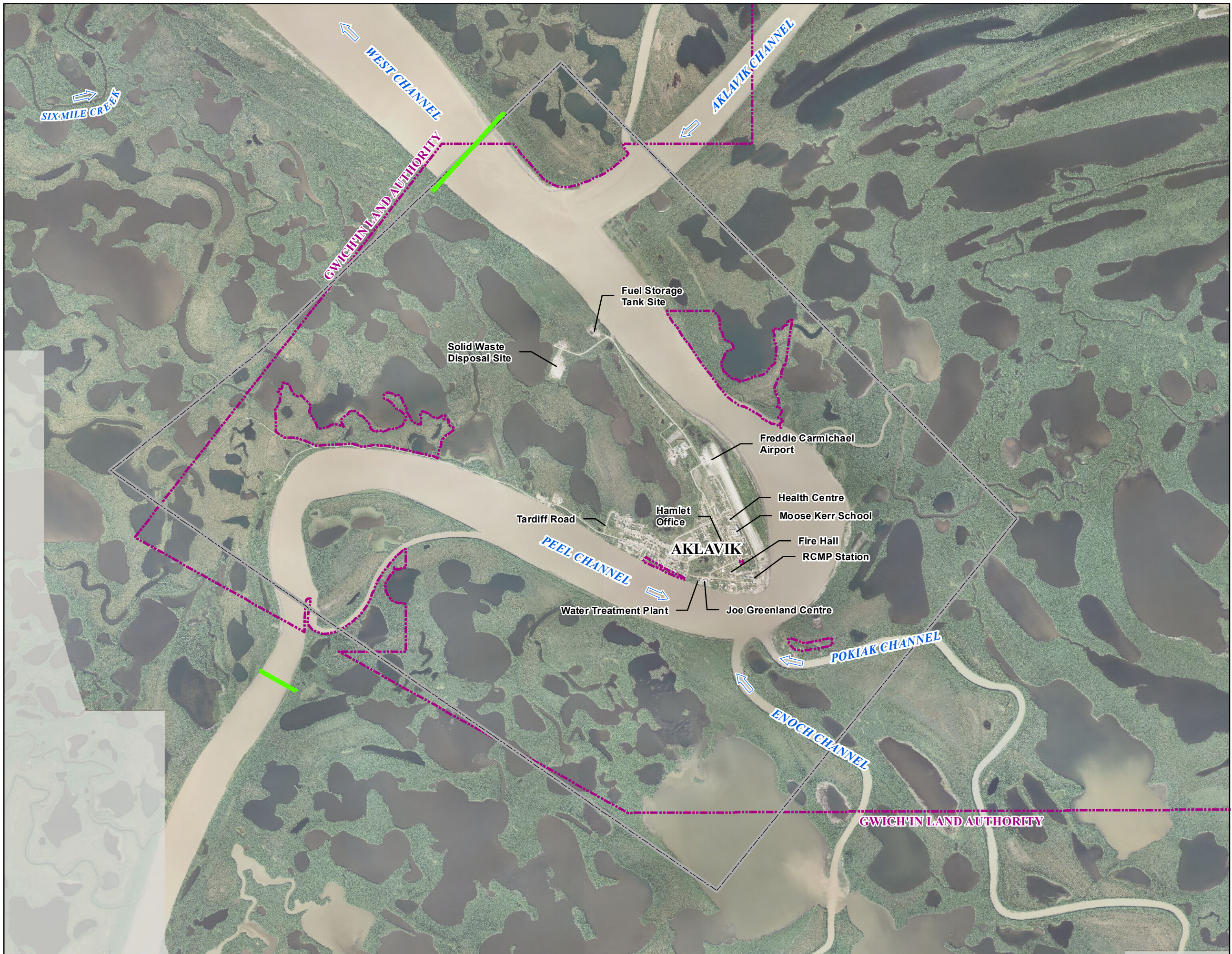
AKLAVIK FLOOD HAZARD MAPPING STUDY

LOCATION MAP

FIGURE 1.1

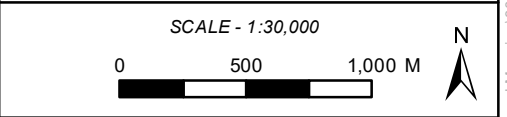
1.3 Study Reach

Flood hazard mapping was completed for 10.8 km of the Peel and West Channels (**Figure 1.2**) through Aklavik in this study. The study reach extends from about 4 km upstream of Tardiff Road to about 2 km downstream of the Tank Farm. Places of note in the hamlet include: Freddie Carmichael Airport, water treatment plant, solid waste disposal site, fuel storage tank site, fire hall, RCMP station, Moose Kerr School, health centre, Joe Greenland Centre, and Hamlet Office.



- FLOW DIRECTION
- STUDY LIMIT
- MUNICIPAL BOUNDARY
- LAND AUTHORITY BOUNDARY

DATA SOURCES: Municipal Boundaries from ATLAS NWT
 Aerial Image 20cm resolution and LIDAR 1m resolution by McElhanney Ltd. for the Survey Division of the Government of Northwest Territories, 2021



Coordinate System: NAD 1983 CSRS UTM ZONE 8N; Vertical Datum: CGVD2013; Units: Metres

Job: 1008469 | Date: 14-MAR-2025

AKLAVIK FLOOD HAZARD MAPPING STUDY

STUDY AREA

FIGURE 1.2

RBA_P:\Projects (Active)\1008469 NWT Flood Hazard Mapping\300 Aklavik\90 GIS\1008469_RBA_Fig1.2_Aklavik Study Area_R2.mxd

2 AVAILABLE DATA

2.1 Previous Studies

This study builds on the previous flood mapping work done at Aklavik by NHC (2023, 2019). There have been several previous studies and reports documenting flood events that occurred at Aklavik dating back to 1933 (Kriwoken, 1983; Coles, 2020).

2.2 Hydrometric Data

Publicly available hydrometric data were collected from Water Survey of Canada (WSC), including peak instantaneous annual and maximum daily water levels and, where available, discharge. **Table 2.1** provides a description of the WSC gauges in the Mackenzie Delta area and summarizes the information available at each gauge. The locations of these gauges are shown in **Figure 1.1**.

Table 2.1 List of hydrometric gauges in the Mackenzie Delta area

Station ID	Station name	Period of record	Data type
10MC003	Mackenzie River (Peel Channel) above Aklavik	1974-76, 2009-17	Discharge
10MC004	Mackenzie River (West Channel) below Aklavik Channel	1974-1975	
10MC005	Mackenzie River (Aklavik Channel) above Schooner Channel	1974-1976	
10LC014	Mackenzie River at Arctic Red River	1972-2019	
10MC001	Mackenzie River (Peel Channel) at Aklavik	1967-1968	Water level
10MC003	Mackenzie River (Peel Channel) above Aklavik	1982, 84-86, 92-93, 97, 2001-03, 06-07, 09-17, 2019	

Additional river ice breakup information provided by GNWT for reference included:

- 2021 Beaufort Delta breakup monitoring reports with a written description of breakup progression prepared by GNWT Environment and Natural Resources
- river ice classification by satellite remote sensing for the years 2020, 2021, and 2022 prepared by C-CORE and NRCan

2.3 Geospatial Data

Various geospatial data sets were received from GNWT for Aklavik for use in this study. The following base data layers were obtained through the ATLAS interactive web-based mapping service:

- Water Bodies
- Water Courses

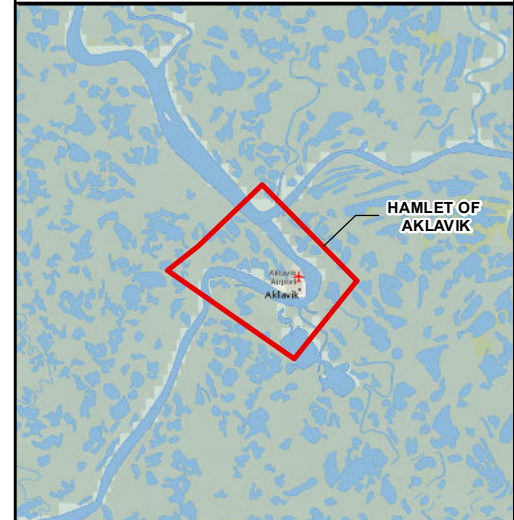
- Municipal Boundaries
- Land Authority
- Transportation Lines
- Floodway and flood fringe extents for previously mapped areas on the 1985 flood map (used only for reference purposes)

The most recent 1 m resolution bare-earth digital terrain model (DTM) data for Aklavik was developed from LiDAR obtained by McElhanney Ltd. on 15 July 2021. The mean point density was 37 pt/m² with a variation of ±9 pt/m² depending on the canopy closure, understory density, and topographic features. The data were received as georeferenced tiff files. A coarse digital elevation model (DEM) with 30 m point resolution was also obtained from Northwest Territories Centre for Geomatics to extend the high resolution DTM coverage.

The most recent orthorectified imagery (20 cm) for Aklavik were collected by McElhanney Ltd. on 15 July 2021, and received as georeferenced tiff files and in ECW format.

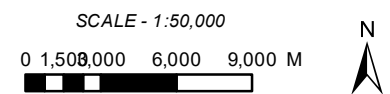
2.4 HEC-RAS Model

The existing, calibrated, U.S. Army Corps of Engineers *Hydrologic Engineering Center-River Analysis System* (HEC-RAS) Version 5.0.6 hydraulic model for the Peel and Aklavik channels at Aklavik developed by NHC (2019) was available for use in this study. **Figure 2.1** shows the cross section locations and HEC-RAS model extents.



- CROSS SECTION
- STUDY REACH

DATA SOURCES: Aerial imagery from
ESRI World Imagery.



Coordinate System: NAD 1983 CSRS UTM ZONE
8N; Vertical Datum: CGVD2013; Units: Metres

Job: 1008469 | Date: 14-MAR-2025

AKLAVIK FLOOD HAZARD MAPPING STUDY
**CROSS SECTION LOCATIONS
AND MODEL EXTENTS**

FIGURE 2.1

3 FLOOD HYDROLOGY

3.1 Flood History

River ice breakup produces the largest hydrologic event in the Mackenzie Delta each year (Marsh and Hay, 1989) and is responsible for numerous flood events at Aklavik. Peak water levels during breakup are several metres higher than recorded water levels during open water conditions. **Table 3.1** contains a list of the documented flooding events experienced in Aklavik resulting from an ice jam occurring during breakup in late May or early June. Context is provided about the impact of each flood event on the surrounding area, along with a list of reference documents. Kriwoken (1983) provides information from Hudson's Bay Company archives and Roman Catholic Church diaries about ice jam flood events since 1933.

The 1961 flood produced the highest water levels on record, with the second highest water levels measuring approximately 0.1 m lower in 1982. Firsthand documentation of the 1982 flood event indicates that the peak flood level was 6.42 m above sea level (masl) at Aklavik, after a vertical datum adjustment of -4.67 m was applied to the published value. The adjustment was estimated by comparing reference points on the air strip depicted on the 1985 flood map against elevations from the 2021 DTM. An attempt was made to locate and survey reference benchmarks indicated on the 1985 map during a site visit in September 2024. One benchmark was confirmed to be destroyed; the others could not be located and are assumed to be destroyed. Therefore, the estimated adjustment cannot be improved.

Detailed information was also gathered describing the flood event in 1961, which measured very similar water levels. Highwater levels recorded after 1982 are based on the WSC gauge station record, with notable events also occurring in 1992, 2006, 2013, and 2021.

3.2 Ice Regime

The ice regime at Aklavik is complex due to its connection with breakup throughout the delta. Flooding at Aklavik may result from ice jams in the channel close to the community and/or ice jams that form in the Middle Channel. Therefore, understanding the causes of flooding each year requires a review of both the local conditions and the conditions throughout the delta.

Breakup usually starts in the second half of May in response to rising discharges on the Mackenzie and Peel rivers, with peak water levels at Aklavik occurring at the end of May or early June. Ice jams often form in the Middle Channel between Point Separation and Horseshoe Bend, raising the water level in the Middle Channel (NHC, 2019). This directs higher volumes of water through the much smaller east and west distributary channels of the delta. The formation of an ice jam in the Turtle can force flow from the Main Channel up the Peel River and redirect flow towards Aklavik (Blackburn et al., 2015).

The flood history at Aklavik during the 1961 flood (Kriwoken, 1983) provides an example of an ice jam in the Middle Channel that caused flooding at Aklavik despite the Peel Channel being clear of ice all the way to Aklavik.

Table 3.1 Documented flood events and estimated flood levels at Aklavik during breakup (1933 to present)

Year	Description	Estimated Flood Level at Community	Reference
1933	Water 1' overbank in front of Hudson Bay Company yard. Observed water level 10.8 masl (see note 1).	6.13 m	Kriwoken (1983)
1961	Concurrent ice jams in West Channel downstream of Aklavik and downstream of Point Separation extending to the confluence of the Mackenzie River and Peel River; over 95% of delta underwater. Observed water level 11.2 masl (see note 1).	6.53 m	Kriwoken (1983); GNWT (2014)
1962	Ice jam downstream; water overbank at Roman Catholic mission. Observed water level 10.5 masl (see note 1).	5.83 m	Kriwoken (1983)
1963	Lower parts of Aklavik flooded: water level 10.0 masl (see note 1).	5.33 m	Kriwoken (1983)
1971	Ice jam downstream; Lower parts of Aklavik flooded. Observed water level 10.7 masl (see note 1).	5.53 m	Kriwoken (1983)
1972	Water overbank in front of Roman Catholic mission; Lower parts of Aklavik flooded. Observed water level 10.7 masl (see note 1).	6.03 m	Kriwoken (1983)
1982	Three separate ice jams formed on the Middle Channel downstream of Point Separation and diverted backwater flow into the Peel Channel; estimated 95% of Mackenzie Delta was underwater; extensive damage within Aklavik. Observed water level 11.09 masl (see note 1).	6.42 m	Kriwoken (1983); GNWT (2014); Public Safety Canada (2023)
1992	Flooding: 6.167 m at WSC gauge (see note 4).	6.00 m	GNWT (2014); WSC (2022)
2006	Flooding due to downstream ice jam; Week-long evacuation of 300 residents, severe infrastructure damage: 6.180 m at WSC gauge (see note 4).	6.01 m	GNWT (2014); Public Safety Canada (2023); WSC (2022);
2013	Ice jam on Peel Channel resulted in a state of emergency; Flooding washed out most of the roads, residents were not evacuated: 5.789 m at WSC gauge (see note 4).	5.62 m	CBC News (2013); WSC (2022)
2021	Ice jam in Middle Channel at Horseshoe Bend forced flow into the Peel Channel towards Aklavik, second ice jam in West Channel about 15 km downstream of Aklavik; flood level reached the about same height as 2006. State of emergency, evacuations, damage to many of the roads: 5.5 m at WSC gauge / 6.1 m from media account.	6.1 m	CBC News (2021); WSC (2022)

Notes:

1. Adjustment of -4.67 m has been applied to flood levels in the town that were based on an assumed datum of 10.00 masl.
2. WSC gauge is Mackenzie River (Peel Channel) at Aklavik (10MC003), located 5.85 km upstream of Aklavik.
3. Adjustment of -10.064 m has been applied to convert WSC water level values to geodetic elevation.
4. Adjustment of -0.17 m has been applied to transpose flood level values recorded at the gauge to the tip of the Aklavik promontory.

3.3 Flood Frequency Analysis

Ice affected floods, which occur during spring breakup in the delta, produce water levels that are much greater than open water floods in response to summer rainfall events. Therefore, a flood frequency analysis on peak water levels recorded during breakup at WSC Station 10MC003, Mackenzie River (Peel Channel) above Aklavik was used in this study. Annual peak water levels during breakup are summarized in **Table 3.2**. The timing of the peaks is generally in late May or early June of each year, which is often after the ice has cleared from the Peel Channel at Aklavik. However, water levels at the gauge are typically still affected by ice downstream of Aklavik and elevated flows diverted by ice accumulations in the Middle Channel when the peaks occur.

Table 3.2 Recorded annual peak water level during breakup at WSC Station 10MC003, Mackenzie River (Peel Channel) above Aklavik

Year	Date	Peak Water Level (m)	Year	Date	Peak Water Level (m)
1985	June 1	4.883	2007	June 1	4.041
1986	June 6	5.310	2008	May 26	4.926
1992	June 5	6.167	2009	May 30	4.597
1993	May 30	4.675	2010	May 23	4.048
1994	May 23	3.930	2011	May 27	5.469
1996	May 29	4.523	2012	May 30	4.936
1997	May 28	4.852	2013	June 3	5.789
1998	May 22	4.210	2014	May 28	3.754
1999	May 29	3.316	2015	May 20	5.051
2000	June 3	3.190	2016	May 17	4.638
2001	June 5	4.567	2017	May 27	4.629
2002	May 31	4.714	2018	May 24	3.938
2003	June 3	4.310	2019	May 22	3.762
2004	May 28	4.346	2020	May 31	4.897
2005	May 25	4.634	2021	June 4	5.500
2006	May 27	6.180	2022	May 31	5.511

Notes:

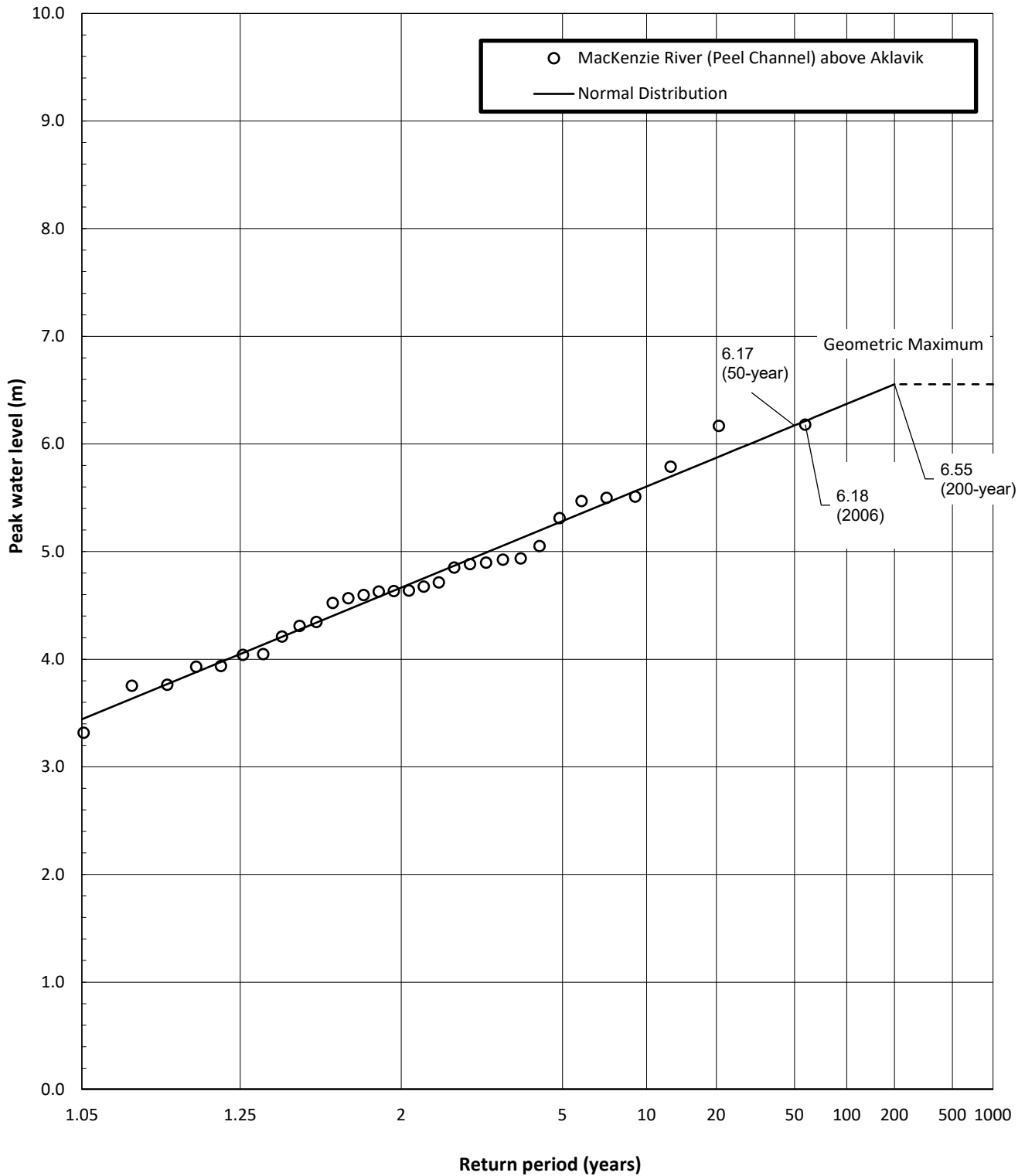
1. WSC gauge Mackenzie River (Peel Channel) at Aklavik (10MC003).
2. Water levels derived from daily maximum and five-minute timeseries data.
3. Adjustment of -10.064 m reported by WSC has been applied to convert published values to geodetic elevation.
4. Peak water levels during breakup are ice-affected.

Figure 3.1 shows the flood frequency curve plotted using a normal distribution, which best fit the data and had been adopted previously by NHC (2023; 2019). The Cunnane plotting position formula was used to plot the data points for visualization purposes. The log-normal, Pearson Type III, and log-Pearson Type III theoretical probability distributions were also tested but did not fit the observed peak water level data as well. Flood levels for selected annual exceedance probabilities are presented in **Table 3.3**. Based on the distance between the gauge (at RS 17 218) and Aklavik (at RS 11 364) of 5854 m and a typical water surface slope of about 0.000029 m/m along this reach, water levels at Aklavik are expected to be 0.17 m lower than those recorded at the WSC gauge.

Table 3.3 Ice affected flood frequency analysis for Aklavik

Flood Return Period	Peak Water Level (m)
200-year	6.55
100-year	6.37
50-year	6.17
20-year	5.87
10-year	5.61
5-year	5.28
2-year	4.67

The curve reaches a maximum water level at the 200-year return period, due to the near infinite storage capacity of the delta floodplain. In other words, floods greater than the 200-year return period cannot be resolved at this site. The largest recorded flood (27 May 2006) produced a peak water level of 6.18 m at the gauge, which is equivalent to the 50-year flood based on the flood frequency analysis. The 1982 flood, when converted to geodetic elevation and transposed to the gauge, is estimated to be 6.59 m or about the 200-year flood magnitude.



NOTE: Adjustment of -10.064 m reported by WSC has been applied to convert published water levels to geodetic elevation.

4 HYDRAULIC MODELLING

4.1 Methodology

HEC-RAS Version 5.0.6 was used to simulate flood levels along the study reach. The basic inputs required by HEC-RAS are a series of cross sections spaced over known lengths of channel, roughness coefficients for the channel and overbank areas at each cross section, a specified water level or slope at the downstream model boundary, and discharge at all upstream reach boundaries and internal flow change locations.

The previously developed and calibrated HEC-RAS model by NHC (2019) was used for this study. The model includes just over 19 km of the Peel/West Channel. The downstream boundary of the model is located 6.4 km beyond the limit of the mapped study reach to capture all the channel bathymetry data that was available. Similarly, a shorter 1.9 km upstream reach above the WSC gauge is included in the model but is outside the study area and mapping boundaries.

Water surface profiles for each return period were simulated by setting the discharge in the Peel and West channel reaches such that the water level at the WSC gauge matched the ice affected flood frequency estimates in **Table 3.3**. Since observations of past breakup events in the delta suggest the channels are either clear of ice or ice is running mostly free during floods at Aklavik, no ice jam modelling was required. Therefore, open water conditions were assumed in all hydraulic computations of flood level profiles.

4.2 Flood Profiles

The computed ice-affected flood water surface profiles are presented in **Table 4.1**. A continuous water surface TIN was generated using the water levels at each cross section. Areas adjacent to the river were included by either extending TIN breaklines beyond the cross section endpoints or by interpolating water levels between adjacent cross section endpoints on the Aklavik promontory.

Table 4.1 Ice-affected flood water surface profiles for Aklavik

River Station (m)	Description	Water Surface Elevation (m)				
		5-year Flood	20-year Flood	50-year Flood	100-year Flood	200-year Flood
17,218	WSC gauge	5.26	5.86	6.16	6.37	6.55
16,825		5.26	5.86	6.15	6.36	6.54
16,449		5.25	5.85	6.15	6.36	6.54
15,812		5.22	5.82	6.12	6.33	6.51
15,641		5.22	5.82	6.12	6.33	6.51
15,312	Access to west traditional trail	5.21	5.81	6.11	6.32	6.50
15,001		5.19	5.79	6.09	6.30	6.49
14,447		5.17	5.77	6.07	6.28	6.46
13,832		5.15	5.75	6.05	6.26	6.44
13,369		5.13	5.73	6.03	6.24	6.42
12,915	Near Tardiff Rd.	5.12	5.71	6.01	6.22	6.40
12,493		5.10	5.70	6.00	6.21	6.39
12,123	Pascal Rd.	5.09	5.68	5.98	6.19	6.37
11,800		5.07	5.67	5.97	6.18	6.35
11,563		5.08	5.67	5.97	6.18	6.36
11,364	Tip of promontory	5.08	5.67	5.97	6.18	6.36
11,157		5.07	5.66	5.96	6.17	6.35
10,906	South end of runway	5.07	5.66	5.96	6.17	6.35
10,622		5.06	5.66	5.95	6.16	6.34
10,303		5.05	5.64	5.94	6.15	6.33
9,941		5.02	5.62	5.91	6.12	6.30
9,701	Airport terminal	5.00	5.60	5.89	6.10	6.28
9,379		5.00	5.59	5.88	6.09	6.27
8,854		4.99	5.58	5.88	6.08	6.26
8,336	Fuel storage tank site	4.98	5.57	5.87	6.07	6.25
7,708		4.97	5.56	5.85	6.06	6.24
7,031		4.94	5.53	5.82	6.03	6.20
6,400		4.92	5.51	5.81	6.01	6.19

5 FLOOD HAZARD MAPPING

The 100- and 200-year ice-affected floods from **Table 4.1** were considered as potential design floods for flood hazard mapping. The 200-year flood is comparable in magnitude to the 1982 flood, which was the basis for the original 1985 flood map for Aklavik. The average water level difference between the 200- and 100-year flood levels is +0.18 m, and this difference is consistent along the study reach.

Flood hazard maps for both design floods are provided as Appendix A. The floodway boundary follows the 1 m depth contour along the major channels of the study reach. Areas deeper than 1 m that are associated with adjacent lakes were not included in the floodway, unless the area surrounding the lake was more than 1 m deep. Inundated areas outside the floodway are included in the flood fringe.

There were minimal differences between the 100- and 200-year floodway limits. On the 200-year flood hazard map, the floodway extents increased along Hansen Road near Tornow Avenue, along John Dick Road, and near the access to the tank farm off Tank Farm Road. Most of the developed areas of Aklavik are inundated for both design floods and part of the flood fringe. However, isolated areas of high ground are larger for the 100-year flood. Notably, much more of the airport runway is inundated for the 200-year flood compared to the 100-year flood.

Inundation maps for the 5-, 20-, and 50-year ice affected floods as well as the 2006 flood inundation map are provided in Appendix B for additional context.

6 CLIMATE CHANGE CONSIDERATIONS

A qualitative assessment of climate change impacts was undertaken for this study. This overview does not provide a comprehensive review of the impacts of climate change on the Mackenzie Delta ice regime.

Climate change is expected to affect ice processes in the delta in several ways, potentially changing the future severity of flooding. The main changes in climate that will affect ice processes are increased temperature and precipitation (Szeto et al., 2008) and increasing river discharge to the western Arctic Ocean (Dery et al., 2016).

Climatic conditions affect the rate of ice formation, accumulation, thickness of the ice cover, nature of river ice breakup in the spring, and the extent of permafrost. Burrell et al. (2023) provides a comprehensive review of the effects of a changing climate on river ice processes. Warmer conditions will generally delay the initial formation of the ice cover and result in earlier breakup. Ice growth rates will be slower and, combined with the shorter period of intact ice cover, will lead to reduced ice thicknesses preceding breakup. The effects of these changes on flood severity at Aklavik, and in the delta more generally, are not well-known. Shorter winters also means that the time over which the snowpack develops is reduced, potentially limiting the volume of the snowmelt runoff wave. Warmer temperatures will also reduce the extents of permafrost and could potentially increase bank erosion rates where thawing of permafrost occurs. Permafrost mitigates bank erosion during large, short

duration floods, when highwater does not have sufficient time to melt pore or excess ice within the soil matrix (Ashmore and Church, 2001).

The timing, not just the magnitude, of changes in temperature and peak discharges will influence the frequency and severity of ice affected floods. Turcotte (2021) concluded that trends in ice-induced highwater events at several locations in Northwestern Canada were stable or there were not enough reliable hydrometric data to discern a trend. Turcotte (2021) also noted that climate tendencies favouring more dynamic breakups (i.e. those typically associated with flooding) could be compensated by others that promote thermal breakup (i.e. much less severe than dynamic breakup).

Downstream of Aklavik, sea levels are expected to increase by around 0.5 m by 2100 (James et al., 2015) due to climate change. Climate change is also expected to worsen the effects coastal storm surge events at the mouth of the delta. However, NHC (2019) found that coastal storm surge is not expected to affect peak water levels during breakup at Aklavik, and sea level rise is not a significant consideration for flood severity in the study area for the period 2055-2100 under climate change conditions.

The effect of the climate change on the severity of breakup is generally site specific due to the complexity of the contributing factors. In general, breakup severity is a balance between downstream resistance (ice strength and thickness) and upstream forces (flood wave). A combination of a strong, thick ice cover with a high spring peak discharge will produce dynamic breakups with large ice jams and the associated flooding. Climate change will reduce the ice cover thickness due to warmer average temperatures though possibly not reduce the strength of the ice cover due to the earlier occurrence of breakup. Much of the reduction in ice strength before breakup is due to solar radiation (Prowse, Demuth, and Chew, 1990), which is less intense earlier in spring, especially at high latitudes where the sun angle and duration of sunlight change most rapidly.

Generation of a high spring peak discharge requires both a large snowpack across the entire Mackenzie River basin and a combination of high spring temperatures combined with dynamic river ice breakup on the Mackenzie River. Reduced snowpack could result in smaller peak discharges during breakup, less severe thermal breakup ice runs, and reduced peak water levels as a result.

7 SUMMARY

Flood hazard maps were developed for Aklavik for two possible design floods: the 100-year and 200-year ice-affected floods. Both maps are similar in terms of the extent of the floodway, although the 200-year map is more aligned with the 1985 flood map for Aklavik that provides floodway and flood fringe extents. Most of the developed areas of Aklavik are situated within the flood fringe.

A frequency analysis of recorded peak water levels during spring breakup at the WSC gauge on the Peel Channel above Aklavik was completed to estimate flood levels for various return periods. These peaks generally occur in May and June when the channel is at least partially ice-free. Ice jams in the Middle Channel of the Mackenzie Delta tend to divert large volumes of water into the Peel and Aklavik Channels and are associated with the highest flood levels at Aklavik. A previously developed and calibrated HEC-

RAS hydraulic model of the Peel/West Channel was used to determine the water surface profile from the WSC gauge down to the lower end of the study reach.

The effect of climate change on storm surge in the Beaufort Sea and the timing and severity of breakup was also considered. A review of recent investigations suggested that the main impact of climate change would be a shift towards earlier breakup, but there is no indication that the frequency of flooding at Aklavik would increase.

8 REFERENCES

- Ashmore, P. and Church, M. (2001). The Impact of Climate Change on Rivers and River Processes in Canada. Geological Survey of Canada, Bulletin 555. Pg 39.
- Beltaos, S. and Carter, T. (2009). Field studies of ice breakup and jamming in the Mackenzie Delta. 15th Workshop on River Ice, CGU HS Committee on River Ice Processes and the Environment.
- Beltaos, S., Carter, T., and Rowsell, R. (2012). Measurements and analysis of ice breakup and jamming characteristics in the Mackenzie Delta, Canada. *Cold Regions Science and Technology*, 82, 110–123. doi:<http://dx.doi.org/10.1016/j.coldregions.2012.05.013>.
- Blackburn, J., Yuntong, S., Hicks, F., and Nafziger, J. (2015). Ice Effects on Flow Distributions in the Mackenzie Delta. 18th Workshop on the Hydraulics of Ice Covered Rivers, CGU HS Committee on River Ice Processes and the Environment.
- Coles, A. (2020). NWT Flood Events. Draft Report.
- Dery, S.J., Stadnyk, T.A., MacDonald, M.K., and Gauli-Sharma, B. (2016). Recent trends and variability in river discharge across northern Canada. *Hydrology and Earth System Sciences*, 20, 4801-4818.
- Goulding, L.H. (2009). An Assessment of Spatial and Temporal Patterns and Driving Hydroclimatic Controls of Break-up and Ice Jam Flooding in the Mackenzie Delta, NWT. M.Sc. Thesis, Department of Geography, University of Victoria, 130 p.
- James, T.S. et al. (2015). Tabulated Values of Relative Sea-level Projections in Canada and the Adjacent Mainland United States. Geological Survey of Canada. Open File 7942, 81 p. doi:[10.4095/297048](https://doi.org/10.4095/297048).
- Kriwoken, L.A. (1983). Historical flood review: Fort Simpson, Fort Norman, Fort Good Hope, Fort McPherson, Aklavik, Fort Liard, Nahanni Butte. Report for the Northwest Territories Technical Committee, Flood Damage Reduction Program, Yellowknife, NT.
- Marsh, P. and Hay, M. (1989). The flooding hydrology of Mackenzie Delta Lakes near Inuvik, N.W.T., Canada. *Arctic*, 42(10), 41-49.
- Northwest Hydraulic Consultants Ltd. (NHC). 2019. Aklavik Disaster Mitigation Study, Part 1 – Data Review, Flood Mapping, and Channel Stability Investigation. Report prepared for Government of Northwest Territories, Municipal and Community Affairs.

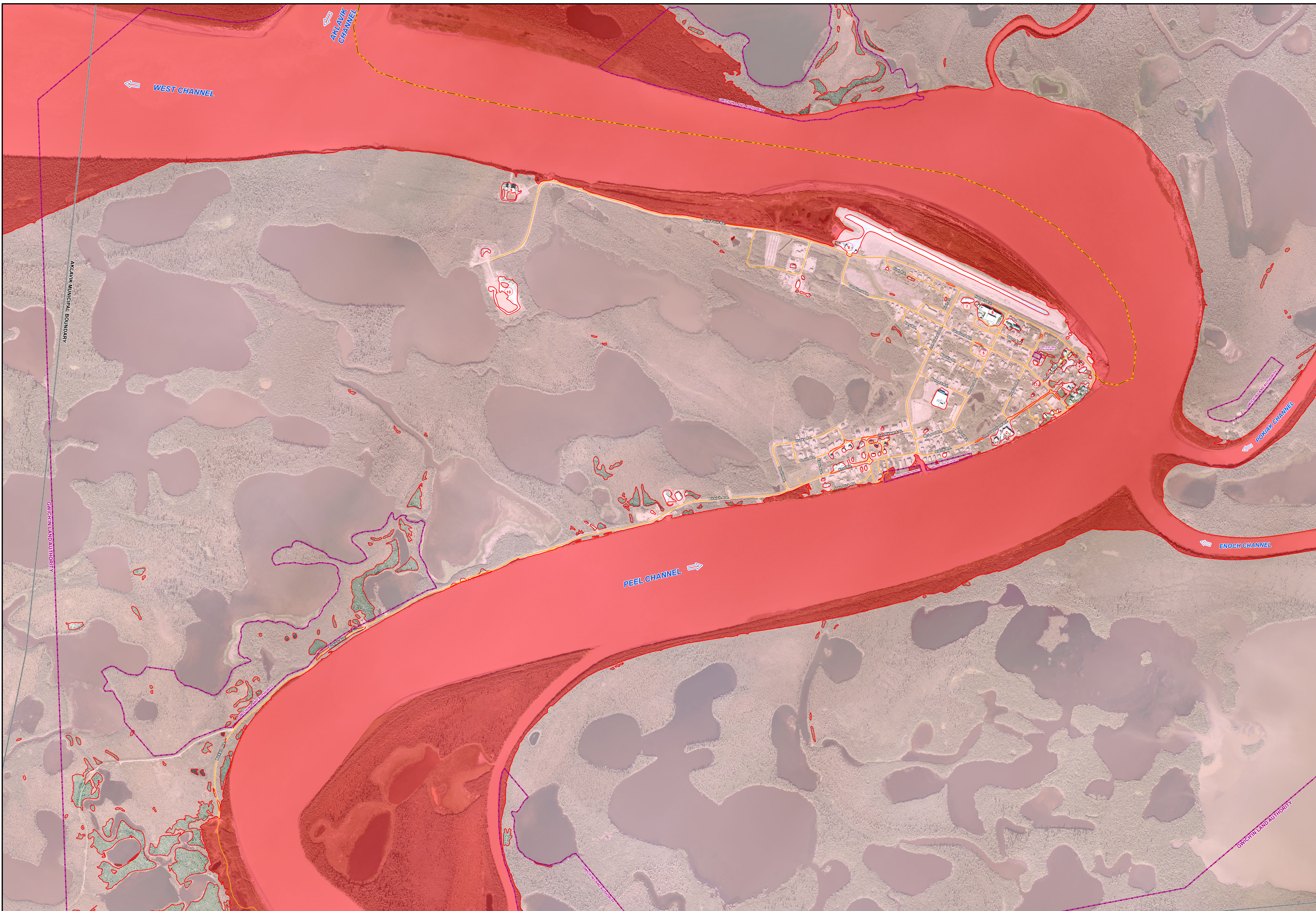
Northwest Hydraulic Consultants Ltd. (NHC). 2023. Northwest Territories Ice Jam Flood Mapping Case Studies V1.0. Report prepared for Natural Resources Canada and Government of Northwest Territories.

Prowse, T.D., Demuth, M.N., and Chew, H.A.M. (1990) The deterioration of freshwater ice due to radiation decay; *Journal of Hydraulic Research*, v. 28, p. 685-697.

Szeto, K.K. et al. (2008) *The Mackenzie Climate System: A Synthesis of MAGS Atmospheric Research. Volume 1. Cold Region Atmospheric and Hydrologic Studies – The Mackenzie GEWEX Experience.*

APPENDIX A

FLOOD HAZARD MAPS



Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

northwest hydraulic consultants

- FLOW DIRECTION
- ROAD
- WATER ROAD
- 100-YEAR FLOODWAY
- 100-YEAR FLOOD FRINGE
- AKLAVIK MUNICIPAL BOUNDARY
- GWICHIN LAND AUTHORITY

- PLACES OF NOTE:**
- | | |
|-------------------------|------------------------------|
| 1 WATER TREATMENT PLANT | 6 MOOSE KERR SCHOOL |
| 2 JOE GREENLAND CENTRE | 7 HEALTH CENTRE |
| 3 FIRE HALL | 8 FREDDIE CARMICHAEL AIRPORT |
| 4 RCMP STATION | 9 FUEL STORAGE TANK SITE |
| 5 HAMLET OFFICE | 10 SOLID WASTE DISPOSAL SITE |

GEOSPATIAL DATA SOURCES:
 Aerial Image 20cm resolution and LIDAR 1m resolution by McElhanney Ltd. for the Survey Division of the Government of Northwest Territories, 2021.
 River Bathymetry Surveyed by NHC, August 2018.



PERMIT TO PRACTICE
 Northwest Hydraulic Consultants Ltd.
 Signature: [Signature]
 Date: 22 Apr 2025
PERMIT NUMBER: P 505
 The Association of Professional Engineers, Geologists and Geophysicists of the NWT (NAGG)

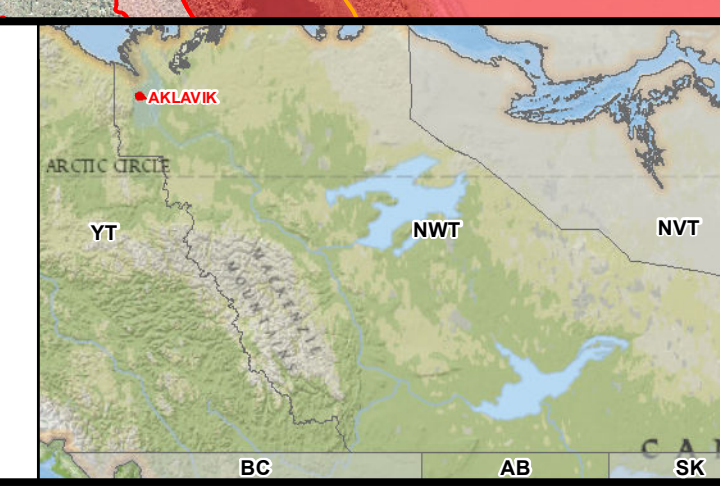
SCALE - 1:5,000








0 100 200 Meters

Coordinate System: NAD 1983 CSRS UTM ZONE 8N
 Vertical Datum: CGVD2013; Units: Metres

Engineer	RBA	GIS	JY	Reviewer	DJH
Job Number	1008469		Date	14-MAR-2025	

AKLAVIK FLOOD HAZARD MAPPING STUDY
100-YEAR FLOOD HAZARD MAP

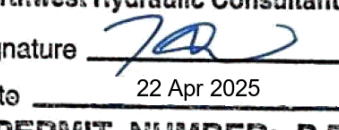


-  FLOW DIRECTION
-  ROAD
-  WINTER ROAD
-  200-YEAR FLOODWAY
-  200-YEAR FLOOD FRINGE
-  AKLAVIK MUNICIPAL BOUNDARY
-  GWICHIN LAND AUTHORITY

- PLACES OF NOTE:**
- 1 WATER TREATMENT PLANT
 - 2 JOE GREENLAND CENTRE
 - 3 FIRE HALL
 - 4 RCMP STATION
 - 5 HAMLET OFFICE
 - 6 MOOSE KERR SCHOOL
 - 7 HEALTH CENTRE
 - 8 FREDDIE CARMICHAEL AIRPORT
 - 9 FUEL STORAGE TANK SITE
 - 10 SOLID WASTE DISPOSAL SITE

GEOSPATIAL DATA SOURCES:
 Aerial Image 20cm resolution and LIDAR 1m resolution by McElhanney Ltd. for the Survey Division of the Government of Northwest Territories, 2021.
 River Bathymetry Surveyed by NHC, August 2018.



PERMIT TO PRACTICE
 Northwest Hydraulic Consultants Ltd.
 Signature: 
 Date: 22 Apr 2025
PERMIT NUMBER: P 505
 The Association of Professional Engineers, Geologists and Geophysicists of the NWT (NAGG)

SCALE - 1:5,000

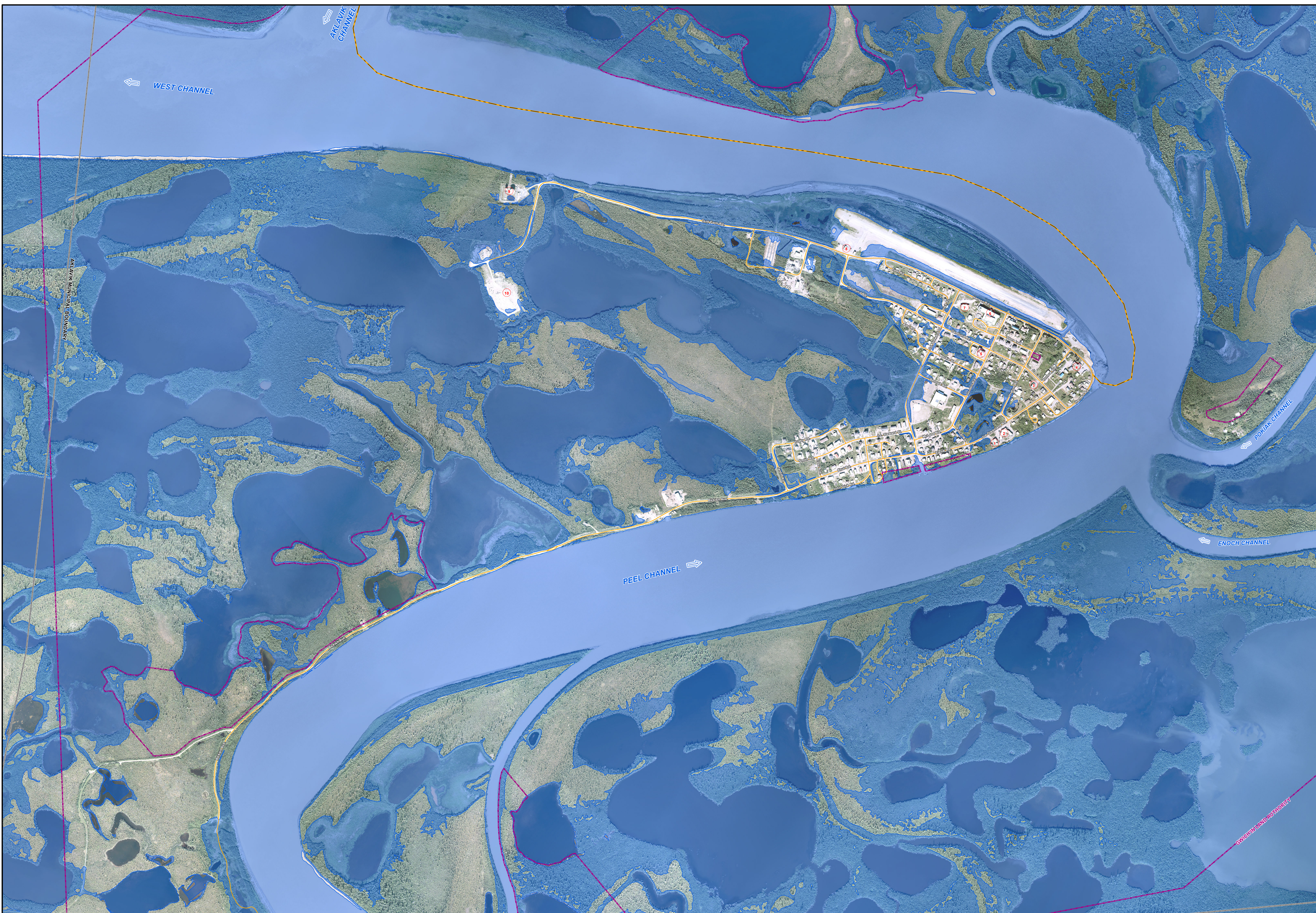
0 100 200 Meters

Coordinate System: NAD 1983 CSRS UTM ZONE 8N
 Vertical Datum: CGVD2013; Units: Metres

Engineer	RBA	GIS	JY	Reviewer	DJH
Job Number	1008469			Date	14-MAR-2025

APPENDIX B

FLOOD INUNDATION MAPS



Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

nhc
northwest hydraulic consultants

- FLOW DIRECTION
- ROAD
- WINTER ROAD
- INUNDATION EXTENT
- AKLAVIK MUNICIPAL BOUNDARY
- GWICH'IN LAND AUTHORITY

- PLACES OF NOTE:**
- 1** WATER TREATMENT PLANT
 - 2** JOE GREENLAND CENTRE
 - 3** FIRE HALL
 - 4** RCMP STATION
 - 5** HAMLET OFFICE
 - 6** MOOSE KERR SCHOOL
 - 7** HEALTH CENTRE
 - 8** FREDDIE CARMICHAEL AIRPORT
 - 9** FUEL STORAGE TANK SITE
 - 10** SOLID WASTE DISPOSAL SITE

NOTES TO USERS:

1. The aerial imagery and topography were obtained in 2021 and will reflect features, such as buildings and roads, that existed at that time (after 2006).
2. This map is intended for emergency planning purposes.

GEOSPATIAL DATA SOURCES:

Aerial Image 20 cm resolution and LIDAR 1 m resolution by McElhanney Ltd. for the Government of Northwest Territories, 2021. River Bathymetry Surveyed by NHC, August 2016.

Funding for this project was provided by the Government of Northwest Territories and Natural Resources Canada, under the Flood Hazard Identification and Mapping Program (FHIMP).



PERMIT TO PRACTICE
Northwest Hydraulic Consultants Ltd.
Signature: *RBA*
Date: 22 Apr 2025
PERMIT NUMBER: P 505
The Association of Professional Engineers, Geologists and Geophysicists of the NWT (NAGG)

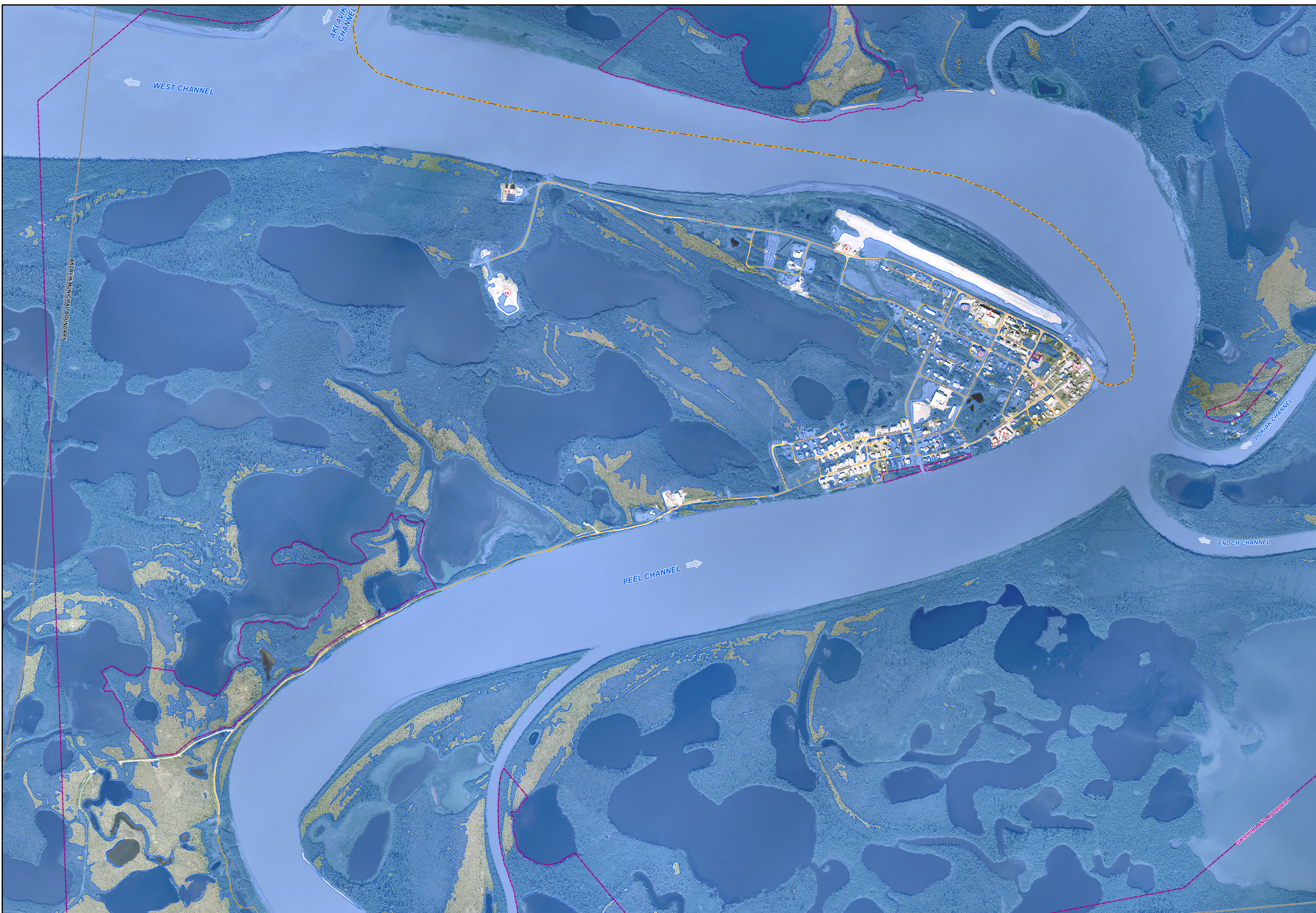
SCALE - 1:5,000

0 50 100 200 metres

Coordinate System: NAD 1983 CSRS UTM ZONE 8N
Vertical Datum: CGVD2013. Units: Metres

Engineer	RBA	GIS	JY	Reviewer	DJH
Job Number	1007306/8332		Date	27-AUG-2024	

**5-YEAR ICE AFFECTED
FLOOD INUNDATION MAP
AKLAVIK**



Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

nhc
northwest hydraulic consultants

- FLOW DIRECTION
- ROAD
- WINTER ROAD
- INUNDATION EXTENT
- AKLAVIK MUNICIPAL BOUNDARY
- GWICH'IN LAND AUTHORITY

- PLACES OF NOTE:**
- | | |
|-------------------------|------------------------------|
| 1 WATER TREATMENT PLANT | 6 MOOSE KERR SCHOOL |
| 2 JOE GREENLAND CENTRE | 7 HEALTH CENTRE |
| 3 FIRE HALL | 8 FREDDIE CARMICHAEL AIRPORT |
| 4 RCMP STATION | 9 FUEL STORAGE TANK SITE |
| 5 HAMLET OFFICE | 10 SOLID WASTE DISPOSAL SITE |

NOTES TO USERS:

1. The aerial imagery and topography were obtained in 2021 and will reflect features, such as buildings and roads, that existed at that time (after 2006).

2. This map is intended for emergency planning purposes.

GEOSPATIAL DATA SOURCES:

Aerial Image 20 cm resolution and LIDAR 1 m resolution by McElhanney Ltd. for the Government of Northwest Territories, 2021. River Bathymetry Surveyed by NHC, August 2016.

Funding for this project was provided by the Government of Northwest Territories and Natural Resources Canada, under the Flood Hazard Identification and Mapping Program (FHIMP).



PERMIT TO PRACTICE
Northwest Hydraulic Consultants Ltd.
Signature: *[Signature]*
Date: 22 Apr 2025
PERMIT NUMBER: P 505
The Association of Professional Engineers, Geologists and Geophysicists of the NWT (NAGG)

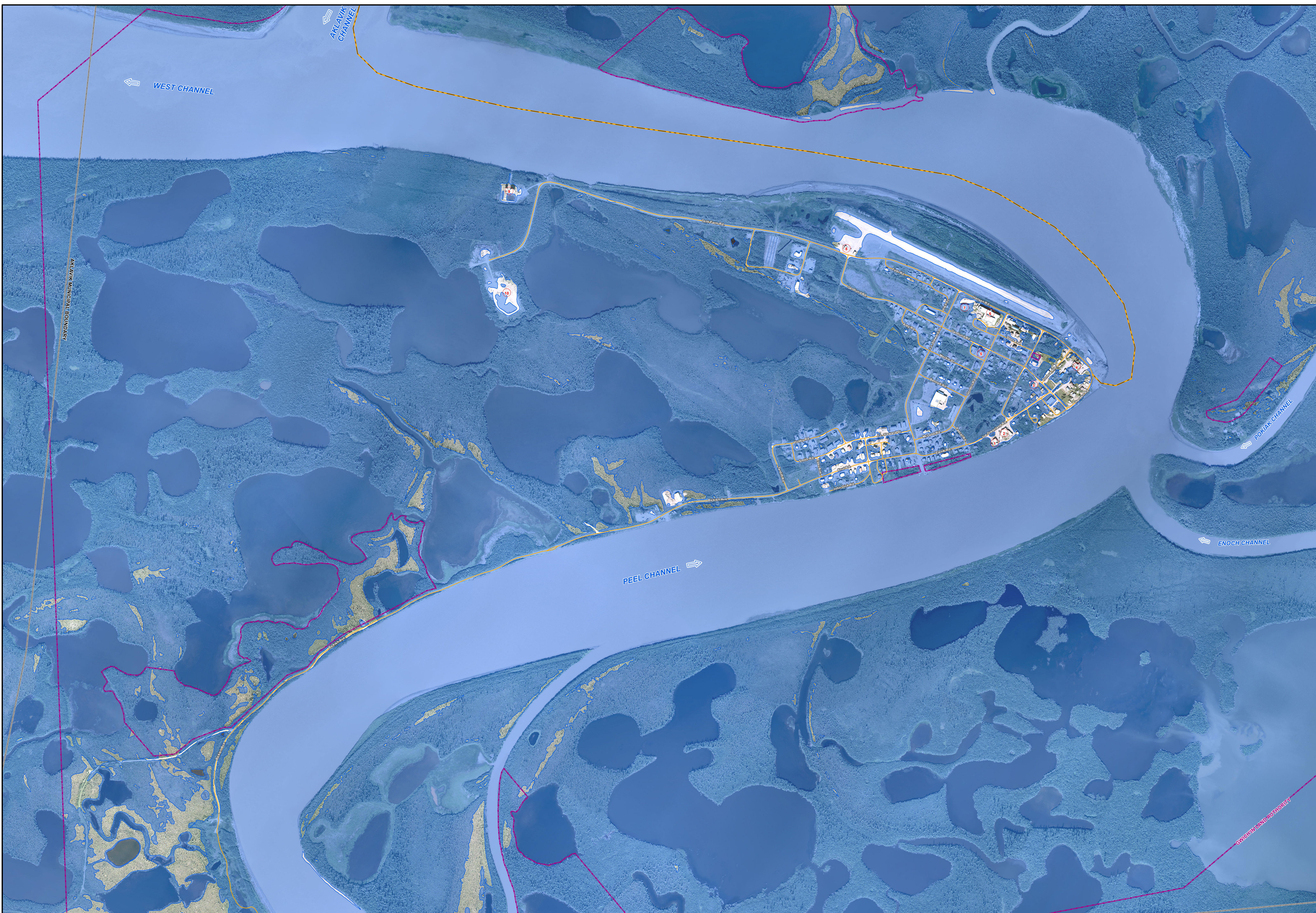
SCALE - 1:5,000

0 50 100 200 metres

Coordinate System: NAD 1983 CSRS UTM ZONE 8N
Vertical Datum: CGVD2013. Units: Metres

Engineer	RBA	GIS	JY	Reviewer	DJH
Job Number	1007306/8332		Date	27-AUG-2024	

20-YEAR ICE AFFECTED FLOOD INUNDATION MAP AKLAVIK





Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest






- FLOW DIRECTION
- ROAD
- WINTER ROAD
- INUNDATION EXTENT
- AKLAVIK MUNICIPAL BOUNDARY
- GWICH'IN LAND AUTHORITY

- PLACES OF NOTE:**
- 1 WATER TREATMENT PLANT
 - 2 JOE GREENLAND CENTRE
 - 3 FIRE HALL
 - 4 RCMP STATION
 - 5 HAMLET OFFICE
 - 6 MOOSE KERR SCHOOL
 - 7 HEALTH CENTRE
 - 8 FREDDIE CARMICHAEL AIRPORT
 - 9 FUEL STORAGE TANK SITE
 - 10 SOLID WASTE DISPOSAL SITE

NOTES TO USERS:

1. The aerial imagery and topography were obtained in 2021 and will reflect features, such as buildings and roads, that existed at that time (after 2006).
2. This map is intended for emergency planning purposes.

GEOSPATIAL DATA SOURCES:
Aerial Image 20 cm resolution and LIDAR 1 m resolution by McElhanney Ltd. for the Government of Northwest Territories, 2021. River Bathymetry Surveyed by NHC, August 2016.



Funding for this project was provided by the Government of Northwest Territories and Natural Resources Canada, under the Flood Hazard Identification and Mapping Program (FHIMP).



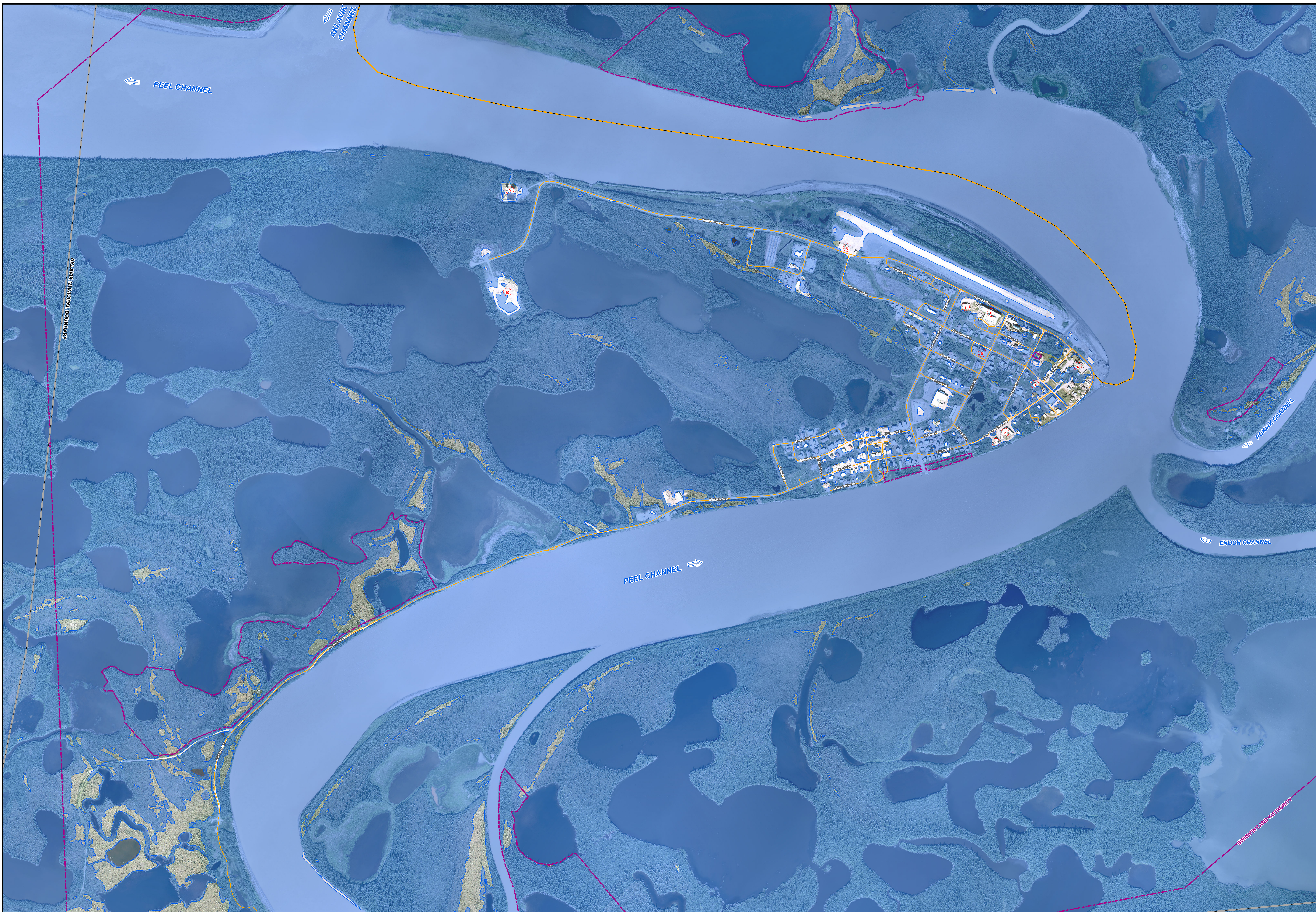
PERMIT TO PRACTICE
Northwest Hydraulic Consultants Ltd.
Signature: *[Signature]*
Date: 22 Apr 2025
PERMIT NUMBER: P 505
The Association of Professional Engineers, Geologists and Geophysicists of the NWT (NAGG)

SCALE - 1:5,000
0 50 100 200 metres

Coordinate System: NAD 1983 CSRS UTM ZONE 8N
Vertical Datum: CGVD2013. Units: Metres

Engineer	RBA	GIS	JY	Reviewer	DJH
Job Number	1007306/8332		Date	27-AUG-2024	

**50-YEAR ICE AFFECTED
FLOOD INUNDATION MAP
AKLAVIK**



Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

nhc
northwest hydraulic consultants

- FLOW DIRECTION
- ROAD
- WINTER ROAD
- INUNDATION EXTENT
- AKLAVIK MUNICIPAL BOUNDARY
- GWICH'IN LAND AUTHORITY

- PLACES OF NOTE:**
- 1 WATER TREATMENT PLANT
 - 6 MOOSE KERR SCHOOL
 - 2 JOE GREENLAND CENTRE
 - 7 HEALTH CENTRE
 - 3 FIRE HALL
 - 8 FREDDIE CARMICHAEL AIRPORT
 - 4 RCMP STATION
 - 9 FUEL STORAGE TANK SITE
 - 5 HAMLET OFFICE
 - 10 SOLID WASTE DISPOSAL SITE

NOTES TO USERS:

1. The aerial imagery and topography were obtained in 2021 and will reflect features, such as buildings and roads, that existed at that time (after 2006).
2. This map is intended for emergency planning purposes.
3. The 2006 flood is equivalent to the 50-year ice affected flood.

GEOSPATIAL DATA SOURCES:
Aerial Image 20 cm resolution and LIDAR 1 m resolution by McElhanney Ltd. for the Government of Northwest Territories, 2021. River Bathymetry Surveyed by NHC, August 2018.

Funding for this project was provided by the Government of Northwest Territories and Natural Resources Canada, under the Flood Hazard Identification and Mapping Program (FHIMP).



PERMIT TO PRACTICE
Northwest Hydraulic Consultants Ltd.
Signature:
Date: 22 Apr 2025
PERMIT NUMBER: P 505
The Association of Professional Engineers, Geologists and Geophysicists of the NWT (NAGG)

SCALE - 1:5,000
0 50 100 200 metres

Coordinate System: NAD 1983 CSRS UTM ZONE 8N
Vertical Datum: CGVD2013. Units: Metres

Engineer	RBA	GIS	JY	Reviewer	DJH
Job Number	1007306/8332		Date	27-AUG-2024	

2006 FLOOD INUNDATION MAP
AKLAVIK