Appendix H Ross River 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.

H.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 Ross River.

H.1.1 POPULATION

Ross River has a population of 355 with 184 private dwellings according to 2021 census data (Statistics Canada 2023c). The population has increased by approximately 21% from 2016 when the population was 293 (Statistics Canada 2023c).

H.1.2 STUDY AREA

The Study Area in Figure H2 outlines the areas that are considered in this Project at Ross River. 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.

H.1.3 FIRST NATIONS

The Ross River area is within the Traditional Territory of the Kaska Dena Nation. The Ross River Dena Council have no land claim selections in this area.

H.1.4 BATHYMETRY AND TOPOGRAPHY

Bathymetry data for Pelly River at Ross River were not provided to Stantec.

The following topographic 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 2022e)

All elevations are reported 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 per NRCan (2022b).

H.1.5 GEOLOGY

Based on the surficial geology mapping (Yukon Geological Survey 2020), the Study Area likely consists of a glacial deposits (till) greater than 1 m thick overlain by floodplain deposits, generally made up of gravel, sands and silts. The mineralogical, textural, structural, and topographic characteristics of till deposits are highly variable and depend upon both the source of material incorporated by the glacier and the mode of deposition. In general, till at the project site consists of well compacted to noncompacted material that is non-stratified and contains a heterogeneous mixture of particle sizes, commonly in a matrix of sand, silt, and clay.

Based on borehole and testpit data provided in the Yukon Permafrost Database (Government of Yukon 2022b), the soil conditions near the flooding areas within the Study Area are likely to consist of intermixed layers of silt, sand and gravel to depths exceeding 6 m. Based on the borehole and testpit data reviewed from the Yukon Permafrost Database (Government of Yukon 2022b) permafrost was encountered in multiple locations consisting of layers with well bonded with no excess ice (Nbn), visible ice crystals and layers (Vx and Vs) and ice layers (ICE). The encountered permafrost ranged between 2 m and 6 m below ground surface with ice lens thicknesses ranging from 10 mm to 50 mm. Boreholes and testpits completed within limits of the proposed flood mitigation options were not available.

Further review of permafrost in the Study Area is based on the Permafrost Probability Model (Yukon Geological Survey 2020) and the Canada Permafrost Map (The National Atlas of Canada, 1995). Based on the Permafrost Probability Model, the project site is located within a region of extensive discontinuous permafrost (60-70% of land area underlain by permafrost). The Canada Permafrost Map also indicates the Study Area is in a region of extensive discontinuous permafrost (50-90% of land area underlain by permafrost) with a low to medium (<10-20%) ground ice content in the upper 10-20 m of the ground. If permafrost is present at this site within the limits of the flood mitigation options, differential settlements of the proposed flood mitigation options may occur and should be further investigated and evaluated in preliminary and detailed designs.

H.1.6 HYDROGEOLOGY

The till deposits with a matrix of gravel, sand, silt and clay and the overlying floodplain deposits encountered within the project site are likely to result in relatively medium to fast rates of groundwater flow. The deposits encompassing most of the shoreline are likely to result in a groundwater table that would be highly dependent on the Pelly River water levels. During flooding, the high-water levels would result in high groundwater levels and after flood waters recede, it is likely that the groundwater levels would recede relatively quickly based on the permeability of the soil conditions in the area. The presence of permafrost could impede groundwater flow.

Residences and structures located west of the dike on Canol Road may experience flooding due to high groundwater if the dike exceeds 693.0m during smaller return events. Based on the anticipated soils at this site, the need for seepage control measures (i.e. seepage cut-off below flood mitigation option, toe drains, sump pits and pumping, etc.) may be required for the proposed flood mitigation options and should be further evaluated in preliminary and detailed designs.

H.1.7 PAST FLOODING EVENTS AND RESPONSE

Ross River has been subject to numerous flooding events in recent decades. A summary of documented flood events is 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.

2013 Flood Event

Ross River experienced its highest flood on record in 2013, although water level data is not recorded prior to 2011. An ice jam caused a peak in WSEs in mid-May, followed by an open water instantaneous flood peak on June 1, 2013 of 693.86 m according to WSC Station 09BC002 (Pelly River at Ross River) (GoC 2023). Morrison Hershfield (2022b) documented aerial photographs that the existing dike to the west of

the community was overtopped during this event. No documentation of flood response (if any occurred) was available to Stantec.

2022 Flood Event

Ross River experienced flood conditions again in June of 2022. The flooding was largely due to record snowpack in the winter of 2021-2022 and the resulting spring freshet runoff. Emergency flood response actions were undertaken including a single superbag dike along a 100 m long low point along the existing dike, a single superbag dike from the north end of the existing dike westward across the turnaround area, Canol Road, and between private properties to high ground. Structure-specific sandbag and superbag flood mitigations were deployed around private properties not within the flood defense line, including at the Ross River Lodge. The ferry crossing and the pedestrian bridge (Photograph 1) were closed during the flood event. WSC Station 09BC002 (Pelly River at Ross River) indicates that WSE during the 2022 flood event at Ross River peaked at 693.48 m (at the WSC station) on June 14, 2022 at 19:05 (GoC 2023).

Photograph 1 Ross River Pedestrian Bridge During 2022 Flood (June 7, 2022)

H.1.8 EXISTING FLOOD MITIGATION INFRASTRUCTURE

There is an existing dike structure along the south (left) bank of the Pelly River (on the east side of the community) which provides partial flood mitigation to the community of Ross River. The existing dike is approximately 440 m long and is used as a trail/pathway by the community. Based on available LiDAR (GeoYukon 2023) and survey completed by Stantec during the 2022 emergency flooding, the top elevation of the existing dike ranges in elevation from 694.2 – 695.8 m, however the majority of the dike crest is between 695.0 – 695.3 m. There is an approximately 120 m long low point in the dike (elevation

of 694.2 – 694.5 m) towards the southern end of the dike. No information on the construction history or composition of the dike was available to Stantec at the time of writing although surficial dike material was observed to be primarily sand and gravel. Trees are actively growing in the dike embankments and root-free zones required for dikes (USACE 2000; BC MWLAP 2003) have not been maintained. A photograph of the existing dike during the 2022 flood is provided in Photograph 2.

Photograph 2 Existing Ross River Dike at Approximate Midpoint (facing north)

H.1.9 WIND, WAVES, AND EROSION

While floodplain mapping and associated hydraulic modelling of the DFSL has not been completed for Ross River to date, it is likely that flow velocities in the Pelly River during flood conditions would likely require some flood mitigations to include erosion protection. In addition, bank erosion and river migration should be studied and considered in preliminary and detailed design phases of flood mitigations.

Wind and wave effects are not anticipated to occur at a scale which would impact flood mitigation design at Ross River.

H.1.10 HYDROLOGY

The community of Ross River is located within the floodplain on the southern (left) side of the Pelly River. The Pelly River originates on the western slopes of Selwyn Mountains. It flows south towards the Pelly Lakes, and then flows west/northwest towards Ross River. The Pelly River passes the communities of Ross River, Faro and Pelly Crossing on its course. WSC Station 09BC002 (Pelly River at Ross River) is located on the south side of the Pelly River (river's left bank), and on the upstream side of the pedestrian suspension bridge. WSC Station 09BC002 has a gross drainage area of 18,400 km^2 (GoC 2023).

Hydraulic modelling has not been completed to date for the Study Area and is beyond the scope of this Project. Therefore, hydrology review considered WSEs but not the discharges at WSC Station 09BC002.

Flood frequency analysis for WSEs was performed by both Morrison Hershfield (2022) and Yukon University (2022) for WSEs at WSC Station 09BC002. Table H1 summarizes the frequency results of these two studies.

Table H1 Flood Frequency Analyses at WSC Station 09BC002 from Morrison Hershfield (2022) and Yukon University (2022)

	Morrison Hershfield (2022)	Yukon University (2022)
Years Included in Analysis	2011 - 2022 [a]	1970 - 2022 [b]
Number of Years	12	53
Selected Distribution	Log-Pearson Type 3	Log-Pearson Type 3 (open water freshet data) and Lognormal (breakup ice jams)
Water Surface Elevation (m) [1]		
1:2-year Event (50% AEP)	692.82	693.00
1:20-year Event (5% AEP)	693.73	693.80
1:100-year Event (1% AEP)	694.17	not provided
1:200-year Event (0.5% AEP)	694.33	694.40

Notes:
[a] Using a dataset of combined open-water and breakup ice jam peaks (11/12 years open water, 1 year break up peak)
[b] Using a dataset of combined open water and breakup ice jam peaks
[1] Elevations provided in CGVD2013 for WSC Station 09BC002

The 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. The Yukon University (2022) WSE's are produced from a combined open water and ice jam flood frequency analysis.

Figure H1 illustrates the on-record daily minimum, mean, and maximum WSEs, the WSE during the highest year on record (2013), and the WSEs for the 1:2-year and 1:200-year event at WSC Station 09BC002 from Yukon University (2022). Flows in the Pelly River near Ross River normally peak late May or early June as a result of spring freshet in the watershed. Flows then recede over the summer months and through the fall, with seasonal low flows often occurring in late winter. The community is prone to both open water flooding as well as ice related flooding during spring breakup due to the morphology of the Pelly River and the spring regime of the Ross River and Pelly River confluence (Morrison Hershfield

2022b; Yukon University 2022). Based on the documented variability in flood processes, flooding in Ross River may occur for a wide range of durations throughout the spring and early summer.

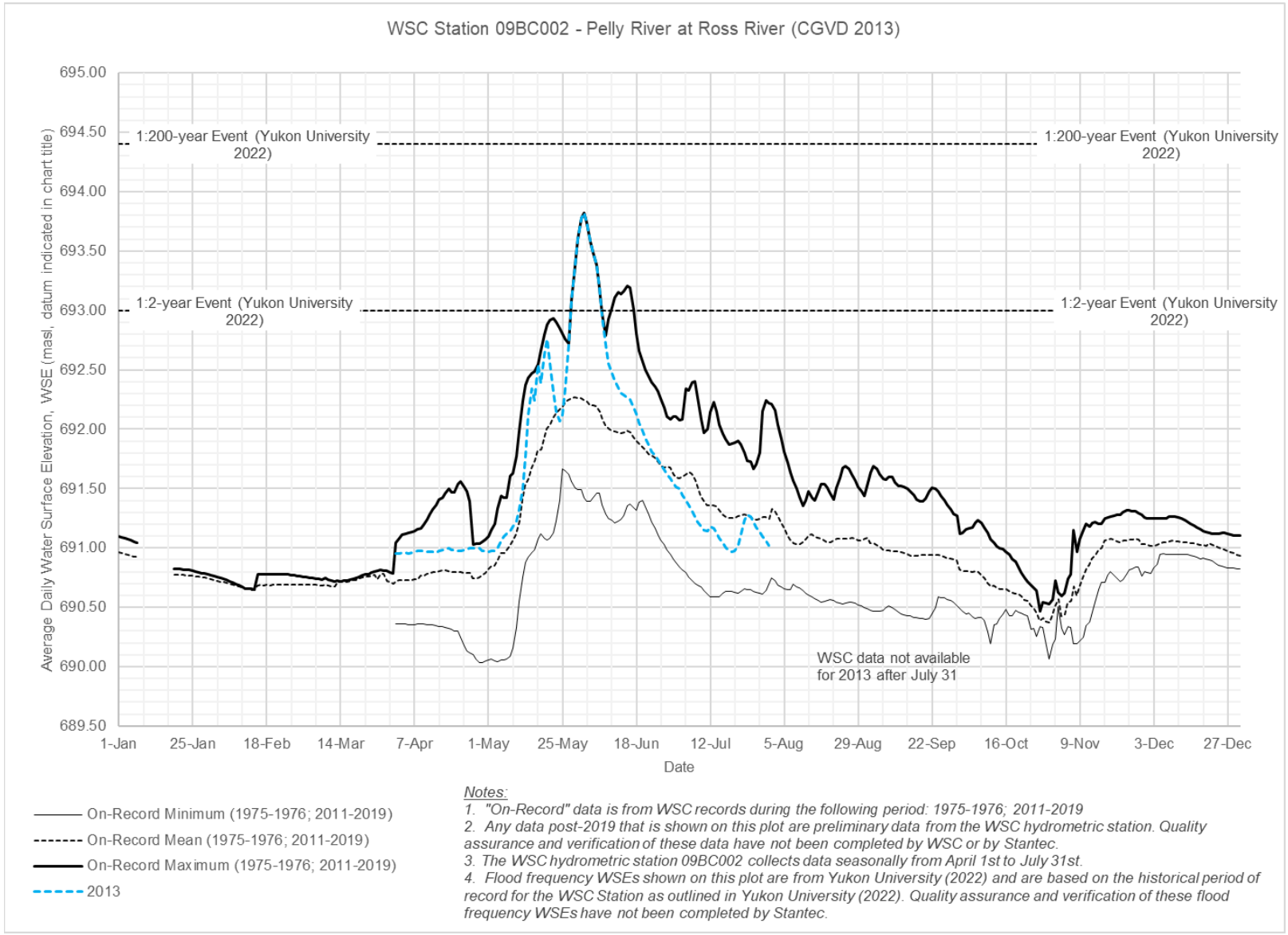


Figure H1 Historical Water Surface Elevations at WSC 09BC002 (Pelly River at Ross River)

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.

H.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 Ross River and is not within the scope of this Project. However, an understanding of inundation extents under the conceptual DFSL (i.e., 1:200-year event) is required for conceptual design of flood mitigations.

In lieu of floodplain mapping, Stantec performed preliminary existing conditions (no mitigation) inundation analysis for Ross River using WSEs for combined open water/ice jam events from Yukon University (2022). This analysis considered the 1:200-year event WSE (694.40 m) developed by Yukon University (2022) with an assumed WSE slope of 0.05% upstream of the pedestrian bridge and 0.15% downstream of the pedestrian bridge (based on survey from Underhill 2022). The resulting water surface was overlain on the existing conditions topographic/bathymetric elevation data (GeoYukon 2023) and the limits of inundation were mapped (Figure H2). 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 inundation analysis performed herein is provided for information only and is considered a high-level estimate of the flood inundation under the 1:200-year WSE from Yukon University (2022). WSE slopes may differ from those applied in the preliminary inundation analysis depending on the flood mechanism (i.e. ice jam vs. open-water).

Preliminary mapping results indicate that the northern portion of Ross River, downstream of where flow constricts at the Canol Road ferry crossing would be inundated under the 1:200-year WSE. The existing dike is overtopped by 0.1 – 0.2 m at the 120 m long low point in the southern portion of the dike. The existing dike does not tie into high ground at the north end which means high water from the Pelly River would enter the community from the north, downstream of the dike. This inundation dynamic means that the existing dike would likely reduce flow velocities in the community, but would not prevent flood water from entering the community.

The preliminary inundation analysis indicated that 11 properties would be inundated, including an estimated 9 private residences and 2 community features (Canol Road ferry landing and approximately 415 m of Canol Road).

Although the inundation/flood vulnerability of the pedestrian bridge that crosses the Pelly River is beyond the scope of work of this project, we note that the pedestrian bridge was closed to the public during the 2022 flood event. Given that the 1:200-year WSE is above the 2022 peak WSE, it is likely that the bridge would be susceptible to damage under the preliminary flood inundation scenario.

Figure No.

H2

Title

Existing Conditions and Preliminary Flood Inundation at Ross River

Client/Project

144903232

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

Project Location

Ross River,
Yukon

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

N

0 50 100 150 200 m

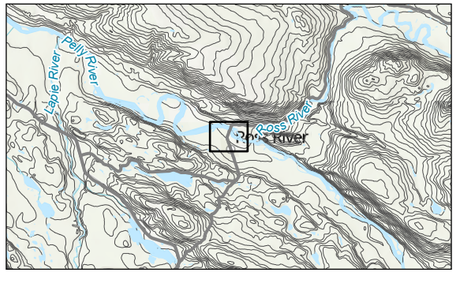
(At original document size of 11x17)
1:30,000

- WSC Station
- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - 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

Stantec Yukon

H.2 Mitigation Options and Evaluation

The scope of this Project is to develop conceptual engineered flood mitigation options; these options for Ross River 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, three flood mitigation options were developed for Ross River (Table H2) using combinations of the typical engineered flood mitigation designs from Section 3.3.2. Flood mitigations in the three options were provided for areas which are inundated under the 1:200-year WSE (694.40 m) in the preliminary inundation mapping (Table H1). The top elevation of the flood mitigations is designed to reach the DFSL which in the case of Ross River (river site) is assumed to be 694.90 m (i.e., 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 H2 Summary of Conceptual Design Options

Location	Option 1	Option 2	Option 3
	existing dike alignment	*partial dike removal - scenario A*	*partial dike removal - scenario B*
Existing Dike, South Portion	Dike Improvement (Earthen Dike)		
Existing Dike, North Portion	Dike Improvement (Earthen Dike)	Removal of Dike	Removal of Dike
Existing Dike Terminus Sawmill Road	Platform with Temporary Superbag Dikes	N/A	N/A
Ross River Lodge	(Within Other Mitigations)	Temporary Sandbag Dike	Temporary Sandbag Dike
Mid-existing Dike to Sawmill Road	N/A	Platform with Temporary Superbag Dikes	Earthen Dike

Section H2.1, H2.2, and H2.3 provide a description, Class D OPC, and qualitative evaluation of the conceptual options specified in Table H2.

H.2.1 OPTION 1

Description

The conceptual flood mitigations for Option 1 are illustrated in Figure H3.

On the east side of the community, approximately 440 m of the existing dike would be upgraded to meet the typical earthen dike design (as outlined in Section 3.3.2). Geotechnical borehole testing and analysis would be required to verify that the existing dike's core material meets the required specifications. If the existing dike's material does not meet design requirements, it would need to be replaced or the dike alignment shifted and a clay core and under seepage upgrades constructed. Approximately 120 m of the

dike at the south end would need to be raised by 0.5 to 1.0 m to reach DFSL. The remainder of the dike meets or exceeds the DFSL. The existing dike slopes are steep (approximately 1H:1V); embankment slopes of 3H:1V would be established on either side per the earthen dike typical design. The footprint of the upgraded earthen dike would be approximately 15 to 20 m wide. The earthen dike footprint and the root-free zone may encroach onto private property meaning agreements may be required with landowners. The river side of the earthen dike would be lined with rip rap to mitigate erosion risk on the dike from flow velocities. Slope stabilization measures may be required pending the findings of geotechnical investigations.

An approximately 640 m long platform would be established from the north end of the existing dike westward through the traffic turnaround, across the Canol Road ferry access, around the Ross River Lodge, and then south to connect with the high point at Sawmill Road. No raising is required along the platform length because the existing ground is within 2 m of the DFSL for its entire length. Vegetation clearing and platform creation between the lodge and Sawmill Road would likely be required. The length of the platform from the north end of the dike to the lodge is unlikely to require ground preparation/platform creation because it would occur along cleared paths or driveways. During flood conditions, the easternmost 200 m of the platform (from the north end of the dike to the west side of Canol Road) would require a single superbag dike to reach the DFSL. The remaining 440 m would require a double superbag dike to reach the DFSL.

Figure No.

H3

Title

Ross River 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
Ross River,
Yukon

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

N

0 50 100 150 200 m

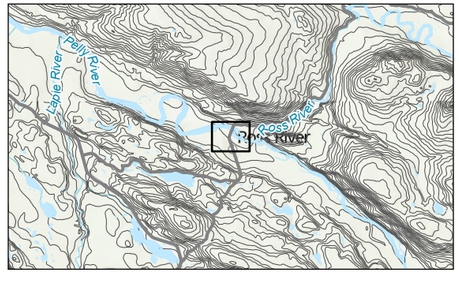
(At original document size of 11x17)
1:30,000

- WSC Station
- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - 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
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3. Imagery Government of Yukon Geomatics Yukon; ESRI World Imagery

Stantec Yukon

Class D OPC

The Class D OPC's for capital and annual costs are summarized in Table H3, considering the Class D level of accuracy (+/-50%). Table H3 also provides the Class D OPCs on a per-inundated property basis (from Section H.1.11).

Table H3 Option 1 Summary of Class D OPCs

	Class D OPC			Number of Inundated Properties (Section H.1.11)[1]	Class D OPC per Inundated Property		
Capital Cost	$8,410,100	-	$12,615,200	11	$764,555	-	$1,146,837
Annual Cost (Flood Year)	$829,900	-	$1,244,850		$75,446	-	$113,169
Annual Cost (Non-Flood Year)	$38,600	-	$57,900		$3,510	-	$5,264
[1] As described in Section H.1.11, the inundated properties from the preliminary inundation analysis consists of 9 private residences and 2 community features.							

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table H4 (capital costs), Table H5 (annual cost, flood year), and Table H6 (annual cost, non-flood year).

Table H4 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	$398,560.00	$398,560.00
b)	Site Preparation/Restoration	LS	1	$79,800.00	$79,800.00
				Total 1A	$478,360.00
Section 1B	**Option 1: Earthworks & Landscaping, Earthern Dike**				
a)	Clearing and Grubbing	M2	7650	$10.00	$76,500.00
b)	Cut and Re-use Onsite - Native Material	M3	380	$15.00	$5,700.00
c)	Cut and Dispose Offsite - Native Material	M3	4600	$30.00	$138,000.00
d)	Import and Place Fill - Native Material	M3	380	$15.00	$5,700.00
e)	Embankment Fill, Clay Core	M3	2280	$100.00	$228,000.00
f)	Embankment Fill, Granular Shell	M3	2320	$50.00	$116,000.00
g)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	2300	$25.00	$57,500.00
h)	Riprap	MT	2250	$141.00	$317,250.00
i)	Geotextile Fabric	M2	1920	$10.00	$19,200.00
j)	Embankment Seeding	M2	6490	$5.00	$32,450.00
k)	Embankment Topsoil	M2	6490	$20.00	$129,800.00
l)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	440	$300.00	$132,000.00
m)	Slope Stablilization	M	440	$3,000.00	$1,320,000.00
				Total 1B	$2,578,100.00
Section 1C	**Option 1: Earthworks & Landscaping, Platform**				
a)	Clearing and Grubbing	M2	6020	$10.00	$60,200.00
b)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	1810	$25.00	$45,250.00
c)	Platform Topsoil	M2	6100	$20.00	$122,000.00
d)	Platform Seeding	M2	6100	$5.00	$30,500.00
e)	Geotextile Fabric	M2	1380	$10.00	$13,800.00
f)	Embankment Fill, Clay Core	M3	1740	$100.00	$174,000.00
g)	Embankment Fill, Granular Shell	M3	2910	$50.00	$145,500.00
h)	Riprap	MT	1610	$141.00	$227,010.00
i)	Seepage Cutoff Wall-Clay, 1m Width	M3	1380	$100.00	$138,000.00
j)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	260	$300.00	$78,000.00
				Total 1C	$1,034,260.00
Section 1D	**Option 1: Floodboxes, Earthern Berm, Platform**				
a)	Reinforced Concrete Pipe	M	140	$1,000.00	$140,000.00
b)	Gatewell Manhole c/w Sluice Gate	EA	7	$17,500.00	$122,500.00
c)	Concrete Headwall	EA	14	$5,000.00	$70,000.00
d)	Flap Gate	EA	7	$3,000.00	$21,000.00

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.

e)	Riprap	MT	140	$141.00	$19,740.00
				Total 1D	$373,240.00
				Contingency (20%)	$892,792.00
				Subtotal	$5,356,752.00
				Location Adjustment Factor (LCAF)	1.57
				Capital Costs Base Price	$8,410,100.00
				Capital Costs Upper Bound	$12,615,200.00

Table H5 Option 1 Annual Costs During a Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1E	**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)	Storage of Superbags and Sandbags	LS	1	$500.00	$500.00
d)	Superbags c/w Sandfill (1.0m - 2.0m)	M	660	$500.00	$330,000.00
				Total 1E	$440,500.00
				Contingency (20%)	$88,100.00
				Subtotal	$528,600.00
				Location Adjustment Factor (LCAF)	1.57
				Annual Cost, Flood Year Base Price	$829,900.00
				Annual Cost, Flood Year Upper Bound	$1,244,850.00

Table H6 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, Non-Flood Year**				
a)	Inspections	LS	1	$10,000.00	$10,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$10,000.00	$10,000.00
c)	Storage of Superbags and Sandbags	LS	1	$500.00	$500.00
				Total 1F	$20,500.00
				Contingency (20%)	$4,100.00
				Subtotal	$24,600.00
				Location Adjustment Factor (LCAF)	1.57
				Annual Cost, Non-Flood Year Base Price	$38,600.00
				Annual Cost, Non-Flood Year Upper Bound	$57,900.00

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.

Qualitative Evaluation

Table H7 summarizes the performance of Option 1 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table H7 Option 1 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	multiple flood processes which can cause flooding (snowmelt or ice jams) mean temporary superbag dikes could face a wide range of flood durations and ice/debris damage hazards; river constriction through Canol Road ferry crossing location may put stress on temporary mitigations; seepage control measures may be required	Low Performance
2	Time to Implementation	medium regulatory risk; geotechnical borehole studies of the existing dike required; hydraulic modelling, river migration, and erosion risk studies required; property owner agreements required; moderate design requirements provided baseline studies have been completed	Low Performance
3	Capital Cost Per Inundated Property	reduced capital costs in exchange for increased operational and maintenance costs when compared to permanent flood mitigation infrastructure (Option 3); per-inundated-property capital cost is $652,546/property	Medium Performance
4	Maintenance and Storage	storage required for substantial number of superbags; stockpiling of material required for superbags; minimal platform inspections given minimal raising of existing ground; inspection and maintenance of upgraded earthen dike required; vegetation clearing and maintenance required; floodbox maintenance required	Low Performance
5	Response and Activation	temporary superbag dikes require training, labour, and a timely response in a flood scenario to be effective; substantial length of temporary superbag dike; floodbox slide gates in earthen dike would need to be manually closed prior to arrival of flood and opened following abatement of the flood	Low Performance
6	Aesthetics and Community Function	minimal change to existing landscape during non-flood conditions; temporary alteration of private/community function during flood conditions from temporary superbag dikes	High Performance
7	Future Adaptability	increased height of temporary superbag dikes may be completed at platform platforms in future enhanced flood mitigation; space exists for platform platforms to be raised if desired; permanent increases in height to earthen dike structure will require engineering study and is likely to require widening of structure	High Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	upgrading of existing dike to meet DFSL and completion of flood defense line around community means that floodplain conveyance will be reduced; may impact ice processes (e.g., evacuation capacity during jamming events) and erosion/sedimentation during flood conditions; slope stabilization measures may be required over a length of approximately 400 m	Low Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	compared to other areas, the ROI for Ross River and Option 1 is low, given that majority of facilities are private entities (11 properties) and no community buildings are at risk	Low Performance

H.2.2 OPTION 2

Description

The conceptual flood mitigations for Option 2 are illustrated in Figure H4. Option 2 moves the flood mitigation line southwards to allow for increased flood flow capacity (and therefore potentially lower flood-stage WSEs) than with Option 1.

On the east side of the community, the northernmost 160 m of the existing dike would be removed. If geotechnical analysis deems the material from the existing dike suitable for platform or dike construction, it may be used in the flood mitigations elsewhere in the Study Area.

The southernmost 280 m of the existing dike would be upgraded to meet the typical earthen dike design (as outlined in Section 3.3.2). Geotechnical borehole testing and analysis would be required to verify that the existing dike's core material meets the required specifications. If the existing dike's material does not meet design requirements, it would need to be replaced or the dike alignment shifted and a clay core and under seepage upgrades constructed. Approximately 120 m of the dike at the south end would need to be raised by 0.5 to 1.0 m to reach DFSL. The remainder of the dike meets or exceeds the DFSL. Embankment slopes of 3H:1V would be established on either side per the earthen dike typical design (existing slopes are approximately 1H:1V). The footprint of the upgraded earthen dike would be approximately 15 to 20 m. The earthen dike footprint and the root-free zone may encroach onto private property meaning agreements may be required with landowners. The river side of the earthen dike would be lined with rip rap to mitigate erosion risk on the dike from flow velocities and ice. Slope stabilization measures may be required pending the findings of geotechnical investigations.

From the northern terminus of the upgraded portion of the existing dike, an approximately 450 m long platform would be established. The platform would extend westward across Canol Road and connect to the high point on Sawmill Road. The existing grade is within 2 m of the DFSL, meaning no raising of the existing ground would be required. Vegetation clearing and ground preparation for the platform would be required. The platform would be located on private property; agreements with property owners would be required.

The Ross River Lodge would have a temporary sandbag ring dike deployed around it in the case of a flood. The temporary sandbag dike would need to be approximately 1.5 m in height to reach the DFSL, however may need to be higher and/or fortified on the upstream side due to river velocities impacting the sandbag dike obstruction.

Figure No.

H4

Title

Ross River 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
Ross River, Yukon

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

N

0 50 100 150 200 m

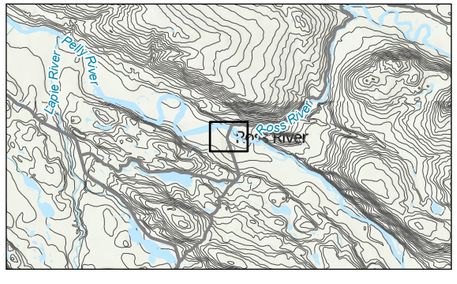
(At original document size of 11x17)
1:30,000

- WSC Station
- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - 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 H8 considering the Class D level of accuracy (+/-50%). Table H8 also provides the Class D OPCs on a per inundated property basis (from Section H.1.11).

Table H8 Option 2 Summary of Class D OPCs

	Class D OPC			Number of Inundated Properties (Section H.1.11)[1]	Class D OPC per Inundated Property		
Capital Cost	$5,795,600	-	$8,693,400	11	$526,873	-	$790,310
Annual Cost (Flood Year)	$773,300	-	$1,160,000		$70,300	-	$105,455
Annual Cost (Non-Flood Year)	$29,200	-	$43,800		$2,655	-	$3,982
[1] As described in Section H.1.11, the inundated properties from the preliminary inundation analysis consists of 9 private residences and 2 community features.							

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table H9 (capital costs), Table H10 (annual cost, flood year), and Table H11 (annual cost, non-flood year).

Table H9 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	$127,530.00	$127,530.00
b)	Site Preparation/Restoration	LS	1	$25,600.00	$25,600.00
				Total 2A	$153,130.00
Section 2B	**Option 2: Existing Dike Decomissioning**				
a)	Dike Removal (material re-used on site)	LS	1	$50,000.00	$50,000.00
				Total 2B	$50,000.00
Section 2C	**Option 2: Earthworks & Landscaping, Earthen Dike**				
a)	Clearing and Grubbing	M2	4950	$10.00	$49,500.00
b)	Cut and Re-use Onsite - Native Material	M3	250	$15.00	$3,750.00
c)	Cut and Dispose Offsite - Native Material	M3	3120	$30.00	$93,600.00
d)	Import and Place Fill - Native Material	M3	250	$15.00	$3,750.00
e)	Embankment Fill, Clay Core	M3	1470	$100.00	$147,000.00
f)	Embankment Fill, Granular Shell	M3	1490	$50.00	$74,500.00
g)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	1690	$25.00	$42,250.00
h)	Riprap	MT	1500	$141.00	$211,500.00
i)	Geotextile Fabric	M2	1280	$10.00	$12,800.00
j)	Embankment Seeding	M2	6050	$5.00	$30,250.00
k)	Embankment Topsoil	M2	6050	$20.00	$121,000.00
l)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	260	$300.00	$78,000.00
m)	Slope Stablilization	M	260	$3,000.00	$780,000.00
				Total 2C	$1,647,900.00
Section 2D	**Option 2: Earthworks & Landscaping, Platform**				
a)	Clearing and Grubbing	M2	10960	$10.00	$109,600.00
b)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	3288	$25.00	$82,200.00
c)	Platform Topsoil	M2	6930	$20.00	$138,600.00
d)	Platform Seeding	M2	6930	$5.00	$34,650.00
e)	Geotextile Fabric	M2	680	$10.00	$6,800.00
f)	Embankment Fill, Clay Core	M3	670	$100.00	$67,000.00
g)	Embankment Fill, Granular Shell	M3	760	$50.00	$38,000.00
h)	Riprap	MT	800	$141.00	$112,800.00
i)	Seepage Cutoff Wall-Clay, 1m Width	M3	680	$100.00	$68,000.00
j)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	470	$300.00	$141,000.00
				Total 2D	$798,650.00
Section 2E	**Option 2: Floodboxes, Platform**				
a)	Reinforced Concrete Pipe	M	160	$1,000.00	$160,000.00

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.

b)	Gatewell Manhole c/w Sluice Gate	EA	8	$17,500.00	$140,000.00
c)	Concrete Headwall	EA	16	$5,000.00	$80,000.00
d)	Flap Gate	EA	8	$3,000.00	$24,000.00
e)	Riprap	MT	160	$141.00	$22,560.00
				Total 2E	$426,560.00
				Contingency (20%)	$615,248.00
				Subtotal	$3,691,488.00
				Location Adjustment Factor (LCAF)	1.57
				Capital Costs Base Price	$5,795,600.00
				Capital Costs Upper Bound	$8,693,400.00

Table H10 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)	Storage of Superbags and Sandbags	LS	1	$500.00	$500.00
d)	Sandbags c/w Sandfill (1.0m - 2.0m)	M	140	$464.00	$64,960.00
e)	Superbags c/w Sandfill (1.0m - 2.0m)	M	470	$500.00	$235,000.00
				Total 2F	$410,460.00
				Contingency (20%)	$82,092.00
				Subtotal	$492,552.00
				Location Adjustment Factor (LCAF)	1.57
				Annual Cost Flood Year Base Price	$773,300.00
				Annual Cost, Flood Year Upper Bound	$1,160,000.00

Table H11 Option 2 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 2G	**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 Superbags and 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)	1.57
				Annual Cost, Non-Flood Year Base Price	$29,200.00
				Annual Cost, Non-Flood Year Upper Bound	$43,800.00

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 H12 summarizes the performance of Option 2 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table H12 Option 2 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	multiple flood processes which can cause flooding (snowmelt or ice jams) mean temporary superbag dikes could face a wide range of flood durations and ice/debris damage hazards; seepage control measures may be required	Low Performance
2	Time to Implementation	medium regulatory risk; geotechnical borehole studies of the existing dike required; hydraulic modelling, river migration, and erosion risk studies required; property owner agreements required; moderate design requirements provided baseline studies have been completed	Low Performance
3	Capital Cost Per Inundated Property	reduced capital costs in exchange for increased operational and maintenance costs when compared to permanent flood mitigation infrastructure (Option 3); per-inundated-property capital cost is $449,691/property	Medium Performance
4	Maintenance and Storage	storage required for substantial number of superbags and sandbags; stockpiling of material required for superbags and sandbags; minimal platform inspections given minimal raising of existing ground; inspection and maintenance of upgraded earthen dike required; vegetation clearing and maintenance required; floodbox maintenance required	Low Performance
5	Response and Activation	temporary superbag and sandbag dikes require training, labour, and a timely response in a flood scenario to be effective; substantial length of temporary superbag dike; floodbox slide gates in earthen dike would need to be manually closed prior to arrival of flood and opened following abatement of the flood	Low Performance
6	Aesthetics and Community Function	moderate change to existing landscape during non-flood conditions through platform establishment on private property; temporary alteration of private/community function during flood conditions from temporary superbag dikes	Medium Performance
7	Future Adaptability	increased height of temporary superbag dikes may be completed at platform platforms in future enhanced flood mitigation; space exists for platform platforms to be raised if desired; permanent increases in height to earthen dike structure will require engineering study and is likely to require widening of structure	High Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	shifting of flood mitigation line to south and removal of northern portion of dike would result in increased floodplain conveyance and may reduce flood WSEs; studies required to identify whether increased floodplain capacity would positively or negatively affect ice processes and erosion/sedimentation; slope stabilization measures may be required over an approximate length of 280 m	Medium Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	compared to other communities, the ROI for Ross River and Option 2 is low, given that majority of facilities are private entities (11 properties) and no community buildings are at risk	Low Performance

H.2.3 OPTION 3

Description

The conceptual flood mitigations for Option 3 are illustrated in Figure H5. As with Option 2, Option 3 moves the flood mitigation line southwards to allow for increased flood flow capacity however considers an earthen dike instead of a platform from the existing dike to Sawmill Road.

The alterations to the existing dike in Option 2 would be maintained in Option 3. That is, the northernmost 160 m of the existing dike would be removed, and the southernmost 280 m of the existing dike would be upgraded to the earthen dike typical design. Slope stabilization measures may be required along the southernmost 280 m length of dike adjacent to the riverbank. Also as in Option 2, the Ross River Lodge would have a temporary sandbag ring dike deployed around it in the case of a flood.

From the northern terminus of the upgraded portion of the existing dike, an approximately 450 m long earthen dike would be established. The earthen dike would extend westward across Canol Road and connect to the high point on Sawmill Road. The earthen dike crest would be approximately 2.0 to 2.5 m above existing ground to meet the DFSL. The river side of the earthen dike would be lined with rip rap to mitigate erosion risk on the dike from flow velocities. Canol Road would need to be raised such that vehicles could drive over the earthen dike. Alternatively, a gap in the earthen dike across Canol Road could be established provided that the gap is sealed with superbags or sandbags in the event of a flood. The earthen dike would be located on private property; agreements with property owners would be required.

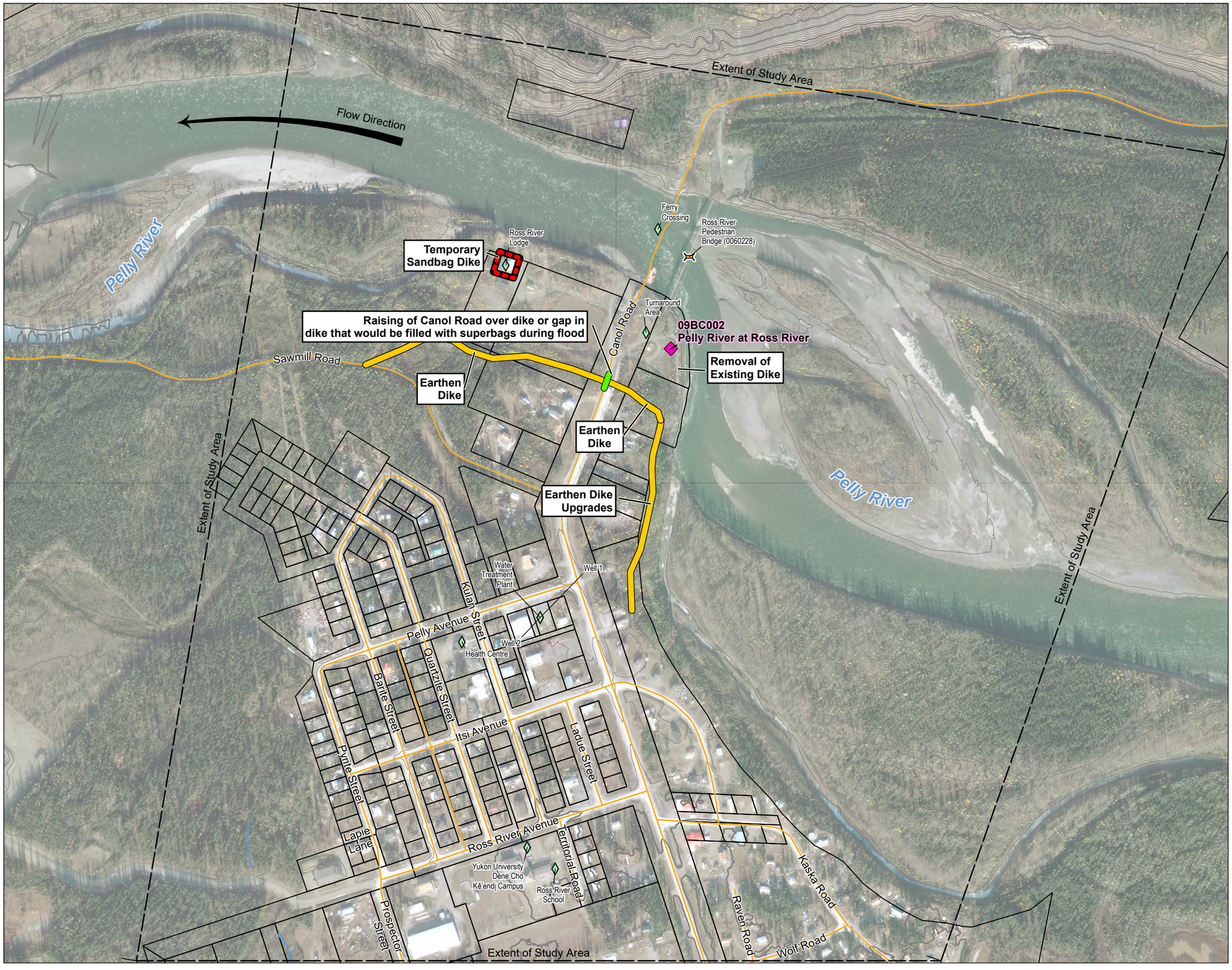


Figure No.

H5

Title

Ross River Conceptual Flood Mitigation Design - Option 3

Client/Project 144903232

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

Project Location
Ross River,
Yukon

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

N

0 50 100 150 200 m

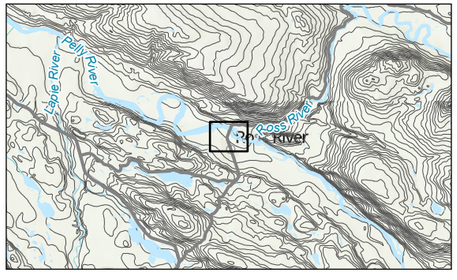
(At original document size of 11x17)
1:30,000

- WSC Station
- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - 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 H18 considering the Class D level of accuracy (+/-50%). Table H18 also provides the Class D OPCs on a per inundated property basis (from Section H.1.11).

Table H13 Option 3 Summary of Class D OPCs

	Class D OPC			Number of Inundated Properties (Section H.1.11)[1]	Class D OPC per Inundated Property		
Capital Cost	$11,332,200	-	$16,998,300	11	$1,030,200	-	$1,545,300
Annual Cost (Flood Year)	$264,600	-	$396,900		$24,055	-	$36,082
Annual Cost (Non-Flood Year)	$38,600	-	$57,900		$3,509	-	$5,264
[1] As described in Section H.1.11, the inundated properties from the preliminary inundation analysis consists of 9 private residences and 2 community features.							

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table H9 (capital costs), Table H10 (annual cost, flood year), and Table H11 (annual cost, non-flood year).

Table H14 Option 3 Capital Costs Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 3A	**Option 3: General Conditions**				
a)	Mobilization/Demobilization	LS	1	$532,580.00	$532,580.00
b)	Site Preparation/Restoration	LS	1	$106,600.00	$106,600.00
				Total 3A	$639,180.00
Section 3B	**Option 3: Existing Dike Decomissioning**				
a)	Dike Removal (material re-used on site)	LS	1	$50,000.00	$50,000.00
				Total 3B	$50,000.00
Section 3C	**Option 3: Earthworks & Landscaping, Earthern Dike**				
a)	Clearing and Grubbing	M2	15680	$10.00	$156,800.00
b)	Cut and Re-use Onsite - Native Material	M3	290	$15.00	$4,350.00
c)	Cut and Dispose Offsite - Native Material	M3	6175	$30.00	$185,250.00
d)	Import and Place Fill - Native Material	M3	290	$15.00	$4,350.00
e)	Embankment Fill, Clay Core	M3	5380	$100.00	$538,000.00
f)	Embankment Fill, Granular Shell	M3	6620	$50.00	$331,000.00
g)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	4704	$25.00	$117,600.00
h)	Riprap	MT	5060	$141.00	$713,460.00
i)	Geotextile Fabric	M2	4320	$10.00	$43,200.00
j)	Embankment Seeding	M2	10120	$5.00	$50,600.00
k)	Embankment Topsoil	M2	10120	$20.00	$202,400.00
l)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	730	$300.00	$219,000.00
m)	Slope Stablilization	M	730	$3,000.00	$2,190,000.00
				Total 3C	$4,756,010.00
Section 3D	**Option 3: Floodboxes, Earthern Dike**				
a)	Reinforced Concrete Pipe	M	160	$750.00	$120,000.00
b)	Gatewell Manhole c/w Sluice Gate	EA	8	$17,500.00	$140,000.00
c)	Concrete Headwall	EA	16	$5,000.00	$80,000.00
d)	Flap Gate	EA	8	$3,000.00	$24,000.00
e)	Riprap	MT	160	$141.00	$22,560.00
				Total 3D	$386,560.00
Section 3E	**Option 3: Road Raising (Canol Rd.)**				
a)	Rough Grading	M2	3740	$5.00	$18,700.00
b)	Subgrade Preparation	M2	3740	$5.00	$18,700.00
c)	80mm Minus Granular Subbase, Variable Depth	M3	1150	$40.00	$46,000.00
d)	100mm Minus Granular Base, 100mm Depth	M3	140	$50.00	$7,000.00
e)	BST Surfacing	M2	1010	$50.00	$50,500.00

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.

f)	Riprap	MT	300	$141.00	$42,300.00
				Total 3E	$183,200.00
				Contingency (20%)	$1,202,990.00
				Subtotal	$7,217,940.00
				Location Adjustment Factor (LCAF)	1.57
				Capital Costs Base Price	$11,332,200.00
				Capital Costs Upper Bound	$16,998,300.00

Table H15 Option 3 Annual Costs During a Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 3F	**Option 3: Annual Costs, Flood Year**				
a)	Inspections	LS	1	$25,000.00	$25,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$50,000.00	$50,000.00
c)	Storage of Superbags and Sandbags	LS	1	$500.00	$500.00
d)	Sandbags c/w Sandfill (1.0m - 2.0m)	M	140	$464.00	$64,960.00
				Total 3F	$140,460.00
				Contingency (20%)	$28,092.00
				Subtotal	$168,552.00
				Location Adjustment Factor (LCAF)	1.57
				Annual Cost Flood Year Base Price	$264,600.00
				Annual Cost, Flood Year Upper Bound	$396,900.00

Table H16 Option 3 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 3G	**Option 3: Annual Costs, Non-Flood Year**				
a)	Inspections	LS	1	$10,000.00	$10,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$10,000.00	$10,000.00
c)	Storage of Superbags and Sandbags	LS	1	$500.00	$500.00
				Total 3G	$20,500.00
				Contingency (20%)	$4,100.00
				Subtotal	$24,600.00
				Location Adjustment Factor (LCAF)	1.57
				Annual Cost, Non-Flood Year Base Price	$38,600.00
				Annual Cost, Non-Flood Year Upper Bound	$57,900.00

Qualitative Evaluation

Table H17 summarizes the performance of Option 3 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table H17 Option 3 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	permanent structures and erosion mitigation measures would withstand wide range of flood durations and ice/debris damage hazards; seepage control measures may be required	High Performance
2	Time to Implementation	high regulatory risk; geotechnical borehole studies of the existing dike required; hydraulic modelling, river migration, and erosion risk studies required; property owner agreements required; substantial design requirements requiring baseline studies to have been completed	Low Performance
3	Capital Cost Per Inundated Property	reduced capital costs in exchange for increased operational and maintenance costs when compared to permanent flood mitigation infrastructure (Option 3); per-inundated-property capital cost is $879,273/property	Low Performance
4	Maintenance and Storage	minimal storage requirements (sandbags for 1 temporary sandbag dike); earthen dike will require inspections, maintenance, and vegetation clearing; periodic road inspections may be required; floodbox maintenance required	Medium Performance
5	Response and Activation	1 property-owner deployed temporary sandbag dikes; floodbox slide gates would need to be manually closed prior to arrival of flood and opened following abatement of the flood	High Performance
6	Aesthetics and Community Function	substantial permanent alteration of existing landscape and river views by earthen dike (2.0 - 2.5 m in height); dike crests may be established as community features (e.g., walking paths) if the community members are supportive	Low Performance
7	Future Adaptability	temporary superbag dike may be deployed on earthen dike crest and raised roads in future for enhanced flood mitigation; additional sandbags may be provided for raising temporary sandbag dikes; permanent increases in height to dike and road are possible but will require engineering study and are likely to require widening of structure	Medium Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	shifting of flood mitigation line to south and removal of northern portion of dike would result in increased floodplain conveyance and may reduce flood WSEs; studies required to identify whether increased floodplain capacity would positively or negatively affect ice processes and erosion/sedimentation; slope stabilization measures may be required over an approximate length of 280 m	Medium Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	compared to other communities, the ROI for Ross River and Option 3 is low, given that majority of facilities are private entities (11 properties) and no community buildings are at risk	Low Performance

H.2.4 SUMMARY TABLES

Table H18 summarizes the Class D OPCs for the three conceptual design options.

Table H18 Summary of Class D Cost Estimates

	Option 1 Class D OPCs	Option 2 Class D OPCs	Option 3 Class D OPCs
Capital Cost	$8,410,100 - $12,615,200	$5,795,600 - $8,693,400	$11,332,200 - $16,998,300
Annual Cost (Flood Year)	$829,900 - $1,244,850	$773,300 - $1,160,000	$264,600 - $396,900
Annual Cost (Non-Flood Year)	$38,600 - $57,900	$29,200 - $43,800	$38,600 - $57,900

Table H19 provides a summary of the evaluation of each of the conceptual design options.

Table H19 Summary of Costs and Evaluation of Conceptual Options

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