Appendix J Mayo 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.

J.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 the Mayo area.

J.1.1 POPULATION

Mayo has a population of 188 with 149 private dwellings according to 2021 census data (Statistics Canada 2023c). The population has decreased by approximately 6% from 2016 when the population was 200 (Statistics Canada 2023c).

J.1.2 STUDY AREA

The Study Area in Figure J2 outlines the areas that flood mitigations are being conceptually designed for in this Project in the Mayo area. The boundaries of the Study Area are based on Stantec's understanding that the flood mitigations are to be conceptually designed for communities, and that individual properties outside of the main community consolidation are not to be included.

J.1.3 FIRST NATIONS

The Mayo area is within the Traditional Territory of the First Nation of Na-Cho Nyak Dun (FNNND). The FNNND have parcels of Category B and Fee Simple Lands in the Mayo area. The land claim selection is C-22B, C-33FS/D, C-37FS/D along the Stewart River, and parcels C-6B and C-55FS along the Mayo River. No Category A Settlement Lands with associated surface and subsurface ownership were identified along the Stewart River or Mayo River within the Study Area. Figure J2 illustrates the TH settlement lands within the Study Area.

J.1.4 BATHYMETRY AND TOPOGRAPHY

Bathymetry data for Stewart River at Mayo were not provided to Stantec.

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, CGVD1928 (Government of Yukon 2022d)
- Bathymetric data from 14 surveyed cross-sections on the Mayo River south of Silver Trail bridge were used for hydraulic calculations, data was obtained from Morrison Hershfield (2015).

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).

J.1.5 GEOLOGY

Based on the surficial geology mapping (Yukon Geological Survey 2020), the Study Area likely consists of a veneer of anthropogenic material (fill) underlain by alluvial plain deposits made up of silt, sand, and gravel. The alluvial deposits near the shoreline of the Stewart River are covered with a blanket of active fluvial deposits also generally made up of gravel, sand, and silt. Thermokarst terrain, such as that seen in Mayo, is typically common in areas underlain by permafrost and is caused by the melting of ground ice.

Based on the Permafrost Probability Model (Bonnaventure et al. 2012), the Study Area is located within a region of extensive discontinuous permafrost (50-60% of land underlain by permafrost). The Canada Permafrost Map (National Atlas of Canada 1995) also indicates the Study Area is in a region of extensive discontinuous permafrost (50-90% of land underlain by permafrost) with a low to medium (<10-20% by volume of visible ice) ground ice content in the upper 10-20 m of the ground.

J.1.6 HYDROGEOLOGY

The fill and alluvial plain deposits made up of silt, sand, and gravel encountered within the Study Area are likely to result in relatively slow to medium 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 Stewart River and Mayo River water levels. There is strong evidence of a direct hydraulic link between the Mayo and Stewart Rivers and the unconfined aquifer that extends under the dike and the Village of Mayo. Rising water levels in Mayo River result in the groundwater levels rising in the aquifer and result in water emerging in low-lying areas in the community within hours (Morrison Hershfield 2015; KGS Group 2012b). The subsurface consists of sands and gravels in a laterally extensive unconfined aquifer approximately 5 to 7 m thick and is underlain by clays and silts to a depth of at least 12.3 m based on drilling programs completed for water wells in the community (Morrison Hershfield 2015).

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.

J.1.7 PAST FLOODING EVENTS AND RESPONSE

Mayo has been subject to three flooding events of note since 2010. 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. Historical water surface elevations (WSEs) at Water Survey of Canada (WSC) Station 09DC006 (Stewart River near Mayo) are illustrated in Figure J1.

All documented events were associated with ice-related flooding on the Mayo River. The Yukon Energy Corporation (YEC) Mayo hydroelectric generating stations and storage facilities are located to the north of the Study Area and flows are modified by dam operations. There is no WSC station or other gauge station on the Mayo River with data made available to Stantec at the time of writing.

In additional to the specific surface water flooding events noted, frequent basement flooding has occurred within the community, generally along Fourth Ave. These events have often occurred yearly and are suspected to be caused by the shallow groundwater table that is hydraulically connected to the Mayo River and Stewart River (KGS Group 2012b).

Winter 2010-2011 Flooding Event

Early winter flooding occurred in December 2010 through January 2011 in Mayo (AECOM 2012). Flooding was attributed to ice accumulation in Mayo River that resulted in reduced flow capacity. Flooding occurred in low-lying locations on the community-side of the dike, including YEC's diesel generating station and neighbouring properties. The cause of the flooding was ice jamming on the Mayo River causing water levels to rise in low-lying areas in the community (Morrison Hershfield 2015). The dike was not overtopped, and post-flood investigations of the dike structure suggest it is constructed of coarse sediment with no inner impermeable core (KGS Group 2012b) and it is suspected that the pervious subsurface conveyed groundwater to the under the dike to the community (Morrison Hershfield 2015). Available documentation is unclear if the water in the community was from surface water seepage through the dike or a rise in the water table, or a combination of both. Additional details on the geotechnical condition of the dike are in Section J.1.8.

YG Emergency Measures Organization (EMO) flood response included in-channel ice removal, excavation of existing side channels to accommodate a larger volume of flow, pumping water from the floodplain back into the active channel, and excavation of two diversion channels at meander necks on the Mayo River, south of the Silver Trail highway (Morrison Hershfield 2015). These measures were successful in lowering water levels and preventing substantial damage to community infrastructure (AECOM 2012).

Winter 2011-2012 Flooding Event

Flooding patterns similar to those experienced the previous winter occurred on the Mayo River in late 2011 (Morrison Hershfield, 2015). The two diversion channels excavated the previous year were re-opened prior to significant flooding in the community occurring (Morrison Hershfield, 2015). No documented occurrences of community flooding were noted in the documentation provided to Stantec. Documented mitigation measures were limited to opening of the diversion channels and stock piling of rip rap for future armoring of eroding riverbanks (Nixon 2011).

Winter 2012-2013 Flooding Event

Early winter flooding attributed to freeze up occurred again in November 2012. The two diversion channels were re-opened in December 2012, and ice removal continued throughout the winter of 2012/2013 and no references to flooding in the community were noted (Morrison Hershfield 2015).

J.1.8 EXISTING FLOOD MITIGATION INFRASTRUCTURE

The most prominent flood mitigation infrastructure is Dike Road which is oriented generally north-south along the west side of the community, and east-west along the Stewart River at the south end of the community. The dike was constructed sometime in the late 1950s/early 1960s. The dike was constructed to protect the community from high water floodevents during spring break-up flood and provide a raised access route during flooding on the Stewart River or Mayo River (KGS Group 2012b; AECOM 2012). The dike was constructed from pervious sandy gravel material and no impermeable core was incorporated into the dike (KGS Group 2012b; AECOM 2012; Morrison Hershfield 2015) and is not expected to be sufficiently competent to protect the community from high water levels and associated seepage. The rising of the water table within the diked area and flooding of the community is expected to occur before the dike is overtopped by surface water (KGS Group 2012b).

The dike crest elevation in the Study Area varies from approximately 490.8 to 493.5 m (assumed to be relative to CGVD28 datum, corresponding to an elevation of approximately 490.9 to 493.6 m CGVD 2013 datum) (KGS Group 2012b). The ground below the dike from 5 to 7 m below the ground surface consists of porous sand and gravel to gravely sand. The berm has proven to be effective at preventing flooding in early spring when the berm and subsurface are frozen at a depth of up to 4.5 m (KGS Group 2012b).

In response to the re-occurring annual flooding caused by ice formation during freeze-up, YEC adopted an alternate winter operations protocol for Mayo River. This protocol was first implemented in winter 2014/15 and promoted the formation of a stable, full ice cover to reduced frazil ice generation. Flows are maintained at a high, consistent level during the freeze-up period while a stable, sufficiently high ice cover is formed that can accommodate flows for the duration of winter (Morrison Hershfield 2015). Throughout the winter, rapid fluctuations in water levels in Mayo River are avoided as this could collapse the ice cover and increase the potential for ice jamming (Morrison Hershfield 2015). The winter freeze-up protocol has been effective at reducing the risk of ice-related flooding on the Mayo River and has been the preferred mitigation option for reducing flooding potential in the community (Morrison Hershfield, 2015, 2017).

In 2016 and 2017 construction works were completed to increase the hydraulic capacity of Mayo River and reduce flooding potential from ice formation. These works included sediment removal and bank protection. The two diversion channels that were constructed as emergency measures in 2010/2011 were formally established as they were effective at reducing water levels in lower Mayo River during subsequent ice jamming events (Morrison Hershfield, 2015).

J.1.9 WIND, WAVES, AND EROSION

While floodplain mapping and hydraulic modelling of the Design Flood Service Level (DFSL) has not been completed for Mayo to date, it is likely that flow velocities in the Stewart River and Mayo River during flood conditions would require erosion mitigations. 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 require additional flood mitigation design at Mayo.

J.1.10 HYDROLOGY

There are two rivers in the Mayo Study area: the Stewart River and the Mayo River (Figure J2).

Stewart River

The Stewart River is the major water feature at Mayo (Figure J2). This river originates in the Selwyn Mountains and conveys snowmelt- and rainfall-induced runoff in a roughly westward direction to Stewart Crossing before eventually discharging into the Yukon River.

WSC Station 09DC006 (Stewart River near Mayo) is located on the north side of the Stewart River in the central part of the community (Figure J2). Gross drainage area to the WSC station is not reported by GoC (2023). Limited historical hydraulic modelling has been completed for Mayo. NHC (2005) estimated design flood flows up to the 1:200-year event on the Stewart River using historical WSC datasets from 1949 to 1995. Quality assurance and verification of these models has not been completed by Stantec and additional and updated hydraulic modelling is beyond the scope of this Project. Therefore, hydrology review considered WSEs but not the discharges at WSC Station 09DC006.

Flood frequency analysis for WSEs was performed by both Morrison Hershfield (2022) and Yukon University (2022) for WSEs at WSC Station 09DC006. Table J1 summarizes the frequency results of these two studies.

Table J1 Flood Frequency Analyses at WSC Station 09DC006 from Morrison Hershfield (2022) and Yukon University (2022)

	Morrison Hershfield (2022)	Yukon University (2022)
Years Included in Analysis	1980-2022 [a]	1970 - 2022
Number of Years	43	53
Selected Distribution	Lognormal 3	Log-Pearson Type 3
Water Surface Elevation (m) [1]		
1:2-Year Event (50% AEP)	486.93	487.00
1:20-Year Event (5% AEP)	488.47	488.50
1:100-Year Event (1% AEP)	489.22	not provided
1:200-Year Event (0.5% AEP)	489.51	489.40

Notes:
[a] Analysis done on open water peaks
[1] Elevations provided in CGVD2013 for WSC Station 09DC006

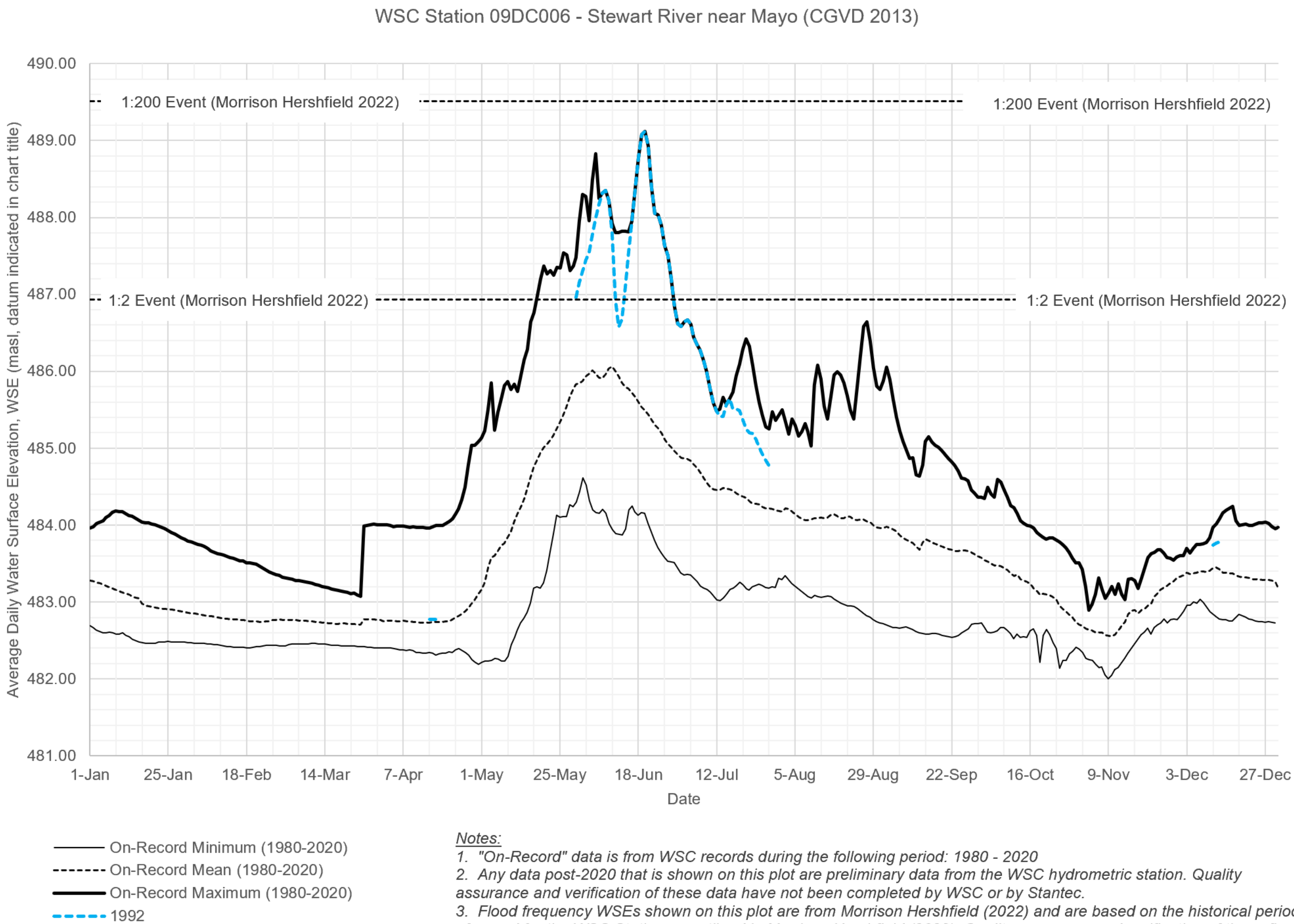
The Morrison Hershfield (2022) flood frequency analysis results were adopted for the Project because the 1:200-year event WSE was higher and would yield more conservative conceptual designs.

Figure J1 illustrates the on-record daily minimum, mean, and maximum WSEs, the WSE during the highest year on record (1992), and the WSEs for the 1:2-year and 1:200-year event at WSC Station 09DC006 from Morrison Hershfield (2022). Due to the presence of a large open water area downstream of the Mayo River outlet, ice processes on the Stewart River are generally governed by thermal processes. Since 1970 ice processes in the Stewart River have been associated with relatively low water levels and high open water levels have historically been the main process for flooding of Stewart River at Mayo (Yukon University 2022).

Mayo River

The Mayo River is the smaller of the two rivers in Mayo. Mayo River originates at the outlet of Mayo Lake, to the northeast of the community. The river flows to the west and then south into Wareham Lake and then joins the Stewart River immediately west of Mayo. YEC operates dams on Mayo Lake and Wareham Lake for water storage for the operation of the Mayo Generating station and as such flows on the Mayo River are regularly modified by the dam operations.

No WSC station is located along the Mayo River and no FFA results for WSEs are available. A historical FFA completed in 1987 (reference unavailable) was used by Morrison Hershfield (2015) and estimated peak flows in Mayo River during the spring freshet, including the 1:50-year flow event (208 m^3/s) and the 1:500-year flow event (335 m^3/s). An estimate of the 1:200-year flow was not included in this analysis. It is unlikely that these flows could be reached on Mayo River due to the flow regulation provided by YEC, and therefore represent conservative estimates of their corresponding AEPs.



Notes:
1. "On-Record" data is from WSC records during the following period: 1980 - 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 Morrison Hershfield (2022) and are based on the historical period of record for the WSC Station as outlined in Morrison Hershfield (2022). Quality assurance and verification of these flood frequency WSEs have not been completed by Stantec.

Figure J1 Historical Water Surface Elevations at WSC 09DC006 (Stewart River near Mayo)

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.

J.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. Limited hydraulic analysis on the Mayo River (Morrison Hershfield 2015) and Stewart River (NHC 2005) have been completed while floodplain mapping not been completed to date. Additional hydraulic studies and floodplain mapping are not within the scope of this Project. However, an understanding of inundation extents under 1:200-year event is required for conceptual design of flood mitigations.

In lieu of floodplain mapping, Stantec performed preliminary inundation analysis for Mayo using WSEs and existing river studies and surveys. The potential flood mitigating effect of the existing dike was not considered in the preliminary inundation analysis. This analysis combined the preliminary inundation at each of the main rivers in the Study Reach:

- The 1:200-year event WSE (489.51 m) at WSC Station 09DC006 from Morrison Hershfield (2022) and an assumed WSE slope of 0.02% on the Stewart River (based on survey from Underhill 2022).
- Open-channel hydraulic calculations using Manning's equation were completed at two cross-sections located 2 km and 1.3 km upstream from confluence with Stewart River (geometry from Morrison Hershfield 2015 and AEP flows as cited in Morrison Hershfield 2015). The estimated WSEs at the two modelled cross-sections for the 1:500-year open water event were approximately 0.4 m higher than the 1:50-year WSEs estimated by a hydraulic model developed by Morrison Hershfield (2015). Therefore, the constant offset of 0.4 m was applied to the Morrison Hershfield (2015) 1:50-year event hydraulic model results to obtain an estimated WSE profile for the 1:500-year event on the Mayo River between the Silver Trail Bridge (493.1 m) and the confluence with the Stewart River (486.1 m), for the purposes of preliminary inundation mapping.

The resulting water surface at each river were overlain on the existing conditions topographic/bathymetric elevation data (GeoYukon 2023) and the limits of inundation were mapped (Figure J2). The outer boundary of the combined inundation (Yukon and Nordenskiold Rivers) was adopted as the overall preliminary inundation for the Study Area (Figure J2). 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 WSE estimates from Morrison Hershfield (2022) and the results of a hydraulic calculations and a hydraulic model from Morrison Hershfield (2015). 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.

Flooding during the freeze-up period has the potential to result in WSE profiles along Mayo River that exceed the inundation mapping developed for open water conditions. No available winter FFA studies were available to Stantec at the time of writing, and available information indicates that YEC's winter freeze-up protocols have been generally effective at reducing winter flooding potential in the community (Morrison Hershfield 2015; Morrison Hershfield 2017). Although winter flooding conditions have not been included in the preliminary analysis, it should be part of a floodplain mapping study in the future.

The preliminary inundation results (with no dike present) indicate nearly the entire main part of the community is inundated. This inundation extends from First Ave to Seventh Ave and from Mayo River to Mayo Road on the east side of community, including portions of the local health centre, fire hall, and the water treatment plant. Approximately 170 m of Mayo Road is inundated, restricting access to the main part of the community to Dike Road. YEC's diesel plant is partially inundated and the gas station at the north end of the community is nearly entirely inundated.

The preliminary inundation analysis indicated that an estimate 103 private residence properties and 5 major community features/properties (health centre, fire hall, recreation complex, YEC's diesel generating plant and Northern Tutchone Regional Duty Office) would have at least 25% of their area inundated and classified as "inundated properties".

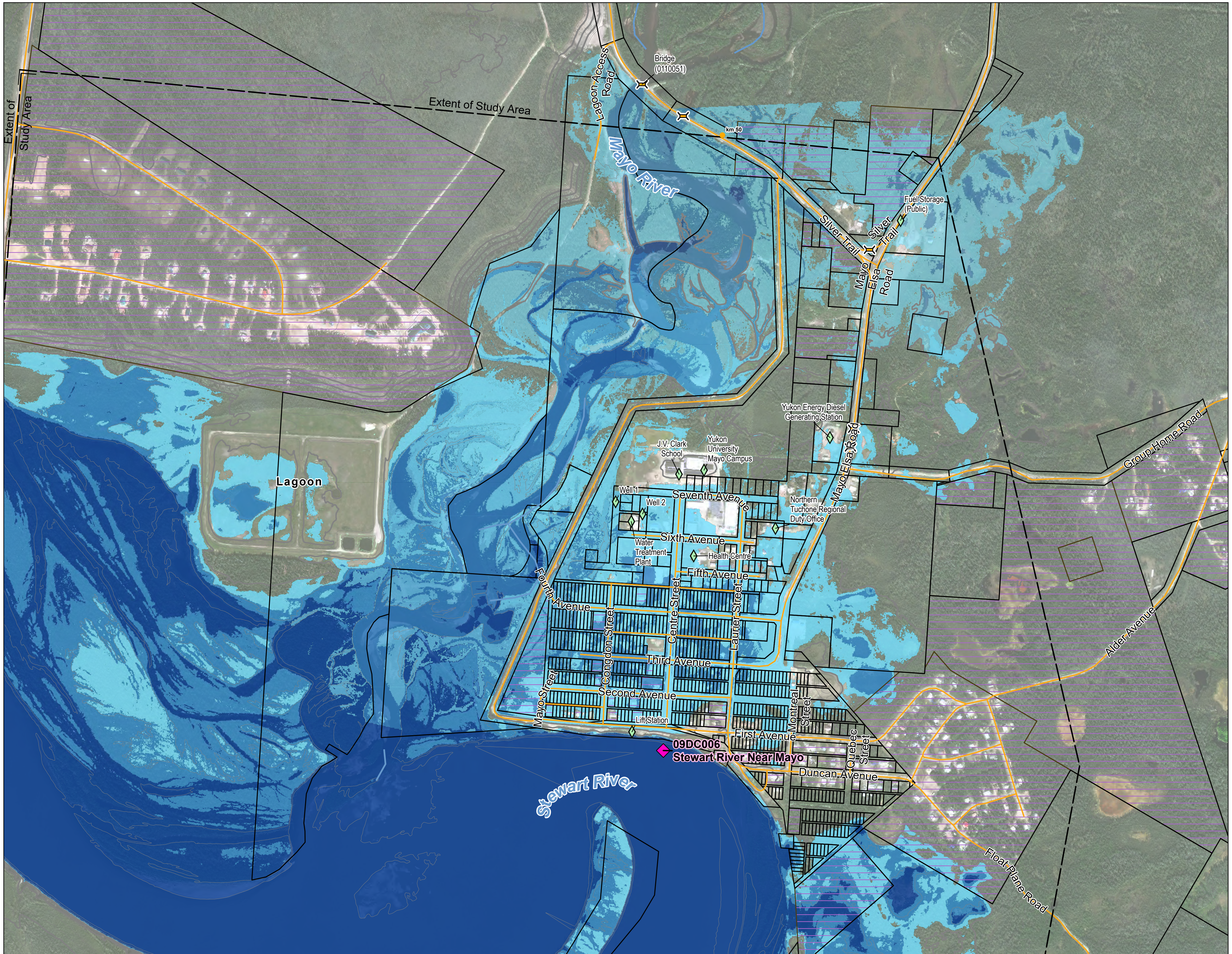


Figure No.

J2

Title

Existing Conditions and Preliminary Flood Inundation at Mayo

Client/Project 144903232

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

Project Location
Mayo,
Yukon

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

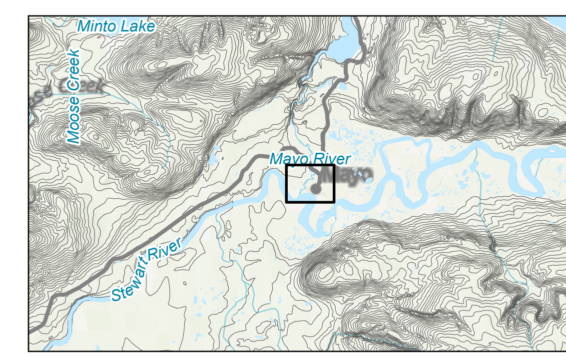
N

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

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
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

Stantec Yukon

S:\1232\projects\144903232\figures\reports\YukonWide\YukonWideFigures.aprx Revised: 2023-07-04 By: LTrudell

J.2 Mitigation Options and Evaluation

The scope of this Project is to develop conceptual engineered flood mitigation options; these options for Mayo 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, one flood mitigation option was developed for Mayo (Table J2) using combinations of the typical engineered flood mitigation designs from Section 3.3.2. A single mitigation option was developed for Mayo as all considered options included the continued use of a dike on the west and south sides of the community. Minor variations on this design option were considered but were not sufficiently different to justify the development of more than one mitigation option:

- The extensive excavation requirements to improve the existing dike to meet the typical dike design standards would result in a near-complete removal of the dike. A complete removal option is therefore not warranted.
- A platform with temporary superbag dikes was considered, but the minor reduction in construction costs was not justified by the reduced resiliency and increased response and activation effort.

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.

Flood mitigations are provided for areas which are inundated under the 1:200-year WSE (489.51 m on Stewart River and 493.1 m on Mayo River at the Silver Trail bridge crossing) in the preliminary inundation mapping (Figure J2).

The top elevation of the flood mitigations are designed to reach the DFSL which in the case of Mayo (river site) is assumed to be the higher of the following at each modelled location in the community: 490.01 m for Stewart River inundation and 493.6 m for Mayo River inundation (i.e., 0.5 m above the 1:200-year WSE as outlined for river sites in Section 3.2).

Table J2 Summary of Conceptual Design Options

Location	Option 1
	higher capital costs, lower response/maintenance
Dike Road	Earthen Dike Upgrades

Section J.2.1 provide a description, Class D costing, and qualitative evaluation of the conceptual option specified in Table J2.

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

- Groundwater seepage to the community-side of the dike has been documented and has the potential to inundate roads and buildings throughout the community. Road raising to maintain access to Mayo and within the community was not advanced as mitigation design specifically for groundwater seepage is beyond the scope of this Project. Additionally, mitigating the risk of potential damage to critical infrastructure in the community (e.g., health centre, water treatment plant and YEC's diesel generating plant) may require the construction of temporary sandbag dikes and sumps with pumps to remove seepage water. Although mitigating the effects of groundwater seepage is beyond the scope of this Project, additional studies are recommended to address this potential.

J.2.1 OPTION 1

Description

The conceptual flood mitigations for Option 1 are illustrated in Figure J3.

On the west and south side of the community, the full 2500 m length of the existing dike would be upgraded to meet the typical earthen dike design, including a clay core (as outlined in Section 3.3.2). The dike would be extended approximately 200 m at the southeast side of the community to mitigate the flood risk for the single property at 57 Montreal Street. Available geotechnical borehole testing and analysis indicate that the dike is constructed from coarse sediment and no impermeable clay core material was incorporated (KGS Group 2012b). Approximately 150 m of the dike would need to be raised by 0.5 to 1.5 m to reach the DFSL. The remainder of the dike meets or exceeds the DFSL. The existing dike slopes vary (sometimes less than 3H:1V, sometimes greater than 3H:1V); proposed conditions embankment slopes of 3H:1V would be established on both sides of the dike to match the typical earthen dike design described in this Report. The footprint of the upgraded earthen dike would be approximately 25 to 30 m wide. The earthen dike footprint and the root-free zone may encroach onto private property meaning agreements may be required with landowners. Clay material would be imported to site for the construction of the new clay core in the dike. The volume of clay required in Mayo may justify studies for alternative methods for construction an impermeable clay core, including clay cutoff walls. The location of the clay core may need to be adjusted at the municipal lift station at the Stewart River between Centre Street and Congdon Steet as to not interfere with buried pipes. Investigations are recommended to confirm the location and alignment of underground infrastructure between the lift station and the western edge of the dike.

Existing coarse material that is excavated during dike upgrades would be re-used for the extended embankment slopes and the granular dike shell. 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 additional geotechnical investigations.

As illustrated in Figure J2, the access road surrounding the lagoon acts as a dike and would mitigate against surface water entering the lagoon under 1:200-year event conditions. However, the land inside the road (i.e., in the lagoon) is below 1:200-year WSE meaning it is susceptible to seepage during flood conditions. Seepage may cause lagoon liners to float and dislodge. Seepage-specific designs are outside the scope of this Project. It is recommended that geotechnical and hydrogeological study be performed to evaluate the seepage and stability risk to the road, lagoons, wells, and pump stations. Portions of the access road leading to the sewage lagoon are inundated during the 1:200-year event. It is suspected that this road is infrequently used and not critical to the operation of the lagoon.

Figure No.

J3

Title

Mayo 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
Mayo,
Yukon

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

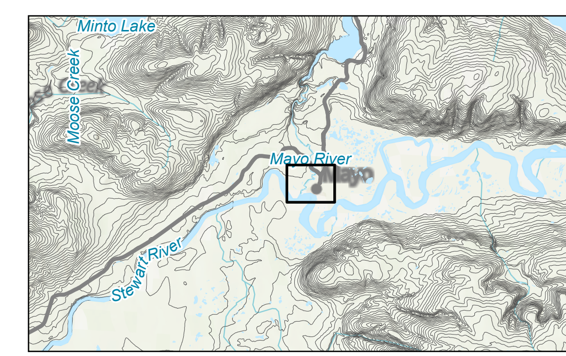
N

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

- WSC Station
- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- 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

S:\1232\projects\144903232\figures\reports\YukonWide\YukonWideFiguresExport.aprx Revised: 2023-07-04 By: LTrudell

Class D OPC

The Class D OPC's for capital and annual costs are summarized in Table J3, considering the Class D level of accuracy (+/-50%). Table J3 also provides the Class D OPCs on a per-inundated property basis (from Section J.1.11).

Table J3 Option 1 Summary of Class D OPCs

	Class D OPC					Number of Inundated Properties (Section J.1.11)[1]	Class D OPC per Inundated Property				
Capital Cost	$	54,845,700	-	$	82,268,550	108	$	507,831	-	$	761,746
Annual Cost (Flood Year)	$	267,960	-	$	401,940		$	2,482	-	$	3,722
Annual Cost (Non-Flood Year)	$	36,540	-	$	54,810		$	339	-	$	508

[1] As described in Section J.1.11, the inundated properties from the preliminary inundation analysis consists of 103 private residences and 5 major community features.

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table J4 (capital costs), Table J5 (annual cost, flood year), and Table J6 (annual cost, non-flood year).

Table J4 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	$2,010,240.00	$2,010,240.00
	b)	Site Preparation/Restoration	LS	1	$402,100.00	$402,100.00
					Total 1A	$2,412,340.00
Section 1B		**Option 1: Earthworks & Landscaping, Earthen Dike (Restoration)**				
	a)	Clearing and Grubbing	M2	73000	$10.00	$730,000.00
	b)	Cut and Re-use Onsite - Native Material	M3	8700	$15.00	$130,500.00
	c)	Cut and Dispose Offsite - Native Material	M3	66680	$30.00	$2,000,400.00
	d)	Import and Place Fill - Native Material	M3	8700	$15.00	$130,500.00
	e)	Embankment Fill, Clay Core	M3	55550	$100.00	$5,555,000.00
	f)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	21900	$25.00	$547,500.00
	g)	Riprap	MT	30370	$141.00	$4,282,170.00
	h)	Geotextile Fabric	M2	25950	$10.00	$259,500.00
	i)	Embankment Seeding	M2	43350	$5.00	$216,750.00
	j)	Embankment Topsoil	M2	43350	$20.00	$867,000.00
	k)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	2500	$300.00	$750,000.00
	l)	Slope Stabilization	M	1100	$3,000.00	$3,300,000.00
					Total 1B	$18,769,320.00
Section 1C		**Option 1: Floodboxes, Earthen Berm**				
	a)	Reinforced Concrete Pipe	M	500	$1,000.00	$500,000.00
	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)	Flap Gate	EA	25	$3,000.00	$75,000.00
	e)	Riprap	MT	500	$141.00	$70,500.00
					Total 1C	$1,333,000.00
					Contingency (20%)	$4,502,932.00
					Subtotal	$27,017,592.00
					Location Adjustment Factor (LCAF)	2.03
					Capital Costs Base Price	$54,845,700.00
					Capital Costs Upper Bound	$82,268,550.00

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 J5 Option 1 Annual Costs During a Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1D	**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
				Total 1D	$110,000.00
				Contingency (20%)	$22,000.00
				Subtotal	$132,000.00
				Location Adjustment Factor (LCAF)	2.03
				Annual Cost Flood Year Base Price	$267,960.00
				Annual Cost, Flood Year Upper Bound	$401,940.00

Table J6 Option 1 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1E	**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
				Total 1E	$15,000.00
				Contingency (20%)	$3,000.00
				Subtotal	$18,000.00
				Location Adjustment Factor (LCAF)	2.03
				Annual Cost, Non-Flood Year Base Price	$36,540.00
				Annual Cost, Non-Flood Year Upper Bound	$54,810.00

Qualitative Evaluation

Table J7 summarizes the performance of Option 1 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table J7 Option 1 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	flooding duration is relatively short (on the scale of weeks not months); wind/wave impacts minimal; permanent dike to withstand high velocities; moderate potential for damage from ice of historical operation of Mayo Generating Station; seepage control measures likely required given history of flooding without overtopping of existing dike	Medium Performance
2	Time to Implementation	medium regulatory risk; additional geotechnical borehole studies of the existing dike required; hydraulic modelling, river migration, and erosion risk studies required; property owner agreements may be required; moderate design requirements provided baseline studies have been completed; seepage studies required to evaluate rate of groundwater flow under dike and potential to cause flooding in community.	Medium Performance
3	Capital Cost Per Inundated Property	Permanent flood mitigation infrastructure provides increased capital costs in exchange for decreased operational and maintenance costs; per-inundated-property capital cost is $507,831/property	Medium Performance
4	Maintenance and Storage	no storage requirements; dike will require inspections, maintenance, and vegetation clearing; floodbox maintenance will be required	High Performance
5	Response and Activation	minimal response required during flooding event, floodbox slide gates need to be manually closed prior to arrival of flood and opened following abatement of the flood; may need to deploy seepage water mitigations within diked area.	High Performance
6	Aesthetics and Community Function	dike widening along entire length and minor extension at southeast end of community produces minor change to existing aesthetics and community function	High Performance
7	Future Adaptability	temporary superbag dike may be deployed on earthen dike crest in future for enhanced flood mitigation; permanent increases in height to dikes are possible but will require engineering study and are likely to require widening of structure. Limited potential to address existing groundwater flow potential under dike.	High Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	intrusions into Stewart River and Mayo River are not anticipated to disrupt existing river processes	High Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	relatively high ROI due to upgrading of existing infrastructure that would reduce flood risk to substantial portion of the community	High Performance

J.2.2 SUMMARY TABLES

Table J8 summarizes the Class D OPC for the one conceptual design options.

Table J8 Summary of Class D Cost OPC

	Option 1 Class D OPCs		
Capital Cost	$54,845,700	-	$82,268,550
Annual Cost (Flood Year)	$267,960	-	$401,940
Annual Cost (Non-Flood Year)	$36,540	-	$54,810

Table J9 provides a summary of the evaluation of each of the conceptual design option.

Table J9 Summary of Costs and Evaluation of Conceptual Options

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