Appendix P Jackfish Bay 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.

P.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 Jackfish Bay.

P.1.1 POPULATION

Census data specific to the Jackfish Bay was not available. Based on available aerial imagery, there are approximately 37 private properties with structure on them within the Study Area.

P.1.2 STUDY AREA

The Study Area in Figure P2 outlines the areas that are being designed in this Project at Jackfish Bay. The boundaries of the Study Area are based on Stantec's understanding that the flood mitigations are to be considered for communities, and that individual properties outside of the main community consolidation are not included.

P.1.3 FIRST NATIONS

The Jackfish Bay area is within the Traditional Territories of the Ta'an Kwäch'än Council (TKC) and Kwanlin Dün First Nation (KDFN). The TKC has parcels of Category B Settlement Lands near Jackfish Bay, along Lake Laberge. The land claim selections are S-39B1 and S-16B1. This means that TKC has surface ownership of these parcels of land (Government of Yukon 2022). Figure P2 illustrates the TKC and KDFN settlement lands within the Study Area.

P.1.4 BATHYMETRY AND TOPOGRAPHY

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

- 2022 LiDAR LAS files UTM Zone 8 CSRS NAD1983, CGVD2013 (McElhanney Ltd, GeoYukon 2023) and interpolated into a derivative 1m horizontal resolution Digital Elevation Model (DEM) (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).

P.1.5 GEOLOGY

Based on the surficial geology mapping (Yukon Geological Survey 2020), the Study Area likely consists of a veneer of glacial deposits (Till), deposited directly by glacier ice without modification by any other agent of transportation. The till deposits are estimated to be between 10 cm to 1 m in thickness and are underlain by Pre-Quaternary Bedrock. 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 in the Study Area likely 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. The underlying bedrock consists of volcanic, volcaniclastic, clastic and carbonate rocks of the Lewes River Group (Upper Triassic); volcaniclastic, clastic and coal of the Laberge Group (Lower-Middle Jurassic); and clastics and coal of the Tantalus Formation (Upper-Lower Cretaceous; Wheeler 1961; Lowey 2005).

Based on the Permafrost Probability Model (Bonnaventure et al. 2012), the Study Area is located within a region of sporadic discontinuous permafrost (20-30% of land area underlain by permafrost). The Canada Permafrost Map (National Atlas of Canada 1995) also indicates the Study Area is in a region of sporadic discontinuous permafrost (10-50% of land area underlain by permafrost) with a low (<10% by volume of visible ice) ground ice content in the upper 10-20 m of the ground.

P.1.6 HYDROGEOLOGY

The veneer of till deposits with a matrix of sand, silt and clay and the underlying bedrock encountered within the Study Area are likely to result in relatively 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 Lake Laberge 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.

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 design.

P.1.7 PAST FLOODING EVENTS AND RESPONSE

A summary of formally documented flood events are provided below. The flood events summarized below do no 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 09AB010 (Lake Laberge near Whitehorse) are illustrated in Figure P1.

2021 Flood Event

In 2021, Jackfish Bay on Lake Laberge experienced high lake levels that affected shoreline properties. The summer peak was caused by high flows from the Southern Lakes and Kusawa Lake, through the Takhini River. YG, Emergency Measures Organization (EMO), and Wildland Fire Management (WMF) supported this community through the flooding in 2021 by raising a small section of Jackfish Bay Road to allow access to private properties that were becoming inaccessible. WFM was on site throughout the summer installing superbags along the road and operating a pump to move water around. These noted Government Organizations also provided sand and sandbags for the community so private property owners were able to build sandbag berms to protect their properties. Property owners also installed their own sump and pumping systems. WSC Station 09AB010 reported a peak instantaneous WSE of 628.00 m (at the WSC station) on July 15, 2021 (GoC 2023).

P.1.8 EXISTING FLOOD MITIGATION INFRASTRUCTURE

Jackfish Bay currently has no existing permanent flood mitigation infrastructure documented within the Study Area. It is unknown if the emergency-state raising of Jackfish Bay Road met design and construction standards for permanent roads.

P.1.9 WIND, WAVES, AND EROSION

The low flow velocities at Lake Laberge are not expected to introduce erosion risks to flood mitigations. Erosion protection from riverine flow velocities is not anticipated to be required at Jackfish Bay flood mitigations.

As a lake community, Jackfish Bay is affected by erosion due to wind and waves. Flood mitigations would need to be capable of withstanding not only the erosion potential from wind and waves, but higher WSEs due to wave runup and potential lake seiche.

P.1.10 HYDROLOGY

The Lake Laberge is the major water feature at Jackfish Bay (Figure P2) and is the waterbody which causes flooding in this community. Lake Laberge is a widening of the Yukon River located approximately 25 km north (downstream) of Whitehorse. The Takhini River discharges into the Yukon River between Whitehorse and Lake Laberge. This means water levels in Lake Laberge are influenced by Yukon River flows through Whitehorse (controlled by the Whitehorse Dam and/or Miles Canyon) and flows in the Takhini River.

WSC Station 09AB010 Lake Laberge near Whitehorse is located on the west of Lake Laberge and Richthofen Island (Figure P1). Gross drainage area to WSC Station 09AB010 is not reported by GoC (2023). The hydrology review considered WSEs at WSC Station 09AB010. Flood frequency analysis for WSEs was performed by both Morrison Hershfield (2022) and Yukon University (2022) for WSEs at WSC Station 09AB010. Table P1 summarizes the frequency results of these two studies.

Table P1 Flood Frequency Analyses at WSC Station 09AB010 from Morrison Hershfield (2022) and Yukon University (2022)

	Morrison Hershfield (2022)	Yukon University (2022)
Years Included in Analysis	1980-2022	1970-2022
Number of Years	43	53
Selected Distribution	GEV	Gumbel
Water Surface Elevation (m) [1]		
1:2 Event (50% AEP)	626.70	626.70
1:20 Event (5% AEP)	627.51	627.60
1:100 Event (1% AEP)	627.96	not provided
1:200 Event (0.5% AEP)	628.14	628.40

NOTE:
[1] Elevations provided in CGVD2013 for WSC Station 09AB010

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.

Figure P1 illustrates the on-record daily minimum, mean, and maximum WSEs, the WSE during the highest year on record (2021), and the WSEs for the 1:2-year and 1:200-year event at WSC Station 09AB010 from Yukon University (2022). WSEs do not include wave runup which could be affected by wind, its direction, intensity, duration, and the beach profile. Normally, high outflows from Marsh Lake and Kusawa Lake (through the Takhini River) cause the summer peaks. During the peak water level in 2021, associated with a 50-year return period, the Takhini River supplied about 25% of the total Lake Laberge inflow; this ratio was even higher in 2022 (Yukon University 2022).

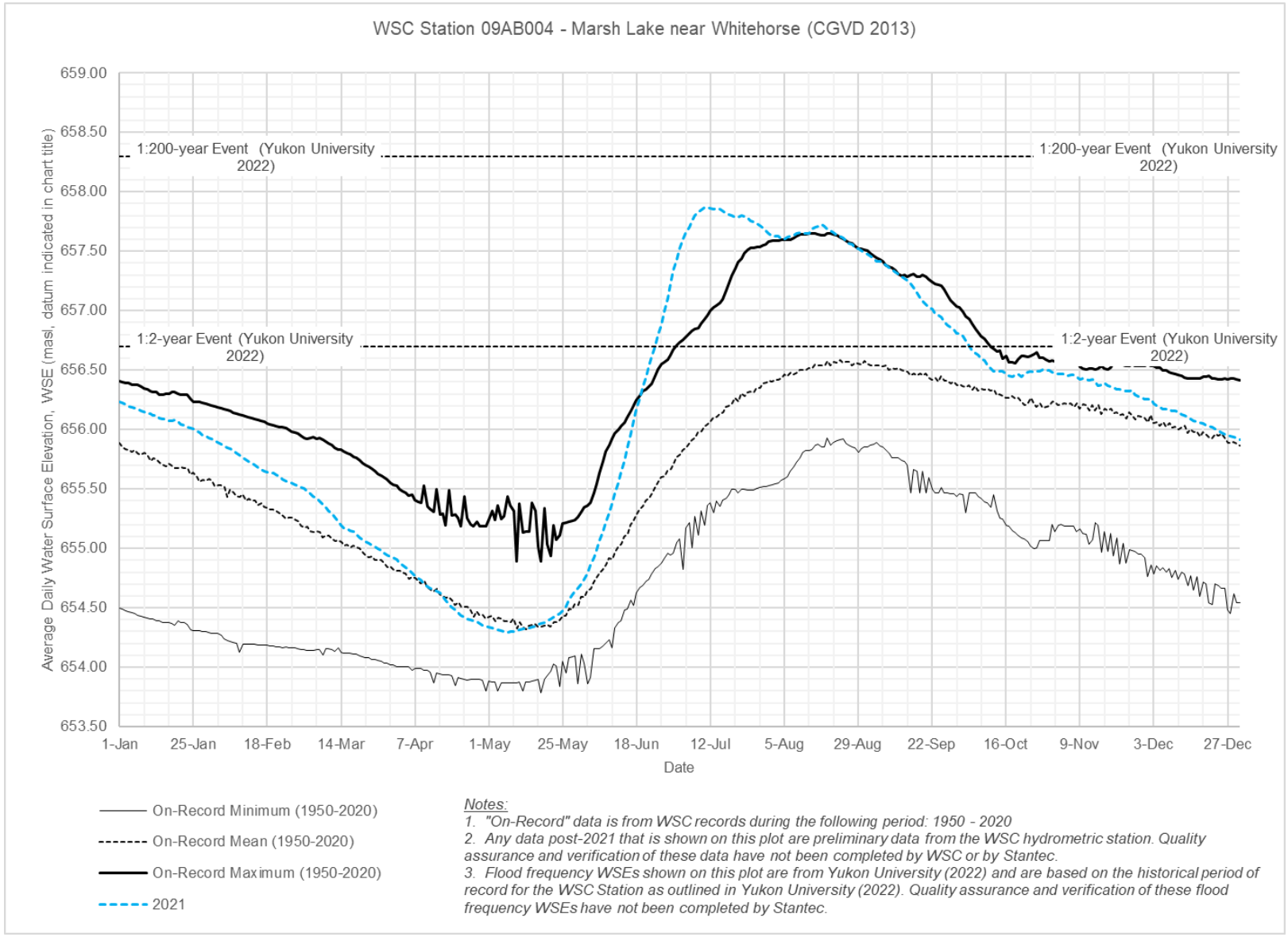


Figure P1 Historical Water Surface Elevations at WSC 09AB010 (Lake Laberge near Whitehorse)

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.

P.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. Wind/wave analysis and floodplain mapping have not been completed to date for the Study Area and is beyond the scope of this Project. However, an understanding of inundation extents under the 1:200-year event is required for conceptual design of flood mitigations.

In lieu of floodplain mapping, Stantec performed preliminary existing conditions (no mitigation) inundation analysis for Jackfish Bay using WSEs. This analysis considered the 1:200-year WSE (628.40 m) developed by Yukon University (2022) in a flat-water inundation scenario. The resulting water surface was overlain on the existing conditions topographic/bathymetric elevation data (GeoYukon 2023) and the limits of inundation were mapped (Figure P2). 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). 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.

Within the Study Area, the preliminary inundation results illustrate approximately 500 m of Jackfish Bay Road inundated; this would restrict access to residences along Duncan Lane and the north end of Jackfish Bay Road. The inundation completely covers a short section of the road and the four private properties near by. The inundation also encroaches a few properties along East Point Road.

The preliminary inundation analysis indicated that an estimated 8 private residence properties and 1 community feature/property (Jackfish Bay Road) would have at least 25% of their area inundated and classify as “inundated properties”.

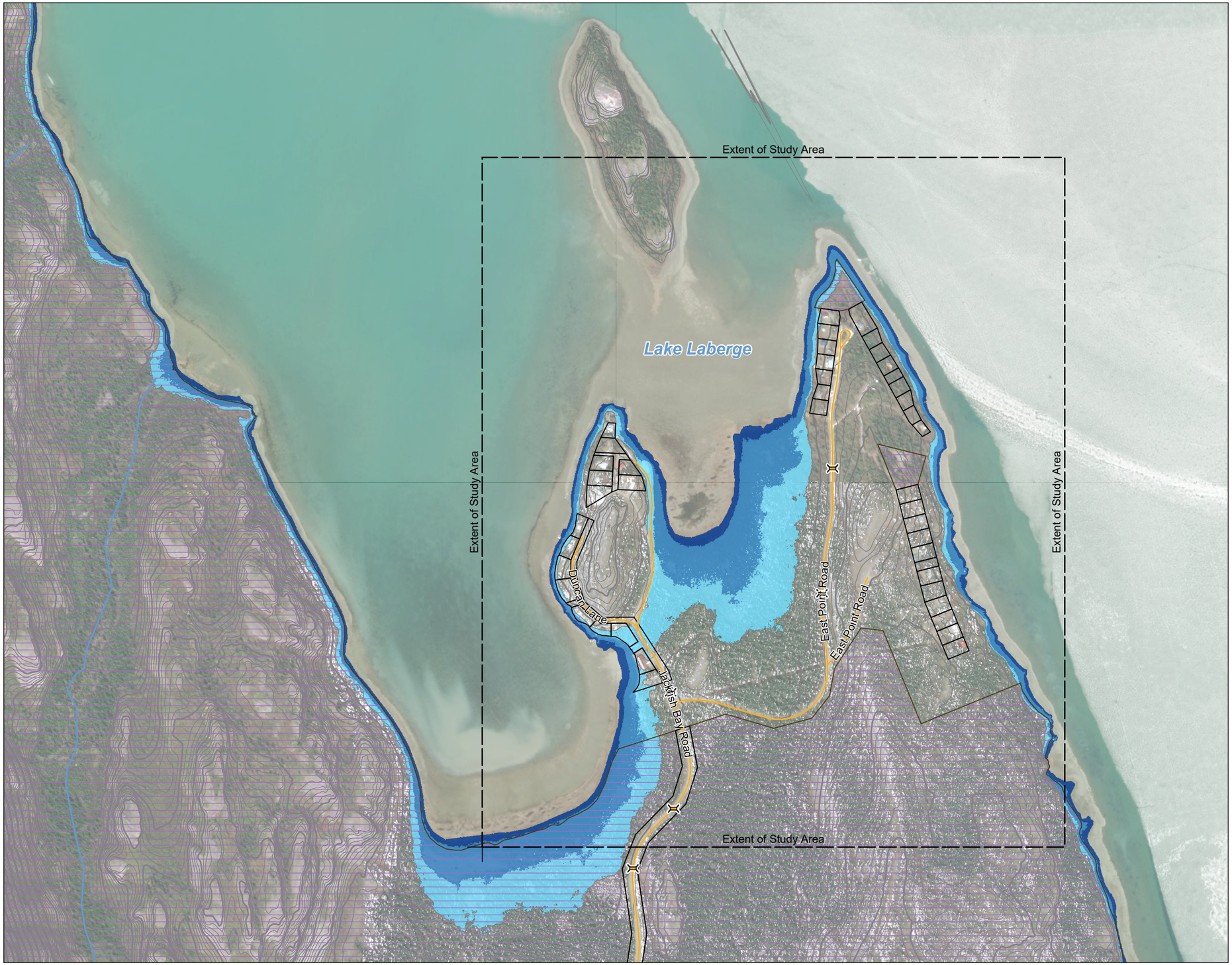


Figure No.

P2

Title

Existing Conditions and Preliminary Flood Inundation at Jackfish Bay

Client/Project 144903232

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

Project Location
Jackfish Bay,
Yukon

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

N

0 50 100 150 200 m

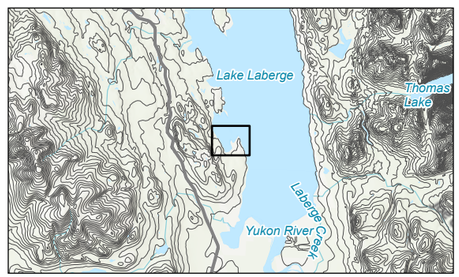
(At original document size of 11x17)
1:8,000

- Culvert/ Bridge
- 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:\123\2\projects\144903232\figures\reports\YukonWide\YukonWideFigures.aprx Revised: 2023-07-04 By: LTrudell

P.2 Mitigation Options and Evaluation

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

Based on the objectives and assumptions presented in the main body of this Report, two flood mitigation options were developed for Jackfish Bay (Table P2) using the typical engineered flood mitigation designs from Section 3.3.2. Flood mitigations in the options are provided for areas which are inundated under the 1:200-year WSE (628.40 m) in the preliminary inundation mapping (Figure P2). The top elevation of the flood mitigations is designed to reach the DFSL which in the case of Jackfish Bay (lake site) is assumed to be 630.40 m (i.e., 2.0 m above the 1:200-year WSE as outlined for lake 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 P2 Summary of Conceptual Design Options

Location	Option 1	Option 2
	lower capital costs, higher response/maintenance	*higher capital costs, lower response/maintenance*
Jackfish Bay Road	Platform with Temporary Superbag Dike	Road Raising
Private Properties on Jackfish Bay Road	Temporary Sandbag Dike	
Private Properties on Duncan Lane	Temporary Sandbag Dike	
Private Properties on East Point Road	Temporary Sandbag Dike	

Sections P.2.1 and P.2.2 provides a description, Class D costing, and qualitative evaluation of conceptual options specified in Table P2.

P.2.1 OPTION 1

Description

The conceptual flood mitigations for Option 1 are illustrated in Figure P3.

As illustrated on the inundation mapping, approximately 300 m of the north end of Jackfish Bay Road is fully inundated and requires flood mitigations. In order to reach the DFSL, a temporary double superbag dike would be constructed on the lake side of this 300 m length of Jackfish Bay Road. An approximately 50 m long section (at the south end of the impacted length of road) would require a double superbag dike on both sides of the road. The construction of a superbag dike for this segment of Jackfish Bay Road would maintain access to dwellings located along Duncan Lane and the north end of Jackfish Bay Road.

There are 8 private properties along Jackfish Bay Road, Duncan Lane and East Point Road that are located within area inundated under the preliminary analysis and would require a temporary sandbag dike around the structures during flood conditions. The depth of flooding around these properties is less than 1 m and as such can be protected with the construction of sandbag dikes. The temporary sandbags would be up to 3 m high to meet the DFSL with a total length of approximately 650 m.

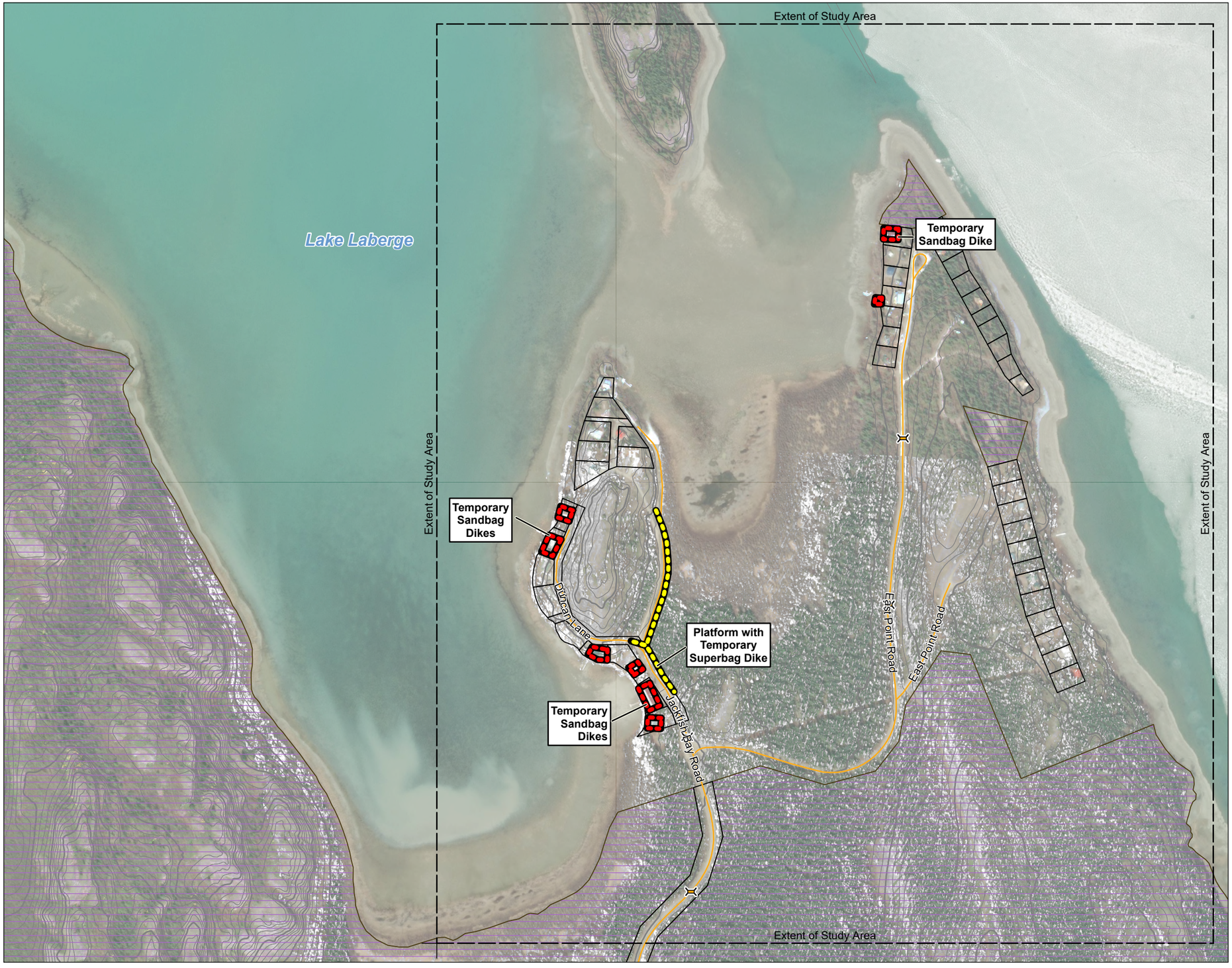


Figure No.

P3

Title

Jackfish Bay 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
Jackfish Bay,
Yukon

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

N

0 50 100 150 200 m

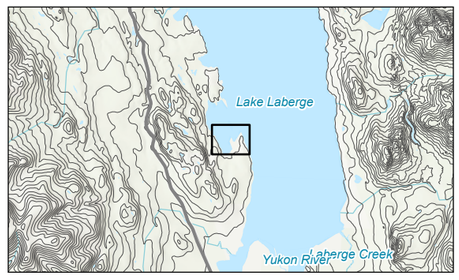
(At original document size of 11x17)
1:30,000

- Culvert/ Bridge
- 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:\1123\2\projects\144903232\figures\reports\YukonWide\YukonWideFigures.aprx Revised: 2023-07-06 By: LTrudell

Class D OPC

The Class D OPC's for capital and annual costs are summarized in Table P3, considering the Class D level of accuracy (+/-50%). Table P3 also provides the Class D OPCs on a per inundated property basis (from Section P.1.11).

Table P3 Option 1 Summary of Class D OPCs

	Class D OPC	Number of Inundated Properties (Section P.1.11)[1]	Class D OPC per Inundated Property
Capital Cost	None	9	None
Annual Cost (Flood Year)	$ 883,300 - $ 1,324,950		$ 98,145 - $ 147,217
Annual Cost (Non-Flood Year)	$ 700 - $ 1,050		$ 78 - $ 117

[1]As described in Section P.1.11, the inundated properties from the preliminary inundation analysis consists of 8 private residences and 1 community feature/property.

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table P4 (annual cost, flood year) and Table P5 (annual cost, non-flood year).

Table P4 Option 1 Annual Costs During a Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1A	**Option 1: Annual Costs, Flood Year**				
a)	Inspections	LS	1	$50,000.00	$50,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$5,000.00	$5,000.00
c)	Storage of Sandbags and Superbags	LS	1	$500.00	$500.00
d)	Sandbags c/w Sandfill (2.0m - 3.0m)	M	650	$695.00	$451,750.00
e)	Superbags c/w Sandfill (1.0m - 2.0m)	M	300	$500.00	$150,000.00
				Total 2E	$657,250.00
				Contingency (20%)	$131,450.00
				Subtotal	$788,700.00
				Location Adjustment Factor (LCAF)	1.12
				Annual Cost Flood Year Base Price	$883,300.00
				Annual Cost, Flood Year Upper Bound	$1,324,950.00

Table P5 Option 1 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1B	**Option 1: Annual Costs, Non-Flood Year**				
a)	Storage of Sandbags and Superbags	LS	1	$500.00	$500.00
				Total 2F	$500.00
				Contingency (20%)	$100.00
				Subtotal	$600.00
				Location Adjustment Factor (LCAF)	1.12
				Annual Cost, Non-Flood Year Base Price	$700.00
				Annual Cost, Non-Flood Year Upper Bound	$1,050.00

Qualitative Evaluation

Table P6 summarizes the performance of Option 1 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table P6 Option 1 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	temporary dikes may degrade under long duration of flooding (several weeks or months); wind/wave impacts would be mitigated by elevated DFSL and erosion mitigation measures however ice/debris damage from wave action is a risk for temporary superbag dikes; risk of vandalism and degradation risk increases with duration that the temporary dikes are deployed; seepage control measures likely required	Low Performance
2	Time to Implementation	moderate anticipated construction effort; no design or regulatory efforts required for sandbag dikes on private properties	High Performance
3	Capital Cost Per Inundated Property	No capital cost associated with this option.	High Performance
4	Maintenance and Storage	minimal storage requirements (sandbags and superbags for low number of temporary dikes);	Medium Performance
5	Response and Activation	organization to construct the superbag dike; organization to provide sandbags and earthen material for private property owners; 8 property-owner deployed temporary sandbag dikes; temporary sandbag dikes require proper installation and a timely response in a flood scenario to be effective	Medium Performance
6	Aesthetics and Community Function	temporary alteration of private function and view during flood conditions from temporary sandbag dikes; superbag dike will not affect aesthetics and community function	High Performance
7	Future Adaptability	additional sandbags may be provided for raising temporary sandbag dikes; demountables could be added to the road in the future, if needed	High Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	no anticipated alterations to existing hydraulics, erosion/sedimentation, ice processes and slope stability	High Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	low return on investment (ROI) given the private properties and access routes within the community that would be mitigated from flooding as a result of improvements	Low Performance

P.2.2 OPTION 2

Description

The conceptual flood mitigations for Option 2 are illustrated in Figure P4.

As illustrated in the inundation mapping, approximately 300 m the north end of Jackfish Bay Road is fully inundated and requires road raising. The road would have to be raised by approximately 1.0 – 2.0 m (compared to existing ground). Raising this segment of Jackfish Bay Road would maintain access to dwellings located along Duncan Lane and the north end of Jackfish Bay Road. Raising of Jackfish Bay Road may require slope stabilization measures installed along the lakeside due to the added weight from the new material for the raised road. The footprint of the road widening would be approximately 15 m and does not extend onto private properties, with all work anticipated to be above the OHWM.

There are 8 private properties along Jackfish Bay Road, Duncan Lane and East Point Road that are located within areas inundated under the preliminary analysis and would require a temporary sandbag dike around the structures during flood conditions. The depth of flooding around these properties is less than 1 m and as such can be protected with the construction of sandbag dikes. The temporary sandbags would be up to 3 m high to meet the DFSL with a total length of approximately 620 m.

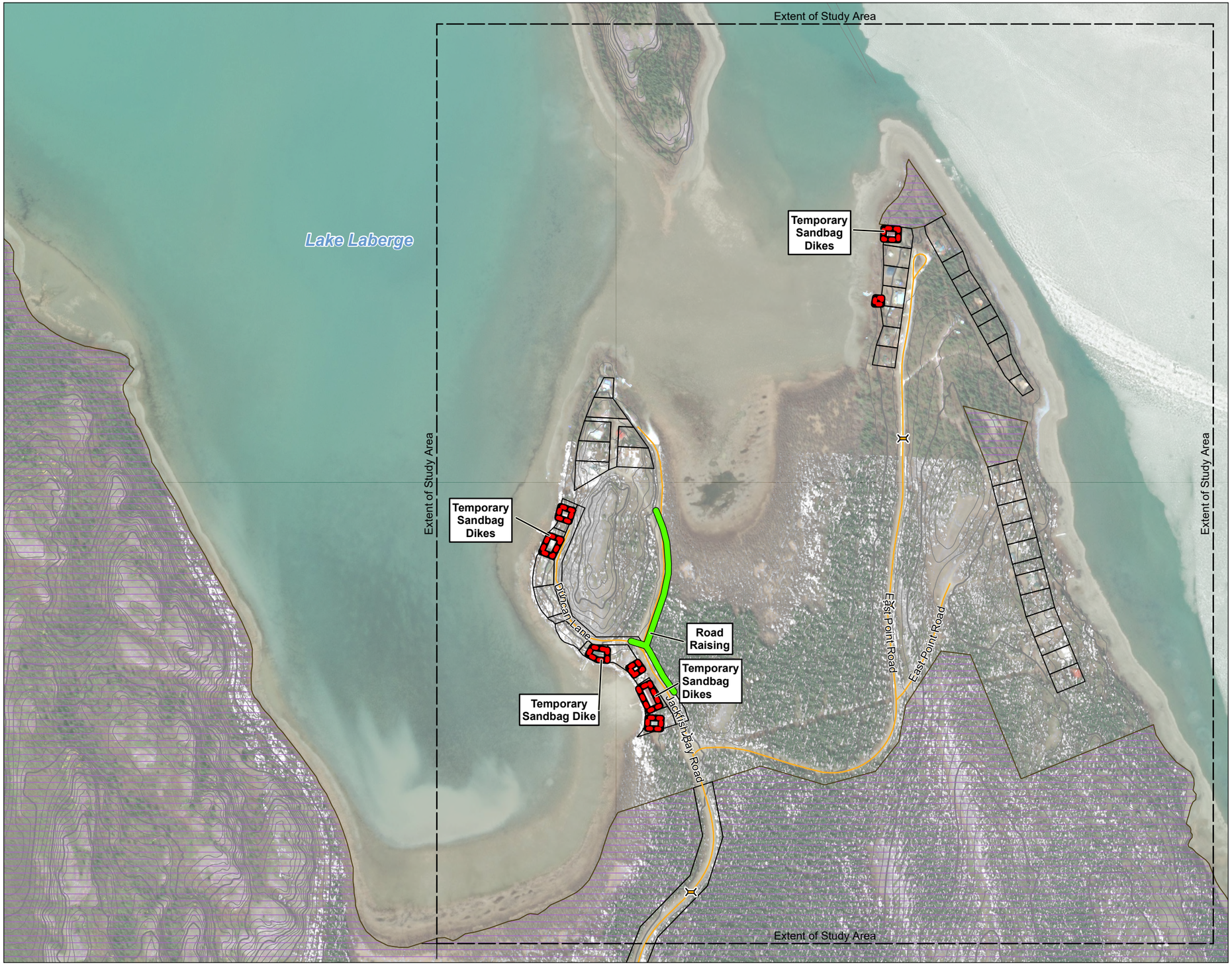


Figure No.
P4

Title
Jackfish Bay 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
Jackfish Bay,
Yukon

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

N

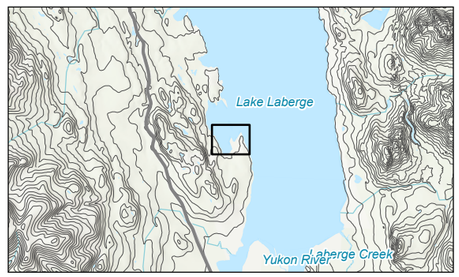
0 50 100 150 200 m
(At original document size of 11x17)
1:30,000

- Culvert/ Bridge
- 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:\1123\2\projects\144903232\figures\reports\YukonWide\YukonWideFigures.aprx Revised: 2023-07-06 By: LTrudell

Class D OPC

The Class D OPC's for capital and annual costs are summarized in Table P7, considering the Class D level of accuracy (+/-50%). Table P7 also provides the Class D OPCs on a per inundated property basis (from Section P.1.11).

Table P7 Option 2 Summary of Class D OPCs

	Class D OPC	Number of Inundated Properties (Section P.1.11)[1]	Class D OPC per Inundated Property
Capital Cost	$ 503,200 - $ 754,800	9	$ 55,912 - $ 83,867
Annual Cost (Flood Year)	$ 648,100 - $ 972,150		$ 72,012 - $ 108,017
Annual Cost (Non-Flood Year)	$ 700 - $ 1,050		$ 78 - $ 117
[1]As described in Section P.1.11, the inundated properties from the preliminary inundation analysis consists of 8 private residences and 1 community feature/property.			

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed In Table P8 (capital costs), Table P9 (annual cost, flood year), and Table P10 (annual cost, non-flood year).

Table P8 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	$33,430.00	$33,430.00
b)	Site Preparation/Restoration	LS	1	$6,700.00	$6,700.00
				Total 2A	$40,130.00
Section 2B	**Option 2: Road Raising**				
a)	Rough Grading	M2	5080	$5.00	$25,400.00
b)	Subgrade Preparation	M2	5080	$5.00	$25,400.00
c)	80mm Minus Granular Subbase, Variable Depth	M3	4500	$40.00	$180,000.00
d)	100mm Minus Granular Base, 100mm Depth	M3	250	$50.00	$12,500.00
e)	BST Surfacing	M2	1820	$50.00	$91,000.00
				Total 2B	$334,300.00
				Contingency (20%)	$74,886.00
				Subtotal	$449,316.00
				Location Adjustment Factor (LCAF)	1.12
				Capital Costs Base Price	$503,200.00
				Capital Costs Upper Bound	$754,800.00

Table P9 Option 2 Annual Costs During a Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 2C	**Option 2: Annual Costs, Flood Year**				
a)	Inspections	LS	1	$25,000.00	$25,000.00
b)	Minor Repairs & Vegetation Management	LS	1	$5,000.00	$5,000.00
c)	Storage of Sandbags	LS	1	$500.00	$500.00
d)	Sandbags c/w Sandfill (2.0m - 3.0m)	M	650	$695.00	$451,750.00
				Total 2C	$482,250.00
				Contingency (20%)	$96,450.00
				Subtotal	$578,700.00
				Location Adjustment Factor (LCAF)	1.12
				Annual Cost Flood Year Base Price	$648,100.00
				Annual Cost, Flood Year Upper Bound	$972,150.00

Table P10 Option 2 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 2D	**Option 2: Annual Costs, Non-Flood Year**				
a)	Storage of Sandbags	LS	1	$500.00	$500.00
				Total 2F	$500.00
				Contingency (20%)	$100.00
				Subtotal	$600.00
				Location Adjustment Factor (LCAF)	1.12
				Annual Cost, Non-Flood Year Base Price	$700.00
				Annual Cost, Non-Flood Year Upper Bound	$1,050.00

Qualitative Evaluation

Table P11 summarizes the performance of Option 2 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table P11 Option 2 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	temporary dikes may degrade under long duration of flooding (several weeks or months); wind/wave impacts would be mitigated by elevated DFSL and erosion mitigation measures however ice/debris damage from wave action is a risk for temporary superbag dikes; risk of vandalism and degradation risk increases with duration that the temporary dikes are deployed; seepage control measures likely required	Low Performance
2	Time to Implementation	geotechnical investigations required including borehole drilling to address bank stability and construction requirements for road raising; work is not anticipated below the OHWM meaning reduced regulatory requirements; moderate anticipated design effort; moderate anticipated construction effort; no design or regulatory efforts required for sandbag dikes on private properties	Medium Performance
3	Capital Cost Per Inundated Property	minor capital costs for sandbag dikes; moderate capital cost for construction of road raising; per-inundated-property capital cost is $55,912/property	High Performance
4	Maintenance and Storage	minimal storage requirements (sandbags for low number of temporary sandbag dikes); periodic road inspections may be required;	Medium Performance
5	Response and Activation	organization to provide sandbags and earthen material for private property owners; property owners to deploy temporary sandbag dikes; 8 property-owner deployed temporary sandbag dikes;	High Performance
6	Aesthetics and Community Function	temporary alteration of private function and view during flood conditions from temporary sandbag dikes; road raising will not affect aesthetics and community function	High Performance
7	Future Adaptability	additional sandbags may be provided for raising temporary sandbag dikes; demountables could be added to the road in the future, if needed	High Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	no anticipated alterations to existing hydraulics, erosion/sedimentation, ice processes and slope stability	High Performance
9	Disaster Mitigation and Adaptation Function (DMAF) Applicability	high return on investment (ROI) given the private properties and access routes within the community that would be mitigated from flooding as a result of improvements	High Performance

P.2.3 SUMMARY TABLES

Table P12 summarizes the Class D OPC for each of the conceptual design options.

Table P12 Summary of Class D OPCs

	Option 1 Class D OPCs	Option 2 Class D OPCs
Capital Cost	None	$ 503,200 - $ 754,800
Annual Cost (Flood Year)	$ 883,300 - $1,324,950	$ 648,100 - $ 972,150
Annual Cost (Non-Flood Year)	$ 700 - $ 1,050	$ 700 - $ 1,050

Table P13 provides a summary of the evaluation of each of the conceptual design options.

Table P13 Summary of Qualitative Evaluation of Conceptual Options

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