

**CHAPTER 6**  
**APPENDIX 6C**

**YEC**

**Mayo Lake Generating Station Re-Development**  
**Mollard Memo November 17, 2008**



J D MOLLARD AND ASSOCIATES LIMITED  
CONSULTING ENGINEERS AND GEOSCIENTISTS

Telephones (306) 352-8811 (306) 352-8855  
Fax 352-8820  
Email: mollard@jdmollard.com



www.jdmollard.com

810 Avord Tower, 2002 Victoria Avenue  
Regina • Saskatchewan • Canada  
S4P 0R7

## MEMO

To: Shaun Beatty, KGS Group  
From: Lynden Penner, J.D. Mollard and Associates Limited (JDMA)  
Date: November 17, 2008

**Re: Yukon Energy Corporation -- Mayo Lake Generating Station Re-development**

### Purpose of Memo:

To provide preliminary thoughts on shore erosion changes that may result from lowering the Mayo Lake minimum drawdown level by 1m or raising the maximum full supply level by 1m.

### Methodology:

These preliminary thoughts on possible shore erosion changes associated with re-development options being considered for the Mayo Lake generating station are based on a review of shore zone profile data, site photographs and shore zone soil samples provided to JDMA by KGS Group. KGS also provided a PowerPoint presentation describing the re-development options under consideration. These data sets were delivered to JDMA during the week of November 10, 2008. Information presented here represents an initial qualitative review of the data to provide input to meetings scheduled for November 18 and 19, 2008, in Whitehorse.

### Data Sets Reviewed:

The following data sets have been reviewed:

1. Shore zone profiles surveyed at 26 transect sites in Mayo Lake (Locations shown in Figure 1, profiles shown in Appendix 1)
2. Shore zone materials and erosion activity around Mayo Lake from an earlier JDMA 2008 report to KGS (Figures 2 and 3).
3. Shore zone photographs provided for 12 of the 26 transect sites (Appendix 1).
4. Sediment samples collected from cross-section sites (preliminary visual grain-size analysis is shown on cross-sections in Appendix 1).

5. A PowerPoint presentation prepared by KGS Group for Yukon Energy Corporation titled, "Project Scoping Workshop; Mayo B Project, October 8 & 9, 2008."

### Discussion:

Table 1 summarizes the distribution of the shore zone cross-section sites with respect to the surficial geology and materials based on mapping by the Geological Survey of Canada (GSC) and the erosion activity as rated from 1:10K airphotos and shoreline video coverage. Locations of the cross-sections with respect to surficial geology and erosion activity are shown on Figures 2 and 3.

A preliminary visual grain-size analysis has been made for sediment samples collected at the cross-section sites. In general, there is good agreement between the surficial geology shown on the GSC map and the sediment composition. Samples collected from glaciolacustrine areas consist of clay and silt. Sediment in alluvial fan areas range from uniform sand to coarse sand and gravel. A single sample from glaciofluvial terrain consists of sand and gravel. Sediment from morainal and colluvial areas are a mix of varying amounts of coarse sand, gravel, clay and silt. Some samples contain angular bedrock fragments that appear to be derived from local shallow bedrock sources (i.e., fresh fracture faces with little rounding suggest very short transport distances). It is possible that some samples have been re-worked by bluff mass wasting or colluvial processes.

Table 1  
Summary of Surficial Geology and Erosion Activity  
at Shore Zone Transect Sites

Transect Number	Surficial Geology	Erosion Activity
3,4,5,10,12,13	Moraine	Low
1,8,15,17,18	Moraine	Low-Moderate
7	Glaciofluvial	Moderate-High
19,20,21,22,23,24	Glaciolacustrine	Moderate-High
6,9,11*,14	Colluvium over bedrock	Low
2,16	Alluvial Fan	Low-Moderate
25,26	Alluvial Fan	Moderate-High

\*Field photographs of transect 11 suggest that this site is located in a low till (moraine) bluff with low-moderate erosion activity

Figure 4 shows an enlarged view of the shore zone profile at cross-section 11, located on the east shore of the southeast arm of Mayo Lake. This cross-section serves as a good example to illustrate the main components of an eroding shore zone profile. The maximum and minimum water levels under the current Mayo Lake operational scheme are shown on the cross-section. The two main geomorphic components of an eroding shore zone are the bluff face and the nearshore slope. As waves approach the shoreline, wave shear stresses are transferred to the lake bottom where water depths are shallower than the wave base depth. If lake bottom sediments are erodible, these shear stresses erode the lake bottom in the nearshore zone (*i.e.*, where water depths are less than the wave base depth). This process is referred to as nearshore downcutting.

The second component of the erosion process is toe-of-bluff erosion which occurs when water levels are sufficiently high so that wave energy is dissipated at the bluff toe. Toe-of-bluff erosion leads to bluff recession as the bluff face is undercut by wave action and the bluff fails due to mass wasting processes.

For a given wave energy condition, the highest erosion rates typically occur at high water levels when nearshore downcutting and toe-of-bluff erosion occur simultaneously. Nearshore downcutting continues to occur during periods of low water level, but overall erosion rates tend to be lower because waves do not reach the bluff toe.

Another factor that affects erosion rates is the water level fluctuation range. If all other factors are equal, a higher water level fluctuation range results in wave energy dissipation across a wider nearshore zone. This reduces overall downcutting rates. Bluff recession rates may also be reduced if the percentage of time that water levels are at their maximum level is also reduced.

This understanding of erosion processes is the basis for the following assessment of possible effects of raising the full supply level in Mayo Lake by 1m, or lowering the minimum water level by 1m.

#### **Raising the full supply level:**

In general, raising the full supply level by 1m is expected to result in increased bluff recession rates, particularly at locations that are undergoing active bluff recession under existing conditions. Over time, however, bluff recession rates may return to current rates, or even reduced rates due to increased wave energy dissipation caused by a higher water level fluctuation range across a wider nearshore slope.

At sites that are currently experiencing low to negligible bluff recession, the impact of raising the full supply level may be relatively small.

#### **Lowering the minimum water level:**

Lowering the minimum water level by 1m is expected to result in increased nearshore downcutting at lower elevations on the nearshore slope. The effect on bluff recession rates will depend primarily on whether the duration of lake levels at the full supply level is changed under future operating scenarios. An increase in the duration of full supply water levels will likely result

in an increase in bluff recession rates. However, this increase may be temporary due to increased wave energy dissipation caused by a higher water level fluctuation range. A decrease in the duration of full supply water levels will likely result in a decrease in bluff recession rates.

Four cross-section sites have been selected to illustrate possible erosion implications of raising the full supply level by 1m or lowering the minimum water level by 1m.

**Cross-section 1 (Figure 5a,b):** This cross-section is located in morainal terrain and experiences low to moderate erosion activity under existing conditions.

Under an increased full supply level bluff recession at this site is expected to increase due to increased wave action on the steep bluff face. Increased bluff recession rates are expected to eventually return to rates that are similar to existing rates, with a possibility that future rates might be lower than existing rates due to increased wave energy dissipation (due to an increased fluctuation range) in the nearshore. Future bluff recession rates will also depend on the duration of full supply water levels in the future.

Under a lower minimum water level increased downcutting is expected to occur on the lower nearshore slope. Bluff recession rates may decrease initially but increased downcutting will likely result in long term bluff recession rates that are similar to existing rates.

**Cross-section 13 (Figure 6a,b):** This cross-section is located in morainal terrain that experiences low erosion rates under existing conditions.

Under an increased full supply level it is expected that a new low bluff will gradually develop about 1m above the current maximum water level. Bluff recession and nearshore downcutting rates are expected to continue to be low.

Under a lower minimum water level increased downcutting is expected to occur on the lower nearshore elevations. Bluff recession rates will likely continue to be similar to existing rates, with a possibility that future rates might be even lower than existing rates due to increased wave energy dissipation (due to an increased fluctuation range) in the nearshore. Future bluff recession rates will also depend on the duration of full supply water levels in the future.

**Cross-section 19 (Figure 7a,b):** This cross-section is located in glaciolacustrine terrain that experiences moderate to high erosion rates under existing conditions.

Under an increased full supply level bluff recession at this site is expected to increase due to increased wave action on the steep bluff face. Increased rates are expected to eventually return to rates that are similar to existing rates, with a possibility that future rates might be lower than existing rates due to increased wave energy dissipation (due to an increased fluctuation range) in the nearshore. Future bluff recession rates will also depend on the duration of full supply water levels in the future.

Under a lower minimum water level increased downcutting is expected to occur on the lower nearshore slope. Bluff recession rates may decrease initially but increased downcutting will likely result in continued bluff recession at rates similar to present rates over the long term.

**Cross-section 16 (Figure 8a,b):** This cross-section is located on an alluvial fan with low to moderate erosion activity under existing conditions. The cross-section is characterized by low upper and lower bluffs that correspond to the existing maximum and minimum water levels. These low bluffs appear to have formed as a result of nearshore downcutting under these two extreme water level conditions.

Under an increased full supply level additional flooding will occur across the gently sloping alluvial fan and the erosion process will be dominated by nearshore downcutting on the newly created nearshore zone. Downcutting will continue on the lower nearshore slope although downcutting rates may decrease due to increased wave energy dissipation caused by an increased water level fluctuation range.

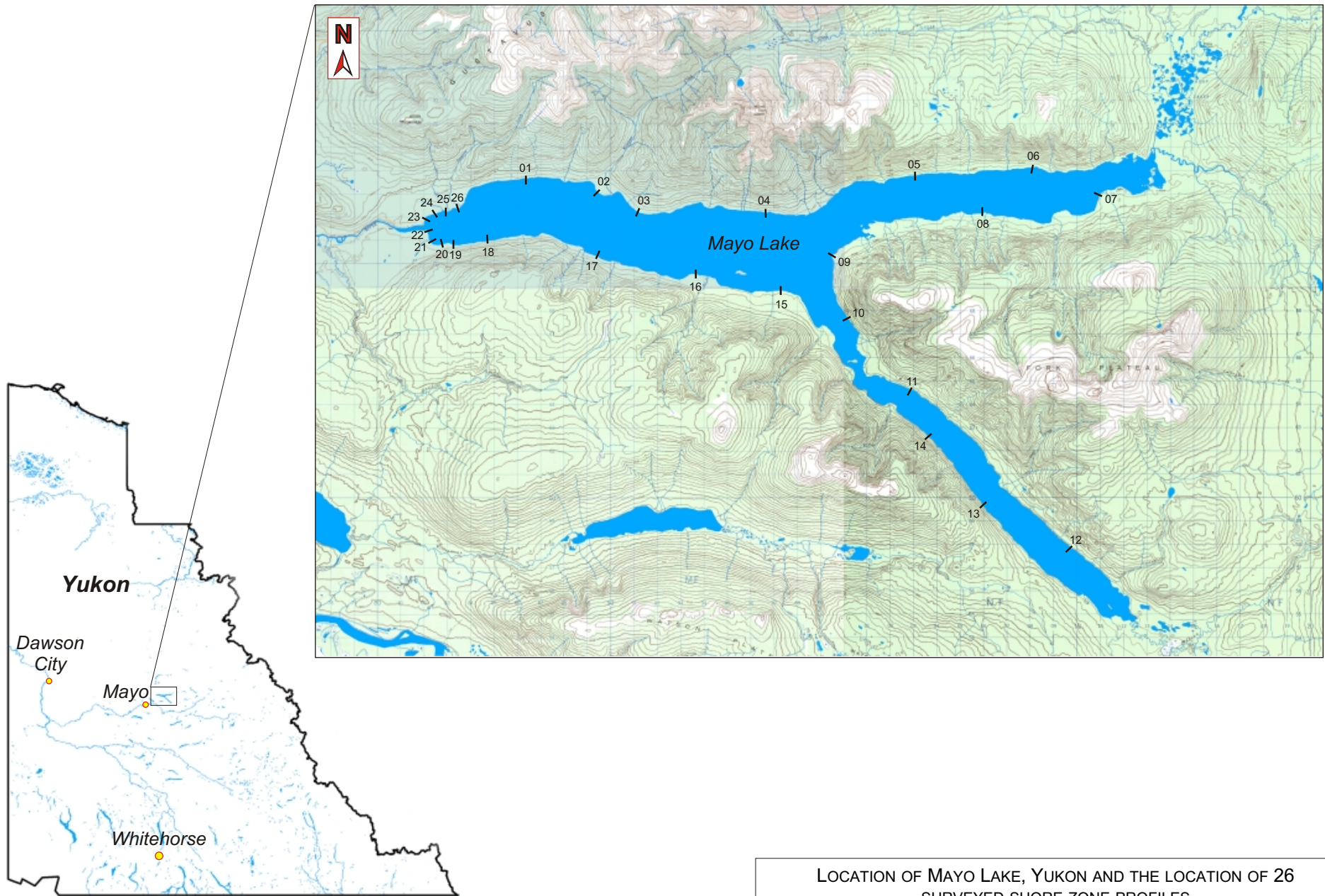
Under a lower minimum water level increased downcutting is expected to occur on the lower nearshore slope. Nearshore downcutting will continue at high water levels although downcutting rates may decrease due to increased wave energy dissipation caused by an increased water level fluctuation range.

## Closing

The intent of this memo is to provide a preliminary qualitative assessment of the nature (direction and type changes associated with various parameters) of possible shore erosion changes that might result from either increasing the full supply level or lowering the minimum water level based on available information available and an understanding of erosion processes from past studies.

This assessment provides a general indication of factors that influence changes to shore erosion processes and rates, and presents selected examples to illustrate some expected changes that may occur as a result of the operational changes that are being considered. As such, it does not provide a full assessment of potential changes that may occur throughout Mayo Lake.

It is anticipated that further discussions will be held with the client regarding details of proposed operational changes and that further studies will be carried out to better define changes that may occur and to assess the impacts of those changes.



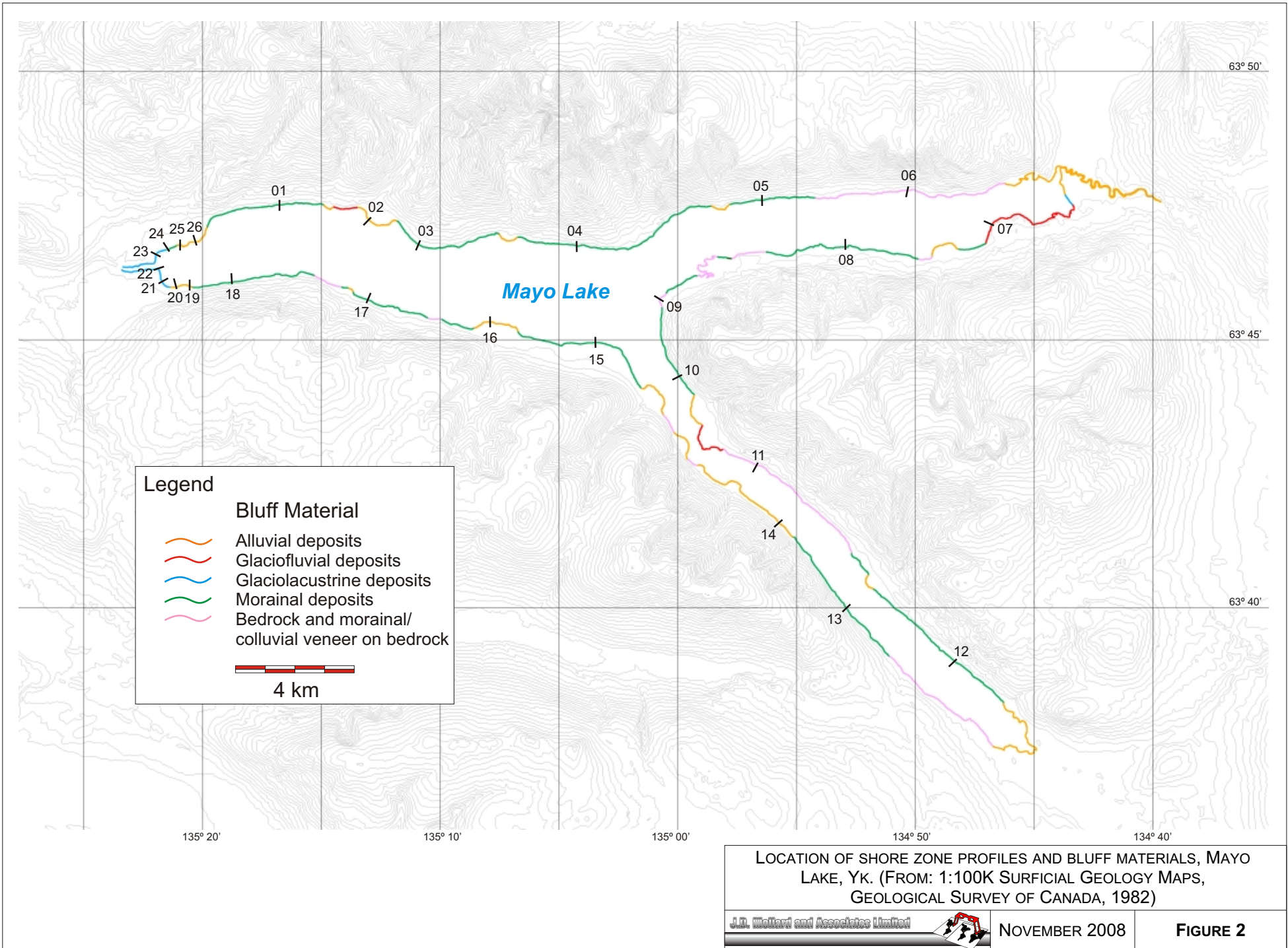
LOCATION OF MAYO LAKE, YUKON AND THE LOCATION OF 26 SURVEYED SHORE ZONE PROFILES

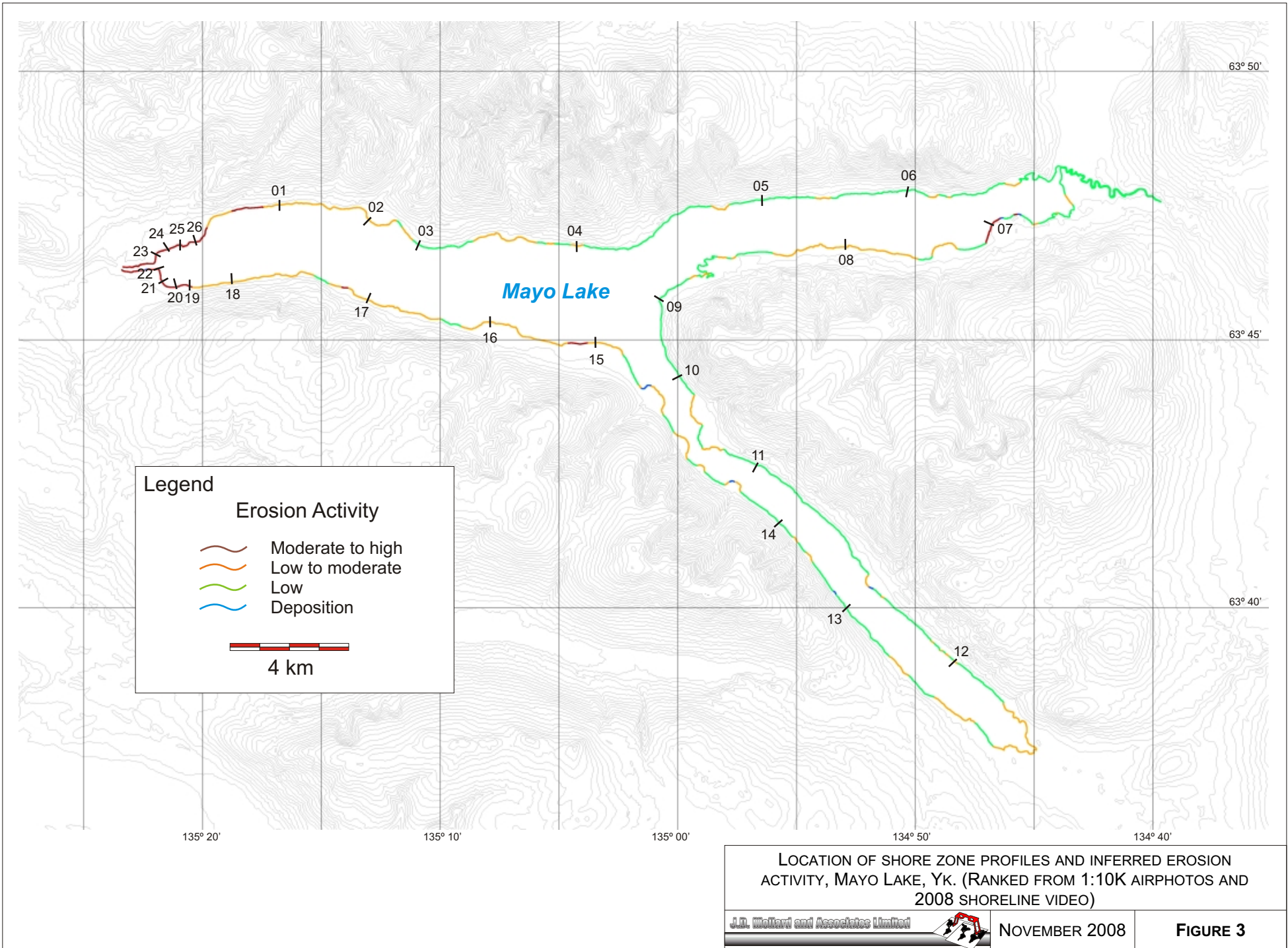
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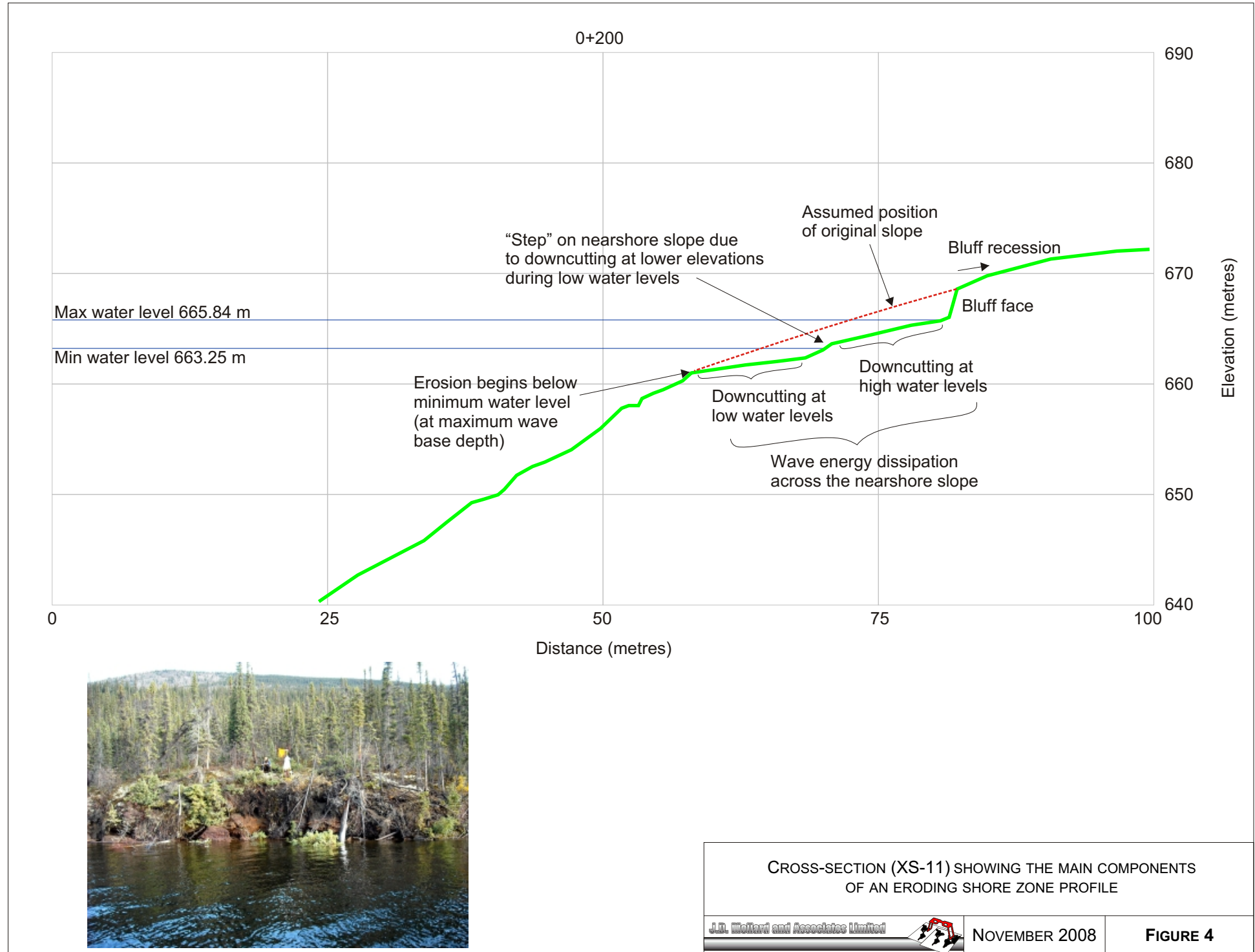


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FIGURE 1



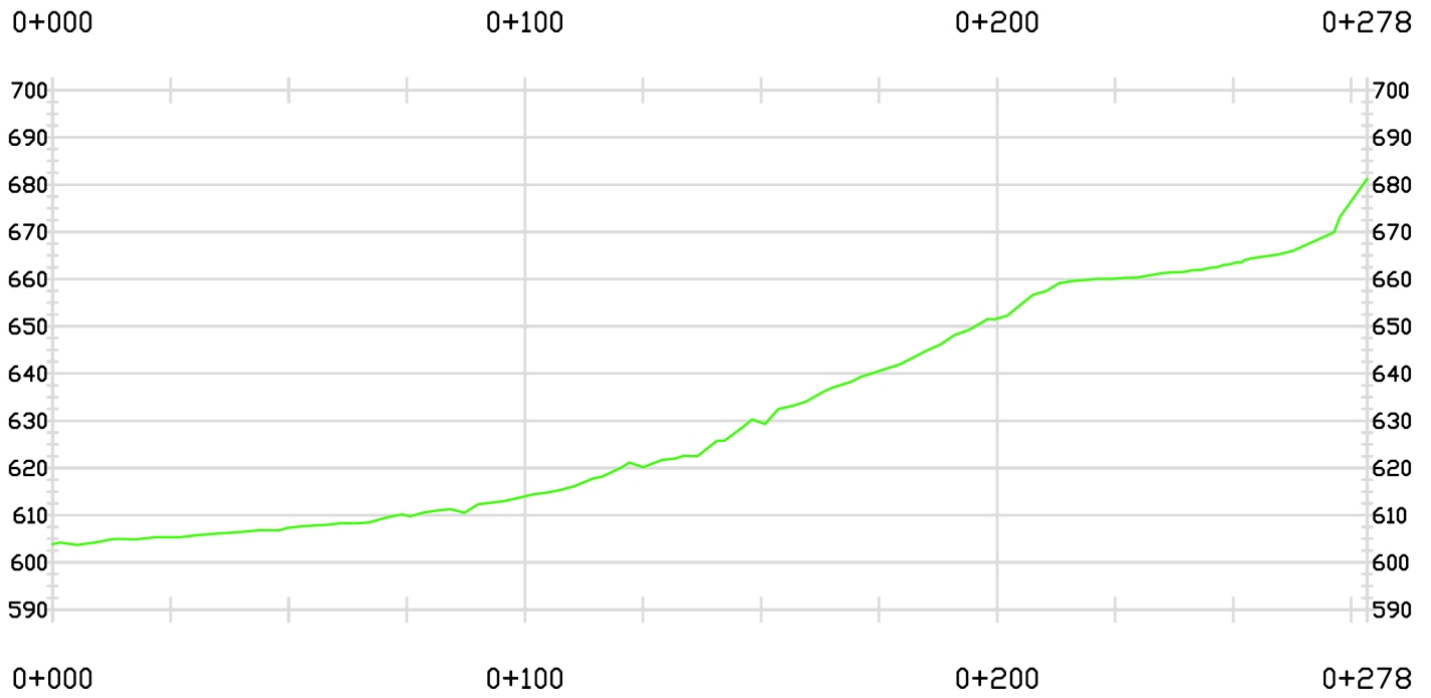




CROSS-SECTION (XS-11) SHOWING THE MAIN COMPONENTS OF AN ERODING SHORE ZONE PROFILE

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Profile View of XSEC\_01



Surficial Geology: Moraine  
 Erosion Activity: Low-Moderate  
 Grain Size: coarse sand - fine gravel  
 (re-worked?)

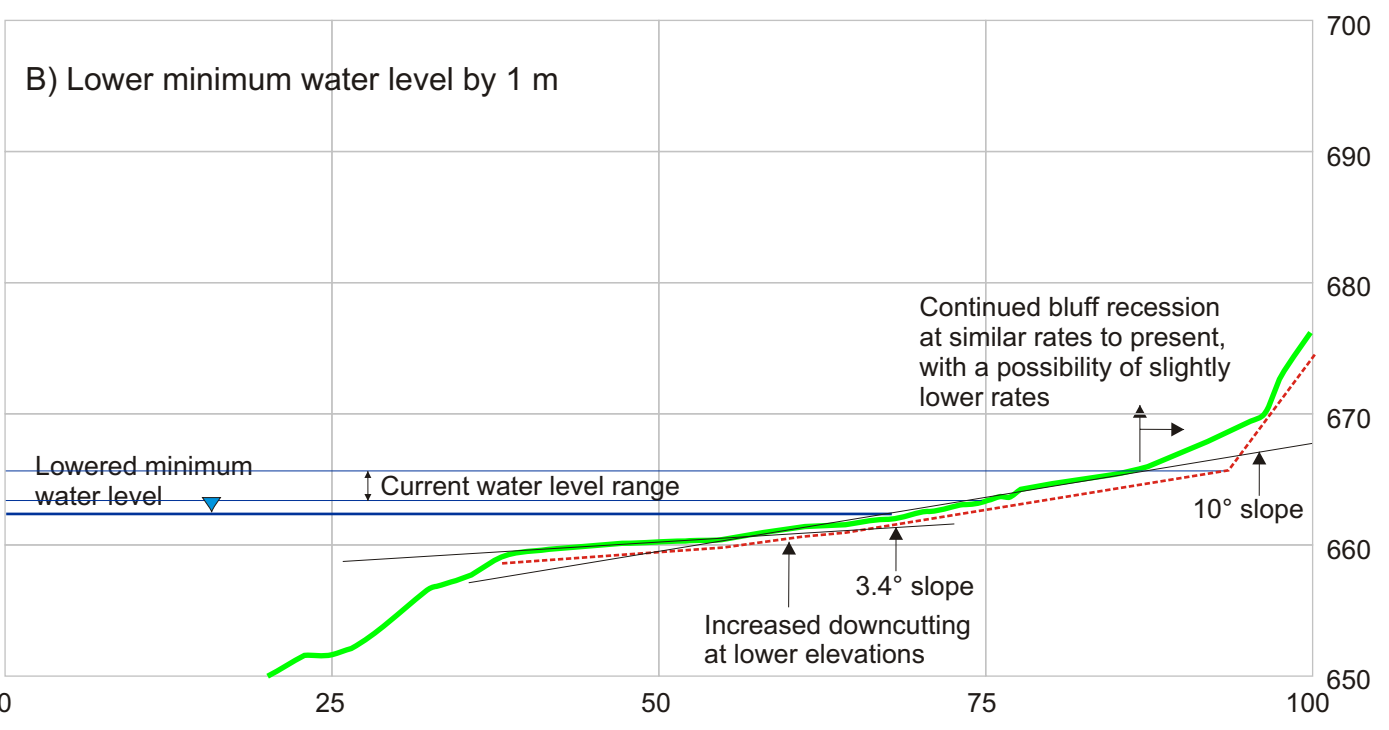
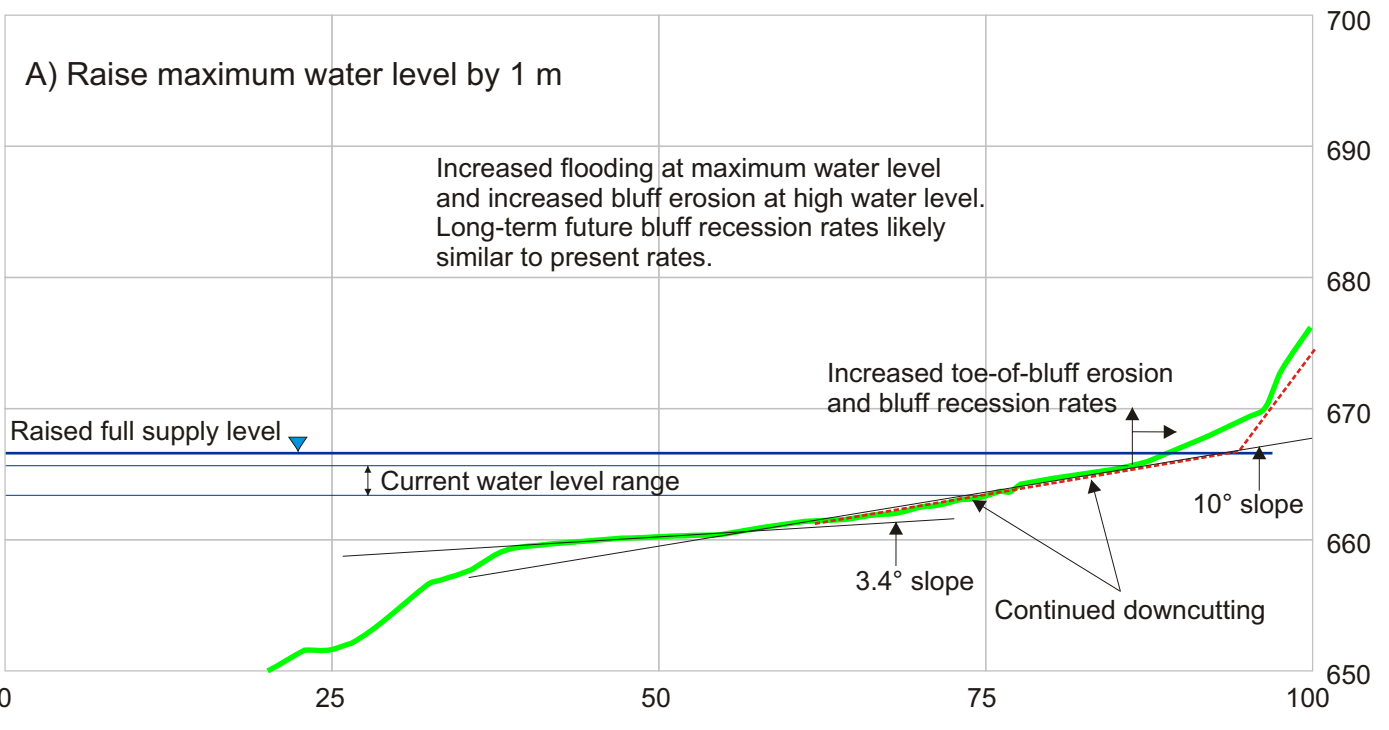
CROSS-SECTION PROFILE AT SITE XS-1, MAYO LAKE

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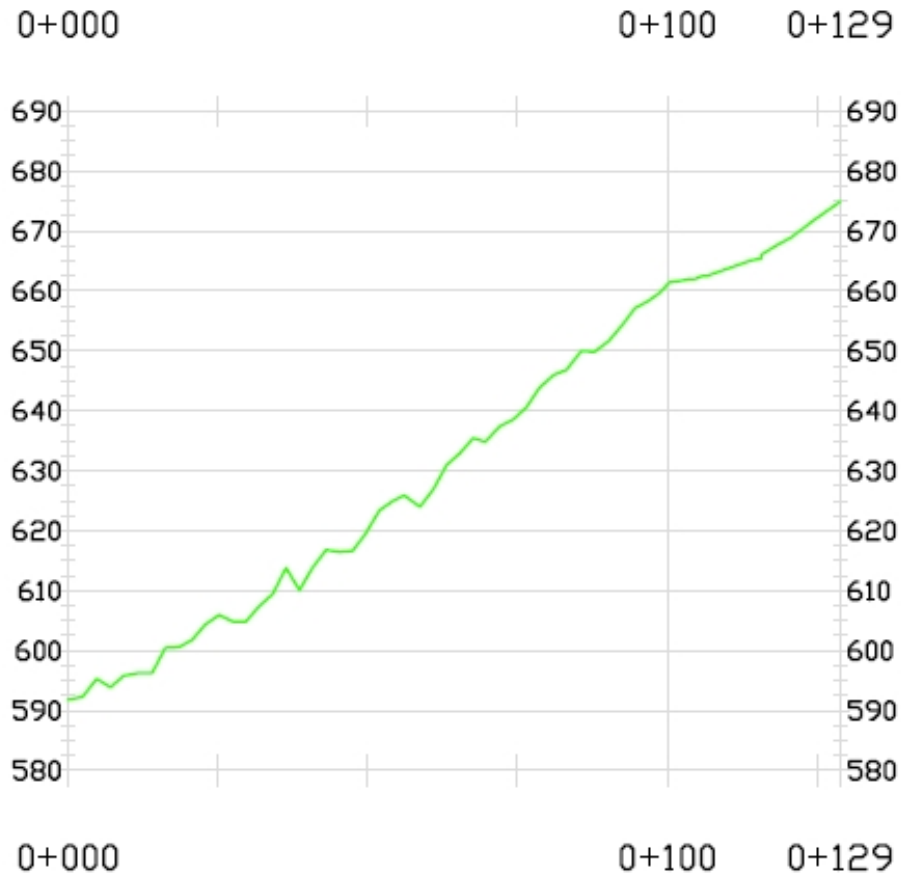
FIGURE 5A



Surficial Geology: Moraine  
 Erosion Activity: Low-Moderate  
 Grain Size: coarse sand - fine gravel  
 (re-worked?)

CROSS-SECTION PROFILE AT SITE XS-1, MAYO LAKE. QUALITATIVE ASSESSMENT OF CHANGES TO EROSION FOR TWO OPERATION SCENARIOS		
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		<b>FIGURE 5B</b>

### Profile View of XSEC\_13



Surficial Geology: Moraine  
 Erosion Activity: Low  
 Grain Size: clay, organics, rock fragments

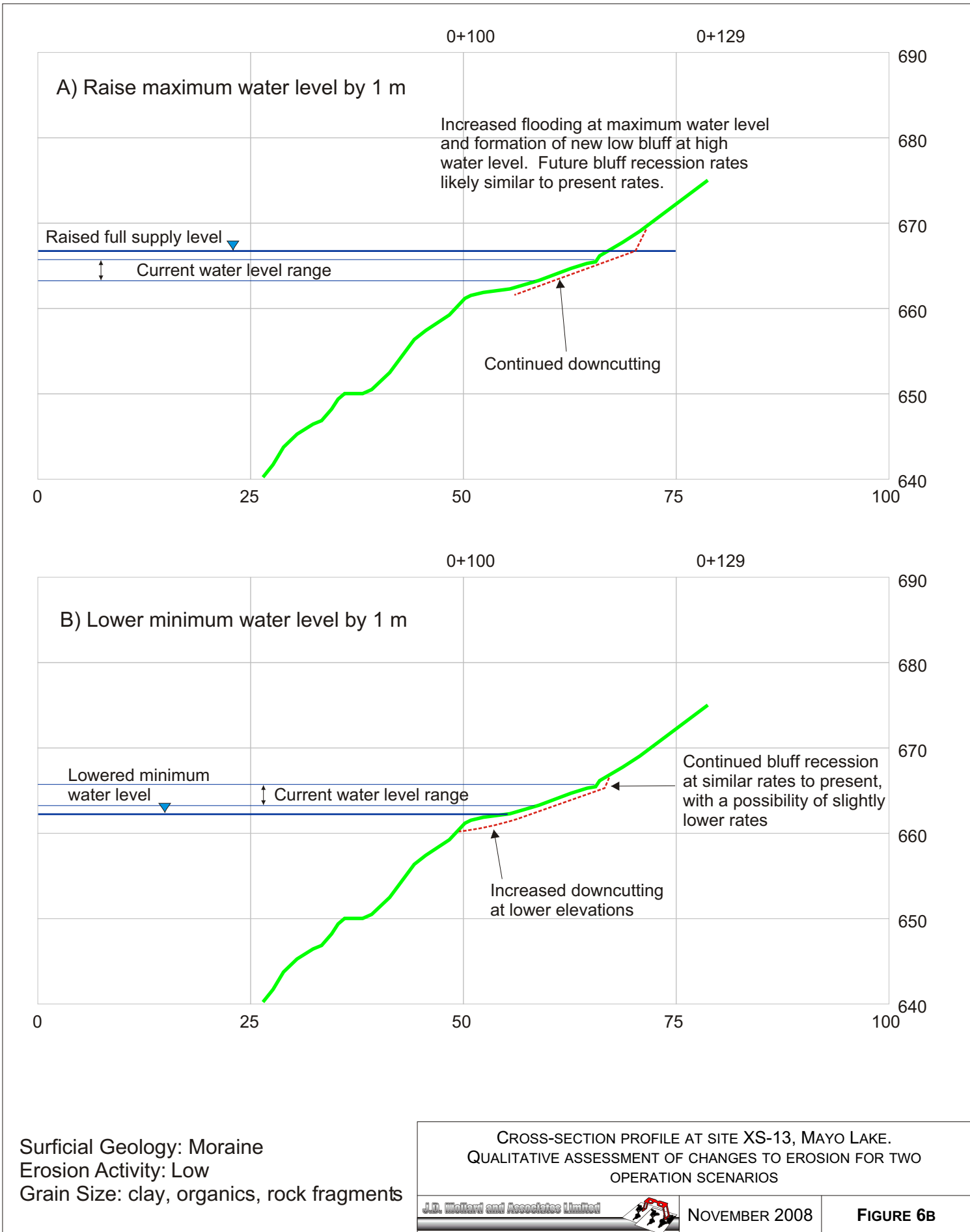
CROSS-SECTION PROFILE AT SITE XS-13, MAYO LAKE

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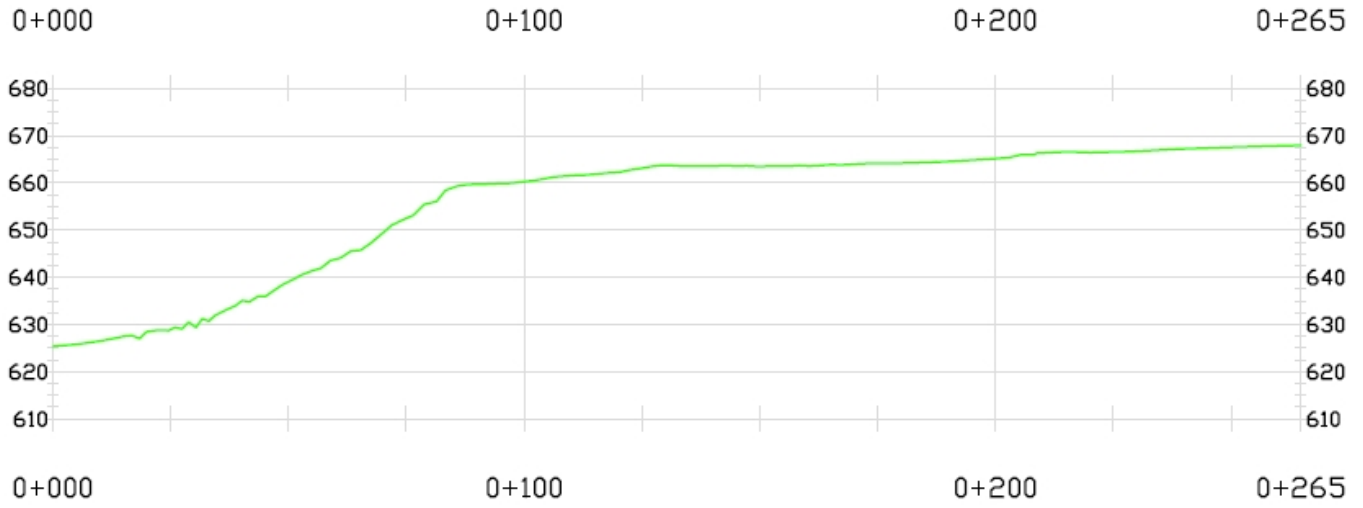
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FIGURE 6A



Surficial Geology: Moraine  
 Erosion Activity: Low  
 Grain Size: clay, organics, rock fragments

Profile View of XSEC\_16



Surficial Geology: Alluvial  
Erosion Activity: Low-Moderate

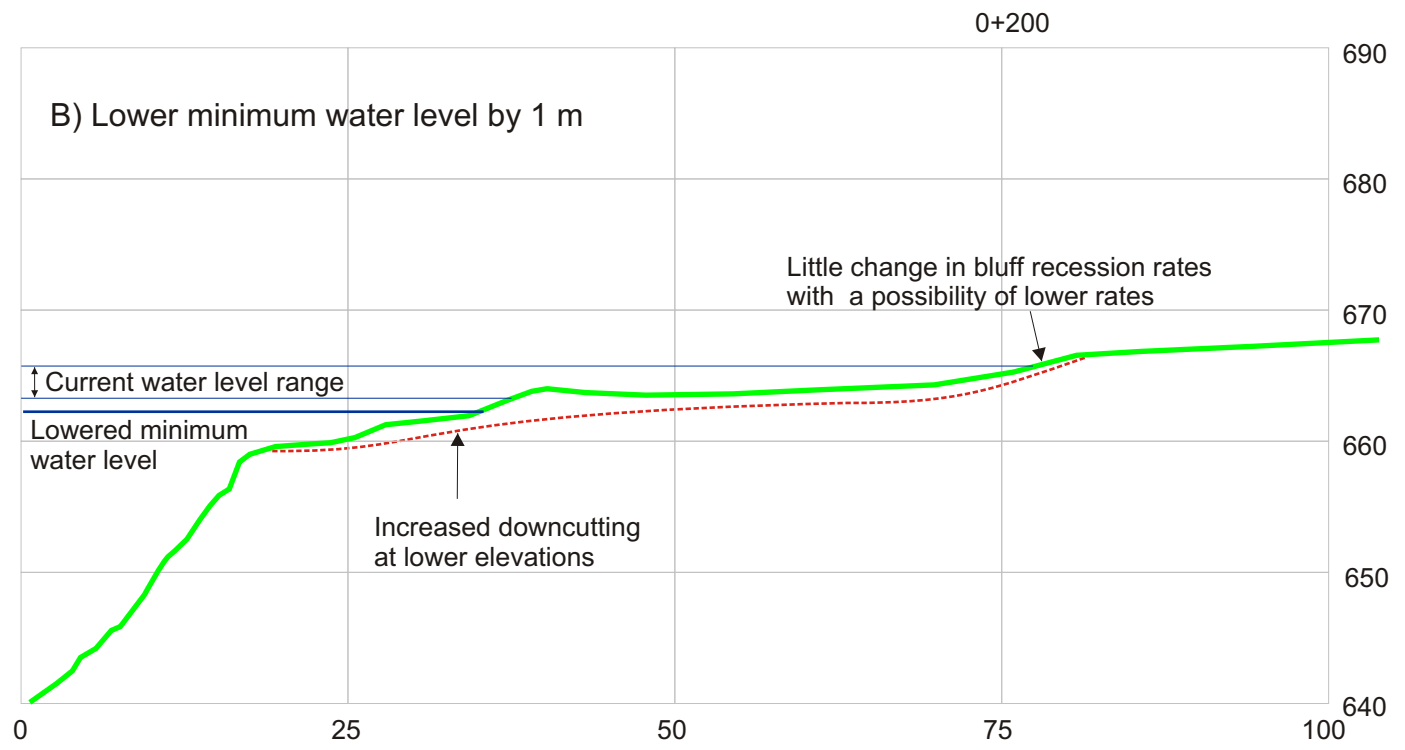
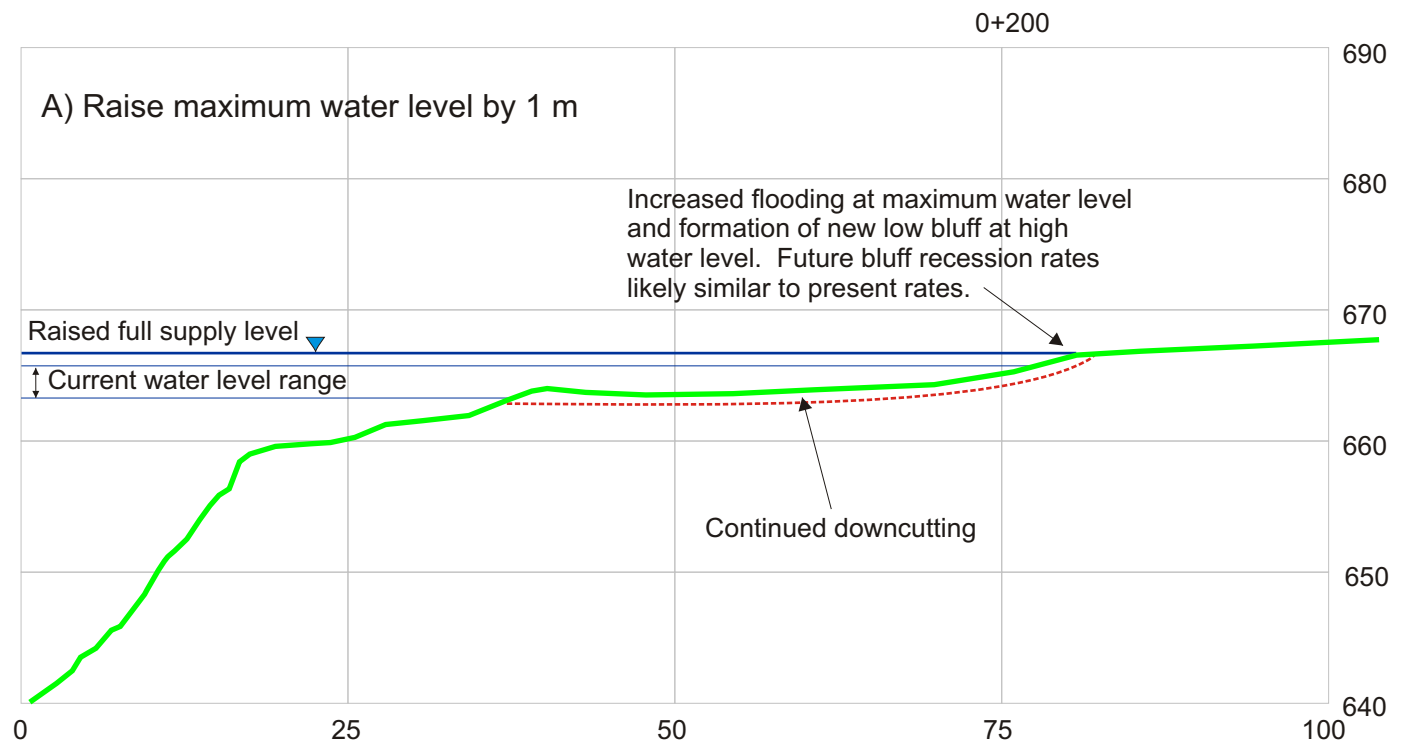
CROSS-SECTION PROFILE AT SITE XS-16, MAYO LAKE

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FIGURE 7A



Surficial Geology: Alluvial  
Erosion Activity: Low-Moderate

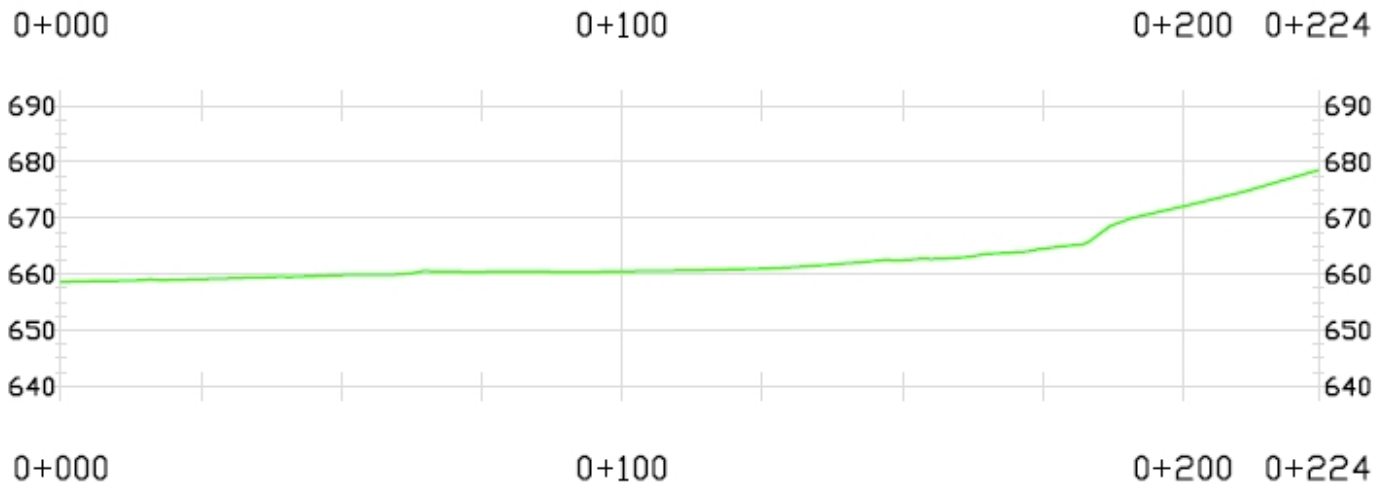
CROSS-SECTION PROFILE AT SITE XS-16, MAYO LAKE.  
QUALITATIVE ASSESSMENT OF CHANGES TO EROSION FOR TWO  
OPERATION SCENARIOS

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FIGURE 7B



Surficial Geology: Glaciolacustrine  
Erosion Activity: Moderate-High  
Grain Size: clay, silt, fine sand

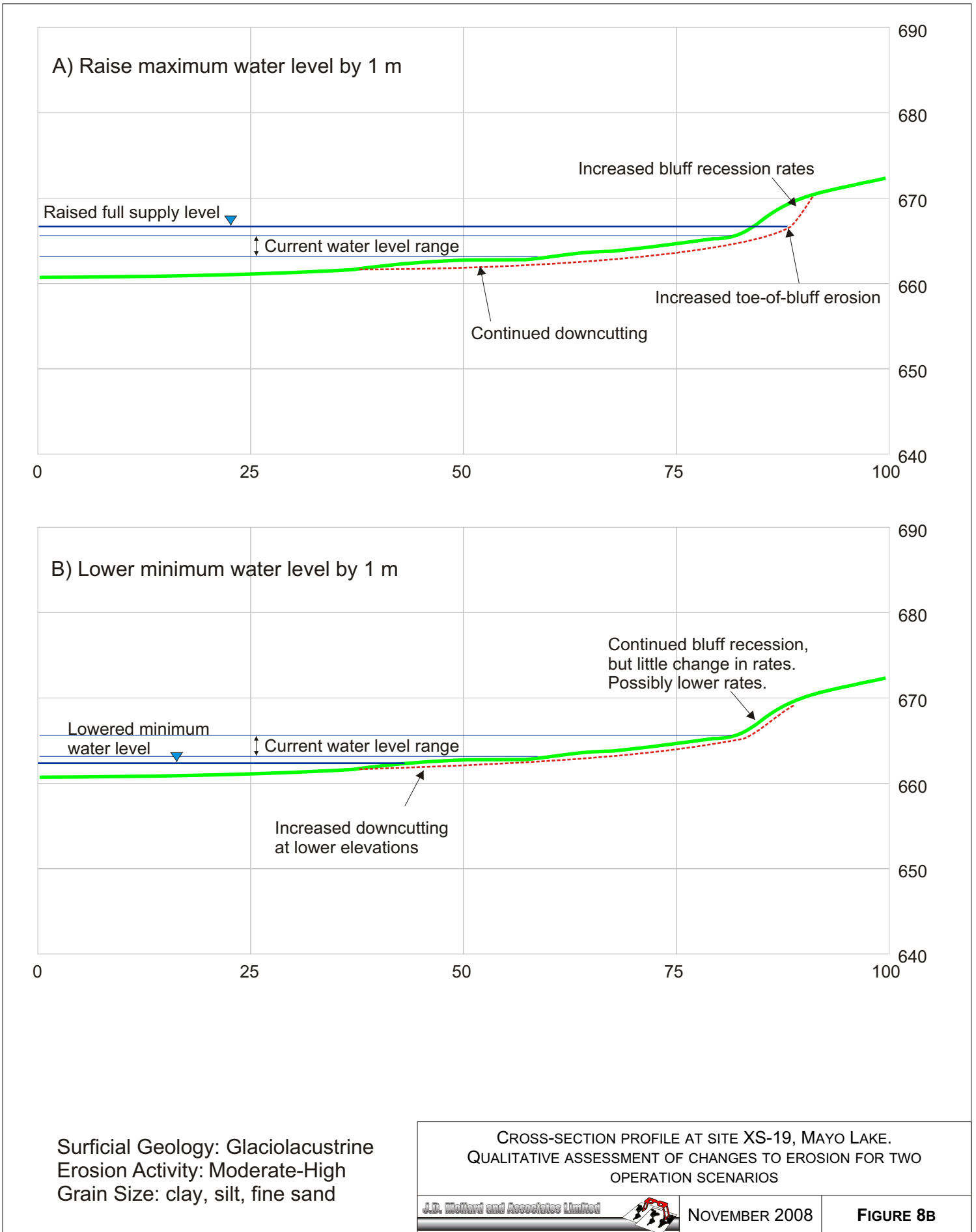
CROSS-SECTION PROFILE AT SITE XS-19, MAYO LAKE

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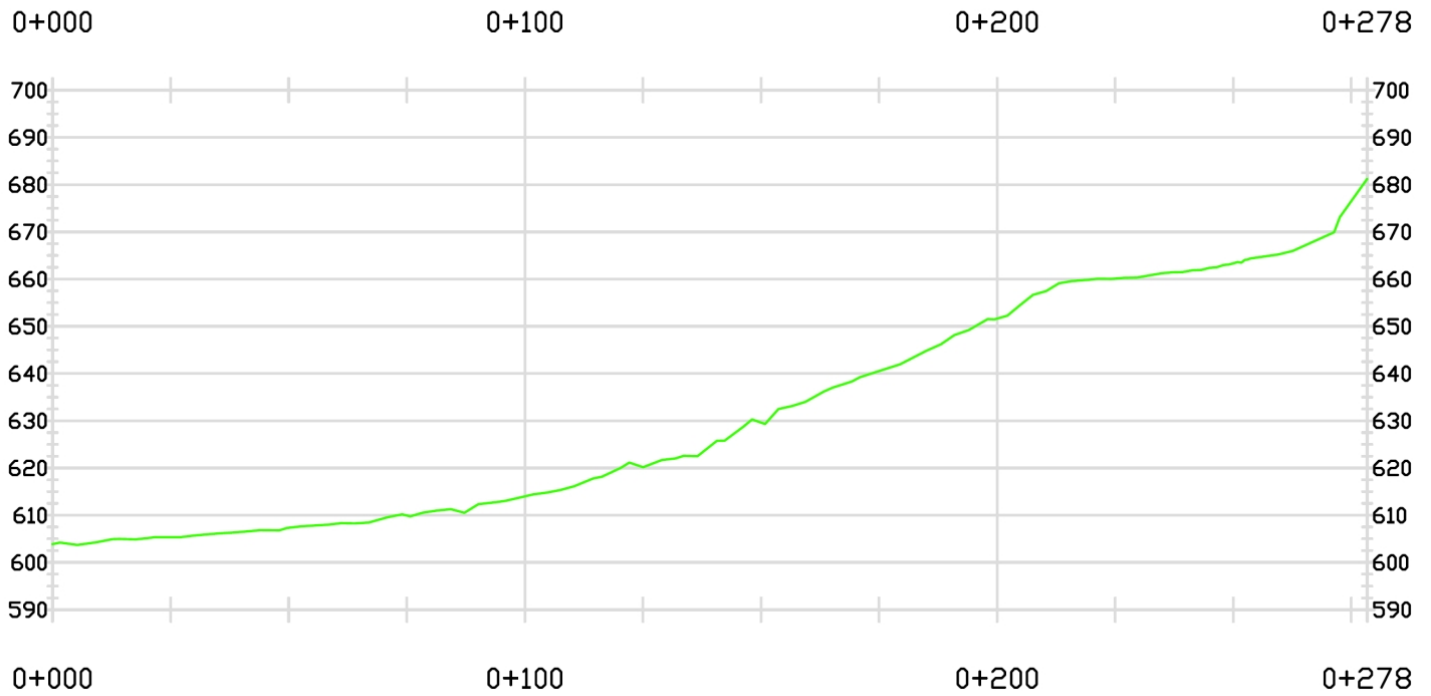
FIGURE 8A



**Appendix 1:**

**Shore zone cross-sections and photographs**

Profile View of XSEC\_01



Surficial Geology: Moraine  
 Erosion Activity: Low-Moderate  
 Grain Size: coarse sand - fine gravel  
 (re-worked?)

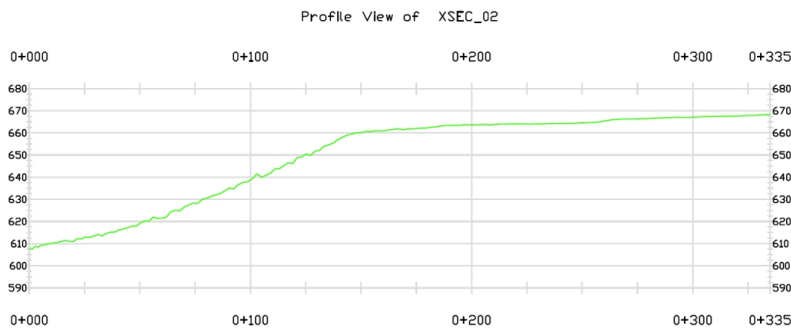
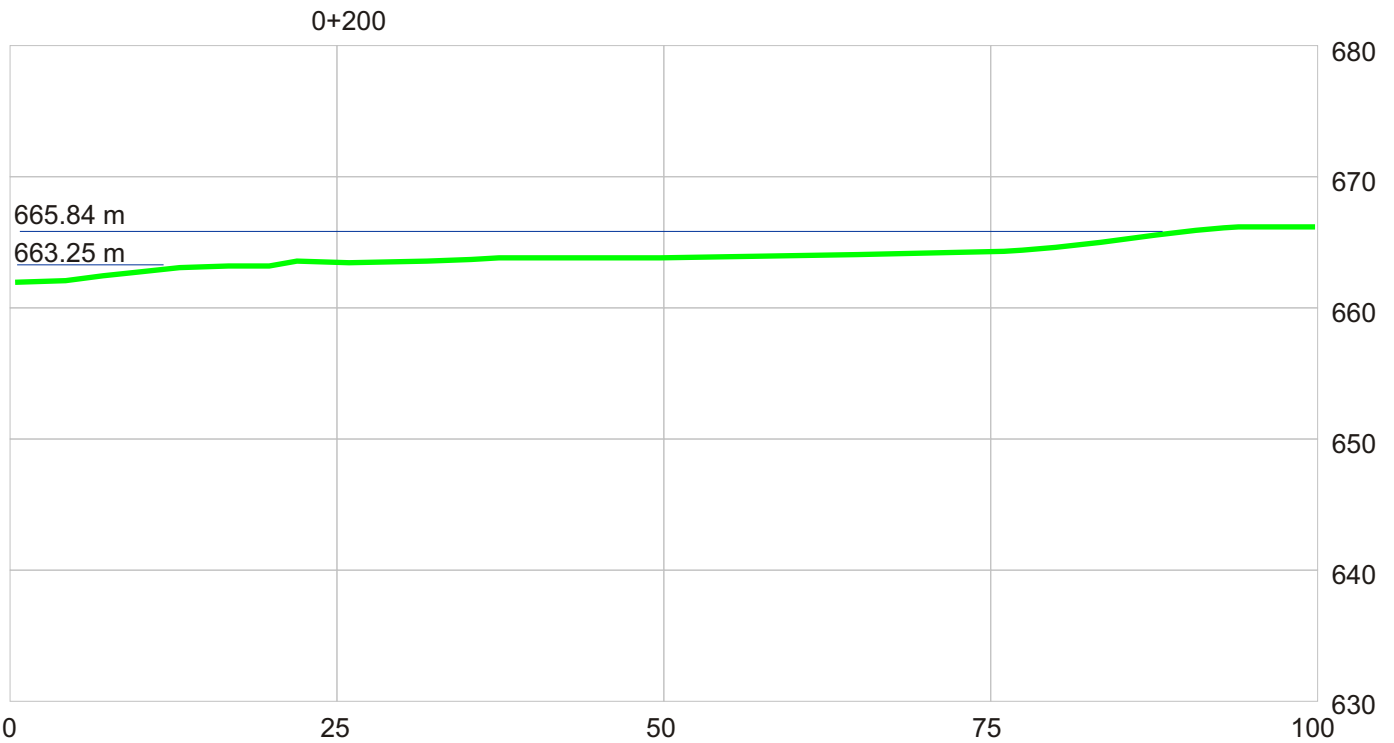
CROSS-SECTION PROFILE AT SITE XS-1, MAYO LAKE

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FIGURE A1



Surficial Geology: Alluvial Fan  
 Erosion Activity: Low-Moderate  
 Grain Size: coarse sand, fine gravel  
 (alluvium)

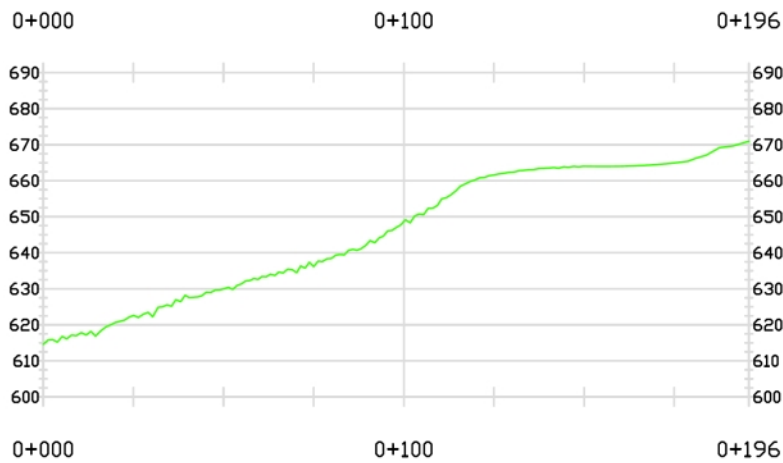
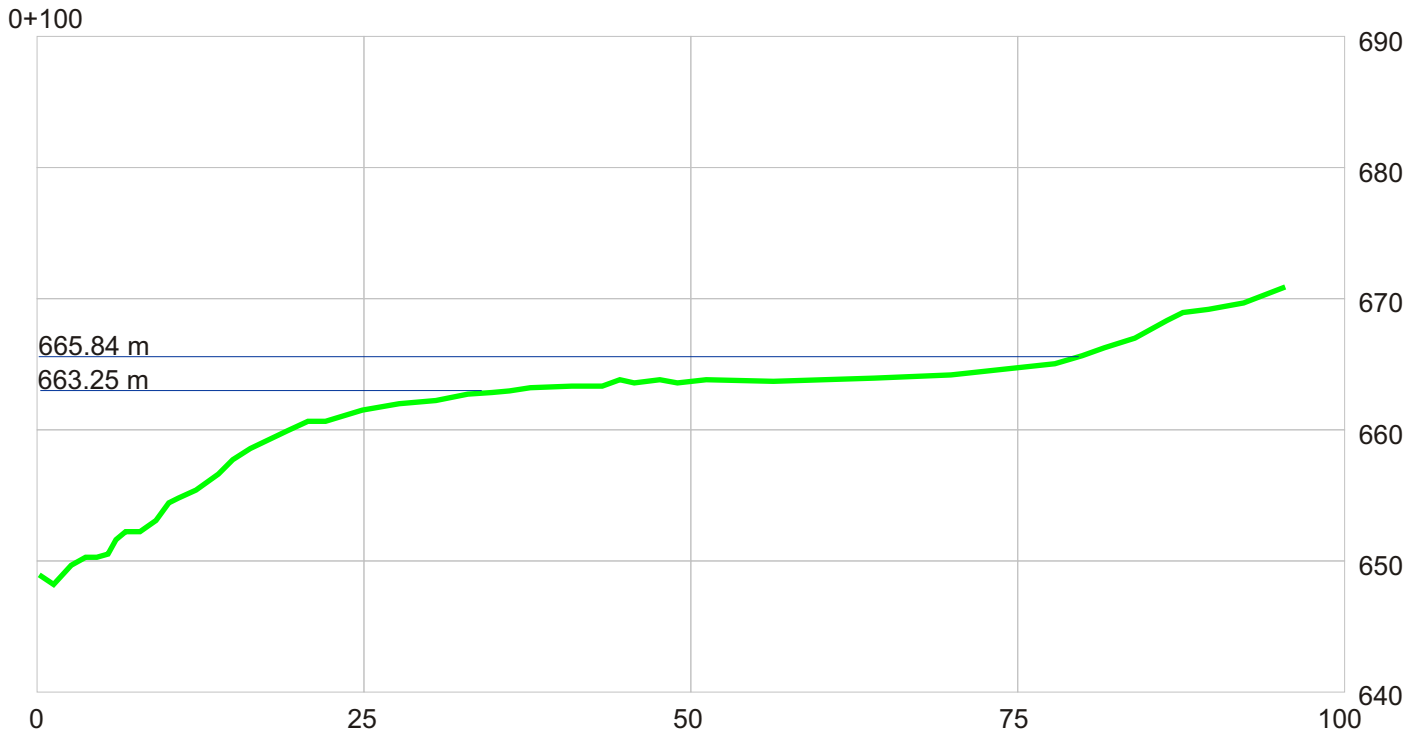
CROSS-SECTION PROFILE AT SITE XS-2, MAYO LAKE

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FIGURE A2



Surficial Geology: Moraine  
 Erosion Activity: Low  
 Grain Size: clay, coarse sand, fine gravel  
 (till)

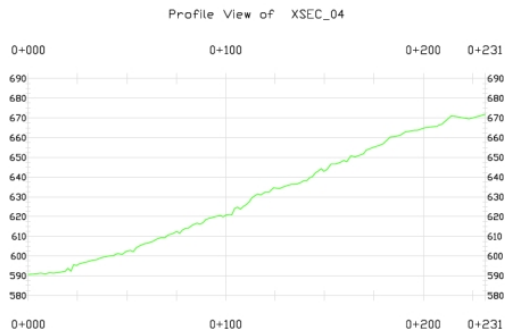
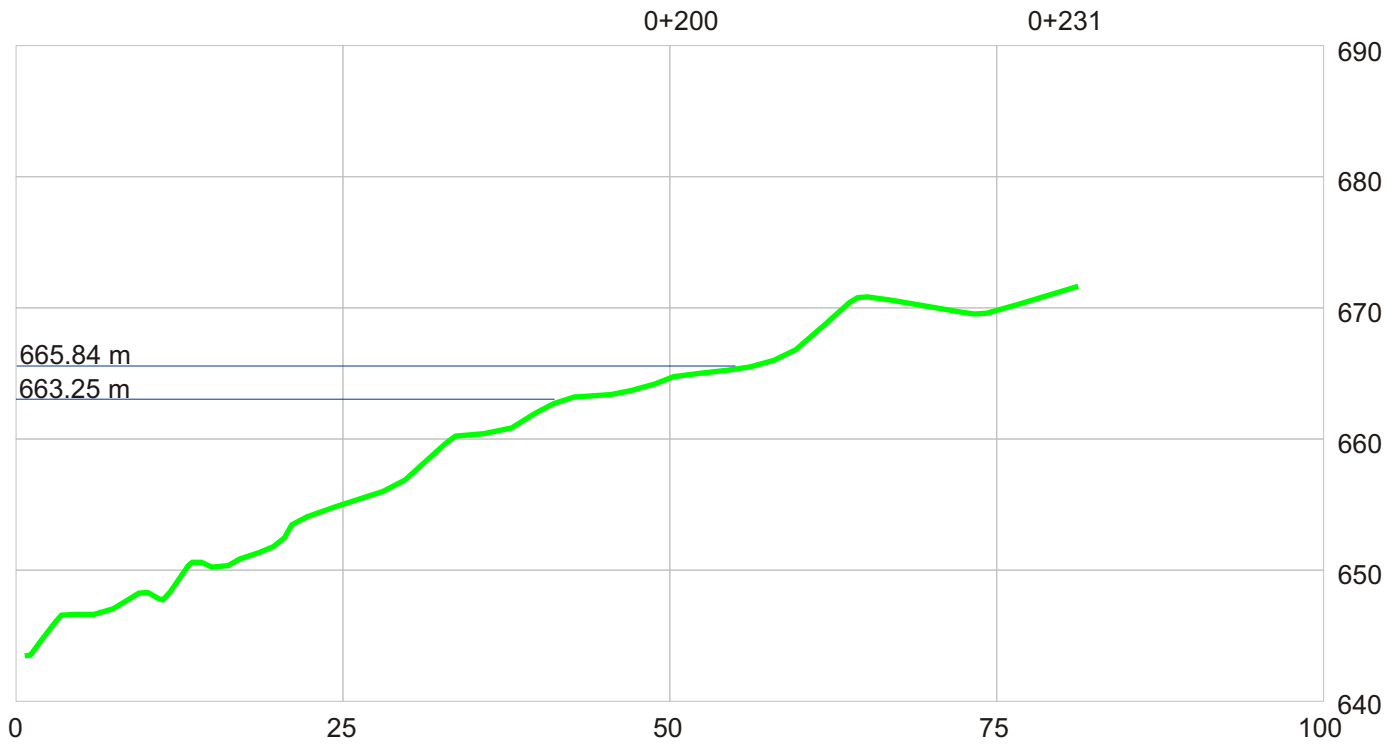
CROSS-SECTION PROFILE AT SITE XS-3, MAYO LAKE

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FIGURE A3



Surficial Geology: Moraine  
 Erosion Activity: Low  
 Grain Size: clay, sand, gravel, organics (till?)

CROSS-SECTION PROFILE AT SITE XS-4, MAYO LAKE

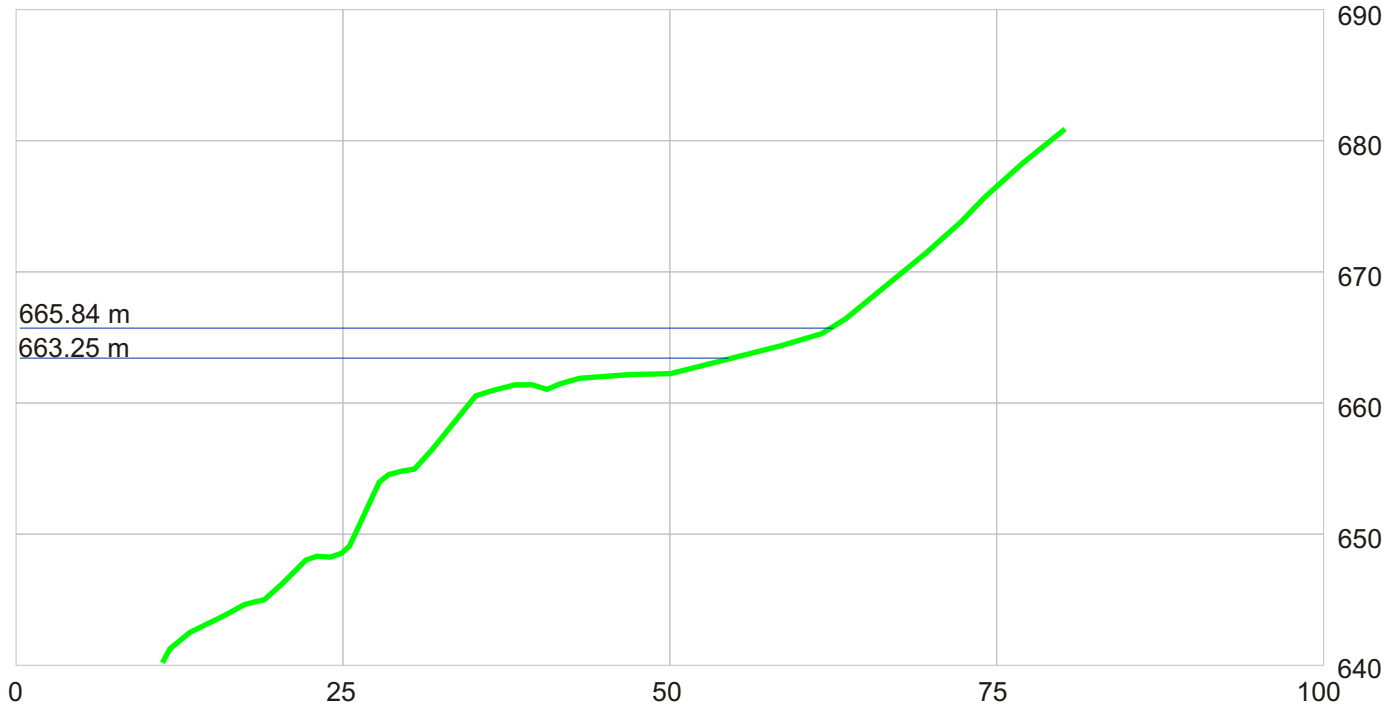
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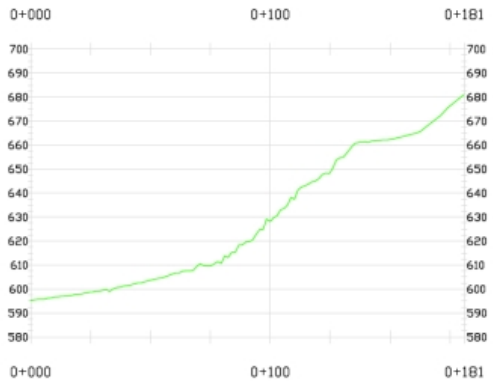
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FIGURE A4

0+181



Profile View of XSEC\_05



Surficial Geology: Moraine  
 Erosion Activity: L  
 Grain Size: clay, silt, sand, gravel (till)

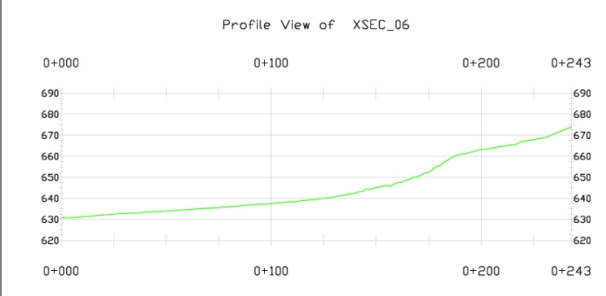
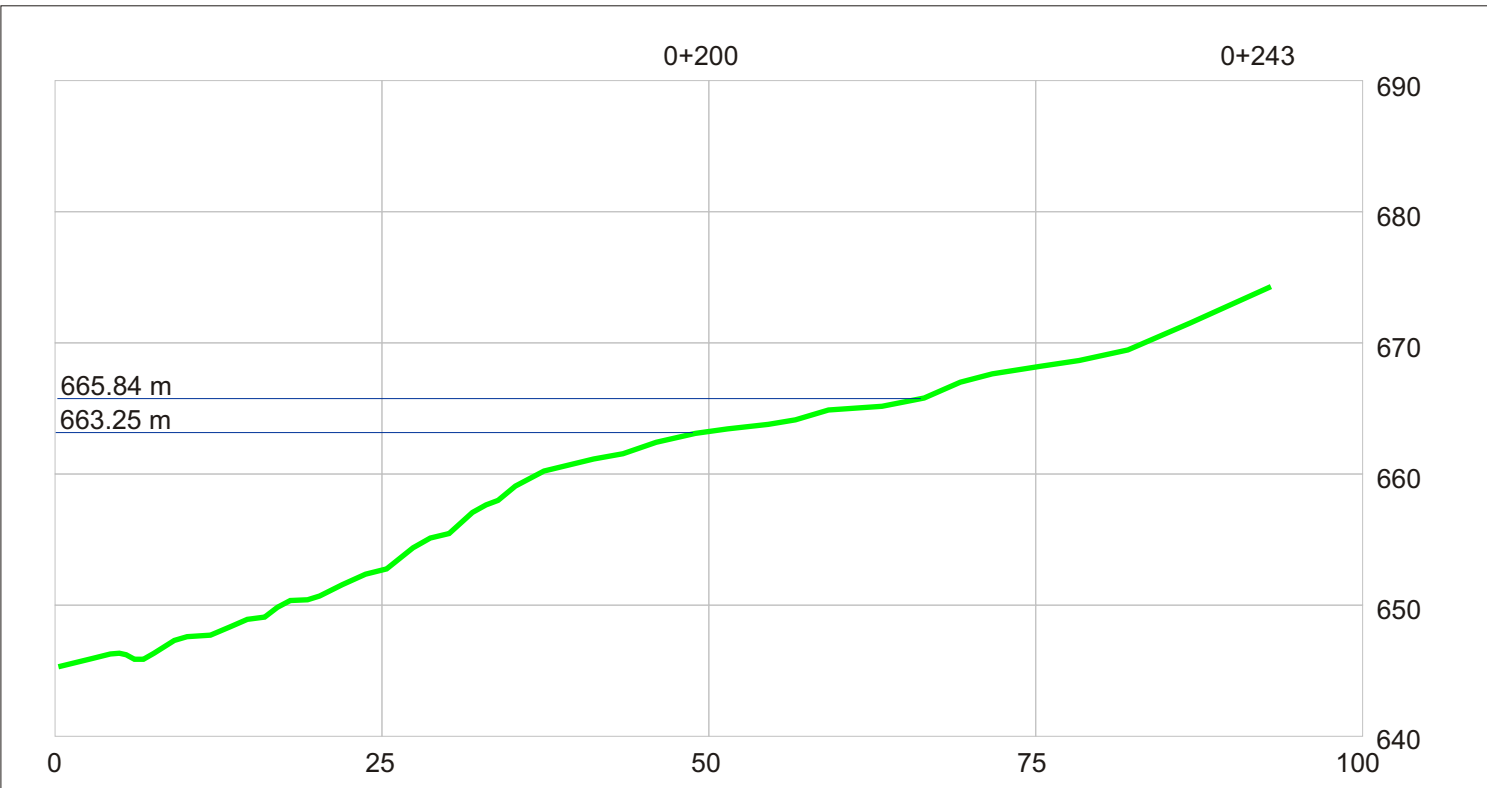
CROSS-SECTION PROFILE AT SITE XS-5, MAYO LAKE

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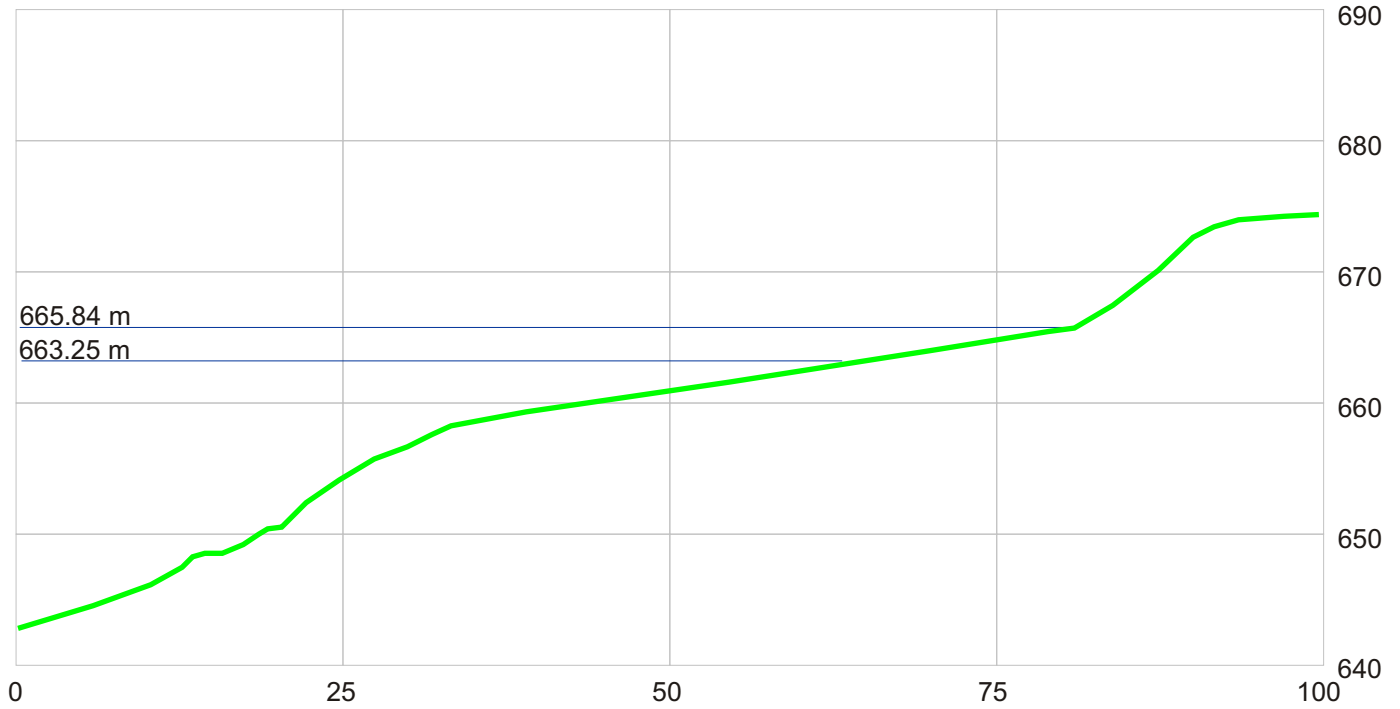
FIGURE A5



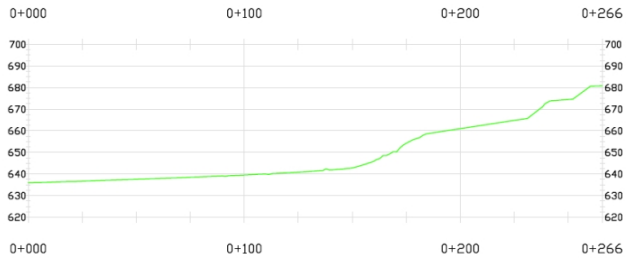
Surficial Geology: Colluvium/bedrock  
 Erosion Activity: L  
 Grain Size: clay, silt, sand, gravel  
 (till vs colluvium)

CROSS-SECTION PROFILE AT SITE XS-6, MAYO LAKE		
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		<b>FIGURE A6</b>

0+200



Profile View of XSEC\_07



Surficial Geology: Glaciofluvial  
 Erosion Activity: Moderate-High  
 Grain Size: sand, gravel (glaciofluvial)

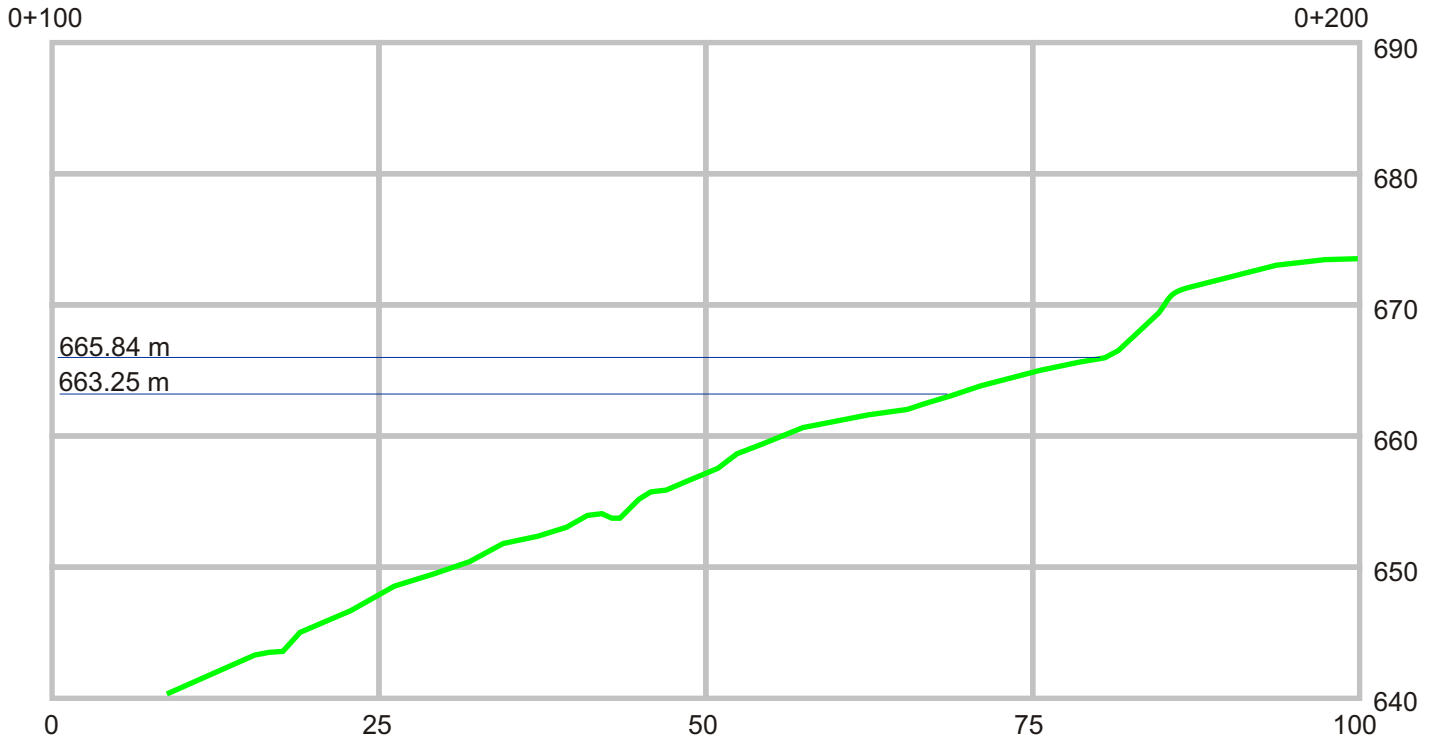
CROSS-SECTION PROFILE AT SITE XS-7, MAYO LAKE

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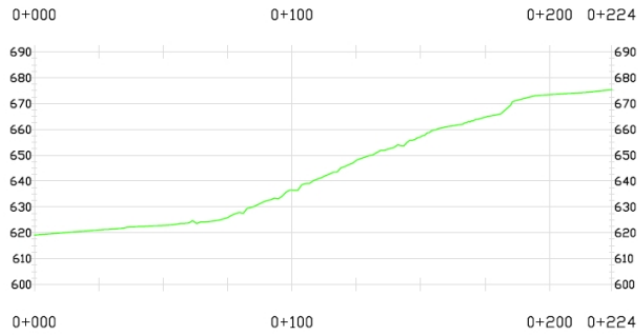


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FIGURE A7



Profile View of XSEC\_08



Surficial Geology: Moraine  
 Erosion Activity: L-M  
 Grain Size: sand, gravel, clay, silt (till?)

CROSS-SECTION PROFILE AT SITE XS-8, MAYO LAKE

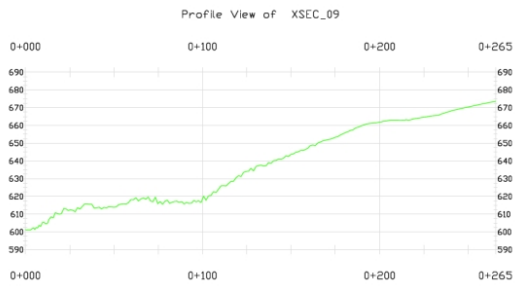
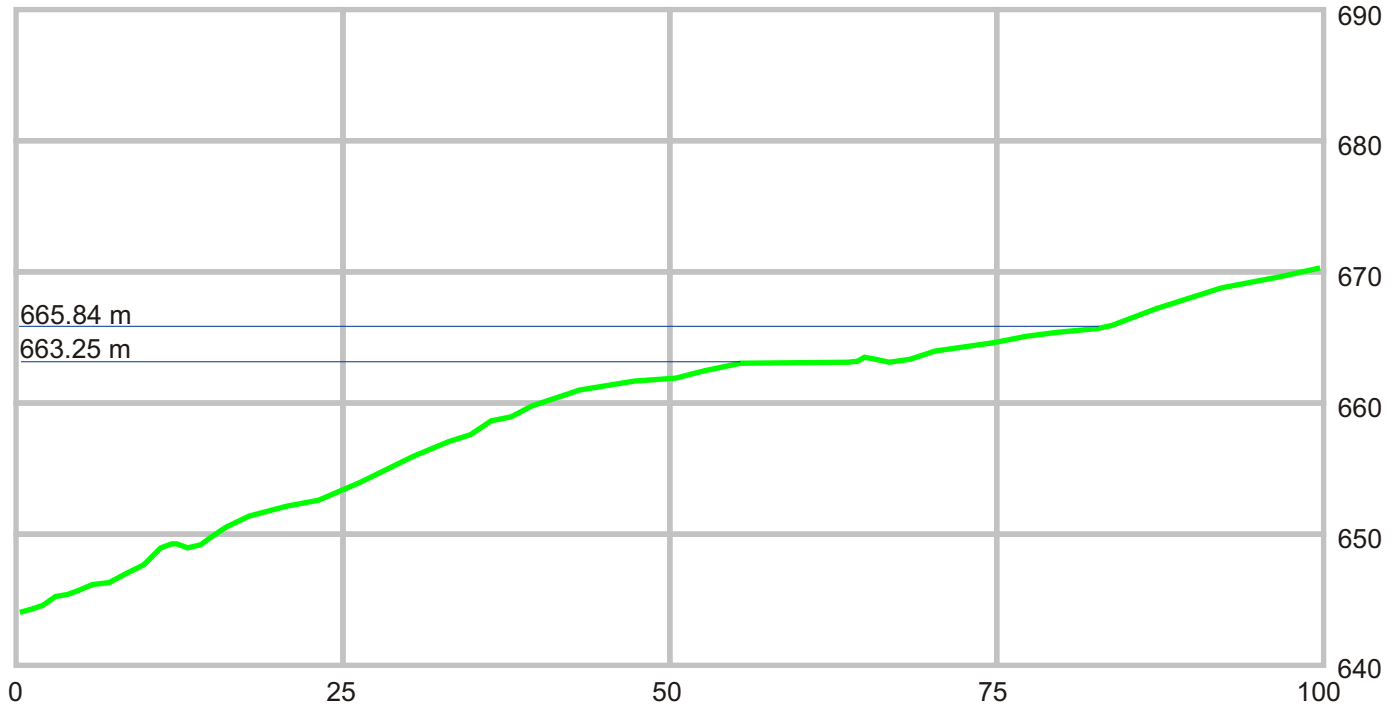
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FIGURE A8

0+200



Surficial Geology: Colluvium/Bedrock  
 Erosion Activity: L  
 Grain Size: clay, silt, sand, gravel  
 (colluvium vs till)

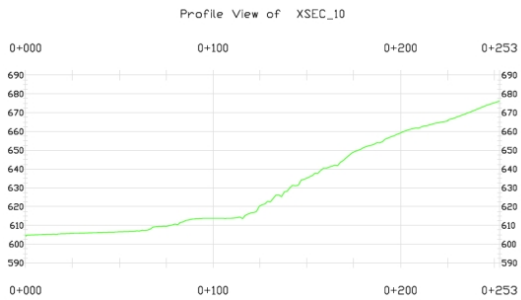
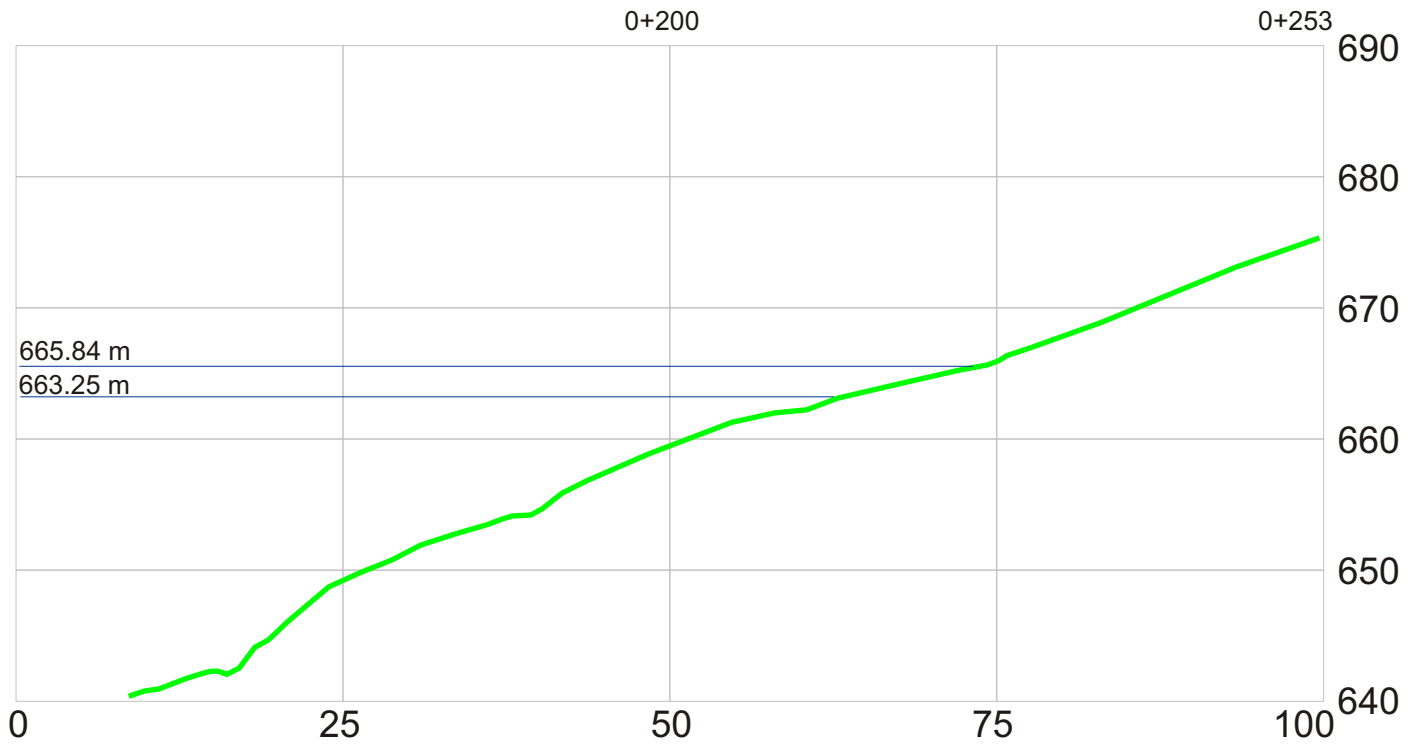
CROSS-SECTION PROFILE AT SITE XS-9, MAYO LAKE

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FIGURE A9



Surficial Geology: Moraine  
Erosion Activity: Low  
Grain Size: 3-4" angular bedrock fragment

CROSS-SECTION PROFILE AT SITE XS-10, MAYO LAKE

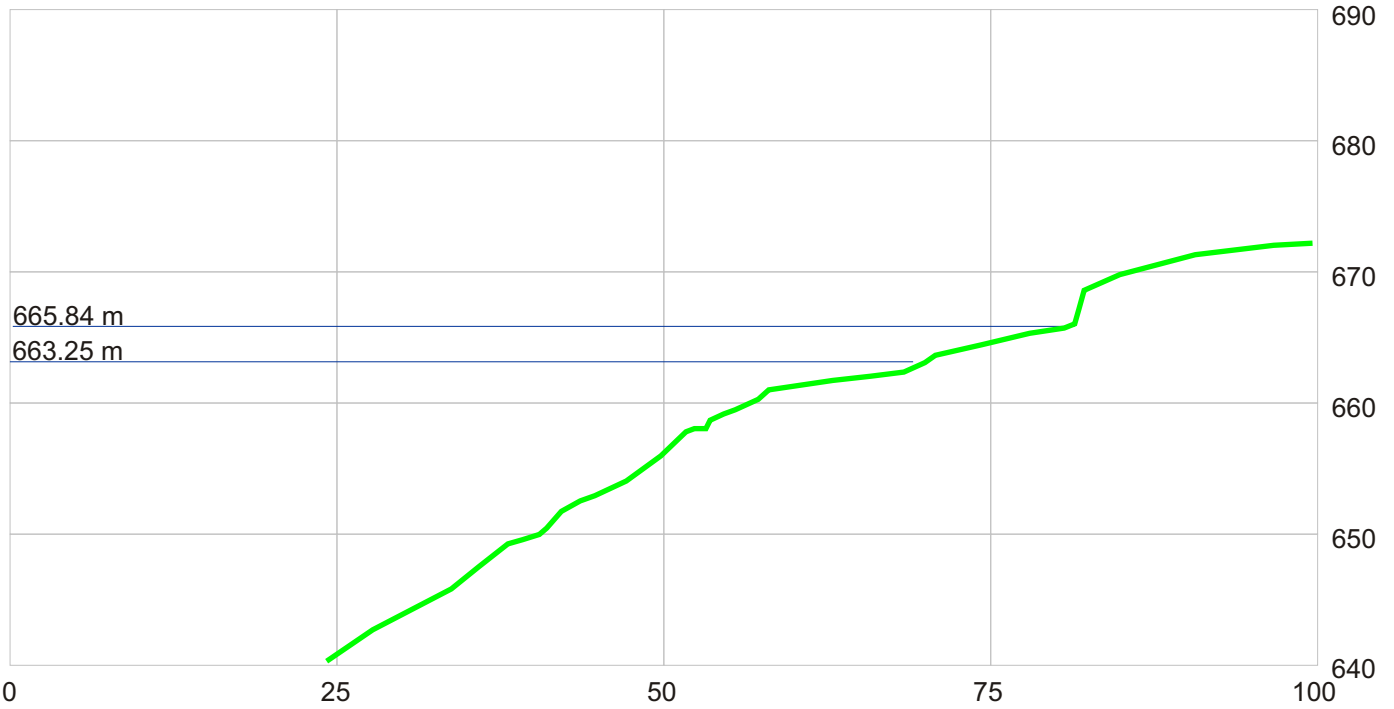
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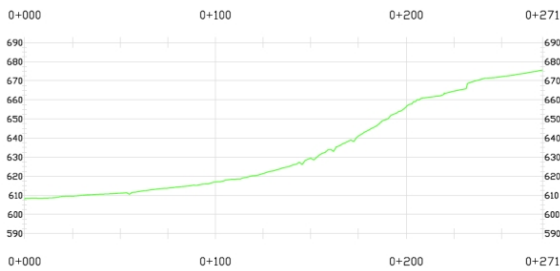
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FIGURE A10

0+200



Profile View of XSEC\_11



Surficial Geology: Colluvium/Bedrock (map) looks like till bluff  
 Erosion Activity: Low-Moderate  
 Grain Size: sand, gravel, clay, till blocks (reworked?)

CROSS-SECTION PROFILE AT SITE XS-11, MAYO LAKE

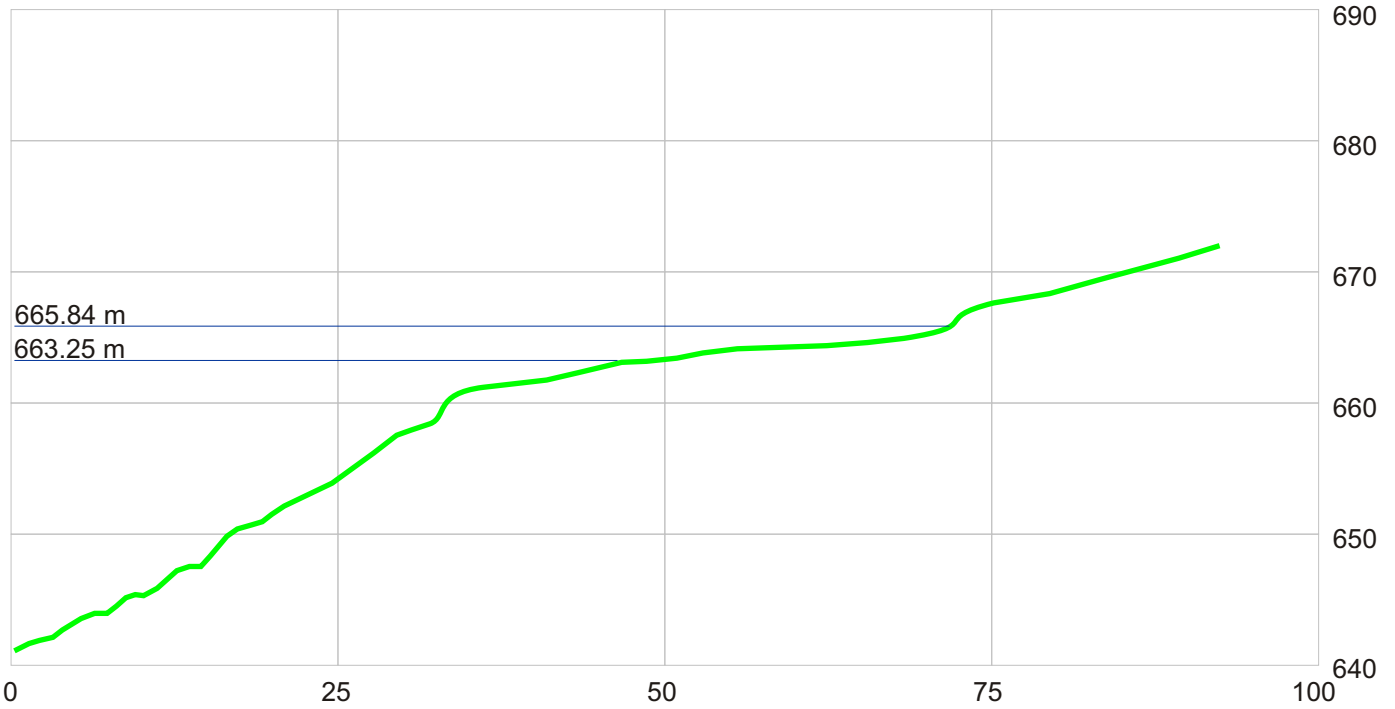
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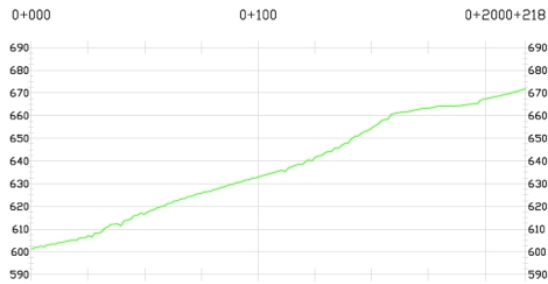
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FIGURE A11

0+200



Profile View of XSEC\_12



Surficial Geology: Moraine  
 Erosion Activity: Low  
 Grain Size: larger flat bedrock fragment organics, clay, coarse sand (wave worked?)

CROSS-SECTION PROFILE AT SITE XS-12, MAYO LAKE

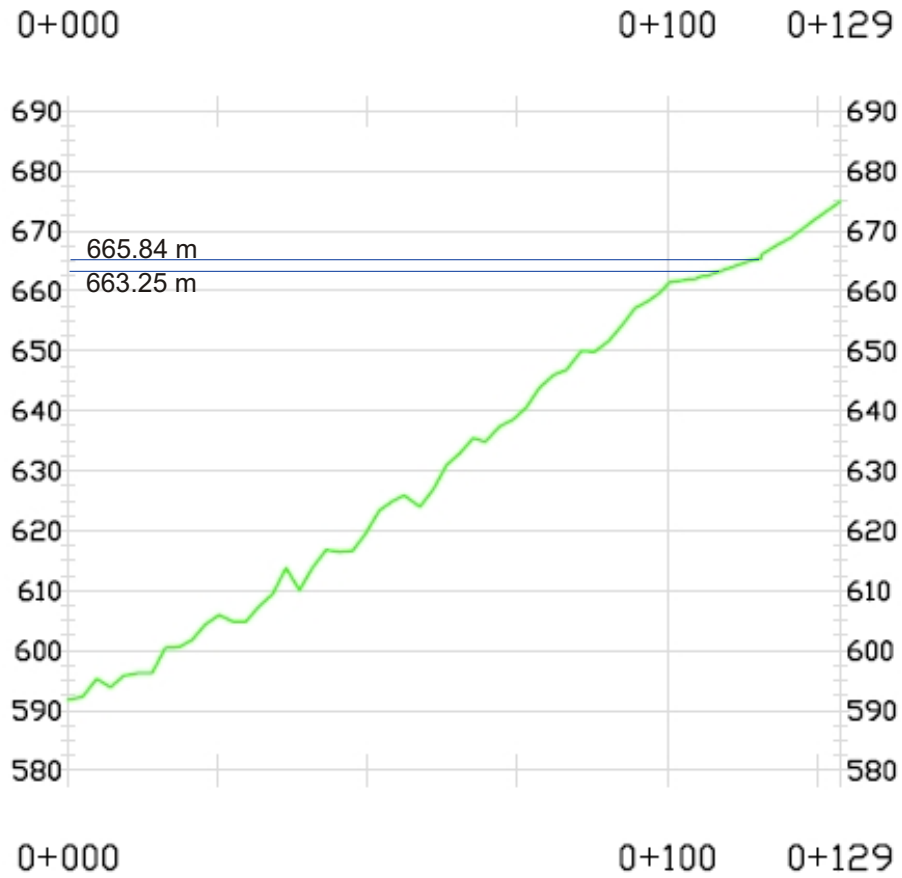
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FIGURE A12

### Profile View of XSEC\_13



Surficial Geology: Moraine  
 Erosion Activity: Low  
 Grain Size: clay, organics, rock fragments

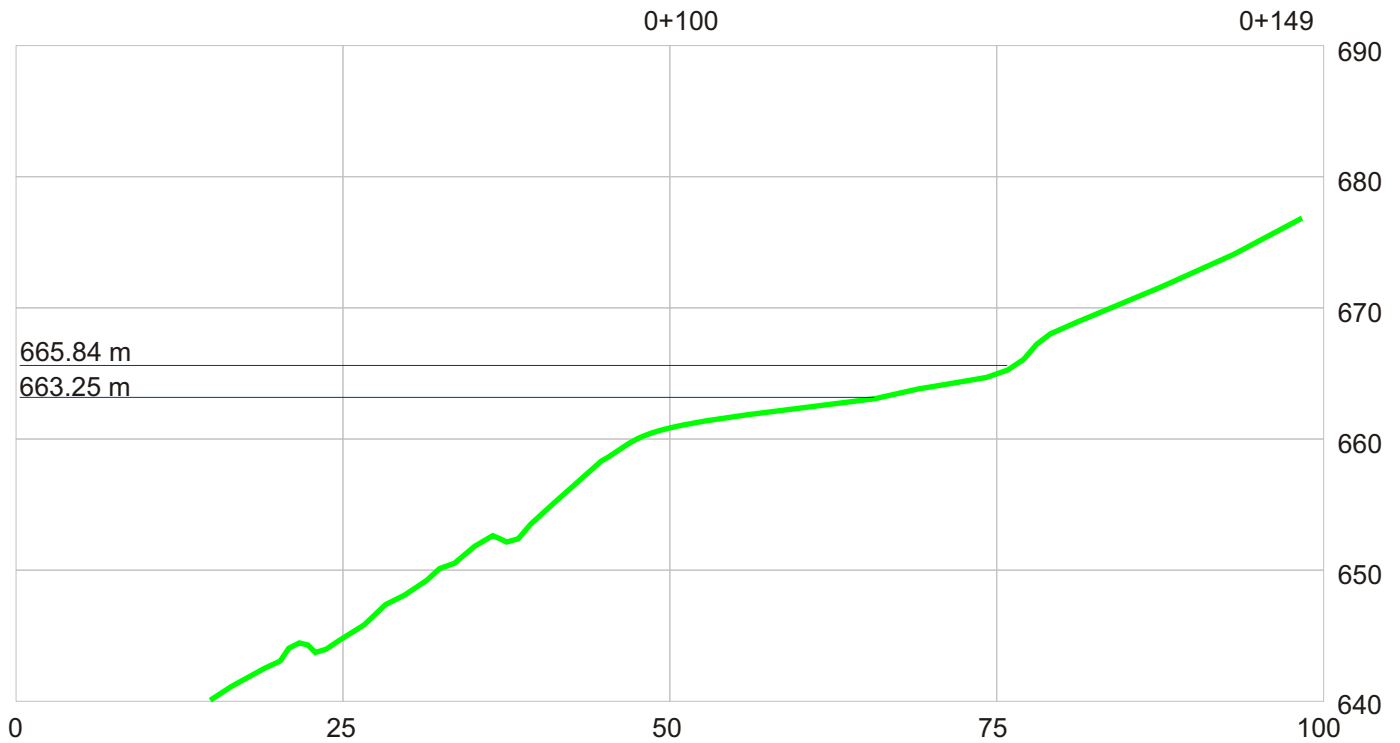
CROSS-SECTION PROFILE AT SITE XS-13, MAYO LAKE

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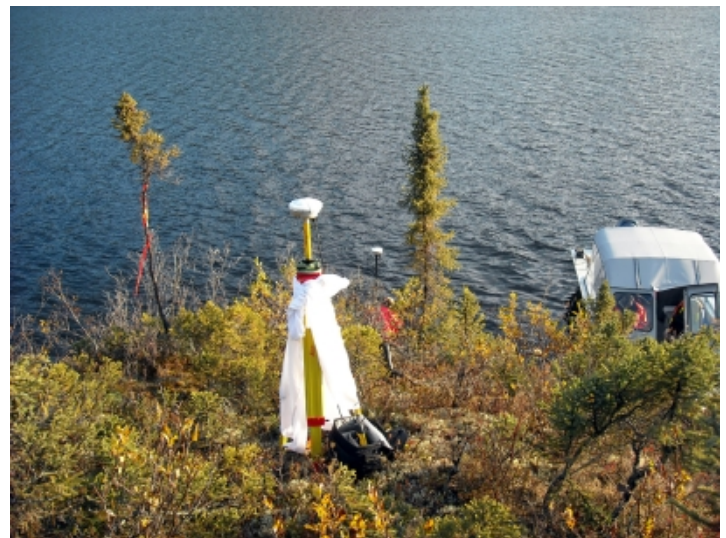
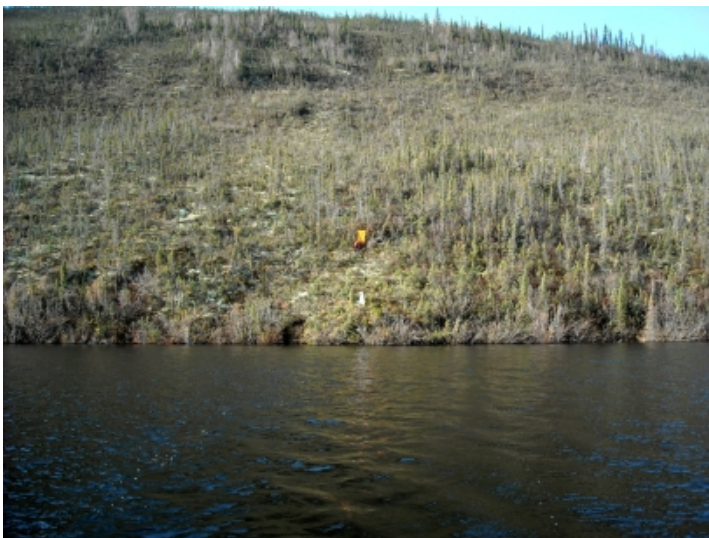
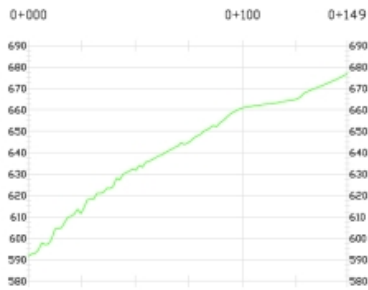


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**FIGURE A13**



Profile View of XSEC\_14



Surficial Geology: Alluvium/Colluvium  
 Erosion Activity: Low-Moderate  
 Grain Size: sand, gravel, clay, organics  
 (wave worked colluvium?)

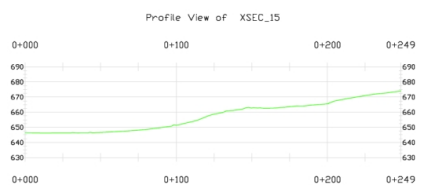
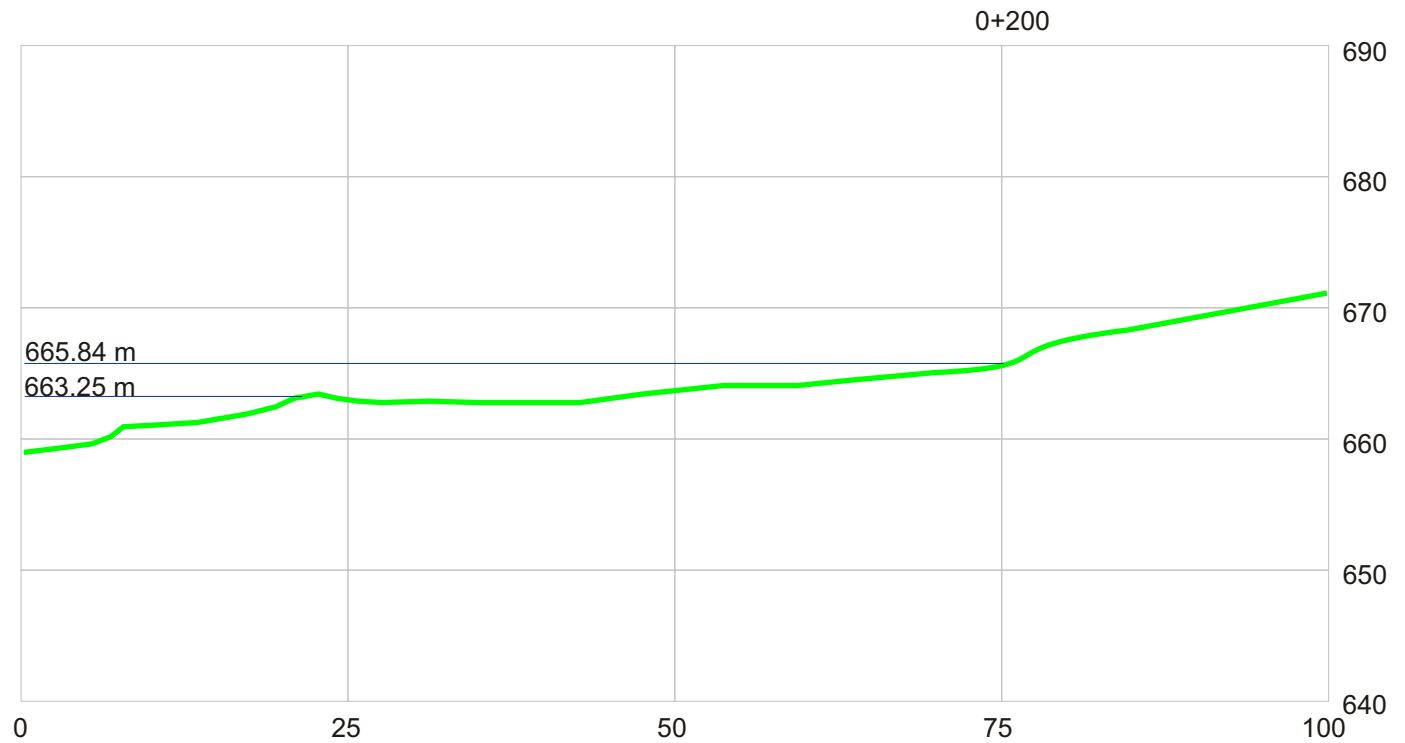
CROSS-SECTION PROFILE AT SITE XS-14, MAYO LAKE

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FIGURE A14



Surficial Geology: Moraine  
 Erosion Activity: Low  
 Grain Size: sand, gravel, clay (reworked?)

CROSS-SECTION PROFILE AT SITE XS-15, MAYO LAKE

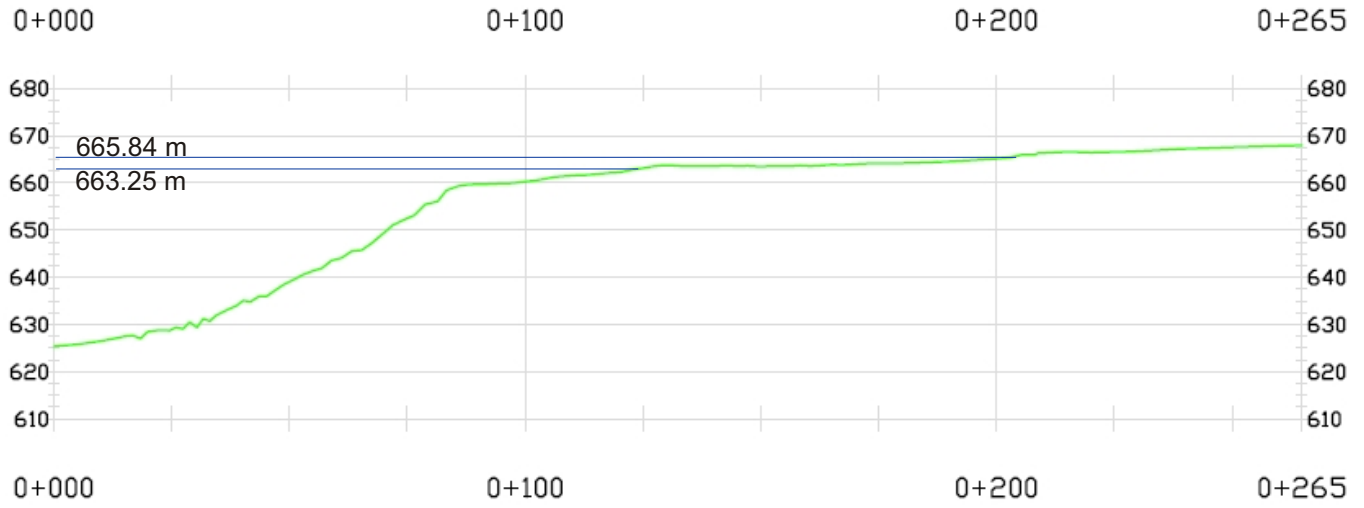
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FIGURE A15

Profile View of XSEC\_16



Surficial Geology: Alluvial  
Erosion Activity: Low-Moderate

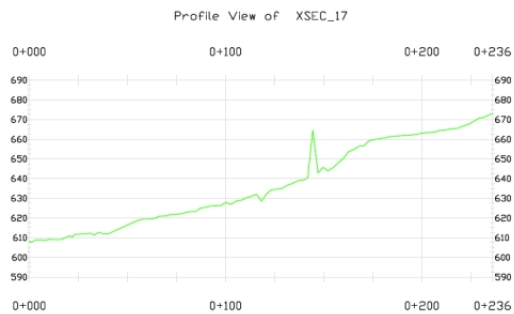
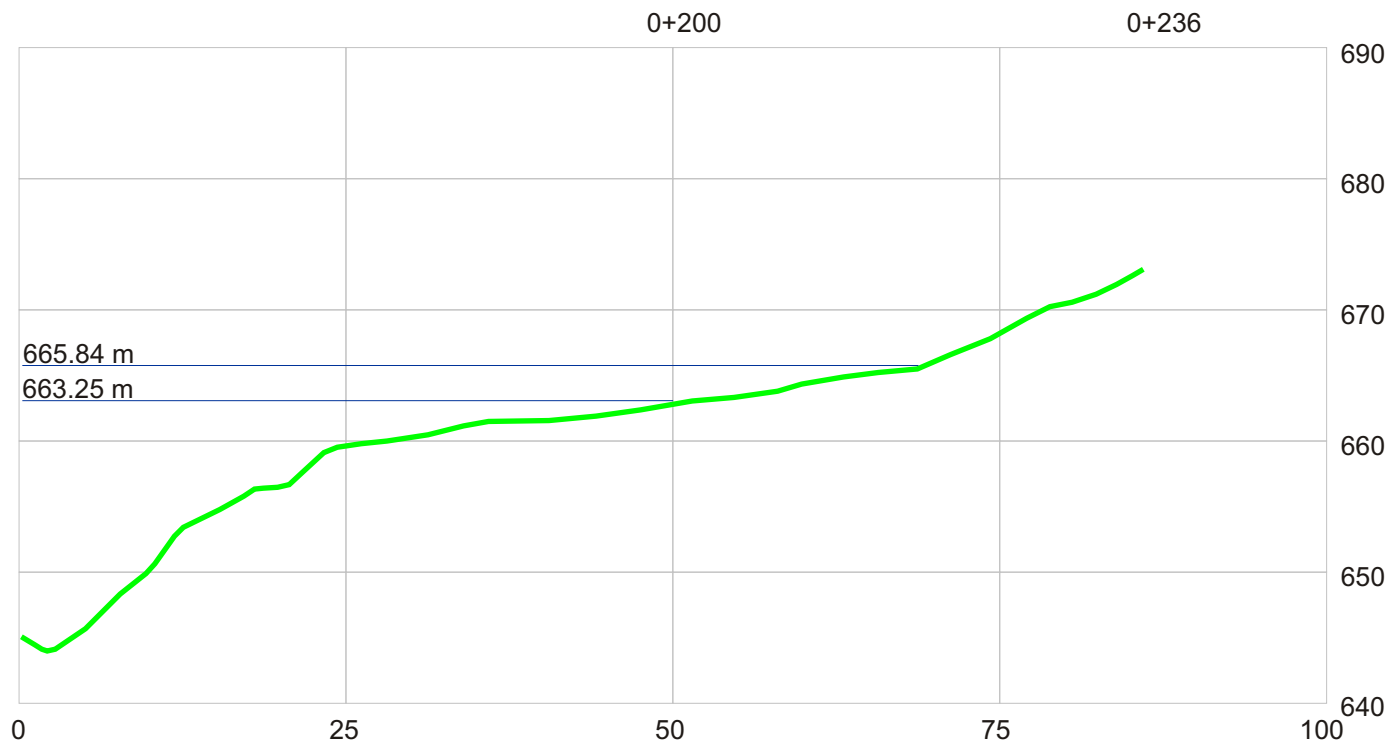
CROSS-SECTION PROFILE AT SITE XS-16, MAYO LAKE

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FIGURE A16



Surficial Geology: Moraine  
 Erosion Activity: Low-Moderate  
 Grain Size: sand, gravel, clay (till?)

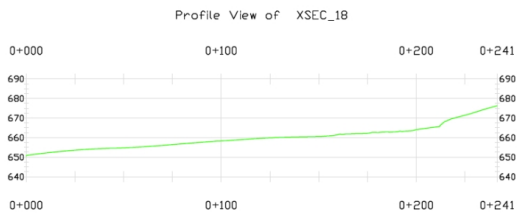
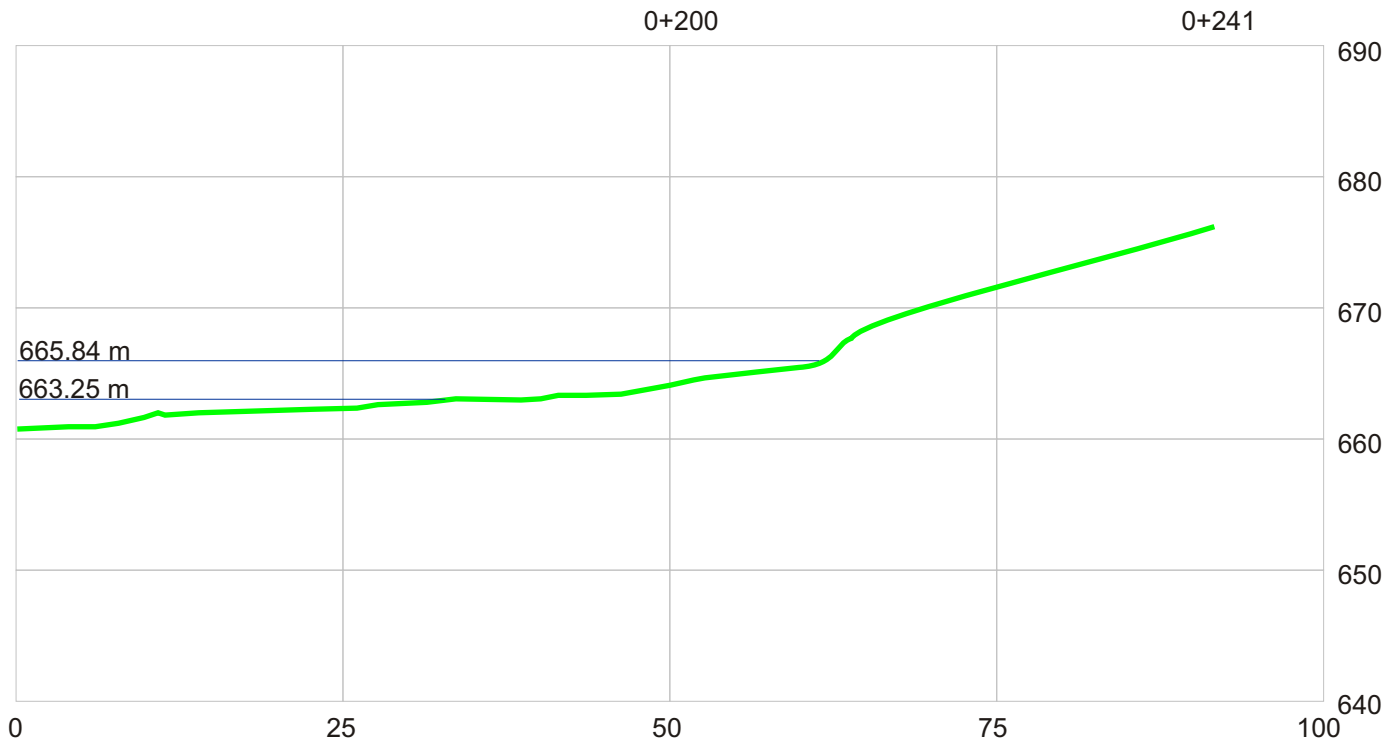
CROSS-SECTION PROFILE AT SITE XS-17, MAYO LAKE

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FIGURE A17



Surficial Geology: Moraine  
 Erosion Activity: Low-Moderate  
 Grain Size: angular bedrock (schist?)  
 Clay, sand (re-worked till vs colluvium?)

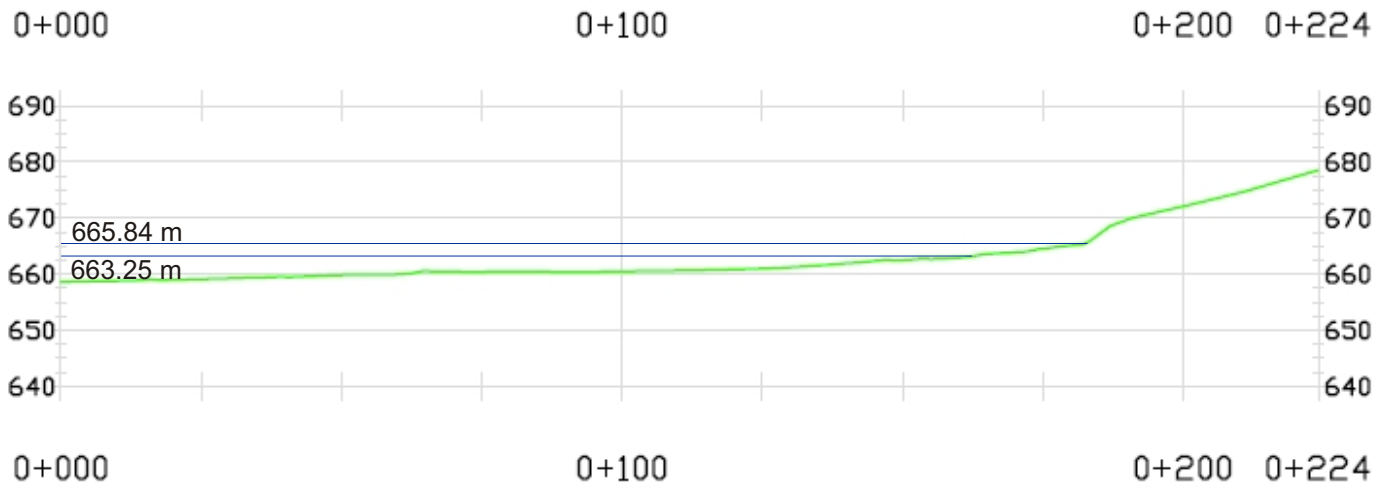
CROSS-SECTION PROFILE AT SITE XS-18, MAYO LAKE

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FIGURE A18



Surficial Geology: Glaciolacustrine  
 Erosion Activity: Moderate-High  
 Grain Size: clay, silt, fine sand

CROSS-SECTION PROFILE AT SITE XS-19, MAYO LAKE

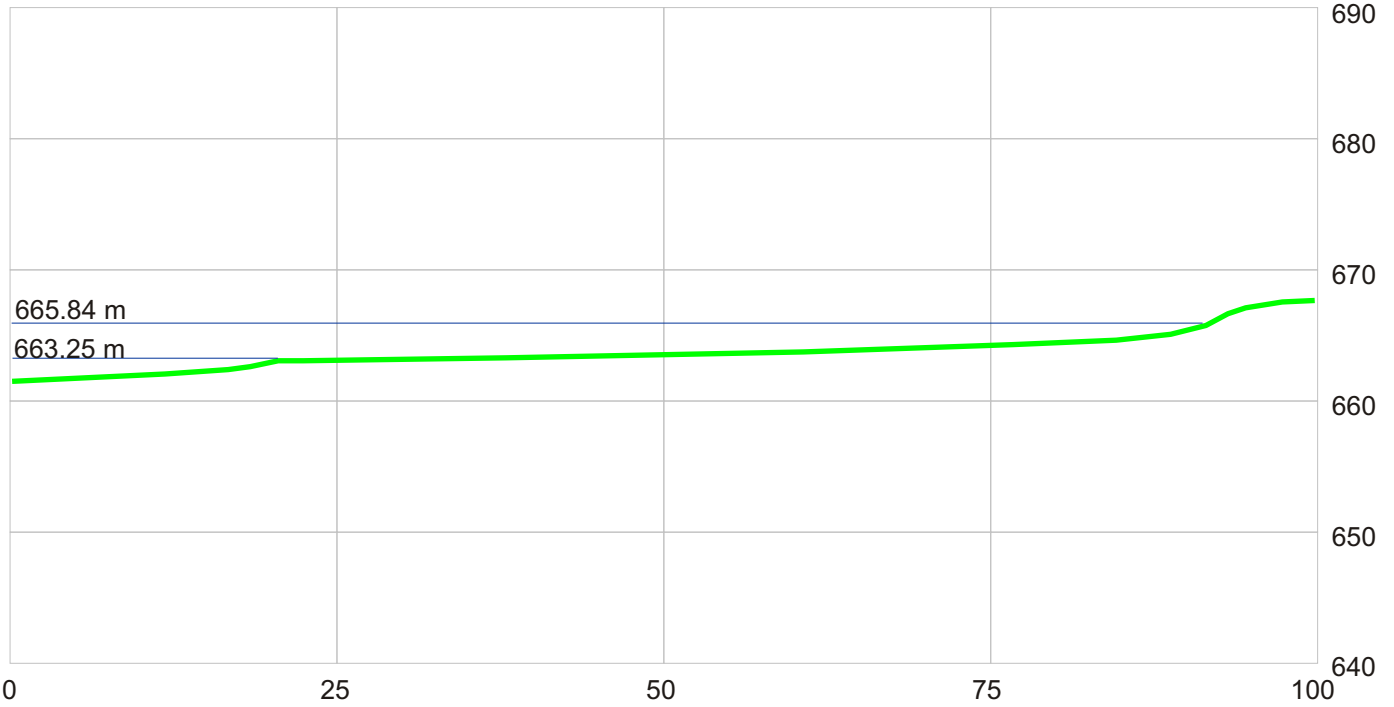
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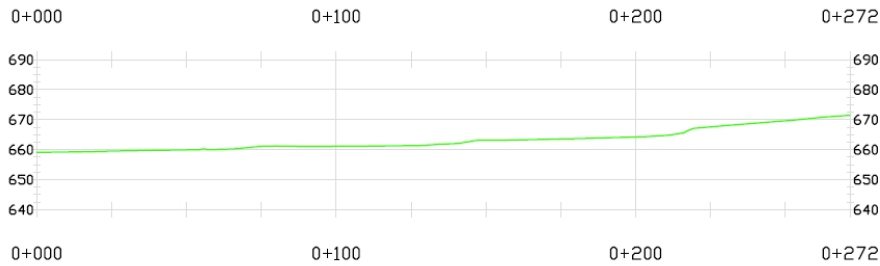
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**FIGURE A19**

0+200



Profile View of XSEC\_20



Surficial Geology: Glaciolacustrine  
 Erosion Activity: Moderate-High  
 Grain Size: clay, silt (glaciolacustrine)

CROSS-SECTION PROFILE AT SITE XS-20, MAYO LAKE

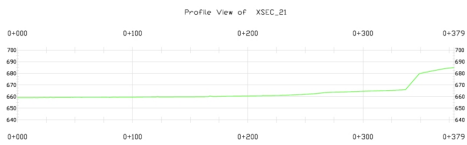
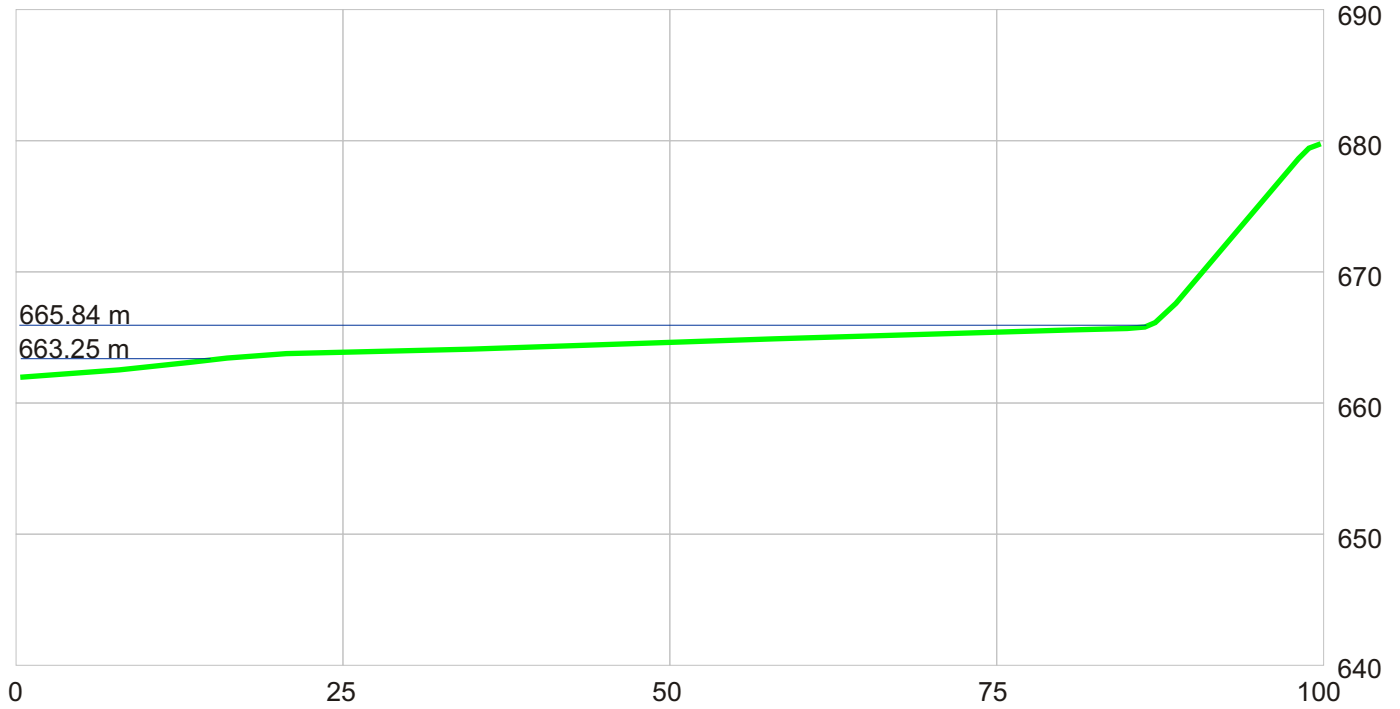
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FIGURE A20

0+300



Surficial Geology: Glaciolacustrine  
 Erosion Activity: Moderate-High  
 Grain Size: clay, silt (glaciolacustrine)

CROSS-SECTION PROFILE AT SITE XS-21, MAYO LAKE

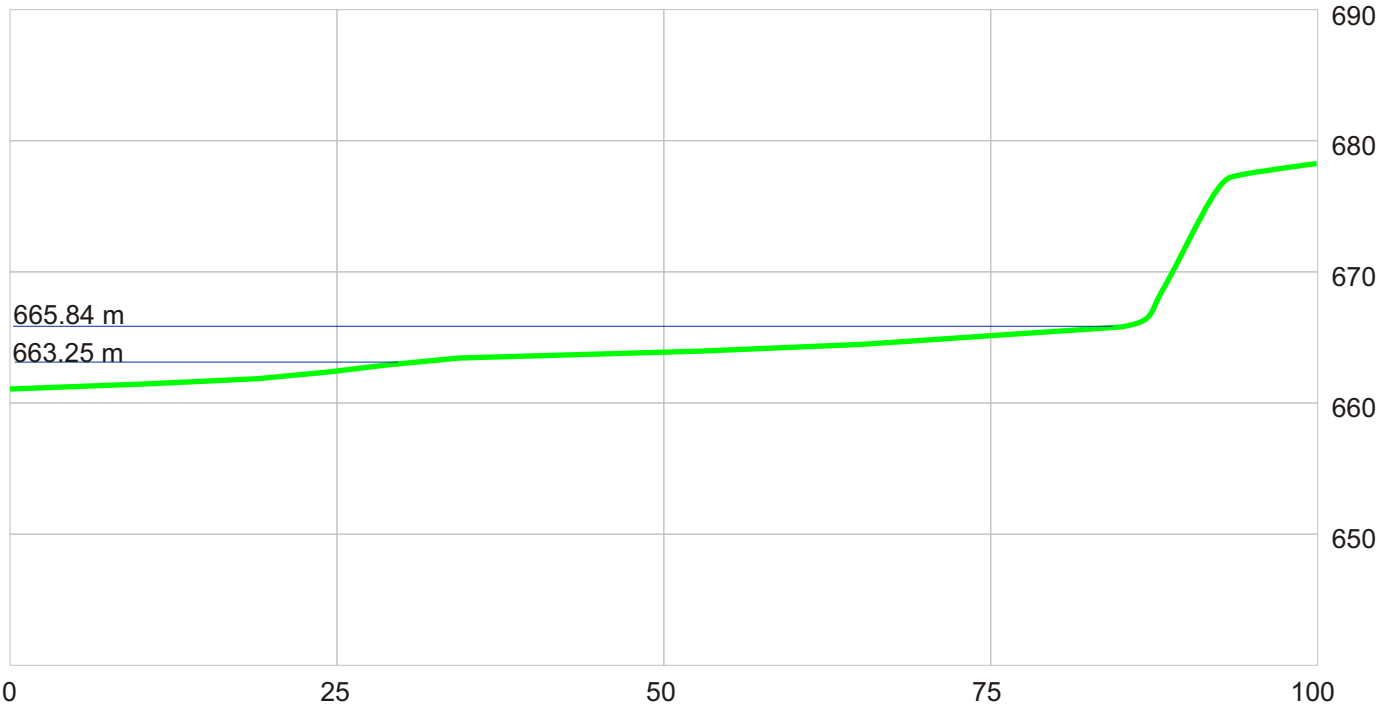
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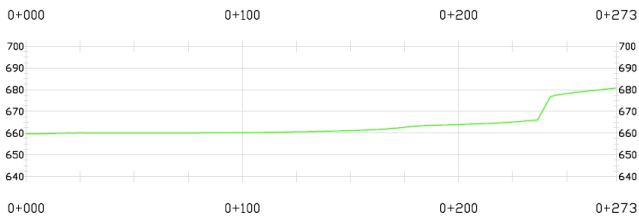
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FIGURE A21

0+200



Profile View of XSEC\_22



Surficial Geology: Glaciolacustrine  
 Erosion Activity: Moderate-High  
 Grain Size: clay, silt  
 (excess water - permafrost?)

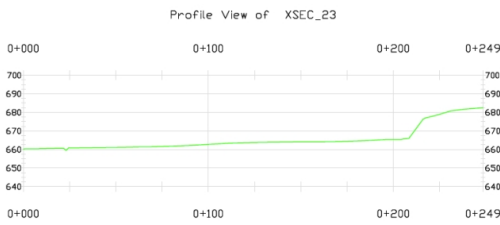
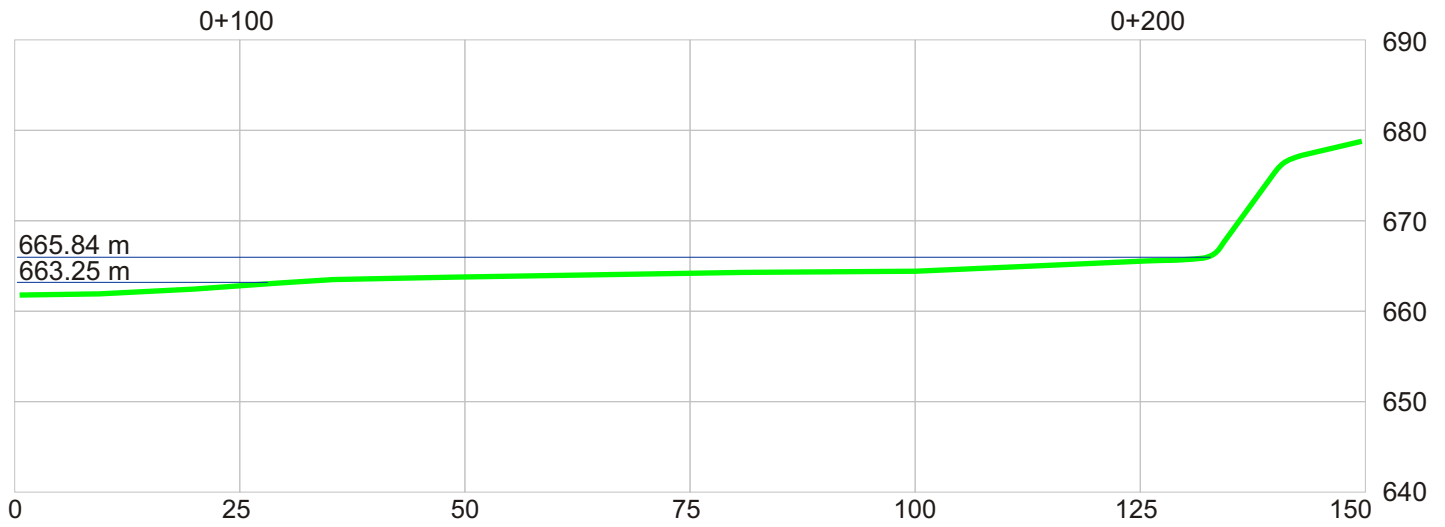
CROSS-SECTION PROFILE AT SITE XS-22, MAYO LAKE

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FIGURE A22



Surficial Geology: Glaciolacustrine  
 Erosion Activity: Moderate-High  
 Grain Size: uniform fine sand

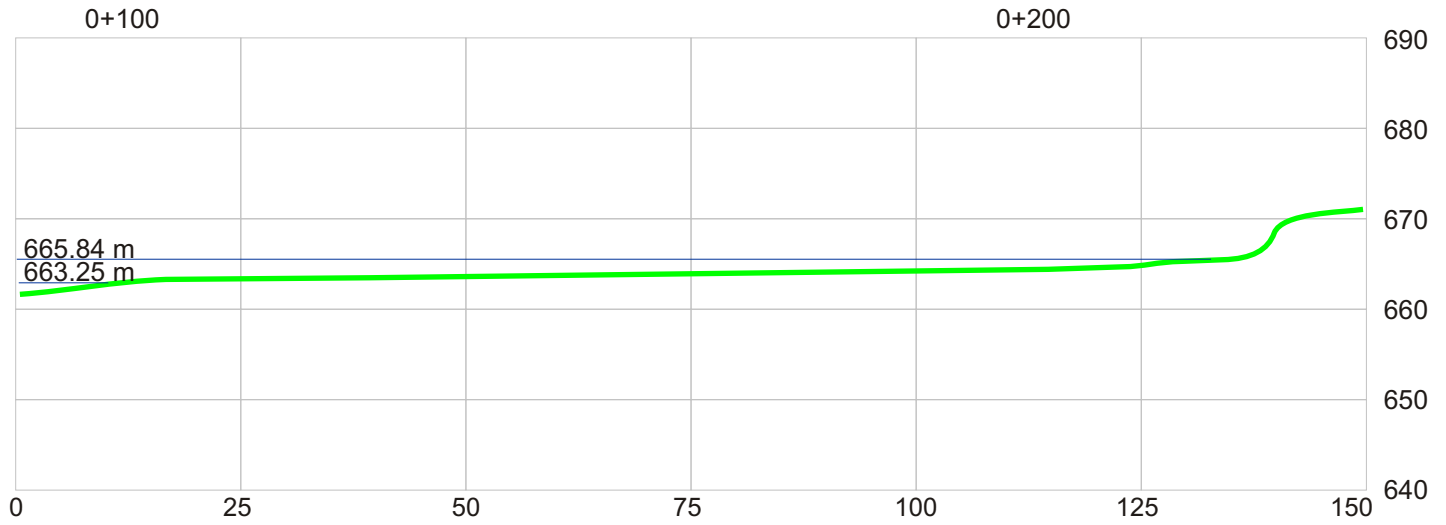
CROSS-SECTION PROFILE AT SITE XS-23, MAYO LAKE

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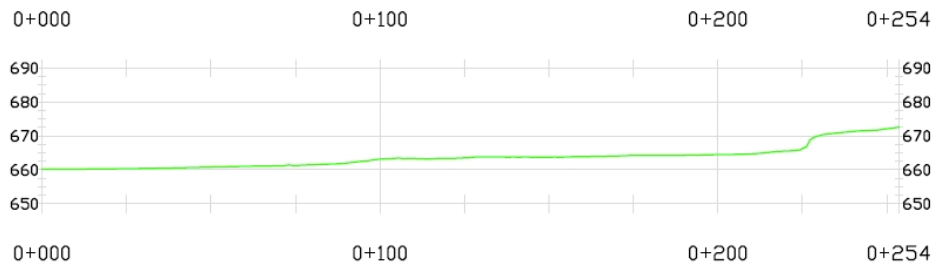


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**FIGURE A23**



Profile View of XSEC\_24



Surficial Geology: Glaciolacustrine  
Erosion Activity: Moderate-High  
Grain Size: silt, clay

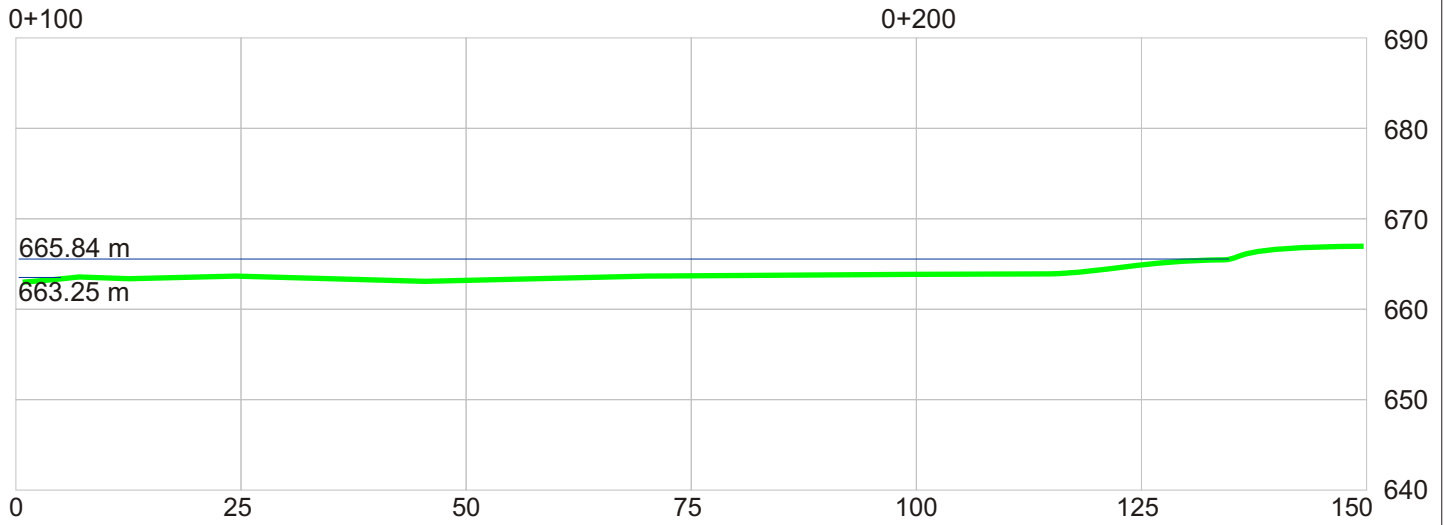
CROSS-SECTION PROFILE AT SITE XS-24, MAYO LAKE

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FIGURE A24



Profile View of XSEC\_25



Surficial Geology: Alluvium  
 Erosion Activity: Moderate-High  
 Grain Size: clay

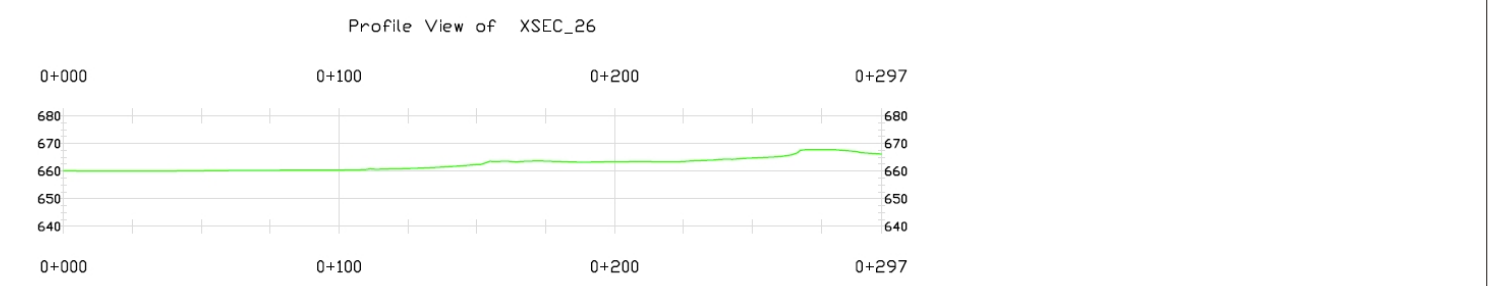
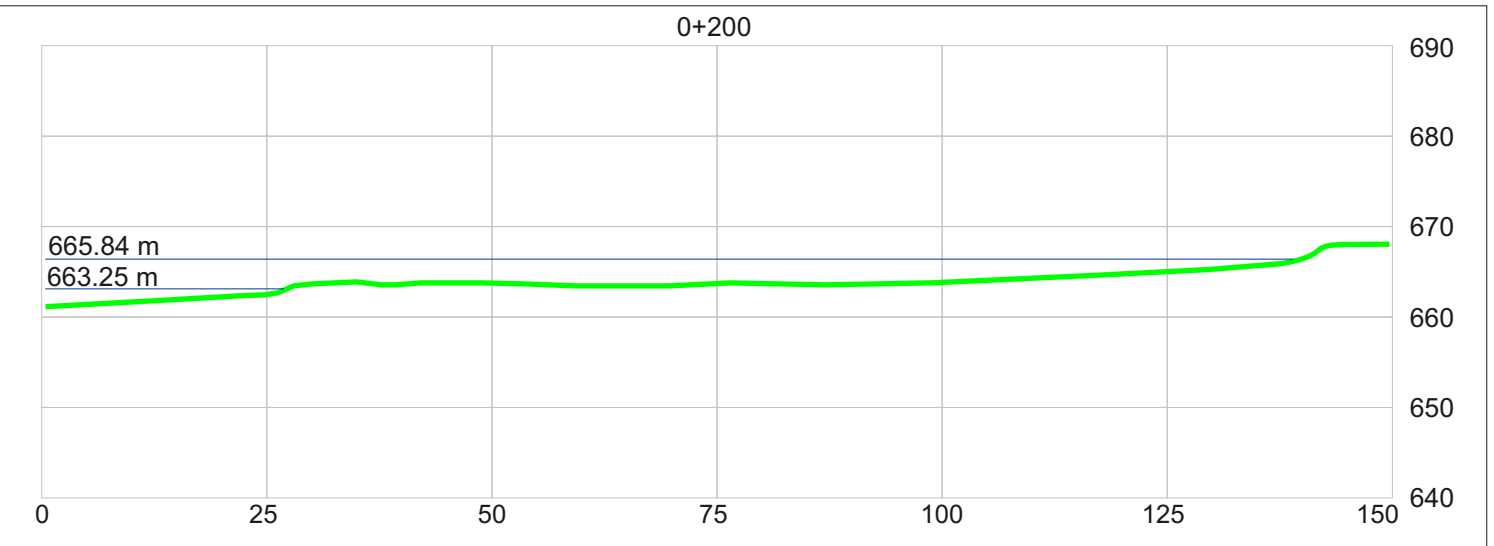
CROSS-SECTION PROFILE AT SITE XS-25, MAYO LAKE

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FIGURE A25



Surficial Geology: Alluvium  
Erosion Activity: Moderate-High  
Grain Size: coarse sand, gravel

CROSS-SECTION PROFILE AT SITE XS-26, MAYO LAKE

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FIGURE A26