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APPENDIX A

MOUNT POLLEY MINES

Tailing Storage Facility
2012 Stage 8 Expansion - Stability Analyses

Submitted to:

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1.0 ANALYSIS PARAMETERS AND METHODOLOGY

1.1 General

Two-dimensional limit equilibrium stability analyses were carried out using the computer code SLOPE/W (GeoStudio, 2007). The analyses utilized the Morgenstern-Price method of slices solution. There are seven main materials incorporated into the analyzed sections, Zone S (compacted till fill), Zone C (rockfill), tailings, foundation tills (ablation, basal), glaciolacustrine and glaciofluvial sediments, and bedrock. The material properties used for the analyses are based on previously established parameters assumed by KP (2007) with minor modifications deemed appropriate by AMEC. The parameters used in the stability analyses presented herein are summarized in Table 1.1.

The stability of the three dam sections is dependent on the strength of the downstream rockfill shell and foundation materials. The compacted till core is supported by the downstream rockfill shell and does not significantly contribute to the stability of the embankment from a slope stability perspective.

1.2 Material Parameters

In the fall of 2011, AMEC conducted a field investigation, involving sonic drilling, to replace broken instrumentation and to gather additional information around the base of the embankment, with specific focus on the extent and geotechnical characteristics of glaciolacustrine and glaciofluvial sediments within the glacial till units that predominate within the dam foundations. The following is the summary of the findings as presented in the AMEC Site Investigation Report:

<u>Main Embankment</u>

> Glaciolacustrine and glaciofluvial units exist between an upper and lower till unit, with thicknesses ranging from approximately 5 to 33m.

<u>Perimeter Embankment</u>

> Glaciolacustrine and glaciofluvial units exist within the glacial till units. At Stn.4+000 the thicknesses are approximately 3 to 4m, while at Stn.3+300 the thickness of the unit is approximately 4m. Glacial till was the only soil unit encountered in the drill hole at Stn.4+500.

<u>South Embankment</u>

> Only a thin unit of glaciolacustrine soil, in the order of 0.6m, was encountered within foundation soils near Stn.1+100.

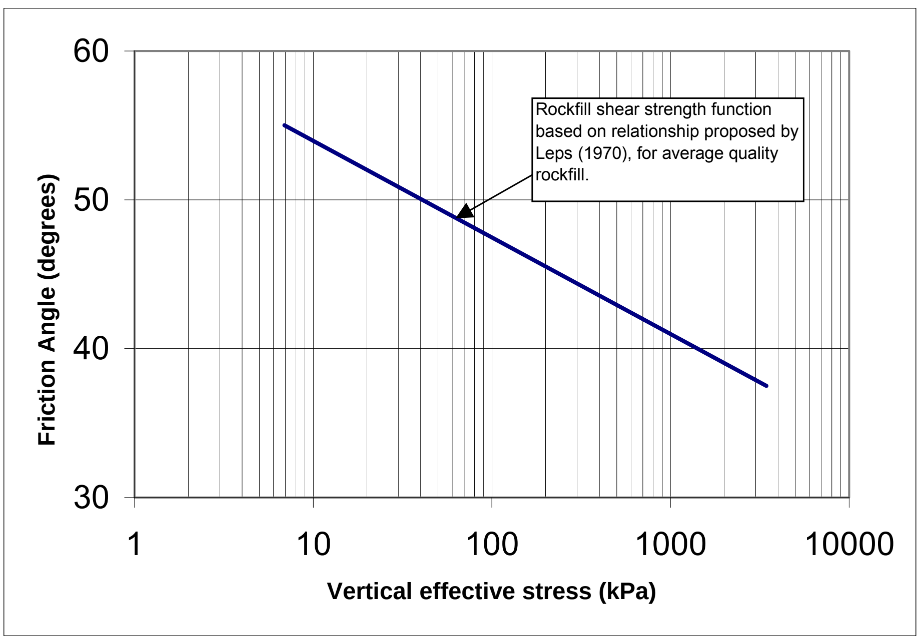
The glaciolacustrine/glaciofluvial unit generally was found to be varved with predominantly silt and clayey silt of low plasticity, interbedded with more granular glaciofluvial deposits. There is no indication of pre-shearing within the glaciolacustrine (each unit was checked by peeling the cores apart for close visual examination, specifically looking for slickensided surfaces). Therefore a shear strength of c' = 0, and ϕ' = 28° is judged reasonable for the glaciolacustrine unit, although sensitivity analyses were carried out within the range given in Table 1.1.

The till unit was generally observed as silty sand and gravel with occasional interbedded sand seams at depth.

The rockfill shear strength is taken as stress-level dependent as per Leps (1970), as illustrated in Figure 1.1. It is anticipated that the rockfill used for construction of the 2012 expansion will be comparable to that used for the past dam raises. As such, the trend for average rockfill was used because the rockfill is anticipated to be:

- strong and durable with high compressive strength;
- well-graded, and comprised of highly angular rock; and
- will receive moderate compactive effort.

Figure 1.1: Shear Strength Relationship Used for Rockfill



During the 2011 construction season, AMEC observed that on average the bulk unit weight of the till on average is 20.5 kN/m^3, so this is now adopted for the purposes of stability analyses. The material strength parameters used in the stability analyses are as summarized in Table 1.1

Table 1.1: Material Strength Parameters

Material	γ_b (Bulk Unit Weight) (kN/m^3)	ϕ' (Friction Angle) (degrees)	c' (Cohesion) (kPa)
Rockfill (Zone C)	22	Defined by Lep's (1970) shear normal function for average quality rockfill (Note 1)	0
Compacted Till Fill (Zone S)	20.5	35	0
Glaciolacustrine/Glaciofluvial	20	28 Sensitivity analysis (24 through 33)	0
Basal Till	21	33	0
Tailings	18	30 (drained) S_u/σ_v' = 0.1 (undrained)	0

Note 1: The shear normal function used for the rockfill accounts for the stress-level dependency of the normalized shear strength as expressed by the effective friction angle (ϕ') – see Figure 1.1.

1.3 Pore Pressure Assumptions

Where possible, the current phreatic surfaces were derived from vibrating wire piezometer readings installed in the embankments or into the embankment foundation. Where no piezometric pressure data was available, the phreatic surface was estimated based on trends on monitored sections, interpolation of piezometer data, observed piezometric trends over the years at this facility, and experience from other tailings dams of similar design with similar foundation conditions.

The phreatic surface for the 2012 expansion was estimated by increasing current phreatic surface on the upstream side of the core by 3.4 m, equivalent to the Stage 8 raise, while maintaining the phreatic surface downstream of the core indicated by interpolation of piezometric data.

The rockfill was assigned zero pore pressure except where located below the phreatic surface, below which pore pressures at any given point were taken as hydrostatic.

The phreatic surface modeled in the analyses reflects the pore pressures observed in the glaciolacustrine/glaciofluvial unit.

1.4 Minimum Factor of Safety Criteria

The minimum factor of safety (FoS) criteria for design is 1.3 for short-term (during construction) and 1.5 for long-term (closure) steady state conditions.

2.0 STABILITY ANALYSES RESULTS

The stability analyses of the TSF 2012 expansion were carried out for three cross sections of the embankment (Perimeter, Main, and South). These sections are near the previously analyzed sections. Slight modifications to the analyzed cross sections were made to eliminate confusion between the planes and sections references in previous reports. The stability results are presented in Figure 2.1 through Figure 2.3 and are summarized below in Table 2.1.

To analyze stability of the embankment two cases were considered for each cross section. Case one considers drained shear strength within the tailings, while the second case considers the undrained tailings shear strength scenario.

Table 2.1: Factor of Safety Summary

Section Embankment	Current Conditions	2012 Stage 8 Expansion	Approximate FoS Reduction
Tailings shear strength: drained ($c' = 0$, $\phi' = 30°$)			
Main (Ch. 20+60)	1.37	1.32	3.6%
Perimeter (Ch. 39+90)	2.01	1.89	6.0%
South (Ch. 7+20)	2.25	2.07	8.0%
Tailings shear strength: post-liquefaction, undrained ($S_u/\sigma_v' = 0.1$)			
Main (Ch. 20+60)	1.33	1.27	4.5%
Perimeter (Ch. 39+90)	1.98	1.82	8.1%
South (Ch. 7+20)	2.23	2.03	9.0%

Sensitivity analyses were undertaken for the main embankment (the one with the lowest FoS) considering a range of shear strengths within the glaciolacustrine/glaciofluvial unit, for peak (drained) and post-liquefaction residual (undrained) shear strength conditions within the tailings. The results of these analyses are summarized on Figure 2.4. For the 2012 raise configuration, an acceptable factor of safety (≥ 1.3) is obtained for a glaciolacustrine/glaciofluvial unit ϕ' value of 27°.

To analyze the 2012 expansion impact on the overall stability of the embankment, analyses comparing the 2011 as-built condition and 2012 expansion were performed. Similar to the 2011 expansion the stability analyses identified that the main embankment was the critical section for the 2012 expansion (i.e. the section yielding the lowest FoS). A FoS reduction of about 3.6% was observed in the main embankment for the case of peak (drained) strength within the tailings, while a 4.5% reduction was observed for the post-liquefaction residual (undrained) strength within the tailings. Similarly, due to the negligible reduction in FoS under static loading conditions, it is reasonable to infer that the seismic stability situation would remain essentially unchanged relative to KP's 2007 analyses, which predicted earthquake-induced deformations, under the design earthquake loading, to be well within tolerable limits. Thus, the stability requirement is satisfied for the 2012 expansion.

A stability analyses for the ultimate embankment configuration will be undertaken in 2012. This analysis will review the embankment to an elevation of 970 m or as specified. In addition, during the ultimate design stability analysis the timing of flattering/extending of the overall downstream slope will be assessed to maintain a FoS during construction above 1.3 and ultimately achieve the minimum closure requirement of 1.5 once the embankment is completed to its final configuration.

2.1 Pore Pressure Trigger Levels

Pore pressure trigger levels are a useful means of relating monitored piezometer data to the stability analyses and the achieved factors of safety. In this way, piezometric alert levels can be quantified, with pre-set actions to be taken if defined trigger levels are approached or exceeded.

To determine the pore pressure trigger levels in the foundation piezometers additional stability analyses were performed. As the main embankment cross sections was determined to be the critical section, as stated above; thus, this cross section and the pore pressures associated with this section were utilized to assess and assign trigger levels. A red, yellow, green stoplight approach was utilized and the conditions are depicted as follows:

Red (factor of safety at or below 1.1) – If the foundation piezometers indicate a red condition, crest raising is to cease. AMEC's Senior Technical Engineer is to be informed immediately, and a corrective course of action will be implemented as per direction of the AMEC's Senior Technical Engineer, including intensified monitoring, and placement of a stabilization buttress to flatten the overall slope in the embankment area of concern.

Yellow (factor of safety above 1.1 and below 1.3) – If the foundation piezometers indicate a yellow condition, work should be temporarily suspended in around the embankment, AMEC's Senior Technical Engineer is to be informed, and a corrective action will be implemented as per direction of the AMEC's Senior Technical Engineer. Access to the embankment should be limited to essential personnel.

Green (factor of safety above 1.3) – If the foundation piezometers indicate a green condition, work in and around the embankment is to continue as needed.

It should be noted that a yellow or red condition is not triggered by a single piezometer on a given instrumentation section yielding a reading of concern. Such conditions will only be triggered if most or all foundation piezometers reach the requisite trigger levels. If individual piezometers on a section approach or reach threshold levels while the remainder do not, additional and/or intensified monitoring may be specified, but the threshold levels described above will not be deemed as having been triggered.

Besides the specified trigger levels, piezometric trends are to be closely monitored in the foundation piezometers. Small variations in the piezometric readings are expected, however if a spike occurs in any of the foundation piezometers, and/or an unexpected a consistent trend of increasing pore pressure is noted, AMEC's Support Engineer is to be informed immediately to assess the situation.

The results of the pore pressure trigger level stability analyses are presented in Figure 2.5 and are summarized in the Table 2.2 below, which applies only for the main embankment piezometers. Factor of safety values for the perimeter and south embankments are sufficiently high that monitoring of piezometric trends, without defined trigger levels, is deemed sufficient.

Table 2.2: Foundation Piezometer Trigger Levels

Condition	Modeled Elevation (m)	Above Original Ground Elevation (912m) (m)
RED	Above 925	>13
YELLOW	Between 921 and 925	9 to 13
GREEN	Less than 921	<9

Figure 2.1: Main Embankment Stability Analysis

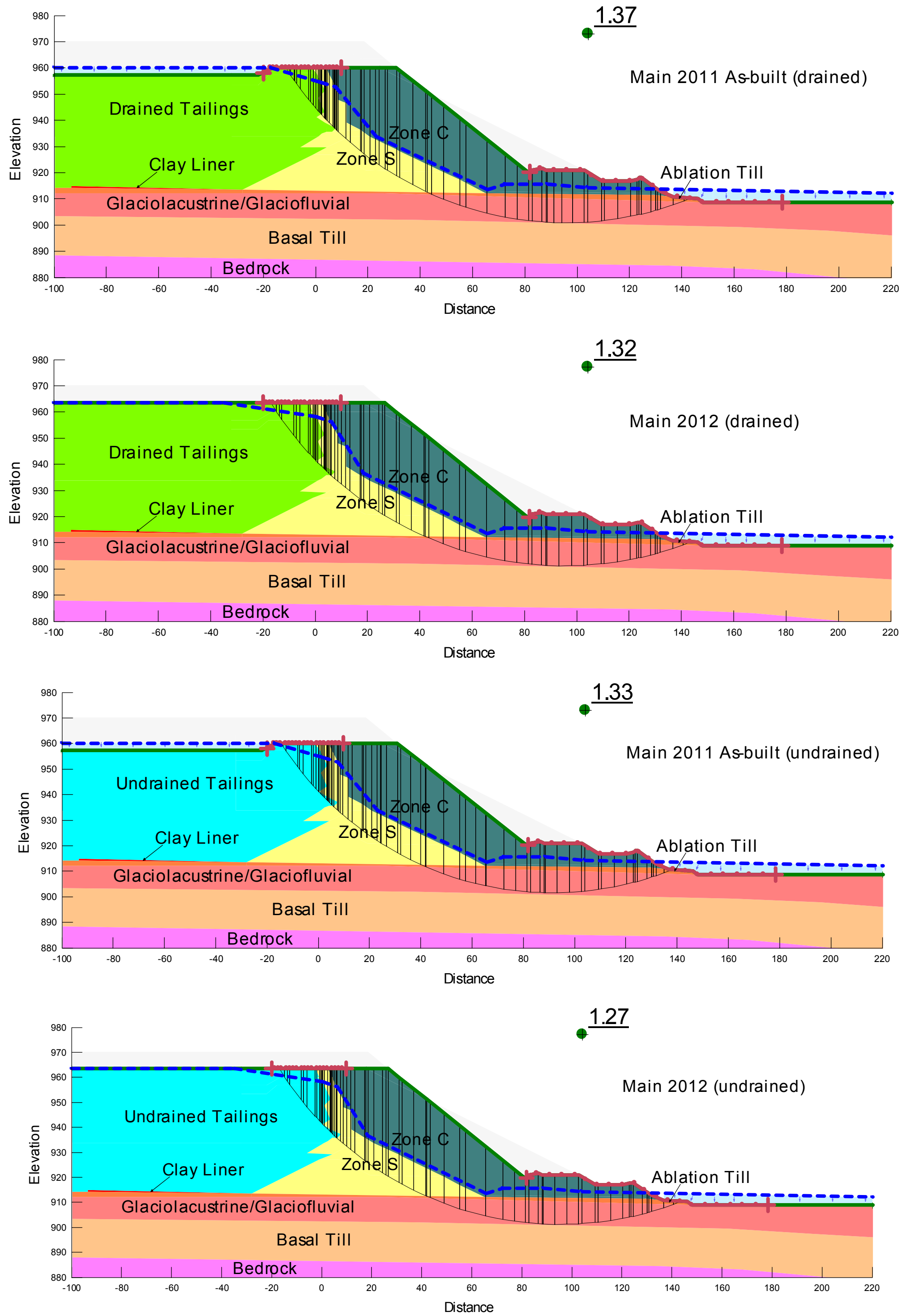


Figure 2.2: Perimeter Embankment Stability Analysis

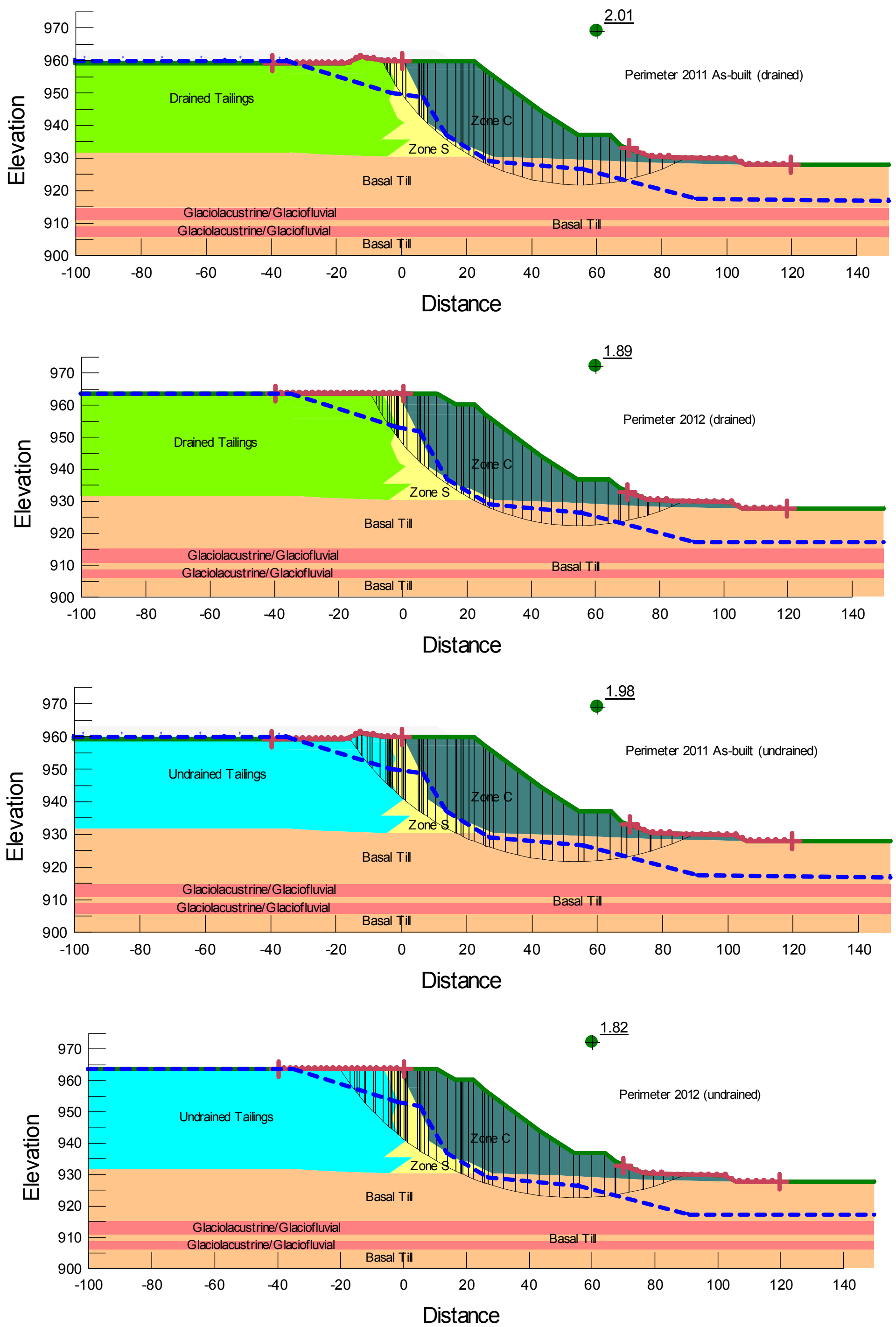


Figure 2.3: South Embankment Stability Analysis

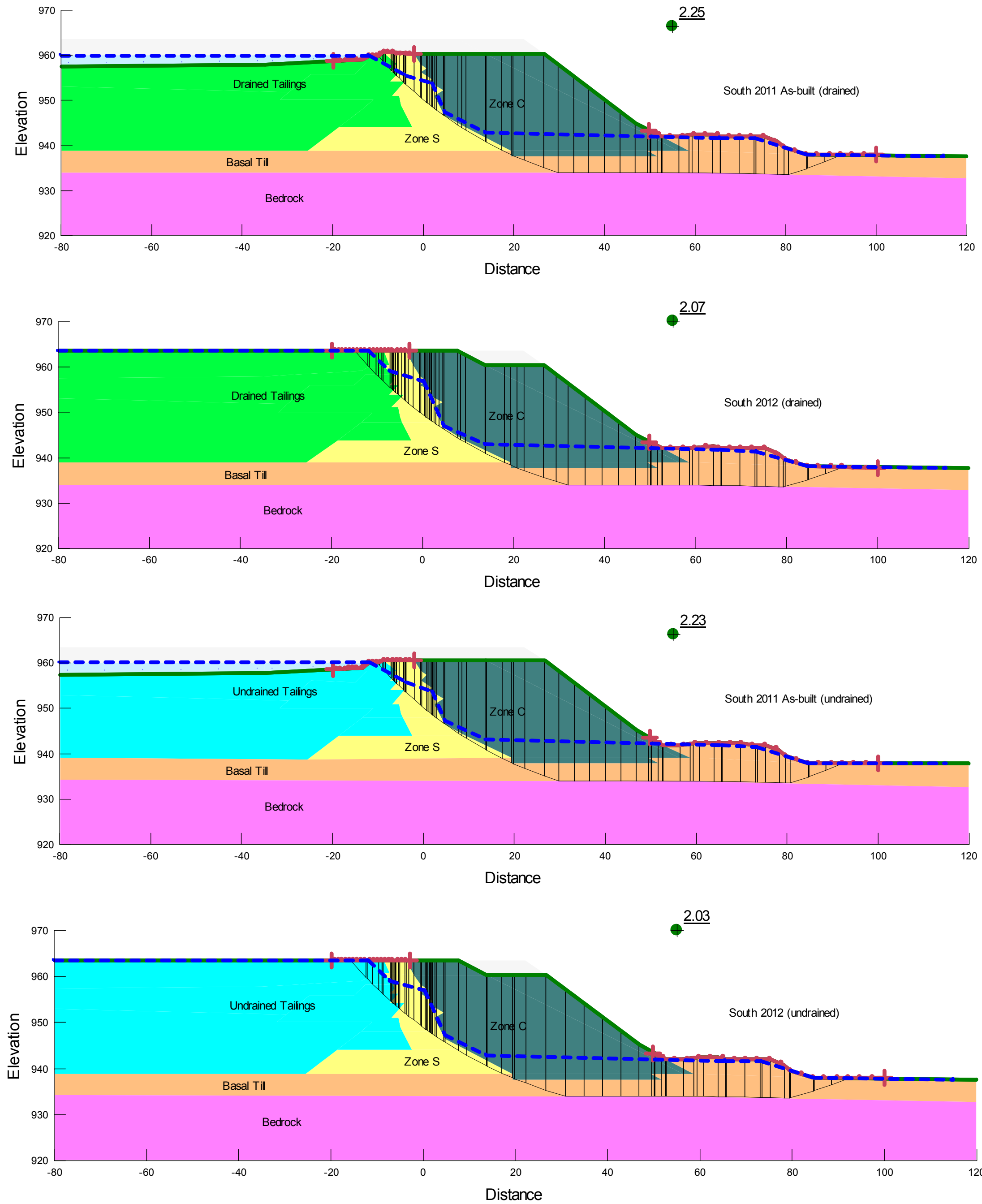


Figure 2.4: Glaciolacustrine Sensitivity Analysis (Main Embankment)

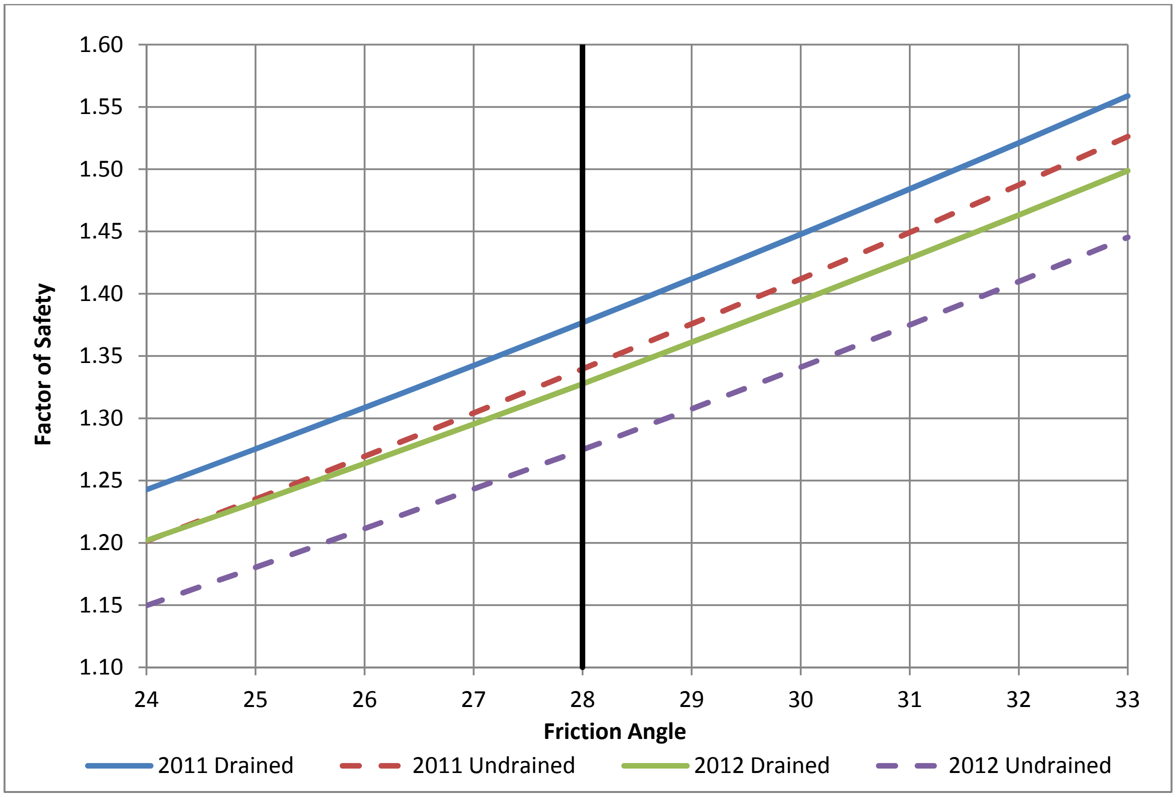
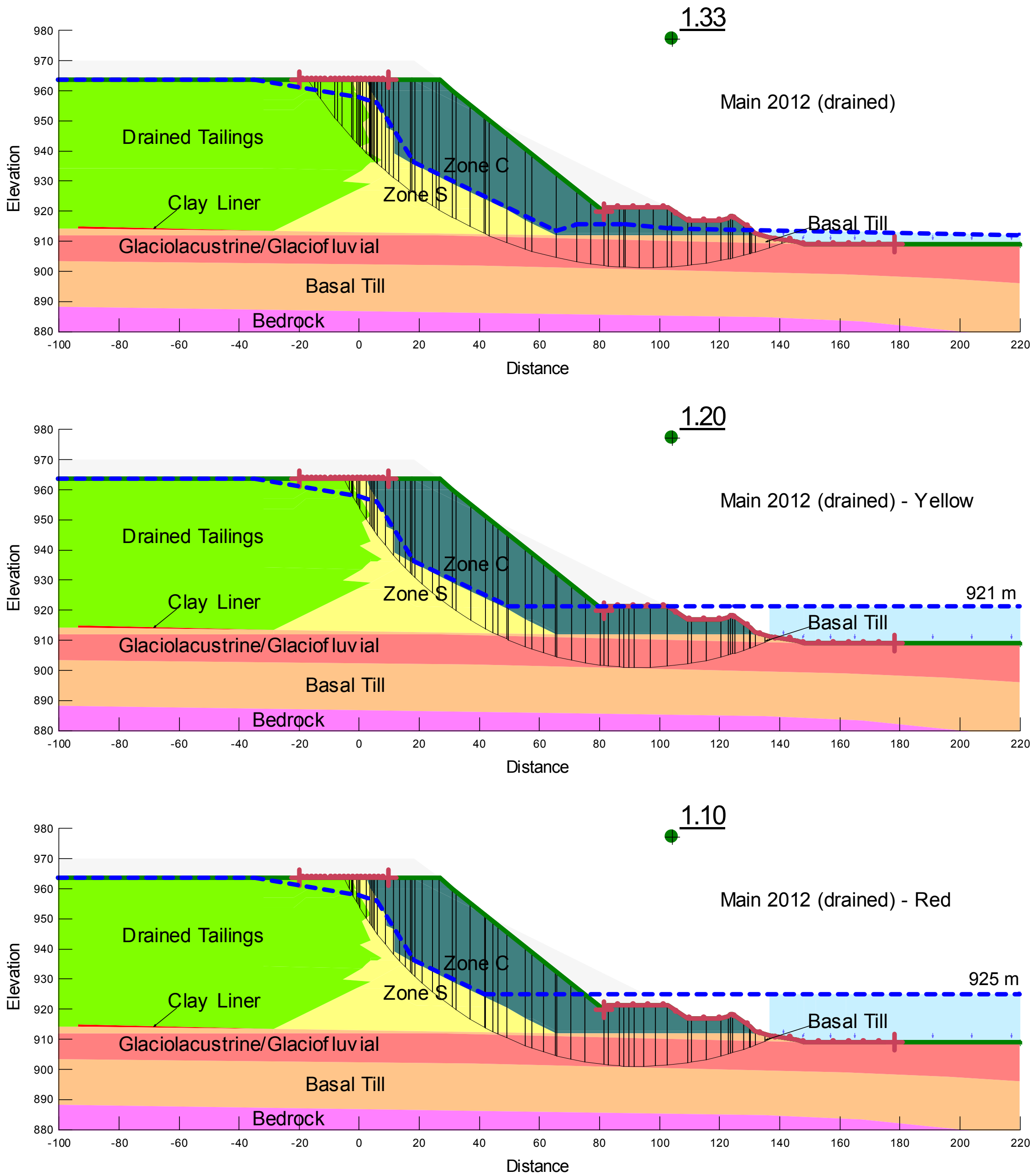


Figure 2.5: Pore Pressure Trigger Levels Stability Analysis



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