Appendix L Old Crow Conceptual Flood Mitigation Design Options

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

L.1 Existing Conditions

The existing conditions presented in this section provide a brief summary of characteristics of the Study Area that are pertinent to the development of mitigation options and their evaluation. The contents of this section are not a comprehensive review of all existing conditions for Old Crow.

L.1.1 POPULATION AND ACCESS

Old Crow has a population of 236 with 168 private dwellings according to 2021 census data (Statistics Canada 2023c). The population has increased by approximately 7% from 2016 when the population was 221 (Statistics Canada 2023c).

Old Crow has no year-round road access. A winter road from the Dempster Highway provides access during the winter months. Flights are available to Old Crow year-round.

L.1.2 STUDY AREA

The Study Area in Figure L1 outlines the areas that flood mitigations are being designed in this Project at Old Crow. The boundaries of the Study Area are based on Stantec's understanding that the flood mitigations are to be designed for communities, and that individual properties outside of the main community consolidation are not included.

L.1.3 FIRST NATIONS

The Old Crow area is within the Traditional Territories of the Vuntut Gwitchin First Nation (VGFN). The VGFN have a parcel of Category A Settlement Lands along the Porcupine River in the Old Crow area. The land claim selection is VGFN C-4FS/D, R-10A, C-2A, C-3A/D, C-1A, and R-1A. This means that VGFN has surface and subsurface ownership of this parcel of land (Government of Yukon 2022).

L.1.4 BATHYMETRY AND TOPOGRAPHY

The following data sources were provided to or obtained by Stantec:

- 2019 LiDAR derivative 1m horizontal resolution Digital Elevation Model (DEM), UTM Zone 8 CSRS NAD1983 (Government of Yukon 2022d)

All elevations are reported in CGVD2013. The DEM model provided to Stantec was classified as CGVD1928 datum, but elevation checks conducted by Stantec strongly suggest that the provided datum is in CGVD2013. This Report has therefore assumed the provided LiDAR is in CGVD2013.

The LiDAR accuracy is assumed to be sufficient for the preliminary flood inundation analysis and conceptual design presented in this Report. There is insufficient metadata to determine whether the LiDAR meets the base requirement in terms of accuracy or precision for flood mapping as per the Federal airborne LiDAR data acquisition guidelines (NRCan 2020).

L.1.5 GEOLOGY

The banks along the Porcupine River, which flows in a westerly direction to the south of Old Crow, consist of 3 m to 6 m of sandy silt and silty sand on top of gravel. In locations where the vegetation is undisturbed, the active layer extends to a maximum depth of approximately 0.3 m and to a 1.0 m depth in cleared areas (Hollingshead 1973; Janowicz 1992). The Canada Permafrost Map (National Atlas of Canada 1995) shows the Study Area is in a region of continuous permafrost (90-100% of land underlain by permafrost) with a low (<10% by volume of visible ice) ground ice content in the upper 10 to 20 m of the ground.

L.1.6 HYDROGEOLOGY

The deposits of sandy silt and silty sand on top of gravel encountered within the Study Area are likely to result in relatively fast rates of groundwater flow if the material is thawed. The deposits encompassing most of shoreline are likely to result in a groundwater table that would be highly dependent on the Porcupine River water levels. During flooding and if the ground is thawed, the high-water levels may result in high groundwater levels and after flood waters recede, it is likely that the groundwater levels would recede relatively quickly based on the assumed high permeability of the soil conditions in the area. If the ground is frozen, groundwater flow rates would be substantially lower.

L.1.7 PAST FLOODING EVENTS AND RESPONSE

A summary of documented flood events are provided below. The flood events summarized below do not represent a comprehensive review of flooding history in the Study Area; rather, they are a summary of the flooding documentation provided to Stantec at the time of writing.

Old Crow has been subject to numerous flooding events dating back earlier than 1962 when WSC began recording data on Porcupine River near Old Crow (WSC Station 09FD001 between 1962 and 1995, and WSC Station 09FD003 from 1995 to present). In addition to WSC hydrometric data, archival documentation of flooding events (e.g., photographs and descriptive reports) and anecdotes from residents provides valuable information on flooding in Old Crow dating back to 1932 (Janowicz 1992).

The most severe flooding documented on the Porcupine River near the community of Old Crow has been a result of ice jams and ice runs during breakup. Janowicz (1992) identifies the six largest flood events based on water level (in order of severity) occurring in 1991, 1932, 1983, 1973, 1989, and 1992. Written documentation of flooding in the community of Old Crow could only be found for four of these events (1932, 1973, 1989, 1991). Reported WSEs are assumed to have been recorded at the active WSC station at the time of the event, and water depths are assumed to be approximate measurements in the main community. A summary of these documented flood events is provided below. The flood events summarized below are based on documentation provided to Stantec at the time of writing. Historical water surface elevations (WSEs) at Water Survey of Canada (WSC) Station 09FD003 (Porcupine River Below Old Crow) are illustrated in Figure L2.

1932 Flood Event

Anecdotal evidence of a flood event documented in the Yukon archives suggests a large flood caused by ice jamming of the Porcupine River occurred at Old Crow in 1932 (Janowicz 1992). The documentation identifies flooding of a home in Old Crow to a depth of 4 feet (approximately 1.2 m) during the 1932 event which, according to the resident, only flooded to a depth of 1.5 feet (approximately 0.45 m) during the 1973 event. No WSC Station existed on the Porcupine River in 1932 however, surveys of high-water level using evidence from historical evidence by Janowicz (1992) estimate a peak water surface elevation of 249.04 m (unknown datum), which would make it the largest flood event in the community of Old Crow.

1973 Flood Event

The formation of an ice jam on the Porcupine River during the Spring of 1973 lead to flooding of the community of Old Crow on May 18. Janowicz (1992) identifies the peak water elevation of this flood at 248.4 m (suspected to be CGVD28 datum, approximately 246.4 m CGVD2018 datum), the third largest flood on record at Old Crow. Water levels began receding at in the morning of May 19, 1973. Airport and electrical services were disrupted until May 19, and only minor damage was sustained (Hollingshead 1973).

1989 Flood Event

Flooding in May 1989 was a breakup ice jam event likely driven by meteorological conditions, when the southern portion of the watershed warmed significantly while the northern portion remained cool. On the morning of May 4, the river jammed in front of the community and began backwatering. Ice jamming approximately 18 km downriver of Old Crow with large ice chunks were noted to be caught in a shallow part of the river. A surge of open water ultimately cleared the ice blockage in front of the community. A YG Emergency Measures coordinator indicted that within a 3.5 hour period, water levels in the Porcupine River had dropped 8 m (Jasek 1997). No description of flooding within the community was noted.

1991 Flood Event

The water level of the 1991 ice jam flood event is the highest recorded by WSC (Turcotte and Saal 2022b), however, discrepancies in the reported WSEs differ within the literature. Jasek (1997), reported a peak WSE of 248.8 m (suspected CGVD28 datum), while Janowicz (1992) reported a peak WSE of 249.2 m (suspected CGVD28 datum).

The flooding was attributed to a combination of rising waters upstream of an ice jam that had developed at the confluence of the Bluefish River and the Porcupine River, paired with increased runoff due to warmer weather in the headwaters of Porcupine River (Jasek 1997). The combination of downstream ice jam and relatively high flow generated a flooding that caused approximately $600,000 in damage to community infrastructure (Jasek 1993).

L.1.8 EXISTING FLOOD MITIGATION INFRASTRUCTURE

Limited existing flood mitigation infrastructure was identified from the available documentation for the community of Old Crow. Multiple drainage culverts with valves are installed through the community to reduce floodwater from the Porcupine River from entering the community during high water events. However, Turcotte and Saal (2022b) note that these culverts are overtopped during high return period events (e.g. greater than the 5-year event) and do not reduce flooding. Minor riverbank armoring with riprap has been installed in the community to mitigate erosion potential. The riprap has been noted to potentially be undersized and installation locations may not have been properly located (Turcotte and Saal 2022b).

L.1.9 WIND, WAVES, AND EROSION

While floodplain mapping and associated hydraulic modelling have not been completed for Old Crow to date, it is likely that flow velocities in the Porcupine River during flood conditions would likely require flood mitigations to withstand erosion hazards from flow velocities and ice runs. In addition, bank erosion and river migration should be studied and considered in preliminary and detailed design phases of flood mitigations; unprotected banks in the community were estimated to erode at an average rate of 1 m per year from hydraulic and thermal erosion (Hollingshead 1973).

Wind and wave effects are not anticipated to occur at a scale which would require additional flood mitigation design at Old Crow.

L.1.10 HYDROLOGY

The Porcupine River is the major water feature at Old Crow (Figure L2). The Porcupine River originates in the Ogilvie Mountains and the river flows north to Old Crow then westerly through the community. The Porcupine River continues west into Alaska where it discharges into the Yukon River at Fort Yukon, Alaska.

WSC Station 09FD003 (Porcupine River below Old Crow) is located on the right (north) bank of the Porcupine River in the centre of the community of Old Crow (Figure L2). Gross drainage area to the WSC station is not reported by GoC (2023). Limited hydraulic modelling has been completed to date for Old Crow (e.g. Jasek 1993) and additional modelling is beyond the scope of this Project. Therefore, hydrology review considered WSEs but not the discharges at WSC Station 09FD003.

Flood frequency analysis for WSEs was performed by both Morrison Hershfield (2022) and Yukon University (2022) for WSEs at WSC Station 09FD003. Table L2 summarizes the frequency results of these two studies for the 1:2-year event (50% Annual Exceedance Probability, or AEP), 1:20-year event (5% AEP), 1:100-year event (1% AEP), and 1:200-year event (0.5% AEP).

Table L1 Flood Frequency Analyses at WSC Station 09FD003 from Morrison Hershfield (2022) and Yukon University (2022)

	Morrison Hershfield (2022)	Yukon University (2022)
Years Included in Analysis	2006-2022 [a]	1970-2022 [a, b]
Number of Years	17	43
Selected Distribution	Lognormal 3	Log Pearson Type 3 (breakup ice jams and ice runs data) and Lognormal (open water freshet)
Water Surface Elevation (m) [1]		
1:2-Year Event (50% AEP)	243.97	244.30
1:20-Year Event (5% AEP)	245.33	246.10
1:100-Year Event (1% AEP)	245.94	not provided
1:200-Year Event (0.5% AEP)	246.17	247.80

	Morrison Hershfield (2022)	Yukon University (2022)
Notes: [a] Using a dataset of combined open water and breakup ice jam peaks [b] Uses data from WSC station 09FD001 (Porcupine River at Old Crow) for 1970 to 1995, station not operated 1996 to 2005, WSC station 09FD001 (Porcupine River Below Old Crow River). Transfer of ice jam data from 09FD001 noted to be challenging. [1] Elevations provided in CGVD2013 for WSC Station 09FD003		

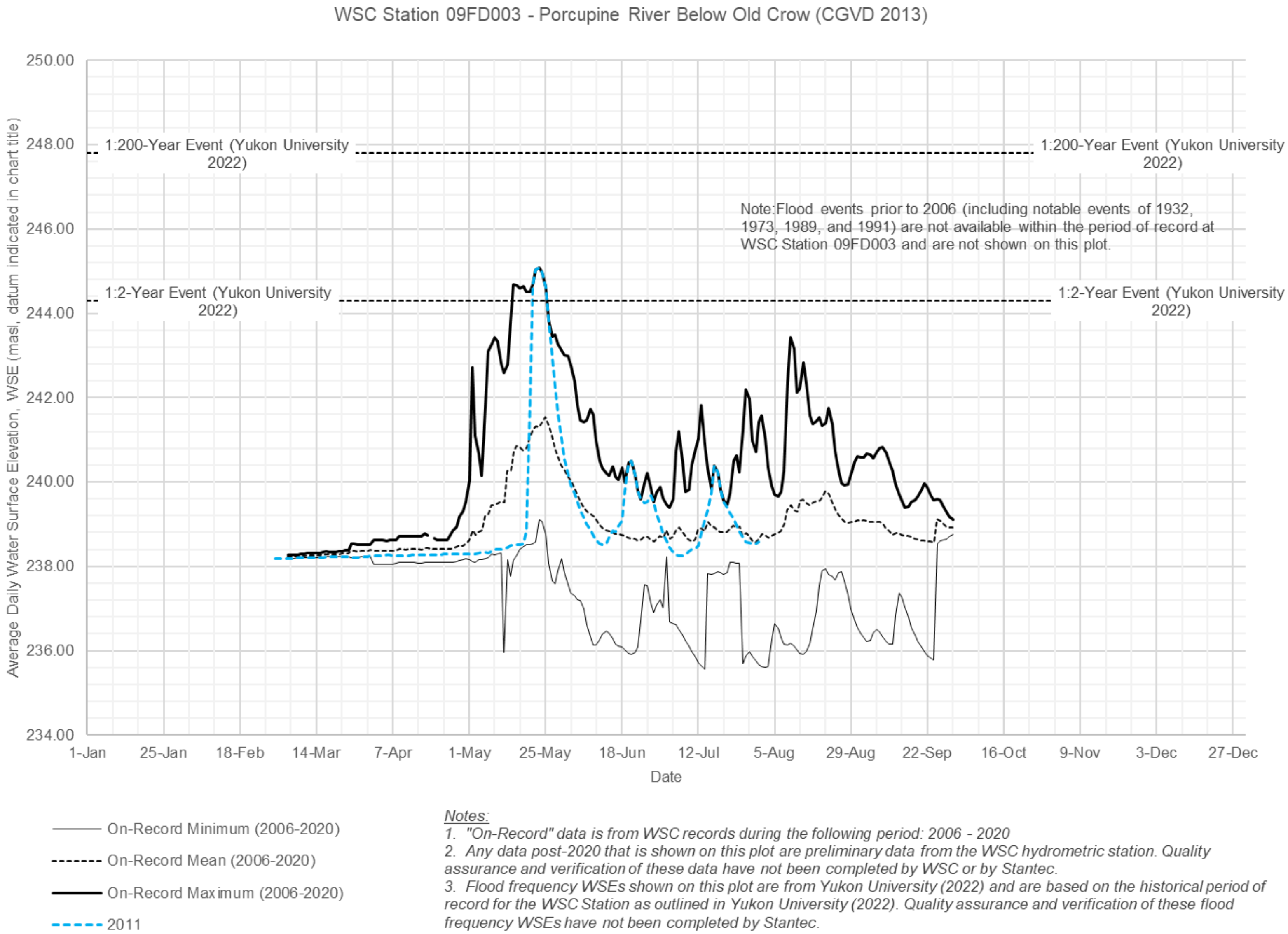
Yukon University (2022) flood frequency analysis results were adopted for the Project because the 1:200-year event WSE was higher and would yield more conservative designs.

Station 09FD001 (Porcupine River at Old Crow) reported flow data from 1961 – 1995. No WSC data for the Porcupine River is available for 1996 – 2006 to Stantec's knowledge. The WSC station was relocated to 09FD003 (Porcupine River below Old Crow River) in 2006. Flow and water levels are reported at this re-located station since 2006. Transferring ice jam water levels from the old station (with data from 1970 – 1995) is challenging (Turcotte and Saal 2022b). Figure L1 illustrates the on-record daily minimum, mean, and maximum WSEs and the WSE during the highest year on record (2011) within the current WSC Station period of record (2006 – present). Figure L1 also includes the WSEs for the 1:2-year and 1:200-year events at WSC Station 09FD003 from Yukon University (2022). The WSEs at WSC Station 09FD003 are not available for documented flood events of 1932, 1973, 1989, and 1991.

Water levels in the Porcupine River normally peak in mid to late May as a result of ice related processes on the river. Flows then recede over the summer months and drop through the fall, with minimum WSEs generally in late winter. Ice jamming events are consistently associated with the peak annual water level but open water events caused by large rainstorms have caused minor flooding in Old Crow (Janowicz 1992). Ice jam events and spring freshet can occur only a few days apart (Janowicz 2017). For a 1:200-year flood event to occur, Turcotte and Saal (2022b) note that three conditions must be present: thick ice cover prior to breakup, above average snowpack and a cold winter with delayed start to spring with the southern portion of the watershed suddenly warming causing the snowpack to melt quicker than the ice degrades. Yukon University (2022) notes that the morphology and hydrologic regime may be severely impacted by climate change in the future.

The south bank floodplain opposite to Old Crow is at a higher elevation than most of the community. This means the south floodplain has limited evacuation capacity during ice jam events compared with the north bank floodplain where the community is located. This increases the susceptibility of Old Crow to ice jam floods (Turcotte and Saal 2022b).

The smaller Old Crow River discharges into the Porcupine River immediately east of the community. Ice breakup in the Old Crow River occurs after breakup on the Porcupine and is typically thermally driven. This means the Old Crow River presents low risk of flooding to the community of Old Crow (Turcotte and Saal 2022b) and is not considered further in this analysis.



Notes:
1. "On-Record" data is from WSC records during the following period: 2006 - 2020
2. Any data post-2020 that is shown on this plot are preliminary data from the WSC hydrometric station. Quality assurance and verification of these data have not been completed by WSC or by Stantec.
3. Flood frequency WSEs shown on this plot are from Yukon University (2022) and are based on the historical period of record for the WSC Station as outlined in Yukon University (2022). Quality assurance and verification of these flood frequency WSEs have not been completed by Stantec.

Figure L1 Historical Water Surface Elevations at WSC 09FD003 (Porcupine River below Old Crow)

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

L.1.11 PRELIMINARY INUNDATION MAPPING

Floodplain mapping and the associated flood policy is ultimately what is required for design and implementation of flood mitigations at communities. Hydraulic analysis and formal floodplain mapping have not been completed to date at Old Crow and is not within the scope of this Project. However, an understanding of inundation extents under the 1:200-year event is required for conceptual design of flood mitigations.

In lieu of formal floodplain mapping, Stantec performed preliminary existing conditions (no mitigation) inundation analysis for Old Crow using WSEs and WSE slopes from previous studies:

- The 1:200-year event WSE (247.80 m) at WSC Station 09FD003 from Yukon University (2022) and an assumed WSE gradient of 0.03% m/m (approximate Porcupine River gradient, as applied for the 1:200-year event in Turcotte and Saal 2022b).

The resulting water surface for the Porcupine River was overlain on the existing conditions topographic elevation data (GeoYukon 2023) and the limits of inundation were mapped (Figure L2). The preliminary inundation extents in Figure L2 demonstrate close alignment to the 1:200-year flood extend illustrated in Figure 4.2.5 in Turcotte and Saal (2022b). The inundation analysis performed herein is provided for information only and is considered a high-level estimate of the flood inundation using the 1:200-year WSEs and flood-stage WSE gradients from Yukon University (2022). The preliminary inundation analysis does not take into account flow pathways and blockages. That is, if the land in a given location is below the 1:200 WSE surface, it presents as inundated whether or not there is an overland flow path for the water to arrive there.

The preliminary inundation results indicate nearly the entire community is inundated. The inundation extends from the landfill/sewage lagoon on the east side of the community, all properties on both sides of the runway, and to the east side of Crow Mountain Road and the slough on the Porcupine River. Approximately 20 properties on the east end of the community on both sides of Crow Mountain Road are at a higher elevation and are not anticipated to be inundated during the 1:200-year event.

The preliminary inundation analysis indicated that an estimated 150 private residential properties and all community features/properties except for the school would have at least 25% of their area inundated (estimated total of 168 inundated properties).

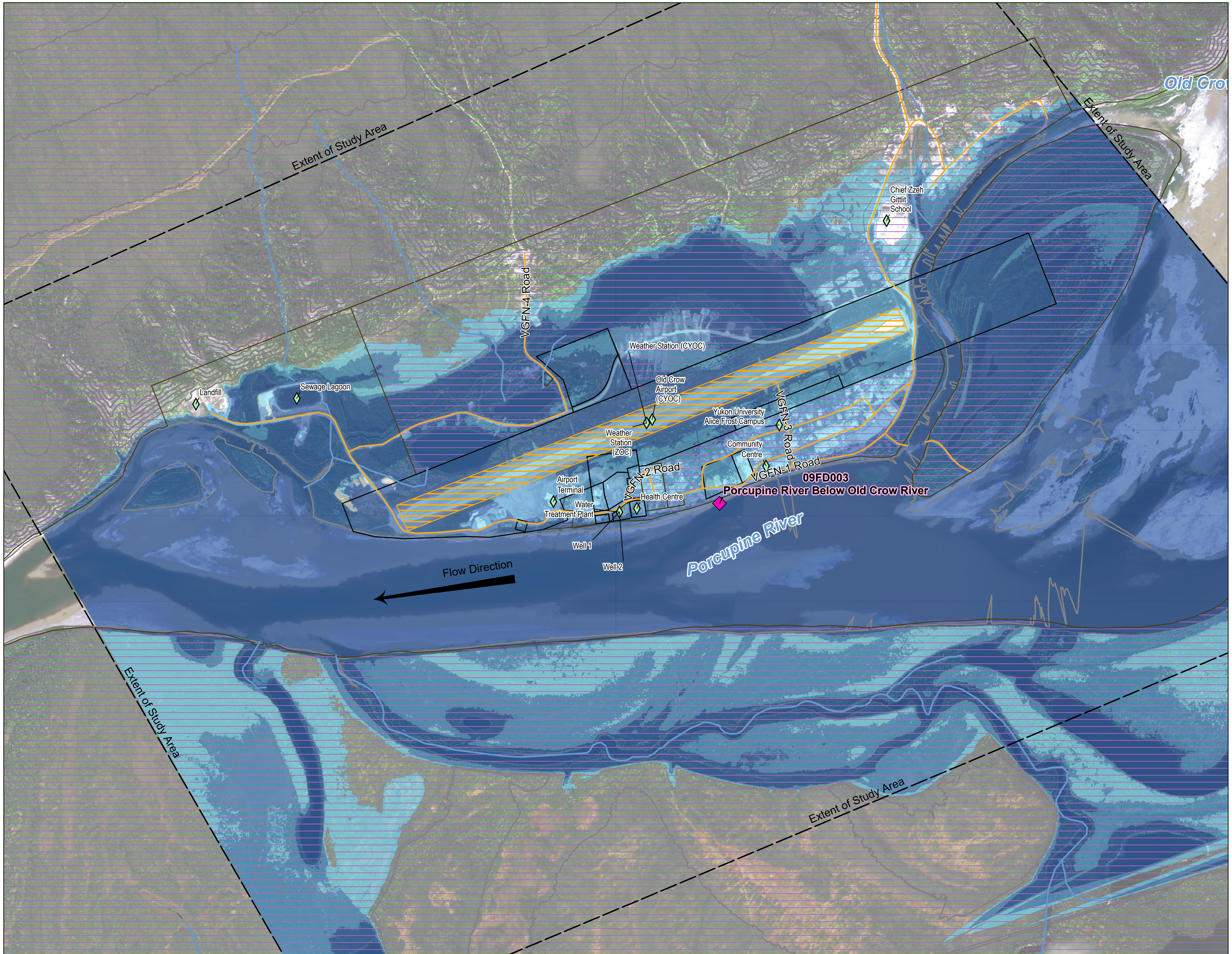


Figure No.
L2

Title
Existing Conditions and Preliminary Flood Inundation at Old Crow

Client/Project 144903232
Government of Yukon
Community Services | Infrastructure Development Branch
Yukon Territory Flood Mitigation Conceptual Design Options

Project Location
Old Crow,
Yukon

Prepared by LLT on 2023-05-08
TR by JM on 2023-05-08

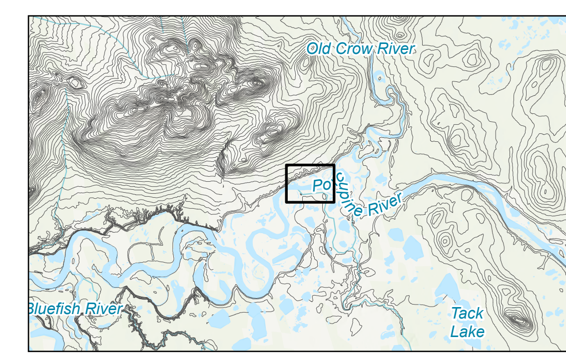
N

0 50 100 150 200 m
(At original document size of 11x17)
1:12,000

- WSC Station
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Runway
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed

Water Depth at 1:200 WSE Inundation (m)
- 0 - 1
- 1 - 2
- > 2

The preliminary inundation analysis does not take into account flow pathways and blockages. That is, if the land in a given location is below the 1:200 WSE surface, it presents as inundated whether or not there is an overland flow path for the water to arrive there.



Notes
1. Coordinate System: NAD 1983 Yukon Albers
2. Data Sources: Government of Yukon; Government of Canada
3. Imagery Government of Yukon Geomatics Yukon; ESRI World Imagery

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L.2 Mitigation Options and Evaluation

The scope of this Project is to develop conceptual engineered flood mitigation options; these options for Old Crow are presented in this section. Non-engineered options presented in Section 3.3.1 of the main body of this Report (emergency response-based, mitigation funding to property owners, land purchase/exchange, regulation of flow, management of ice, nature-based approaches) should be considered as part of a comprehensive approach to flood mitigation in the Yukon.

Based on the objectives and assumptions presented in the main body of this Report, two flood mitigation options were developed for Old Crow (Table L2) using combinations of the typical engineered flood mitigation designs from Section 3.3.2. Flood mitigations in the two options are provided for areas which are inundated under the 1:200-year WSE in the preliminary inundation mapping (Figure L2). The top elevation of the flood mitigations is designed to reach the DFSL which in the case of Old Crow is assumed to be 0.5 m of freeboard above the 1:200-year WSE (as outlined for river sites in Section 3.2).

Areas which are above the 1:200-year WSE in the preliminary inundation analysis but below the DFSL are not included in this Project. These areas may need to be included in future design advancements depending on the requirements of future territorial flood policy.

Table L2 Summary of Conceptual Design Options

Location	Option 1	Option 2
	higher capital costs, lower response/maintenance - scenario A	*higher capital costs, lower response/maintenance - scenario B*
North Bank of Porcupine River, East End	Earthen Dike	Earthen Dike/Structural Dike/Road Raising
North Bank of Porcupine River, East End of Runway to Community Centre	Road Raising	
North Bank of Porcupine River, Community Centre to West of Airport Terminal	Structural Dike	
North Bank of Porcupine River, Airport Terminal to Upslope of Sewage Lagoon/Landfill	Road Raising	Road Raising/Structural Dike
North of Runway	n/a	Earthen Dike/Structural Dike/Road Raising
Private Properties	n/a	Temporary Sandbag Dike

Section L2.1 and L2.2 provide a description, Class D OPC, and qualitative evaluation of the conceptual options specified in Table L2.

Other engineered flood mitigation approaches that may have merit but were not advanced to conceptual design in this Project include:

- Temporary flood mitigations (e.g., temporary sandbag dikes, temporary superbag dikes). It was assumed that the resources (labour, equipment) required to deploy these temporary flood mitigations would not be available at Old Crow on the rapid timeframe needed to respond to ice-jam induced flood events.

- Excavation of the southern bank of the Porcupine River to provide additional flood conveyance (with or without the implementation of Option 1 or 2). Extensive studies regarding the impact of this excavation to existing hydraulics, erosion/sediment transport processes, ice processes, permafrost, environmental impact, and geotechnical stability would be required to assess the feasibility of this action.

- Raising of structures throughout the community. This approach may have merit and should likely be investigated further but was not advanced in this Project due to substantial structure details required to adequately describe, cost, and evaluate it even at the conceptual level. Many properties in Old Crow are built on elevated platforms (wooden cribbing or steel piles) to prevent heat from the building warming the frozen ground below, which may enable raising of properties to the DFSL to mitigate against flooding. However, this approach carries substantial engineering challenges. Some properties in the community are constructed with slab-on-grade foundations and cannot be raised. Many residential properties sit on wooden cribbing and would need to be inspected to determine if structural retrofits can be completed to raise them to a higher elevation; the condition and age of some buildings may make this infeasible. Residential utilities including fuel supply line, water delivery, sewage pump-outs and electrical hook-ups would require re-design to continue to be operational at a higher elevation. Some buildings in the community require access ramps which would need to be re-engineered to continue to provide barrier-free access. Detailed inventory of structure type, condition, and characteristics of utilities/appurtenances would be required to enable advancement of this approach to the conceptual design level.

L.2.1 OPTION 1

Description

The conceptual flood mitigations for Option 1 are illustrated in Figure L3. Option 1 considers the construction of flood mitigations around the entire community in an “envelope”, connecting to high ground to the north on east and west ends. Road raising, earthen dikes (where no road exists), and structural dikes (where insufficient space exists for earthen dikes) would be implemented. The mitigations are described in an upstream to downstream order (east to west) below.

On the east side of the community at the Porcupine River slough, an approximately 560 m long earthen dike would be constructed. The earthen dike crest (meeting the DFSL) would be approximately 1.5 m above the existing ground for 460 m, and 4 m high for the remaining 100 m. The earthen dike would be approximately 20 m wide at the base. The earthen dike would tie-in to the high elevation ground at its eastern terminus and connect to the road raising (described below) at its western terminus. Riprap of adequate size would be required on the outer bank to mitigate erosion and ice damage hazards. Slope stabilization would likely be required.

An approximately 1000 m long section of road raising would be required along the north bank of the Porcupine River slough and Porcupine River mainstem. The road raising would extend from the earthen dike to the RCMP building. The road crest (meeting the DFSL) would be 1.5 – 2.0 m above the existing ground. Riprap of adequate size to mitigate erosion and ice damage hazards would be required. Slope stabilization would likely be required.

An approximately 920 m long structural dike would be required along the north bank of the Porcupine River, from the Community Centre to west of the airport terminal. A structural dike would be required in this area because of space limitations between the river and the structures. The structural dike crest (meeting the DFSL) would be approximately 3 m higher than the existing ground.

At the west end of the community, an approximately 950 m long section of road would be raised from west of the airport terminal to high ground to the west of the community near the landfill. The road crest (meeting the DFSL) would be 1.5 – 2.0 m above the existing ground. Riprap of adequate size to mitigate erosion and ice damage hazards would be required. Slope stabilization would likely be required.

Implementation of Option 1 would result in a substantial reduction in flood flow capacity around Old Crow. Existing vs. proposed conditions hydraulic modelling would be required and may show that i) implementation of Option 1 would raise 1:200-year WSEs at Old Crow under proposed conditions and ii) erosion risks would be substantially increased on the south bank of the Porcupine River. Item i) would require mitigations to be raised and extended to provide the desired flood mitigation. Hydraulic modelling is outside of the scope of this Project; we highlight the above because it means the extent, size and costing of Option 1 flood mitigations presented herein are likely an underestimation of what would be required to provide engineered flood mitigation at Old Crow.

Figure No.
L3

Title
Old Crow Conceptual Flood Mitigation Design - Option 1

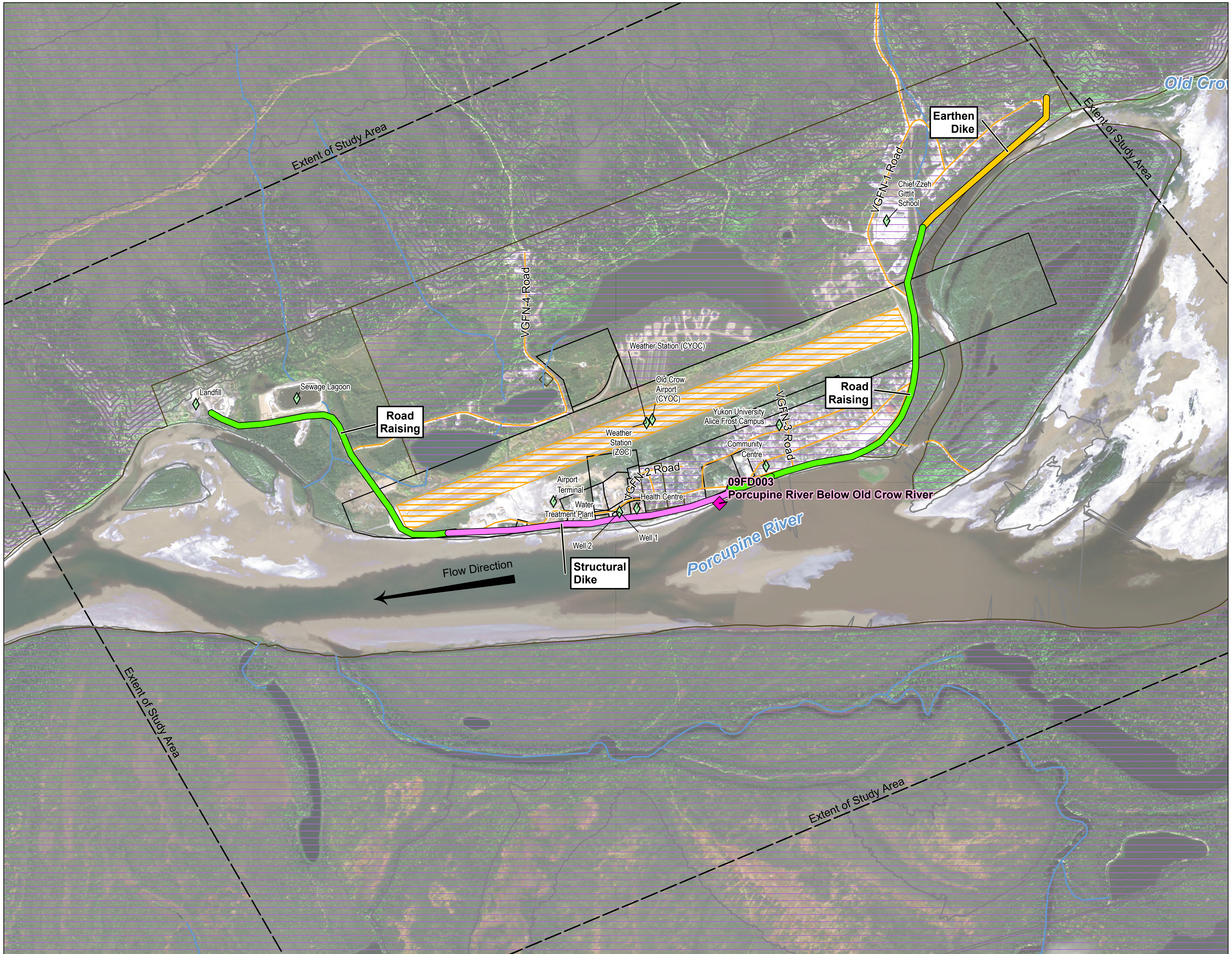
Client/Project 144903232
Government of Yukon
Community Services | Infrastructure Development Branch
Yukon Territory Flood Mitigation Conceptual Design Options

Project Location
Old Crow,
Yukon

Prepared by LLT on 2023-04-11
TR by JM on 2023-04-11

N

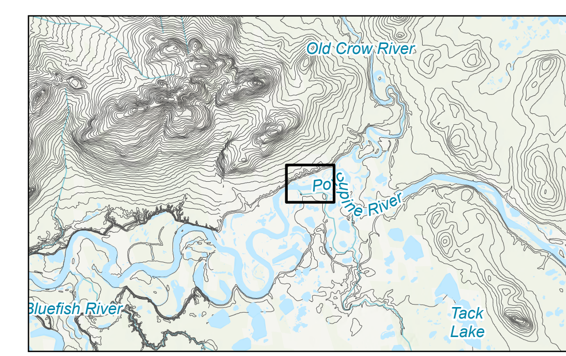
0 50 100 150 200 m
(At original document size of 11x17)
1:10,000



- WSC Station
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Runway
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed

Proposed Mitigation Feature
- Earthen Dike
- Platform with Temporary Superbag Dike
- Road Raising
- Structural Dike
- Temporary Sandbag Dike

CONCEPTUAL DESIGN
This document is for general information only and is not for permits, tendering, or construction.



Notes
1. Coordinate System: NAD 1983 Yukon Albers
2. Data Sources: Government of Yukon; Government of Canada
3. Imagery Government of Yukon Geomatics Yukon; ESRI World Imagery

Stantec Yukon

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Class D OPC

The Class D OPC's for capital and annual costs are summarized in Table L3, considering the Class D level of accuracy (+/-50%). Table L3 also provides the Class D OPCs on a per-inundated property basis (from Section L.1.11).

Table L3 Option 1 Summary of Class D OPCs

	Class D OPC	Number of Inundated Properties (Section L.1.11)[1]	Class D OPC per Inundated Property
Capital Cost	$ 86,636,600 - $ 129,954,900	168	$ 515,695 - $ 773,542
Annual Cost (Flood Year)	$ 542,500 - $ 813,750		$ 3,230 - $ 4,844
Annual Cost (Non-Flood Year)	$ 39,200 - $ 58,800		$ 234 - $ 350
[1] As described in Section L.1.11, the inundated properties from the preliminary inundation analysis consists 168 total inundated properties			

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table L4 (capital costs), Table L5 (annual cost, flood year), and Table L6 (annual cost, non-flood year).

Table L4 Option 1 Capital Costs Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1A	**Option 1: General Conditions**				
a)	Mobilization/Demobilization	LS	1	$3,055,060.00	$3,055,060.00
b)	Site Preparation/Restoration	LS	1	$611,100.00	$611,100.00
				Total 1A	$3,666,160.00
Section 1B	**Option 1: Structural Dike**				
a)	Clearing and Grubbing	M2	4120	$10.00	$41,200.00
b)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	1240	$25.00	$31,000.00
c)	Dike Topsoil	M2	2760	$20.00	$55,200.00
d)	Dike Seeding	M2	2760	$5.00	$13,800.00
e)	Dike Fill	M3	10400	$100.00	$1,040,000.00
f)	Sheet Pile Wall	M2	5690	$1,700.00	$9,673,000.00
g)	Concrete Lock-Block Retaining Wall	M2	2850	$1,000.00	$2,850,000.00
h)	Handrail	M2	920	$140.00	$128,800.00
l)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	920	$300.00	$276,000.00
m)	Slope Stablilization	M	920	$3,000.00	$2,760,000.00
				Total 1B	$16,869,000.00
Section 1C	**Option 1: Road Raising**				
a)	Rough Grading	M2	53700	$10.00	$537,000.00
b)	Subgrade Preparation	M2	53700	$10.00	$537,000.00
c)	80mm Minus Granular Subbase, Variable Depth	M3	80300	$40.00	$3,212,000.00
d)	100mm Minus Granular Base, 100mm Depth	M3	1700	$50.00	$85,000.00
e)	Riprap	MT	25144	$141.00	$3,545,304.00
				Total 1C	$7,916,304.00
Section 1D	**Option 1: Earthworks & Landscaping, Earthen Berm**				
a)	Clearing and Grubbing	M2	12500	$10.00	$125,000.00
c)	Cut and Dispose Offsite - Native Material	M3	1210	$30.00	$36,300.00
e)	Embankment Fill, Clay Core	M3	6450	$100.00	$645,000.00
f)	Embankment Fill, Granular Shell	M3	13900	$50.00	$695,000.00
g)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	3750	$25.00	$93,750.00
h)	Riprap	MT	9100	$141.00	$1,283,100.00
i)	Geotextile Fabric	M2	7800	$10.00	$78,000.00
j)	Embankment Seeding	M2	10450	$5.00	$52,250.00
k)	Embankment Topsoil	M2	10450	$20.00	$209,000.00
l)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	560	$300.00	$168,000.00
m)	Slope Stablilization	M	560	$3,000.00	$1,680,000.00
				Total 1D	$5,065,400.00

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

Section 1E	**Option 1: Floodboxes, Structural Dike and Earthen Berm**				
a)	Reinforced Concrete Pipe	M	200	$1,000.00	$200,000.00
b)	Gatewell Manhole c/w Sluice Gate	EA	15	$17,500.00	$262,500.00
c)	Concrete Headwall	EA	30	$5,000.00	$150,000.00
d)	Slide Gate	EA	15	$3,000.00	$45,000.00
e)	Riprap	MT	300	$141.00	$42,300.00
				Total 1E	$699,800.00
				Contingency (20%)	$6,843,332.80
				Subtotal	$41,059,996.80
				Location Adjustment Factor (LCAF)	2.11
				Capital Costs Base Price	$86,636,600.00
				Capital Costs Upper Bound	$129,954,900.00

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

Table L5 Option 1 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1F	**Option 1: Annual Costs, Flood Year**				
a)	Inspections	LS	1	$100,000.00	$100,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$10,000.00	$10,000.00
c)	Sandbags c/w Sandfill (2.0m - 3.0m)	LM	150	$695.00	$104,250.00
				Total 1F	$214,250.00
				Contingency (20%)	$42,850.00
				Subtotal	$257,100.00
				Location Adjustment Factor (LCAF)	2.11
				Annual Cost Flood Year Base Price	$542,500.00
				Annual Cost, Flood Year Upper Bound	$813,750.00

Table L6 Option 1 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1G	**Option 1: Annual Costs, Non-Flood Year**				
a)	Inspections	LS	1	$5,000.00	$5,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$10,000.00	$10,000.00
c)	Storage of Sandbags	LS	1	$500.00	$500.00
				Total 1G	$15,500.00
				Contingency (20%)	$3,100.00
				Subtotal	$18,600.00
				Location Adjustment Factor (LCAF)	2.11
				Annual Cost, Non-Flood Year Base Price	$39,200.00
				Annual Cost, Non-Flood Year Upper Bound	$58,800.00

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

Qualitative Evaluation

Table L7 summarizes the performance of Option 1 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table L7 Option 1 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	high potential for ice damage to mitigations (particularly raised roads and earthen dikes) even with riprap installed; implementation of mitigations may alter existing processes to a degree which would result in entirely different (increased) flood elevations would render the mitigations ineffective	Low Performance
2	Time to Implementation	geotechnical investigations required including borehole drilling to address shoreline stability and construction requirements for platforms; extensive hydraulic modelling including iterative modelling to evaluate effect of infrastructure limiting floodplain access on north (community side) of river, erosion mitigation design required, permafrost studies required for effect of earthen structures on frozen ground; high regulatory risk; high anticipated design effort; community agreements required; extremely high anticipated construction effort	Low Performance
3	Capital Cost Per Inundated Property	per-inundated-property capital cost is $515,695/property; capital costs may be underestimated due to the remoteness of Old Crow, logistical challenges with sourcing infrastructure materials, and potentially elevated proposed conditions WSEs following completion of hydraulic modelling	Medium Performance
4	Maintenance and Storage	no storage requirements; dike will require inspections erosion monitoring, maintenance, and vegetation clearing.	High Performance
5	Response and Activation	despite permanent infrastructure being implemented, ice jam processes and hydraulic implications of restricting floodplain access at Old Crow are complex and future flood processes/severity may deviate from what has been historically observed; even with permanent flood mitigations, response and activation plans/preparedness will likely still be required	Medium Performance
6	Aesthetics and Community Function	height of mitigations are substantial (up to 4 m in certain locations); alterations to existing landscape during non-flood conditions however the dikes/raised roads represent substantial alteration to existing community aesthetic/appearance; mitigation features may be used as a community feature (e.g., walking path) if the community members are supportive; reduced number of river access points	Low Performance
7	Future Adaptability	deployment of temporary mitigations on crest of dikes and roads is considered unreasonable given the flooding timing and resources available in Old Crow; permanent increases in height to dikes/raised roads are possible but require engineering study and substantial construction effort	Medium Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	flood conveyance capacity will be reduced; likely to result in proposed conditions having higher 1:200 WSEs and accelerated flow velocities, causing potentially significant geomorphological changes, including additional areas of erosion and sedimentation; morphologic changes have the potential to alter icing processes in the river with the potential to increase ice jam flood risk at the community; slope stabilization measures will be required along bank	Low Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	permanent infrastructure providing mitigation for flood hazard endangering almost the entire community; substantial capital costs	Medium Performance

L.2.2 OPTION 2

Description

The conceptual flood mitigations for Option 2 are illustrated in Figure L4. Option 2 considers i) the construction of flood mitigations encircling the main community consolidation, and ii) two separate "envelopes" of mitigation defense lines around inundated community components along the north slope (connecting to high ground to the north). Road raising, earthen dikes (where no road exists), and structural dikes (where insufficient space exists for earthen dikes) would be implemented. The mitigations are described in an upstream to downstream order (east to west) below.

Option 2 is similar to Option 1 with the construction of flood mitigations surrounding community infrastructure. The primary difference is that this option allows for partial flood conveyance on the north side of the runway by providing gaps in the dike (non-raised locations) for water to enter the floodplain, flow past the community and ultimately back to the main channel of the Porcupine River downstream of the community. At the upstream end of the gap in the mitigations/partial floodplain route, the installation of steel piles spaced 5 – 10 m apart (as described in Turcotte et al. 2022b) could be considered to block large ice pieces from entering the floodplain and potentially damaging flood mitigation infrastructure. Providing this partial flood conveyance route would (compared to Option 1) reduce the amount of water flowing in the main channel of the Porcupine and potentially reduce flood WSEs compared to Option 1. It is not anticipated that this partial floodplain pathway would be sufficient to offset the reduction in flood conveyance capacity from the flood mitigations. This means flood stage WSEs under Option 2 proposed conditions would likely still be higher than existing conditions and the extent, size, and cost of Option 2 as presented here is likely an underestimation of what would be required.

The main part of the community including the runway would be surrounded by raised roads (approximately 1700 m total length), structural dikes (approximately 1550 m total length) and an earthen dike (approximately 950 m). These segments would be raised 1.5 to 4.0 m above the existing ground to reach the DFSL. The dike and the required root-free zone would encroach on residential properties and would require property owner agreements. Outer slopes of the road raising, and earthen dikes would need to be lined with riprap for erosion mitigation. Annual inspection and maintenance would be required and may reveal the need for continual supplementation of riprap due to ice damage. Slope stabilization measures may be required due to the added weight from the new fill along the top of bank.

Smaller dikes would be constructed at the east and west ends of the community. At the west end, a 450 m long segment of the road leading to the landfill would be raised to the DFSL and tied into a new earthen dike (250 m long) at the east side of the sewage lagoon and tied into high ground. These dike segments would be constructed up to 5.5 m above the existing ground to reach the DFSL. At the east side of Old Crow, an earthen dike (approximately 560 m long), structural dike (700 m long) and raised road (approximately 250 m long) would be constructed to mitigate flooding for properties on both sides of Crow Mountain Road. These segments would be approximately 1.5 – 4.0 m above the existing ground to reach the DFSL. The dike and the required root-free zone would encroach on residential properties and would require property owner agreements. Outer slopes of the road raising and earthen dikes be lined with riprap for erosion mitigation. Annual inspection and maintenance would be required and may reveal the need for continual supplementation of riprap due to ice damage. Slope stabilization measures may be required due to the added weight from the new fill along the top of bank.

As with Option 1, extensive engineering studies are required to evaluate the impact of a potential dike while providing limited floodplain access. Hydraulic modelling would be required to assess the benefit of providing partial floodplain access for water levels and erosion potential in the Porcupine River. Additional hydraulic studies would be required for assessing the potential for geomorphic changes along the floodplain, including the channel avulsion, permafrost degradation and erosion and deposition potential. It is likely that bank failures and prolonged erosion along the south bank of the river, opposite of the community would occur during flooding events. This has the potential to alter icing processes in the river with the potential to increase ice jamming potential downstream of the community.

Temporary sandbag ring dikes would be constructed to protect one residential property on the north side of the airport runway. The total length of this ring dike would be approximately 125 m and the height may be up to 3.0 m to reach the DFSL. The effectiveness of this ring dikes to protect against flowing water and potential ice in the floodplain may be insufficient to protect the property. A hydraulic model to evaluate shear stresses along the floodplain at this location is recommended.

As with Option 1, implementation of Option 2 would result in a substantial reduction in flood flow capacity around Old Crow. Existing versus proposed conditions hydraulic modelling would likely show that i) implementation of Option 2 would raise 1:200-year WSEs at Old Crow under proposed conditions, ii) erosion risks would be substantially increased on the south bank of the Porcupine River, and iii) erosion and avulsion risks may be present in the flood conveyance route north of the runway. Specifically related to i), flood mitigations around Old Crow would need to be raised even further to provide the desired flood mitigation. Hydraulic modelling is outside of the scope of this Project; we highlight the above because it means the extent, size and costing of Option 1 flood mitigations presented herein are likely an underestimation of what would be required to provide engineered flood mitigation at Old Crow.

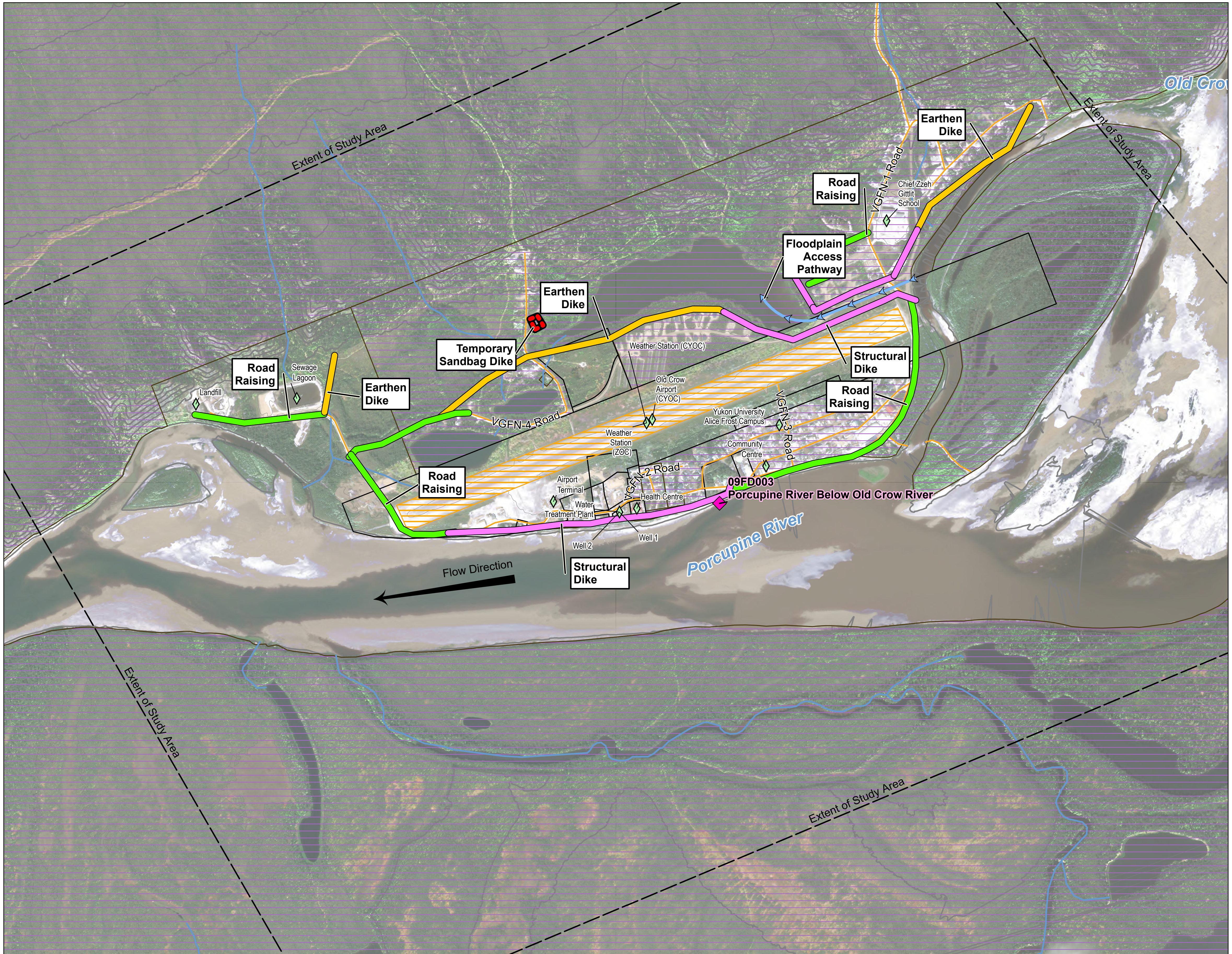

Figure No.

L4

Title

Old Crow Conceptual Flood Mitigation Design - Option 2

Client/Project 144903232

Government of Yukon
Community Services | Infrastructure Development Branch
Yukon Territory Flood Mitigation Conceptual Design Options

Project Location
Old Crow,
Yukon

Prepared by LLT on 2023-04-11
TR by JM on 2023-04-11

N

0 50 100 150 200
m
(At original document size of 11x17)
1:10,000

- WSC Station
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Runway
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed

Proposed Mitigation Feature
- Earthen Dike
- Platform with Temporary Superbag Dike
- Road Raising
- Structural Dike
- Temporary Sandbag Dike
- Floodplain Access Pathway

CONCEPTUAL DESIGN
This document is for general information only
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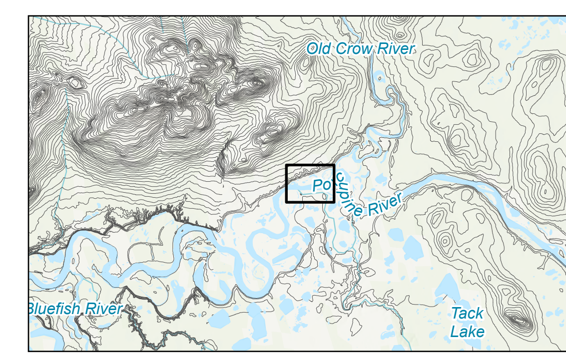

Notes
1. Coordinate System: NAD 1983 Yukon Albers
2. Data Sources: Government of Yukon; Government of Canada
3. Imagery Government of Yukon Geomatics Yukon; ESRI World Imagery

Stantec Yukon

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Class D OPC

The Class D OPC's for capital and annual costs are summarized in Table L8, considering the Class D level of accuracy (+/-50%). Table L8 also provides the Class D OPCs on a per-inundated property basis (from Section L.1.11).

Table L8 Option 2 Summary of Class D OPCs

	Class D OPC	Number of Inundated Properties (Section L.1.11)[1]	Class D OPC per Inundated Property
Capital Cost	\$ 187,675,200 - \$ 281,512,800	168	\$1,117,115 - \$1,675,672
Annual Cost (Flood Year)	\$ 542,500 - \$ 813,750		\$ 3,230 - \$ 4,844
Annual Cost (Non-Flood Year)	\$ 39,200 - \$ 58,800		\$ 234 - \$ 350

[1] As described in Section L.1.11, the inundated properties from the preliminary inundation analysis consists 168 total inundated properties

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table L9 (capital costs), Table L10 (annual cost, flood year), and Table L11 (annual cost, non-flood year).

Table L9 Option 2 Capital Costs Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 2A	**Option 2: General Conditions**				
a)	Mobilization/Demobilization	LS	1	$6,617,980.00	$6,617,980.00
b)	Site Preparation/Restoration	LS	1	$1,323,600.00	$1,323,600.00
				Total 2A	$7,941,580.00
Section 2B	**Option 2: Structural Dike**				
a)	Clearing and Grubbing	M2	9930	$10.00	$99,300.00
b)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	2980	$25.00	$74,500.00
c)	Dike Topsoil	M2	6660	$20.00	$133,200.00
d)	Dike Seeding	M2	6660	$5.00	$33,300.00
e)	Dike Fill	M3	24900	$100.00	$2,490,000.00
f)	Sheet Pile Wall	M2	13750	$1,700.00	$23,375,000.00
g)	Concrete Lock-Block Retaing Wall	M2	6860	$1,000.00	$6,860,000.00
h)	Handrail	M2	4440	$140.00	$621,600.00
l)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	2220	$300.00	$666,000.00
m)	Slope Stablilization	M	2220	$3,000.00	$6,660,000.00
				Total 2B	$41,012,900.00
Section 2C	**Option 2: Road Raising**				
a)	Rough Grading	M2	74600	$10.00	$746,000.00
b)	Subgrade Preparation	M2	74600	$10.00	$746,000.00
c)	80mm Minus Granular Subbase, Variable Depth	M3	98200	$40.00	$3,928,000.00
d)	100mm Minus Granular Base, 100mm Depth	M3	2400	$50.00	$120,000.00
e)	Riprap	MT	26500	$141.00	$3,736,500.00
				Total 2C	$9,276,500.00
Section 2D	**Option 2: Earthworks & Landscaping, Earthen Berm**				
a)	Clearing and Grubbing	M2	38800	$10.00	$388,000.00
c)	Cut and Dispose Offsite - Native Material	M3	2720	$30.00	$81,600.00
e)	Embankment Fill, Clay Core	M3	22150	$100.00	$2,215,000.00
f)	Embankment Fill, Granular Shell	M3	34410	$50.00	$1,720,500.00
g)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	15390	$25.00	$384,750.00
h)	Riprap	MT	23000	$141.00	$3,243,000.00
i)	Geotextile Fabric	M2	19700	$10.00	$197,000.00
j)	Embankment Seeding	M2	29400	$5.00	$147,000.00
k)	Embankment Topsoil	M2	29400	$20.00	$588,000.00
l)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	1725	$300.00	$517,500.00
m)	Slope Stablilization	M	1725	$3,000.00	$5,175,000.00
				Total 2D	$14,657,350.00

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

Section 2E	**Option 2: Floodboxes, Structural Dike and Earthen Berm**				
a)	Reinforced Concrete Pipe	M	400	$1,000.00	$400,000.00
b)	Gatewell Manhole c/w Sluice Gate	EA	25	$17,500.00	$437,500.00
c)	Concrete Headwall	EA	50	$5,000.00	$250,000.00
d)	Slide Gate	EA	25	$3,000.00	$75,000.00
e)	Riprap	MT	500	$141.00	$70,500.00
				Total 2E	$1,233,000.00
				Contingency (20%)	$14,824,266.00
				Subtotal	$88,945,596.00
				Location Adjustment Factor (LCAF)	2.11
				Capital Costs Base Price	$187,675,200.00
				Capital Costs Upper Bound	$281,512,800.00

Table L10 Option 2 Annual Costs During a Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 2F	**Option 2: Annual Costs, Flood Year**				
a)	Inspections	LS	1	$100,000.00	$100,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$10,000.00	$10,000.00
c)	Sandbags c/w Sandfill (2.0m - 3.0m)	LM	150	$695.00	$104,250.00
				Total 2F	$214,250.00
				Contingency (20%)	$42,850.00
				Subtotal	$257,100.00
				Location Adjustment Factor (LCAF)	2.11
				Annual Cost Flood Year Base Price	$542,500.00
				Annual Cost, Flood Year Upper Bound	$813,750.00

Table L11 Option 2 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1G	**Option 2: Annual Costs, Non-Flood Year**				
a)	Inspections	LS	1	$5,000.00	$5,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$10,000.00	$10,000.00
c)	Storage of Sandbags	LS	1	$500.00	$500.00
				Total 2G	$15,500.00
				Contingency (20%)	$3,100.00
				Subtotal	$18,600.00
				Location Adjustment Factor (LCAF)	2.11
				Annual Cost, Non-Flood Year Base Price	$39,200.00
				Annual Cost, Non-Flood Year Upper Bound	$58,800.00

Qualitative Evaluation

Table L12 summarizes the performance of Option 1 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table L12 Option 2 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	high potential for ice damage to mitigations (particularly temporary sandbag dikes, raised roads and earthen dikes) even with riprap installed; implementation of mitigations may alter existing processes to a degree which would result in entirely different (increased) flood elevations would render the mitigations ineffective; partial flood conveyance route to north of runway may experience elevated velocities and erosion/degradation (mitigation of the introduced erosion hazard would involve additional floodplain armouring)	Low Performance
2	Time to Implementation	geotechnical investigations required including borehole drilling to address shoreline stability and construction requirements for platforms; extensive hydraulic modelling including iterative modelling to evaluate effect of infrastructure limiting floodplain access on north (community side) of river, erosion mitigation design required, permafrost studies required for effect of earthen structures on frozen ground; high regulatory risk; high anticipated design effort; community agreements required; extremely high anticipated construction effort	Low Performance
3	Capital Cost Per Inundated Property	per-inundated-property capital cost is $1,117,115/property; capital costs may be underestimated due to the remoteness of Old Crow, logistical challenges with sourcing infrastructure materials, and potentially elevated proposed conditions WSEs following completion of hydraulic modelling	Low Performance
4	Maintenance and Storage	minimal storage requirements; dike will require inspections erosion monitoring, maintenance, and vegetation clearing.	High Performance
5	Response and Activation	despite permanent infrastructure being implemented, ice jam processes and hydraulic implications of restricting floodplain access at Old Crow are complex and future flood processes/severity may deviate from what has been historically observed; even with permanent flood mitigations, response and activation plans/preparedness likely still required	Medium Performance
6	Aesthetics and Community Function	height of mitigations are substantial (up to 4 m in certain locations); alterations to existing landscape during non-flood conditions however the dikes/raised roads represent substantial alteration to existing community aesthetic/appearance; mitigation features may be used as a community feature (e.g., walking path) if the community members are supportive; reduced number of river access points	Low Performance
7	Future Adaptability	deployment of temporary mitigations on crest of dikes and roads is considered unreasonable given the flooding timing and resources available in Old Crow; permanent increases in height to dikes/raised roads are possible but require substantial engineering/construction effort	Medium Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	flood conveyance capacity will be reduced; likely to result in proposed conditions having higher 1:200 WSEs and accelerated flow velocities, causing potentially significant geomorphological changes, including additional areas of erosion and sedimentation; morphologic changes have the potential to alter icing processes in the river with the potential to increase ice jam flood risk at the community; slope stabilization measures will be required along bank; Option 2 may induce erosion and avulsion risks within the flood conveyance route to the north of the runway	Low Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	permanent infrastructure providing mitigation for flood hazard endangering almost the entire community; substantial capital costs	Medium Performance

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

L.2.3 SUMMARY TABLES

Table L13 summarizes the Class D OPC for the conceptual design options.

Table L13 Summary of Class D OPCs

	Option 1 Class D OPCs	Option 2 Class D OPCs
Capital Cost	$ 86,636,600 - $ 129,954,900	$ 187,675,200 - $ 281,512,800
Annual Cost (Flood Year)	$ 542,500 - $ 813,750	$ 542,500 - $ 813,750
Annual Cost (Non-Flood Year)	$ 39,200 - $ 58,800	$ 39,200 - $ 58,800

Table L14 provides a summary of the evaluation of each of the conceptual design options. The increased length (and therefore, cost) of the Option 2 mitigations did not provide improved qualitative performance compared to Option 1.

Table L14 Summary of Qualitative Evaluation of Conceptual Options

Criteria No.	Criteria Title	Option 1	Option 2
1	Viability and Reliability under Extreme Conditions	Low Performance	Low Performance
2	Time to Implementation	Low Performance	Low Performance
3	Capital Cost Per Inundated Property	Medium Performance	Low Performance
4	Maintenance and Storage	High Performance	High Performance
5	Response and Activation	Medium Performance	Medium Performance
6	Aesthetics and Community Function	Low Performance	Low Performance
7	Future Adaptability	Medium Performance	Medium Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	Low Performance	Low Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	Medium Performance	Medium Performance