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Slope Failure on Northbound Lagimodiere Blvd between Betournay St and Elizabeth Rd

Geotechnical Investigation and Slope Instability Assessment Report

Prepared for:
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106-1155 Pacific Avenue
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Project Number: 0015 037 00

Date: September 14, 2020

GEOTECHNICAL Quality Engineering | Valued Relationships

September 14, 2020 Our File No. 0015 037 00

Mr. Jean-Luc Lambert, M.Sc., P.Eng.
Support Services Engineer
Streets Maintenance
Public Works Department
106-1155 Pacific Avenue
Winnipeg, MB
R3E 3P1

RE: Slope Instability on Northbound Lagimodiere Blvd between Betournay St and Elizabeth Rd
Geotechnical Investigation and Slope Assessment Report

TREK Geotechnical Inc. is pleased to submit our Final Report for the geotechnical investigation and slope stability assessment for the above noted project.

Please contact the undersigned should you have any questions.

Sincerely,

TREK Geotechnical Inc.
Per:

Michael Van Helden Ph.D., P.Eng.
Senior Geotechnical Engineer

Encl.

Revision History

Revision No.	Project Engineer	Issue Date	Description
0	MVH	August 6, 2020	Draft Final Report
1	MVH	September 14, 2020	Final Report

Authorization Signatures

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2020-09-14
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Senior Geotechnical Engineer

ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: 2020/09/14

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1.0 Introduction

This report summarizes the results of the geotechnical investigation and provides geotechnical recommendations for slope stabilization measures to address instabilities that occurred on the west slope of a retention pond located on CN property, that has impacted the east shoulder of Lagimodiere Boulevard between Betournay Street and Elizabeth Road. The terms of reference of the work are included in our proposal to Mr. Jean-Luc Lambert, P.Eng. of the City of Winnipeg Public Works Department, Streets Maintenance Division (the City) dated March 1, 2020. The scope of work includes a visual assessment of the existing site conditions, subsurface investigations, monitoring of instrumentation, and the preliminary design of slope stabilization works and associated Class 3 construction cost estimate.

2.0 Background

In early November 2019, the City of Winnipeg Public Works Department, Streets Maintenance Division observed two slope instabilities on the west slope of an existing retention pond on CN property that has impacted the east shoulder of Lagimodiere Boulevard between Betournay Street and Elizabeth Road.

The two instabilities occurred after an exceptionally wet fall, with total precipitation of over 150 mm in September compared to the typical monthly total of approximately 45 mm. On October 11th, Winnipeg also experienced an unprecedented storm of over 35 cm of snow, sleet and rain within 2 days. It is likely that the accumulation of soil moisture through September combined with the October 11th storm triggered the instability.

Similar instabilities have occurred on other areas of the retention pond slopes. In 2014, TREK was retained by CN to visually assess instabilities of the east pond slope. At the time, our assessment concluded the instabilities were shallow, saturation-induced instabilities due to periods of prolonged heavy rainfall.

3.0 Field Program

3.1 Site Conditions

A site reconnaissance was completed by Michael Van Helden, P.Eng. of TREK on February 23, 2020 and subsequently on April 1, 2020 as part of the sub-surface investigation. The existing west pond slope stands approximately 7 m in height at about a 4H:1V to 5H:1V slope. At the time of the site visit, a 0.5 to 1.0 m high head scarp and various tension cracks were observed in two general areas – the north and south instability areas. The north instability is located at the north end of the pond and extends a distance of approximately 40 m. The south instability is located at the south end of the pond and extends a distance of approximately 80 m. The head scarps (tension cracks) for both instabilities are located at or just upslope of the edge of shoulder, but outside the main traffic lanes of Lagimodiere Blvd. Based on the visual assessment, the slope instability poses an imminent risk to public and road safety, and therefore stabilization is required. Photos 1 and 2 show the instability head scarps of the south and north instabilities, respectively. The site location and plan view extents of the instabilities are shown in Figure 01. Site photos are included in Appendix A.

Photo 1 Looking North-East at south instability (taken 2020-Apr-01)

Photo 2 Looking South-West at north instability (taken 2020-Apr-01)

In between the two instabilities, there are no apparent signs of movement. However, these types of shallow, saturation driven instabilities can occur at unpredictable locations and therefore similar conditions may developed within the unfailed section in the future. The entire west slope is therefore considered unstable to marginally stable.

3.2 Site Survey

A topographic survey was performed at the site on May 06 and May 14, 2020 by TREK. Test holes and instrumentation locations and elevations, topography and relevant site features were measured as part of the survey. Site features and elevation contours generated from the survey are shown on Figure 01 and cross-sections of the existing conditions are shown on Figures 02 to 04.

3.3 Sub-surface Investigation

A sub-surface investigation was undertaken on May 06 and May 07, 2020 under the supervision of TREK personnel to determine the soil stratigraphy and groundwater conditions at the site. Test holes TH20-01 to TH20-03 were on the slope using a track-mounted geotechnical soils rig using 125 mm diameter solid-stem augers at the locations shown on Figure 01.

TH20-01, -02 and -03 were drilled to respective depths of 12.2 m, 12.3 m, and 11.9 m below ground surface. Two vibrating wire (VW) piezometers (VW-1A and VW-1B) were installed staggered vertically in test hole TH20-01 (VW-1A, VW-1B) with two additional VWs (VW-3A and VW-3B) installed in test hole TH20-03. A standpipe piezometer was installed in test hole TH20-02 (SP-02). The standpipe consists of a 50 mm diameter PVC pipe installed to the bottom of the test hole. Slope inclinometer casings SI-01 and SI-03 were installed in additional test holes immediately adjacent to THs 20-01 and 20-03 respectively.

Sub-surface soils observed during drilling were visually classified based on the Unified Soil Classification System (USCS). Samples retrieved during drilling included disturbed auger cuttings. All samples retrieved during drilling were transported to TREK's testing laboratory in Winnipeg, Manitoba. Laboratory testing consisted of moisture contents on all samples and Atterberg limits on select samples. Laboratory testing results are included in Appendix B.

A brief description of the soil stratigraphy and groundwater conditions encountered during drilling is provided in the following sections. All interpretations of soil stratigraphy for the purposes of design should refer to the detailed information provided on the attached test hole logs.

3.3.1 Soil Stratigraphy

The soil stratigraphy consists of 0.4 m of clay (fill) overlying silty clay. The clay (fill) is soft and of high plasticity and the silty clay is generally firm and of high plasticity, becoming soft below approximately 4.5 m below ground surface. Silt (till) was observed approximately 9.2 m below ground surface in all test holes. The silt till layer is moist and loose to compact to approximately 10.7 m below ground surface and becomes dry and dense below 10.7 m below ground surface.

3.3.2 Groundwater and Sloughing Conditions

Groundwater seepage and sloughing was observed in test holes TH20-01 and TH20-03 at depths ranging from 9.0 m to 10.7 m below ground surface. Table 1 summarizes the measured piezometric elevations in the vibrating-wire and standpipe piezometers following installation.

Table 1 - Groundwater Monitoring Results

Date (yyyy-mm-dd)	Elevation (m)				
	VW-1A (TH20-01)	VW-1B (TH20-01)	VW-3A (TH20-03)	VW-3B (TH20-03)	SP-02 (TH20-02)
Tip Elevation >	225.97	222.62	225.03	222.18	217.10
2020-05-07 (approximately 1 hour after installation)	-	-	-	-	223.60
2020-05-14	229.19	229.13	227.56	227.53	222.97
2020-05-29	229.17	229.12	227.85	227.81	223.39
2020-06-16	229.06	229.01	227.77	227.70	223.72
2020-07-03	229.36	229.32	228.12	228.05	223.94

The groundwater observations made during drilling are short-term and should not be considered reflective of (static) groundwater levels at the site which would require monitoring over an extended period to determine. It is important to recognize that groundwater conditions may vary seasonally, annually, or as a result of construction activities.

3.3.3 Slope Movement Monitoring

Slope inclinometer (SI) casings were used to monitor for shear movements. The SI's were monitored on four occasions after drilling, including a baseline reading on May 14, 2020 and subsequent readings on May 29, June 16 and July 03, 2020. Traffic gravel was placed at the top of the instabilities on June 29, 2020 (prior to the latest SI reading) to restore the shoulder for traffic safety purposes. Inclinometer monitoring results are included in Appendix C and show negligible movement until after placement of traffic gravel. Thereafter, approximately 50 mm and 4 mm of movement was observed in SI-01 and SI-02, respectively, occurring at shallow depths ranging from 2 to 3 m below ground surface.

4.0 Slope Stability Analysis

A slope stability analysis was conducted to determine the existing stability of the road embankment and pond slope under critical conditions (post-failure) and to evaluate remedial alternatives to improve stability, The cross-section generated from the site survey was used in the assessment of the riverbank. Figure 01 shows the site plan indicating the location of the cross-section.

The objective of the slope stability analysis was to first evaluate the existing (post-failure) stability of the slope using soil material information obtained from the subsurface investigation and laboratory testing. The output of the slope stability analysis is presented as a factor of safety (FS) related to the stability of the slope along a particular slip surface and the analysis examines thousands of potential slip surfaces to determine the minimum FS. With respect to factor of safety (FS) targets, the probability of riverbank instabilities occurring increases as values approach unity (FS=1.0). Slopes with a minimum FS greater than 1.3 are considered to be relatively stable. In this regard, a target factor of safety of 1.30 was selected for design of slope stabilization works, applied to the observed (back-analysed) slip surface at each design cross-section. In addition, a minimum factor of safety of 1.30 was targeted for the edge of the roadway Stability model methods, assumptions, parameters, results and recommendations are provided below.

4.1 Numerical Model Description

The slope stability analysis was conducted using a 2-dimensional limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2016 software package (Geo-Slope International Inc.). The slope stability model used the Morgenstern-Price method of slices with a half-sine inter-slice force function to calculate factors of safety (FS) along potential slip surfaces.

The observed instabilities initiate at or just downslope of the slope crest (along the edge of the shoulder) and exits just above the toe of slope, which is typical of near-surface saturation induced instabilities. The observed instability was likely triggered by near-surface saturation of the soil and a loss of soil suction resulting from prolonged periods of continuous precipitation. This type of instability is often localized in extent and shallow in nature and can be influenced by undetected pre-existing conditions (e.g. localized zones of pre-sheared or soft soils, or discontinuous layers of permeable soils with high piezometric levels). For the purposes of the analysis a zone of residual soils, indicative of soils that have undergone movement, was included downslope of the slope crest in the area of the instabilities and slightly deeper than the observed depth of shear movements in the inclinometers.

Cross-sections A and C are considered the critical cross-sections for the north and south instabilities, respectively and were used in the slope stability analysis, while Cross-section B is located within a secondary portion of the south instability, as shown on Figure 01 The soil stratigraphy assumed in the model is based on TREK's test holes, which are shown in cross-section on Figures 02 and 04.

Groundwater conditions were represented in the model using static piezometric lines. A piezometric line slightly higher than the piezometric elevations measured in the piezometers was included in the lower (intact) clay layer. It should be noted that this deeper groundwater level is considered representative of the conditions for global (deep-seated) slip surfaces. It is assumed that the shallower, residual clay soils were fully saturated at the time of the instability, and are therefore represented with a separate piezometric line coincident with ground surface. Two piezometric lines were necessary to predict a critical slip surface that matches the observed failure mechanism.

The material parameters assumed in the model for each soil unit are summarized in Table 2 below and represent typical values based on local experience. A zone of residual clay was included in the model, the extent of which is based on the observed zones of movement, and the critical slip surface geometry determined from the back-analysis case. For the back analysis, the properties of the residual clay were adjusted along with the slight changes to the groundwater level to achieve a factor of safety of approximately 1.0 for a slip surface that closely matches the interpreted depth of movement, head scarp and toe bulge locations. It should be noted that the slip surface geometry is controlled by the extent of the assumed residual clay.

Table 2 - Material Parameters used in Slope Stability Analysis

Material	Unit Weight (kN/m³)	Cohesion (kPa)	Friction Angle (degrees)
Silty Clay	17	5	17
Residual Clay	17	2	11-13
Clay Fill	18	3	23
Rockfill (toe berm)	20	0	45
Rockfill Ribs (1:1 ratio)	19	1	28

4.2 Analysis Results

The results of the analyses are summarized in Table 3 and are shown on Figures D-01 to D-06 (as referenced in Table 3) which are included in Appendix D, and are discussed in the following sections.

Table 3 - Summary of Calculated Factors of Safety

Stability Case	Cross-section	Slip Surface	Factor of Safety (Change from Baseline)	Figure No. (Appendix D)
Back-Analysis (Post-Failure Geometry)	A (north)	Critical / Observed Edge of Shoulder Edge of Roadway	1.01 (baseline) 1.01 1.32	D-01
	C (south)	Critical / Observed Edge of Shoulder Edge of Roadway	1.01 (baseline) 1.06 1.20	D-02
Rockfill Ribs (1:1 Replacement Ratio) and Regrading to Original Grades	A (north)	Critical / Observed Edge of Shoulder Edge of Roadway	1.30 (+21%) 1.29 (+21%) 1.52 (+12%)	D-03
	C (south)	Critical / Observed Edge of Shoulder Edge of Roadway	1.36 (+42%) 1.25 (+22%) 1.38 (+19%)	D-04
Rockfill Toe Berm and Slope Flattening (6.3H:1V upslope of berm)	A (north)	Critical / Observed Edge of Shoulder Edge of Roadway	1.46 (+36%) 1.24 (+16%) 1.47 (+8%)	D-05
	C (south)	Critical / Observed Edge of Shoulder Edge of Roadway	1.44 (+50%) 1.25 (+22%) 1.38 (+19%)	D-06

4.2.1 Back-Analysis

The back-analysis was performed on the surveyed post-failure (existing) slope geometry, with residual friction angles of 11 and 13 degrees along cross-sections A and C respectively. The difference in residual friction angles is reflective of the degree of movement and strain weakening observed within each slide area. The calculated factors of safety along the critical slip surface within the zone of residual clay is 1.01 (Figures D-01 and D-02) for both cross-sections A and C. The factors of safety at the edge of shoulder ranged from 1.01 to 1.06, while those at the edge of roadway ranged from 1.20 to 1.32. It should be noted that the back-analysis may be slightly conservative since the post-failure geometry was used. Also, expanding the zone of residual clay deeper or beyond the slope crest would result in factors of safety less than unity and slip surfaces that do not match the geometry of the observed instability.

4.2.2 Slope Stabilization Measures

Slope stabilization alternatives considered included drainage improvements (e.g. French drains), a rockfill toe berm and slope regrading, a rockfill shear key and rockfill ribs. Based on preliminary analyses (not reported herein), drainage improvements and rockfill shear keys are not suitable options. Drainage improvements were insufficient to achieve a satisfactory stability improvement. Rockfill shear keys can be expected to result in significant slope movements along the pre-sheared slip surface and may lead to further retrogression into the roadway pavement during construction. As such, a rockfill toe berm or rockfill ribs are considered better suited to the site conditions for slope stabilization given the lower risk of movements during construction and that they improve stability both in the lower and mid bank areas, provide mechanical stabilization and (in the case of rockfill ribs) provide drainage enhancement as a secondary benefit.

Rockfill ribs installed at a 1:1 replacement ratio in plan view (e.g. 1.5 m wide with 1.5 m clear spacing between ribs) and a base width of 1.5 m for both cross-sections A and C satisfy the design stability targets (Figures D-03 and D-04). The calculated factors of safety for the observed slip surface with rockfill ribs and regrading to pre-existing grades increases to 1.30 (+21%) and 1.36 (+42%), respectively, for cross-sections A and C. The factors of safety at the edge of shoulder increase to between 1.25 and 1.29, while those at the edge of roadway increase to between 1.38 and 1.52. It should be noted that some degree of drainage improvements due to rockfill ribs were incorporated in the model by lowering the piezometric line immediately upslope of the ribs.

A rockfill toe berm extending to the bottom of the pond, approximately 1.5 m high, combined with slope regrading (flattening) with clay fill will satisfy the design stability targets (Figures D-03 and D-04). The calculated factors of safety for the observed slip surface with the rockfill toe berm and regrading increases to 1.46 (+36%) and 1.44 (+50%), respectively, for cross-sections A and C. The factors of safety at the edge of shoulder increase to between 1.24 to 1.25, while those at the edge of roadway increase to between 1.38 and 1.47.

5.0 Slope Stabilization Recommendations

5.1 Comparison of Options

Both rockfill ribs and a rockfill toe berm satisfy the target factor of safety of 1.30 at the observed slip surface, and also satisfy the target minimum factor of safety of 1.30 for the edge of roadway, and therefore both options are feasible for stabilizing the slope. Class 3 construction cost estimates are provided for both options, below. The cost estimates have been split to account for work in the two failed areas (120 m slope length) as well as the unfailed area in between the two instabilities (50 m slope length). The observed shallow instabilities often occur in unpredictable locations or extents, and the risk remains high of future instability if left unmitigated. Since there is no particular reason instabilities have not yet occurred along this stretch, we recommend that the stabilization works be extended into the unfailed area; incremental costs are provided below.

Ideally, site access to the lower toe area can be obtained from the open area on CN property, just north of the site, especially if the tow berm stabilization option is selected. However, we anticipate that the greater the degree of work undertaken on CN property, the greater the risk will be of delays to the project associated CN design review and approvals, construction site access requirements culminating in an overall higher project risk. Further, any permanent impacts to the pond capacity (i.e. rockfill berm option) may require additional design and assessment both by the City and CN, thereby extending the design timeline. Rockfill ribs, however, have the option of being installed from the roadway, provided a lane closure can be implemented for the duration of construction, thereby limiting temporary works on CN property and resulting in no permanent changes to the pond capacity. As a result, the risk posed by work on CN property to the project schedule and cost is greater for the toe berm option as compared to the rockfill rib option.

Table 4 provides a Class 3 (-20% to +30%) estimated construction cost for rockfill rib stabilization of failed and unfailed slope areas, respectively (respective slope lengths of 120 and 50 m), along with an estimated total cost. Similarly, Table 5 provides a Class 3 estimated construction cost for stabilization using a rockfill toe berm.

We anticipate that no additional mobilization or site access works would be required to stabilize the unfailed section located between the two failed areas. As shown, the total estimated costs to stabilize both failed and unfailed areas of the slope range from ~$214,000 for a rockfill toe berm up to ~$233,000 for rockfill ribs (excluding contingency); the difference in cost between options is within the range of accuracy for the Class 3 estimates.

Unit prices represent our estimate of current market prices based on recent projects. The cost estimate includes mobilization and demobilization and access development, temporary traffic control, but exclude taxes, engineering, administration costs and contingencies (e.g. delays due to CN).

Table 4 - Class 3 Cost Estimate for Rockfill Ribs

Item	Units	Est. Qty	Unit Price	Subtotal
FAILED AREAS (80 m south, 40 m north)				
Mob/Demob	L.S.	1	$30,000	$30,000
Site Access (incl. traffic control)	L.S.	1	$25,000	$25,000
Remove and Replace Chain Link Fence	L.m	200	$150	$30,000
Waste Excavation (Rockfill Ribs)	m^3	628	$15	$9,420
Supply and Compact Rockfill (Rockfill Ribs)	tonne	1112	$65	$72,280
Regrading to Final (incl. clay cap)	m^2	1205	$5	$6,025
Erosion Control Blanket	m^2	1205	$8	$9,640
Topsoil and Seed	m^2	1205	$10	$12,050
Subtotal FAILED AREAS				**$194,415**
UNFAILED AREAS (50 m)				
Waste Excavation (Rockfill Ribs)	m3	281	$10	$2,810
Supply and Compact Rockfill (Rockfill Ribs)	tonne	502	$65	$32,628
Regrading to Final (incl. clay cap)	m2	150	$5	$750
Erosion Control Blanket	m2	150	$8	$1,200
Topsoil and Seed	m2	150	$10	$1,500
Subtotal UNFAILED AREAS				**$38,888**
Total Class 3 Cost Estimate Total (excl. Contingency, Engineering and Administration Costs)				**$233,303**

Table 5 - Class 3 Cost Estimate for Rockfill Toe Berm

Item	Units	Est. Qty	Unit Price	Subtotal
FAILED AREAS				
Mob/Demob	L.S.	1	$30,000	$30,000
Site Access (incl. traffic control)	L.S.	1	$15,000	$15,000
Remove and Replace Chain Link Fence	L.m	200	$150	$30,000
Clay Fill	m³	516	$15	$7,733
Supply and Place Rockfill Toe Berm	tonne	1124	$55	$61,793
Regrading	m²	1490	$5	$7,450
Erosion Control Blanket	m²	1490	$8	$11,920
Topsoil and Seed	m²	1490	$10	$14,900
Subtotal FAILED AREAS				**$178,794**
UNFAILED AREAS				
Supply and Place Rockfill Toe Berm	tonne	490	$65	$31,832
Regrading	m²	150	$5	$750
Erosion Control Blanket	m²	150	$8	$1,200
Topsoil and Seed	m²	150	$10	$1,500
Subtotal UNFAILED AREAS				**$35,282**
Total Class 3 Cost Estimate Total (excl. Contingency, Engineering and Administration Costs)				**$214,076**

5.2 Recommended Option

Given that the two options are comparable in terms of stability improvement and construction cost, but that the rockfill ribs present advantages in terms of reduced permanent impact to CN operations and option of construction from the roadway, the rockfill ribs option is recommended.

The estimated construction costs for the rockfill ribs option have been added to the City's "Basis of Estimate Capital Cost Detail" template (Appendix E). We have included estimated allowances for engineering, however these should be confirmed based on an engineering services proposal for the scope of the subsequent assignments. We have not included any contingencies, however, we can assist the City in developing appropriate contingencies, if required.

5.3 Future Considerations

As part of detailed design, the following work is recommended:

1. Consult with CN to confirm site access permission and constraints, and any special provisions required to include in the project specifications.
2. Confirm construction schedule and requirements for traffic management in consultation with Traffic Services. Construction of rockfill ribs in the summer or fall would be possible, although it may be advantageous to construct these works in the winter to utilize frozen ground, for ease of site access.

6.0 Closure

The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation and laboratory testing). Soil conditions are natural deposits that can be highly variable across a site. If subsurface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work or standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of the City of Winnipeg (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

Figures

TREK GEOTECHNICAL

0015 037 00
City of Winnipeg
Slope Failure on Northbound Lagimodiere Blvd. Between Betourney St. and Elizabeth Rd.

ANSI full bleed B (11.00 x 17.00 Inches)

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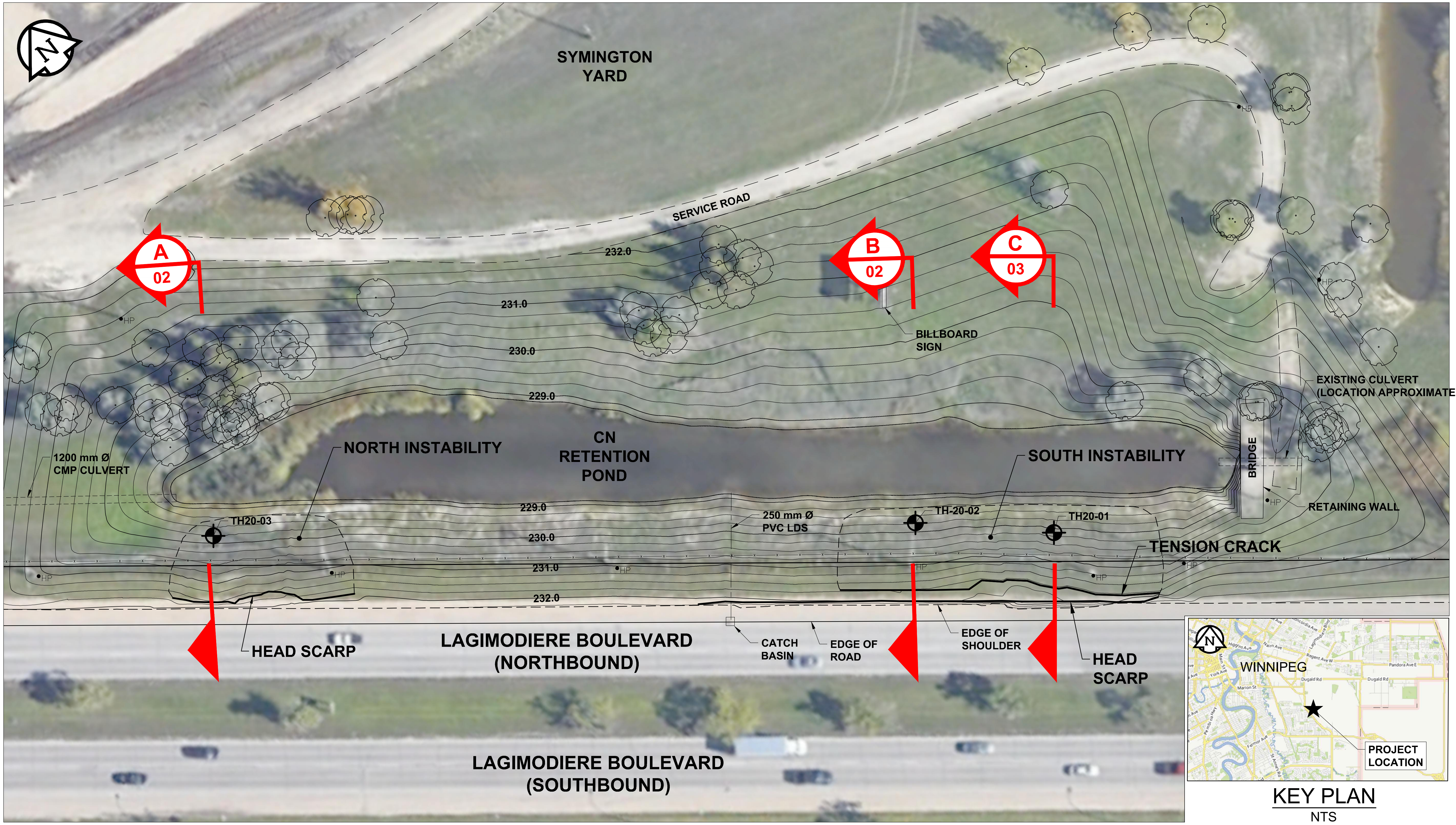

0 5 10 15 20 25 30 m
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LEGEND:

---·---	FENCE
– – – –	SERVICE ROAD
⊕	TEST HOLE (TREK, 2020)
•HP	EXISTING HYDRO POLE
◌	EXISTING TREE

NOTES:

1. AERIAL PHOTO FROM GOOGLE EARTH (2020)
2. TOPOGRAPHIC SURVEY PERFORMED BY GDS SURVEYS INC. ON MAY 06, 2020 & MAY 14, 2020

Figure 01
Site Plan

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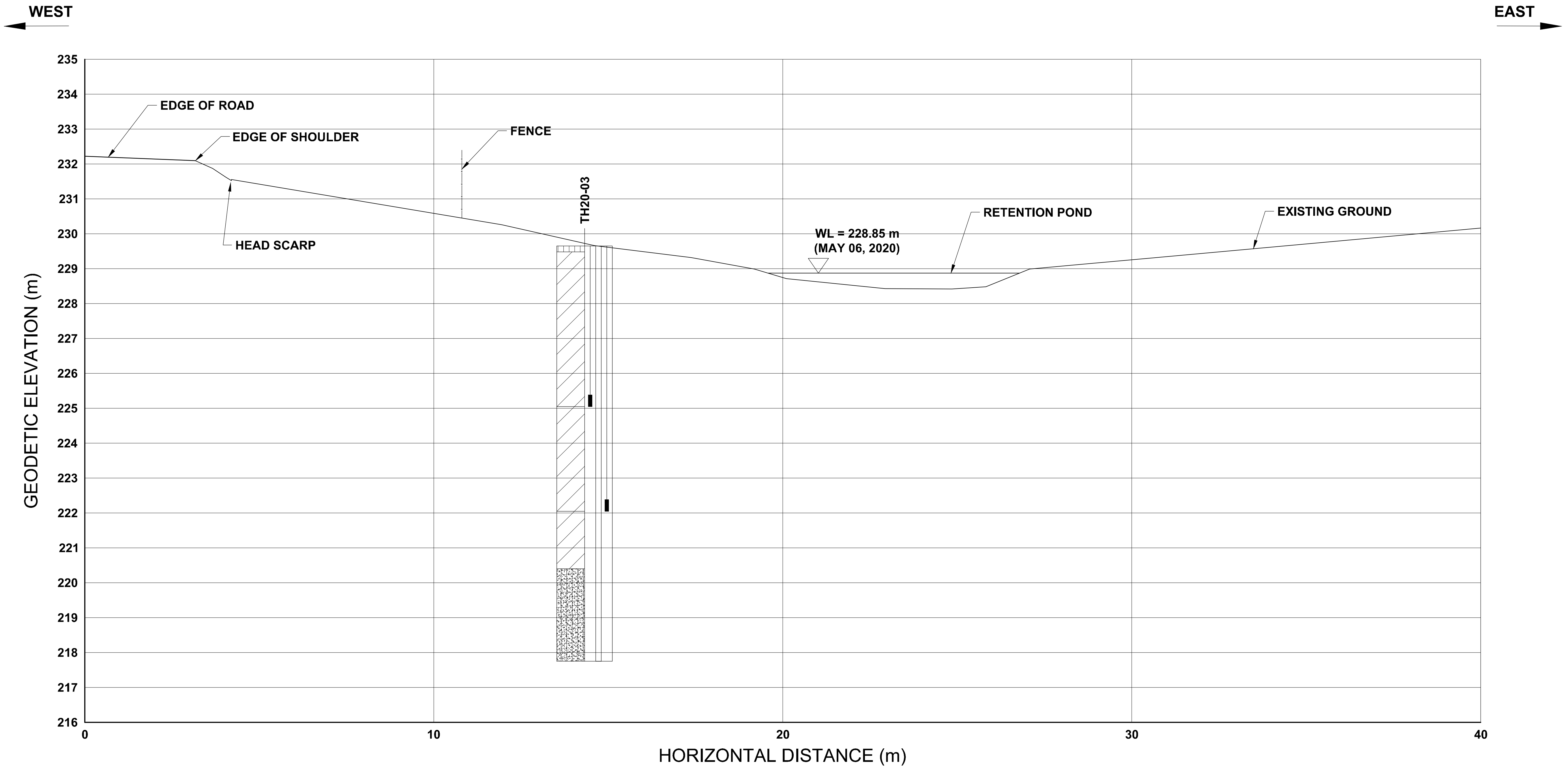

A / **01** **CROSS-SECTION**
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LEGEND

▥ SILT
▨ CLAY
▩ SILT TILL
▯ SLOPE INCLINOMETER
▮ VW PIEZOMETER

NOTES:
1. TOPOGRAPHIC SURVEY PERFORMED BY GDS SURVEYS INC. ON MAY 06, 2020 & MAY 14, 2020

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ANSI full bleed B (11.00 x 17.00 Inches)

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Figure 02
CROSS-SECTION A

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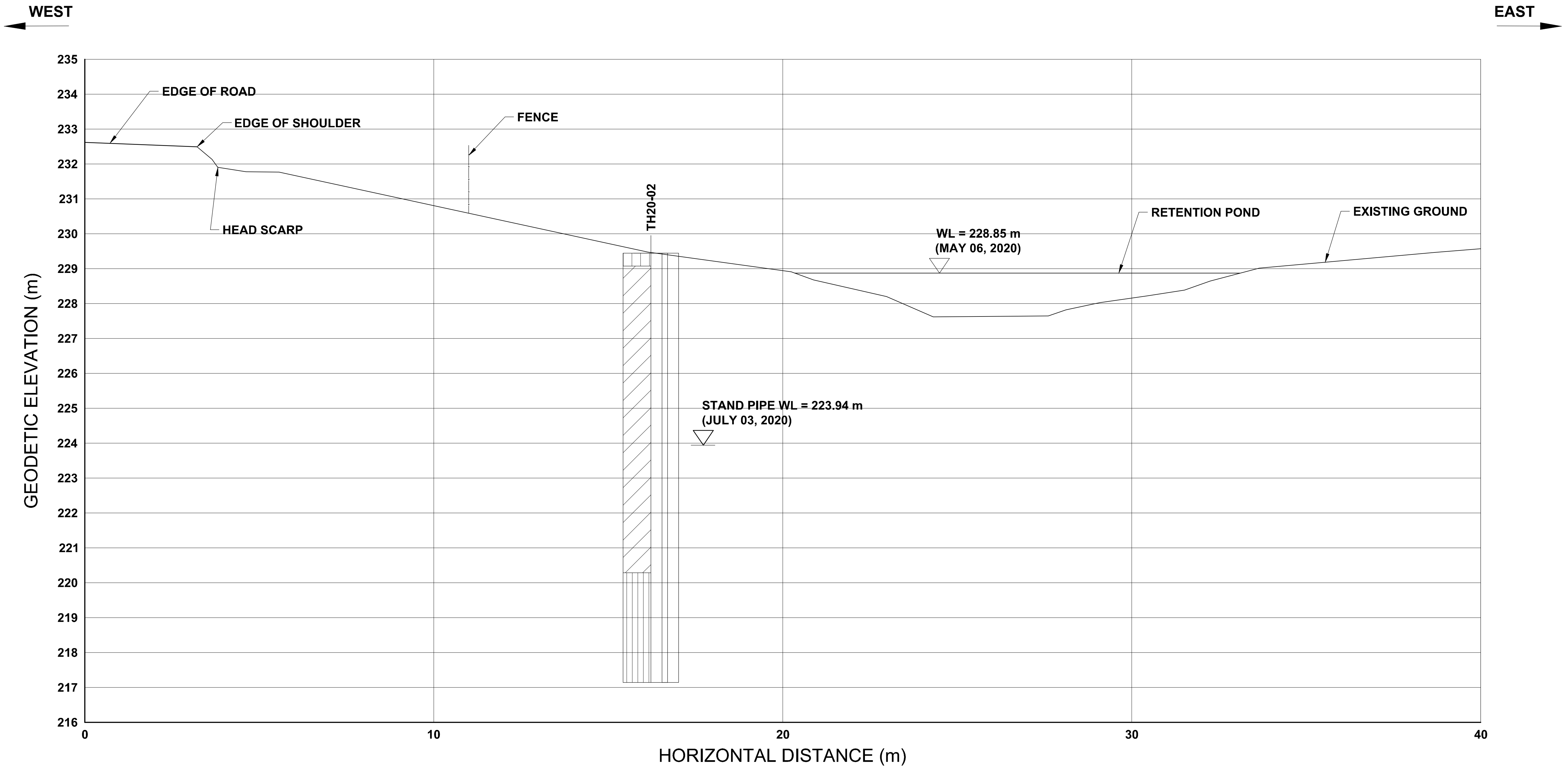
City of Winnipeg
Slope Failure on Northbound Lagimodiere Blvd. Between Betourney St. and Elizabeth Rd.



B
01
CROSS-SECTION
SCALE (H:V) = 1:1

LEGEND

▥ SILT
▨ CLAY
▩ SILT TILL
▯ STAND PIPE
▮ VW PIEZOMETER

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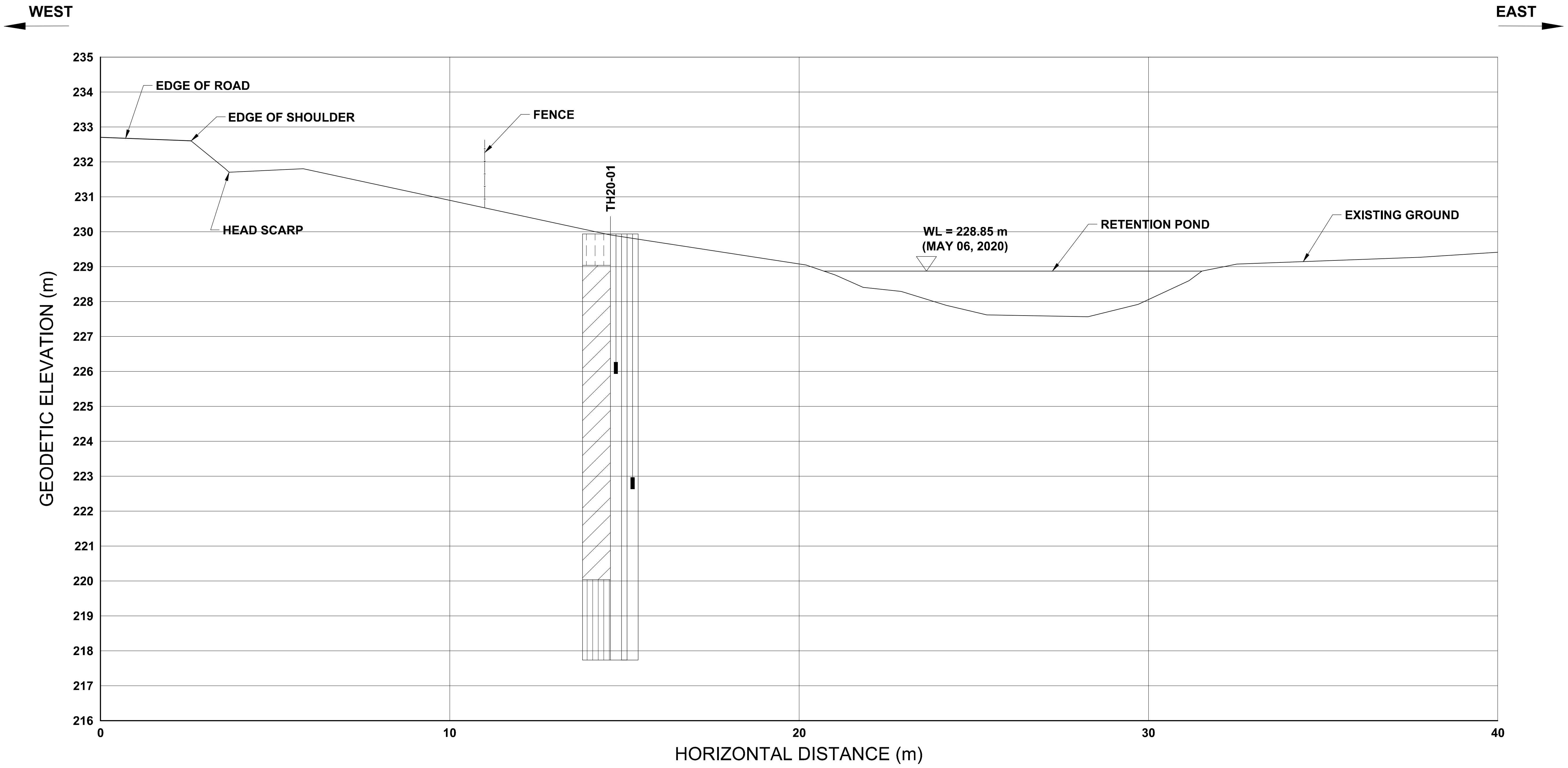
NOTES:
1. TOPOGRAPHIC SURVEY PERFORMED BY GDS SURVEYS INC. ON MAY 06, 2020 & MAY 14, 2020

Figure 03
CROSS-SECTION B



C
01
CROSS-SECTION
SCALE (H:V) = 1:1

LEGEND

▥	SILT	▯	SLOPE INCLINOMETER
▨	CLAY	▮	VW PIEZOMETER
▩	SILT TILL		

0 1 2 3 4 5 6
SCALE = 1 : 125 (279 mm x 432 mm)

NOTES:
1. TOPOGRAPHIC SURVEY PERFORMED BY GDS SURVEYS INC. ON MAY 06, 2020 & MAY 14, 2020

Figure 04
CROSS-SECTION C

ANSI full bleed B (11.00 x 17.00 Inches)

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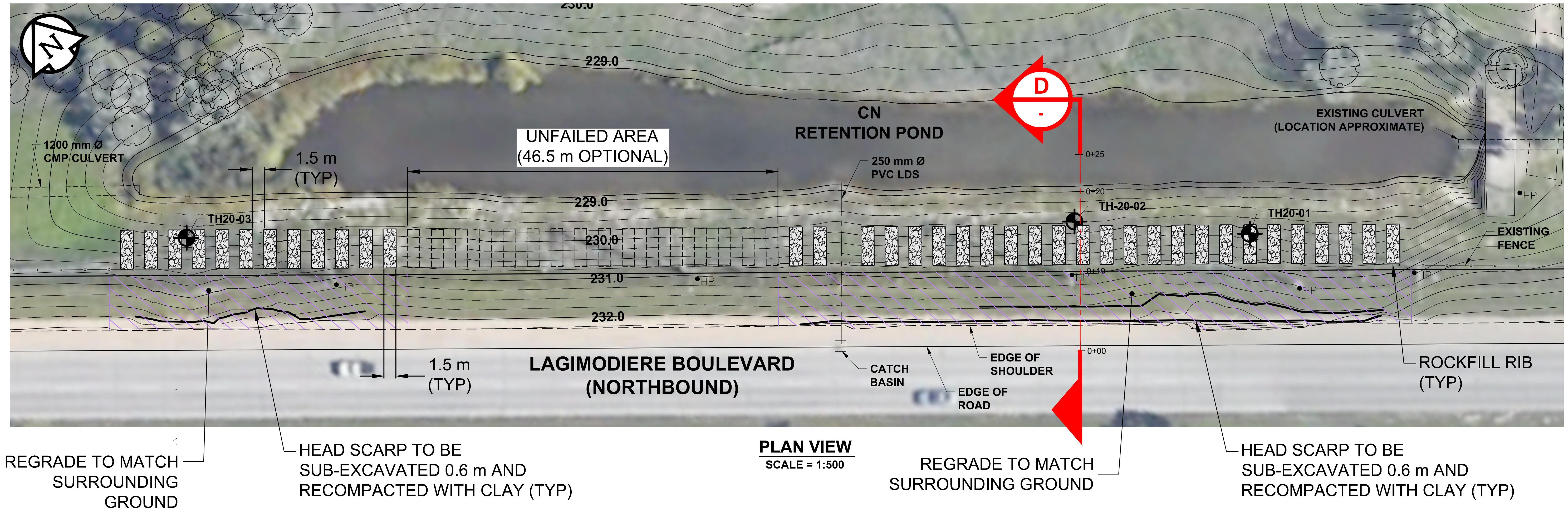
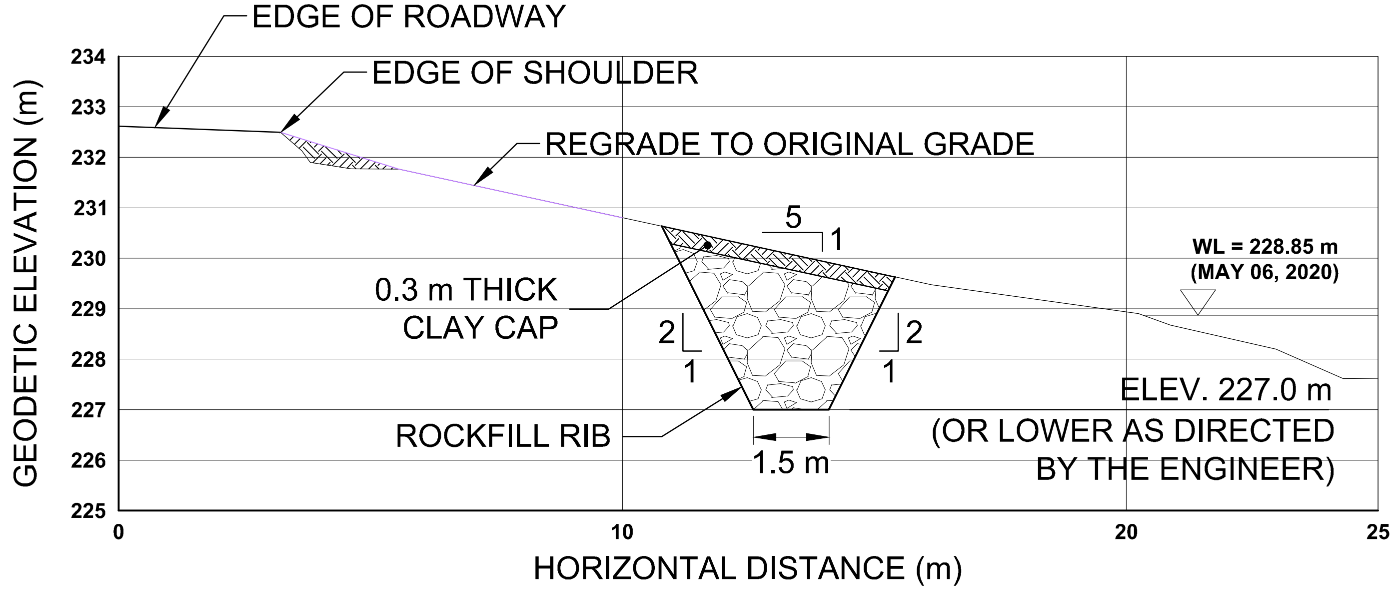
City of Winnipeg
Slope Failure on Northbound Lagimodiere Blvd. Between Betourney St. and Elizabeth Rd.



PLAN VIEW
SCALE = 1:500



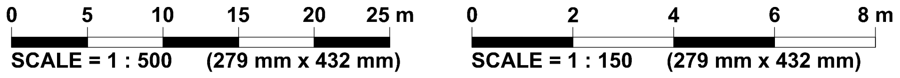
D
-
CROSS-SECTION (TYPICAL)
SCALE = 1:150

LEGEND

▨ AREA TO BE REGRADED

ANSI full bleed B (11.00 x 17.00 Inches)

Z:\Projects\0015 City of Winnipeg\0015 037 00 Lagimodiere Slope Failure CN Pond\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\0015-037-00_Lagimodiere Slope_11_05_20_A_CJH.dwg.
2020-08-07 11:17:03 AM



NOTES:
1. TOPOGRAPHIC SURVEY PERFORMED BY GDS SURVEYS INC. ON MAY 06, 2020 & MAY 14, 2020

Figure 05
Recommended Slope Stabilization
Plan and Section

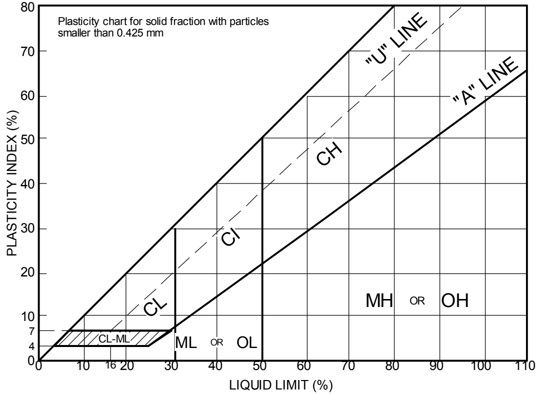
Sub-Surface Logs

TREK GEOTECHNICAL

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classi-fication	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	●	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP More than 12 percent...... GM, GC, SM, SC 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	○	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	▦	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▨	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	░	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	░	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▥	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▨	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart  		
			CL	▨	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	☰	Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit greater than 50)		MH	▥	Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts			
			CH	▨	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⁂	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size mm	Particle Size ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size mm	Particle Size ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▨	Bedrock (undifferentiated)	○	Cobbles
░	Concrete	▦	Limestone Bedrock	●	Boulders and Cobbles
▩	Fill	☰	Cemented Shale	▥	Silt Till
		▤	Non-Cemented Shale	▨	Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

▼ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

The undrained shear strength (Su) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

Sub-Surface Log

Test Hole TH20-01

Client: City of Winnipeg

Project Number: 0015-037-00

Project Name: Lagimodiere Blvd Slope Failures (CN Pond)

Location:

Contractor: Maple Leaf Drilling Ltd.

Ground Elevation: 229.93 m -

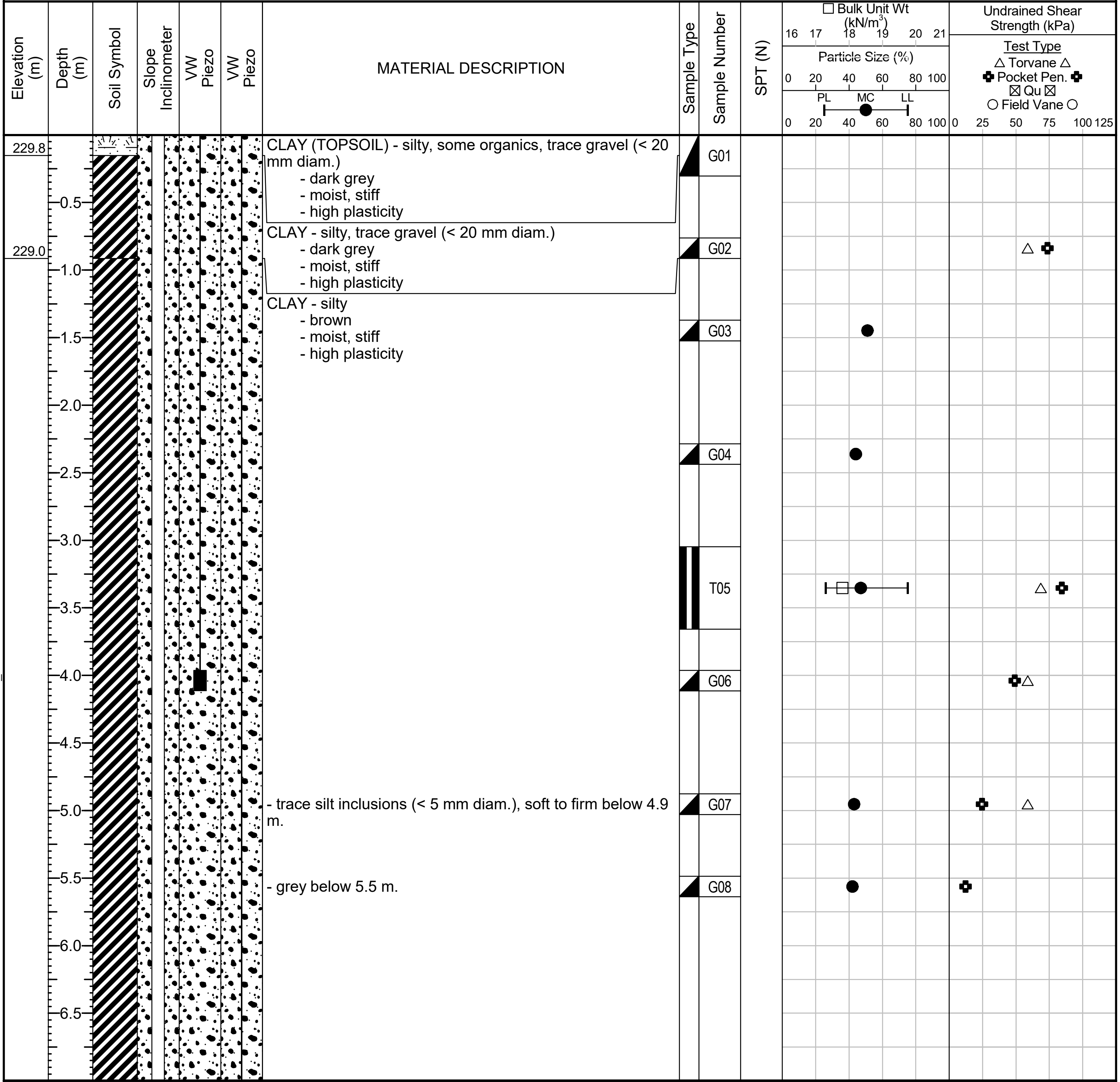
Method: 125 mm Solid Stem Augers / HQ Coring, Acker Renegade Track Mount

Date Drilled: May 6, 2020

Sample Type: ◩ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧗ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ░ Sand ▩ Gravel ▧ Cobbles ■ Boulders

Backfill Legend: ■ Bentonite ▨ Cement ▨ Drill Cuttings ░ Filter Pack Sand ▩ Grout ▩ Slough



CLAY (TOPSOIL) - silty, some organics, trace gravel (< 20 mm diam.)
- dark grey
- moist, stiff
- high plasticity

CLAY - silty, trace gravel (< 20 mm diam.)
- dark grey
- moist, stiff
- high plasticity

CLAY - silty
- brown
- moist, stiff
- high plasticity

- trace silt inclusions (< 5 mm diam.), soft to firm below 4.9 m.

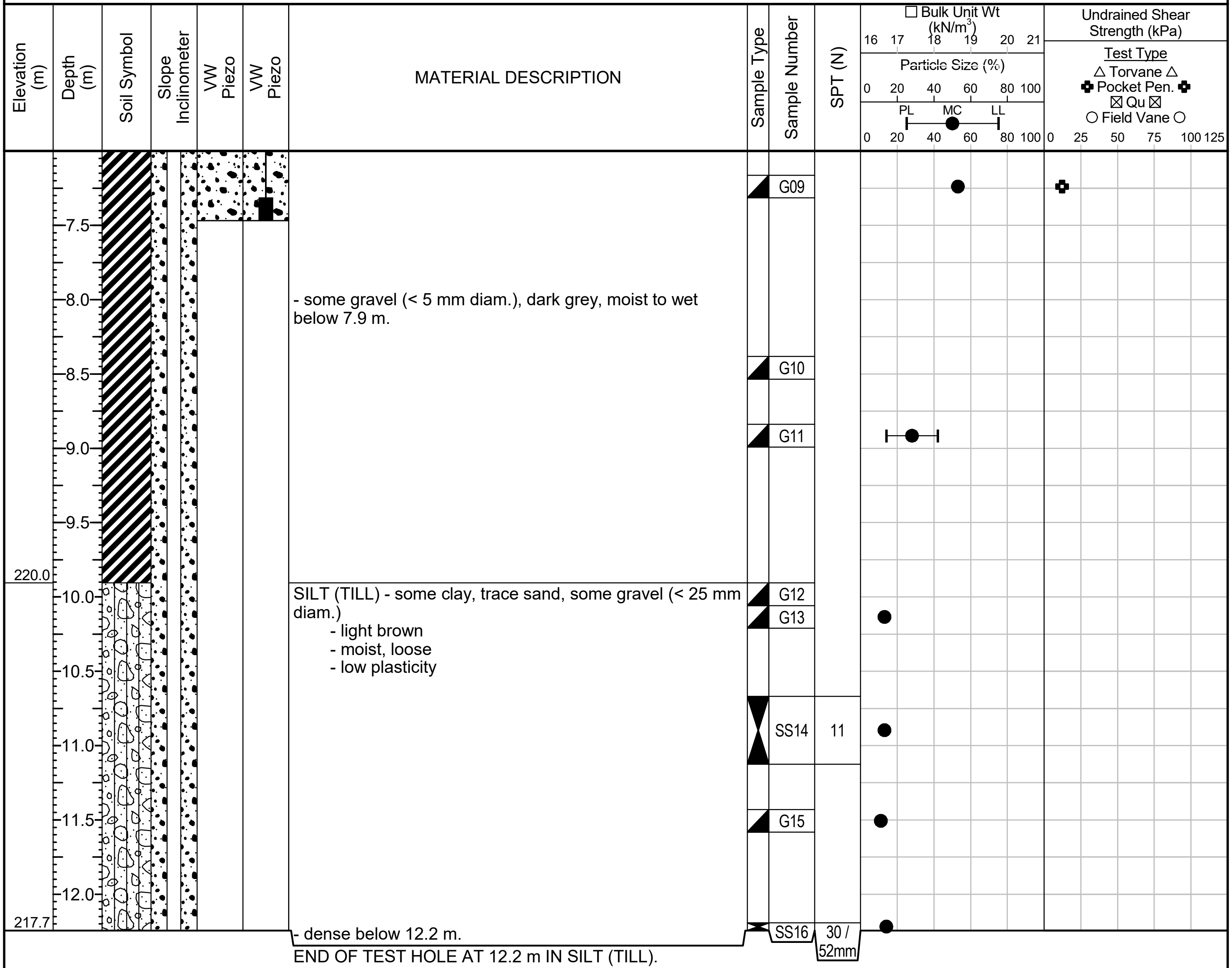
- grey below 5.5 m.

Logged By: Ruslan Amarasinghe **Reviewed By:** N.J Ferreira **Project Engineer:** Michael Van Helden

Sub-Surface Log

Test Hole TH20-01

2 of 2



- some gravel (< 5 mm diam.), dark grey, moist to wet below 7.9 m.

SILT (TILL) - some clay, trace sand, some gravel (< 25 mm diam.)
- light brown
- moist, loose
- low plasticity

- dense below 12.2 m.

END OF TEST HOLE AT 12.2 m IN SILT (TILL).

Notes:

1) Power auger refusal at 12.2 m depth below ground surface.

2) Seepage and sloughing observed below 10.7 m below ground surface.

3) SI20-01 was installed to 12.2 m below ground surface in TH20-01.

4) Vibrating wire (VW) piezometers VWA20-01A (S/N: 1901751) and VW20-01B (S/N: 1901576), respectively, were installed at 4.0 m and 7.3 m below ground surface in a companion hole approximately 0.6 m North of TH20-01.

5) TH20-01 and the VW companion test hole were backfilled with bentonite cement grout.

Logged By: Ruslan Amarasinghe **Reviewed By:** N.J Ferreira **Project Engineer:** Michael Van Helden

Sub-Surface Log

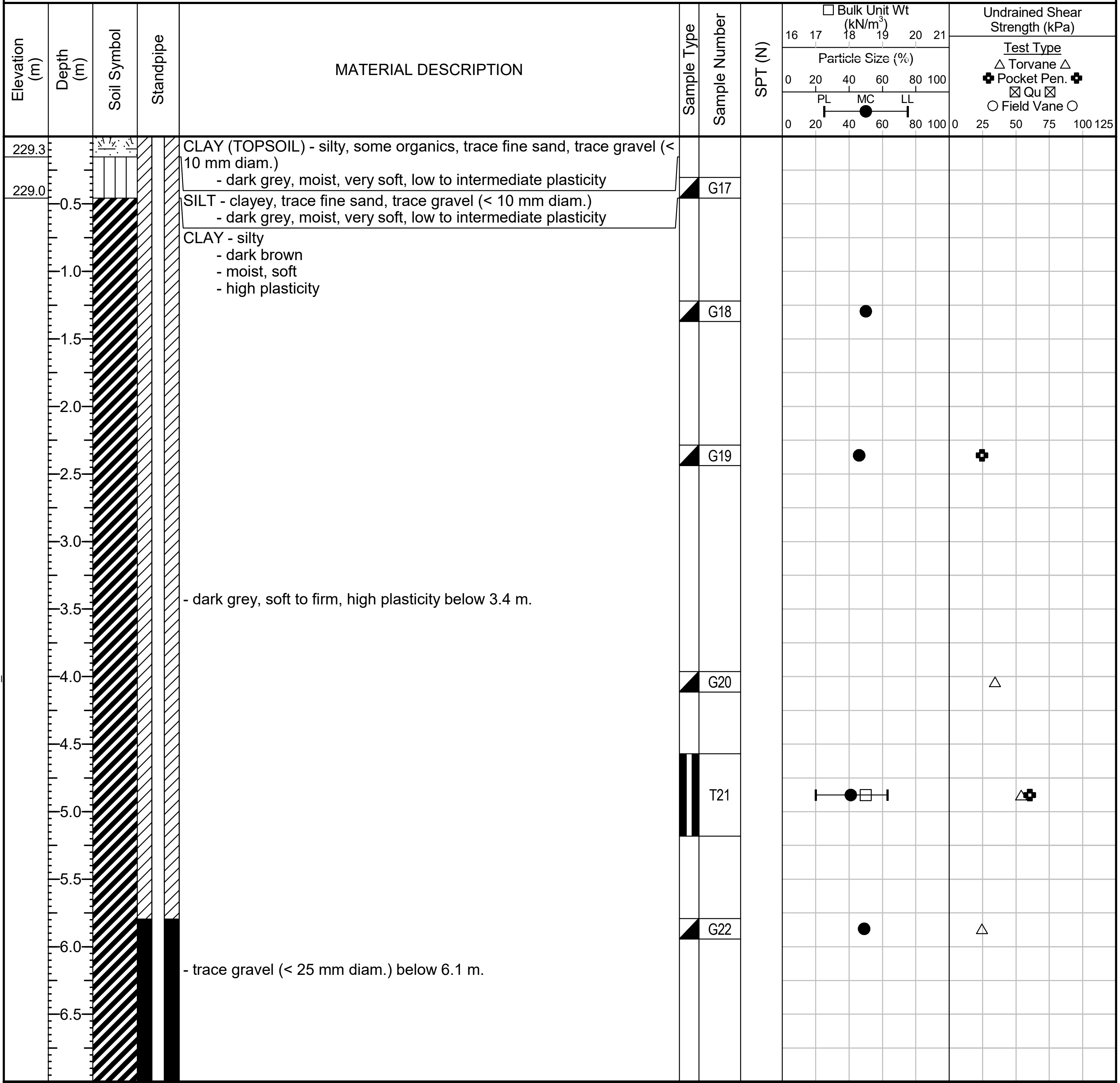
Test Hole TH20-02

Client:	City of Winnipeg	**Project Number:**	0015-037-00
Project Name:	Lagimodiere Blvd Slope Failures (CN Pond)	**Location:**	
Contractor:	Maple Leaf Drilling Ltd.	**Ground Elevation:**	229.44 m -
Method:	125 mm Solid Stem Augers / HQ Coring, Acker Renegade Track Mount	**Date Drilled:**	May 7, 2020

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▥ Fines ▨ Clay ▥ Silt ⁙ Sand ● Gravel ◌ Cobbles ■ Boulders

Backfill Legend: ■ Bentonite ▩ Cement ▨ Drill Cuttings ⁙ Filter Pack Sand ⁘ Grout ▩ Slough



CLAY (TOPSOIL) - silty, some organics, trace fine sand, trace gravel (< 10 mm diam.)
- dark grey, moist, very soft, low to intermediate plasticity

SILT - clayey, trace fine sand, trace gravel (< 10 mm diam.)
- dark grey, moist, very soft, low to intermediate plasticity

CLAY - silty
- dark brown
- moist, soft
- high plasticity

- dark grey, soft to firm, high plasticity below 3.4 m.

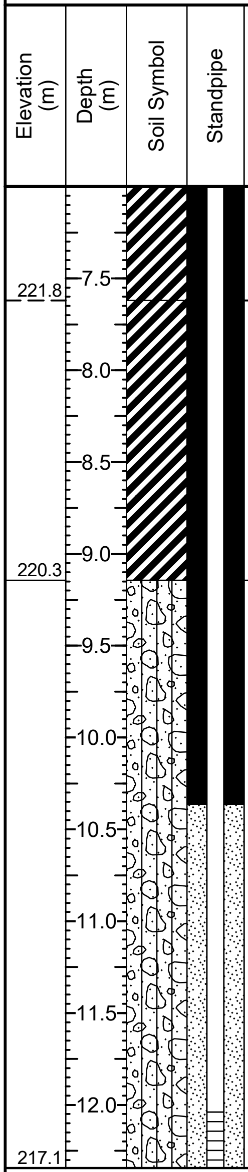
- trace gravel (< 25 mm diam.) below 6.1 m.

Logged By:	Ruslan Amarasinghe	**Reviewed By:**	N.J Ferreira	**Project Engineer:**	Michael Van Helden

Sub-Surface Log

Test Hole TH20-02

2 of 2



MATERIAL DESCRIPTION

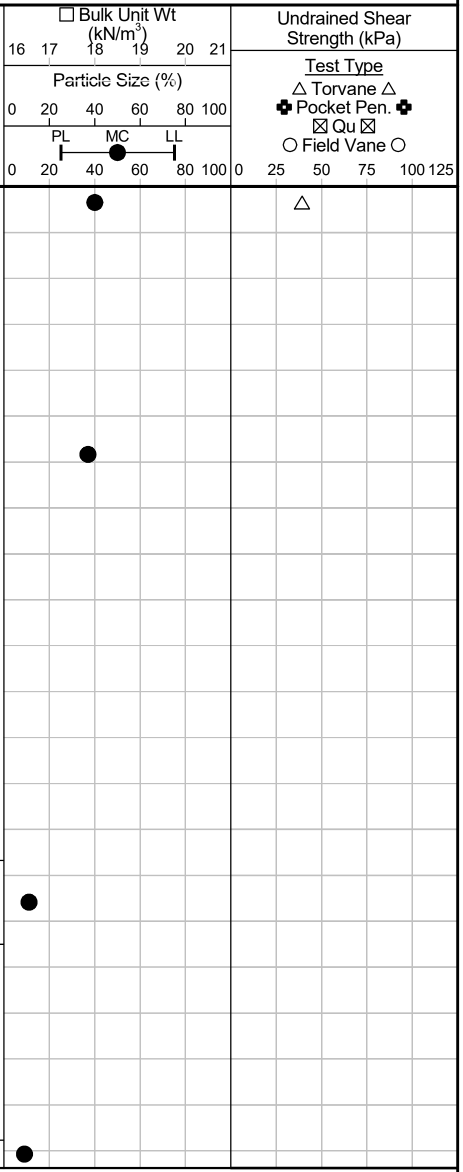
TRANSITION ZONE FROM CLAY TO SILT (TILL) - trace gravel (< 50 mm diam.)
- dark brown
- moist, soft to firm
- intermediate plasticity

SILT (TILL) - some clay, trace sand, some gravel (diam. < 20 mm)
- light brown
- moist, compact
- no to low plasticity

- trace clay below 11.0 m.

- dense below 11.6 m.

Sample Number	SPT (N)
G23	
G24	
G25	
SS26	19
G27	
SS28	32



END OF TEST HOLE AT 12.3 m IN SILT (TILL).
Notes:
1) Power auger refusal at 12.3 m depth below ground surface.
2) Seepage observed at 4.6 m below ground surface. Sloughing not observed.
4) Test hole dry and open to 12.3 m immediately after drilling.
5) Standpipe SP20-01 installed to 12.3 m depth below ground surface. Water level in standpipe observed at 5.8 m below ground surface approximately 2 hours after drilling.
6) Test hole backfilled with sand, bentonite and auger cuttings.

Logged By: Ruslan Amarasinghe **Reviewed By:** N.J Ferreira **Project Engineer:** Michael Van Helden

Sub-Surface Log

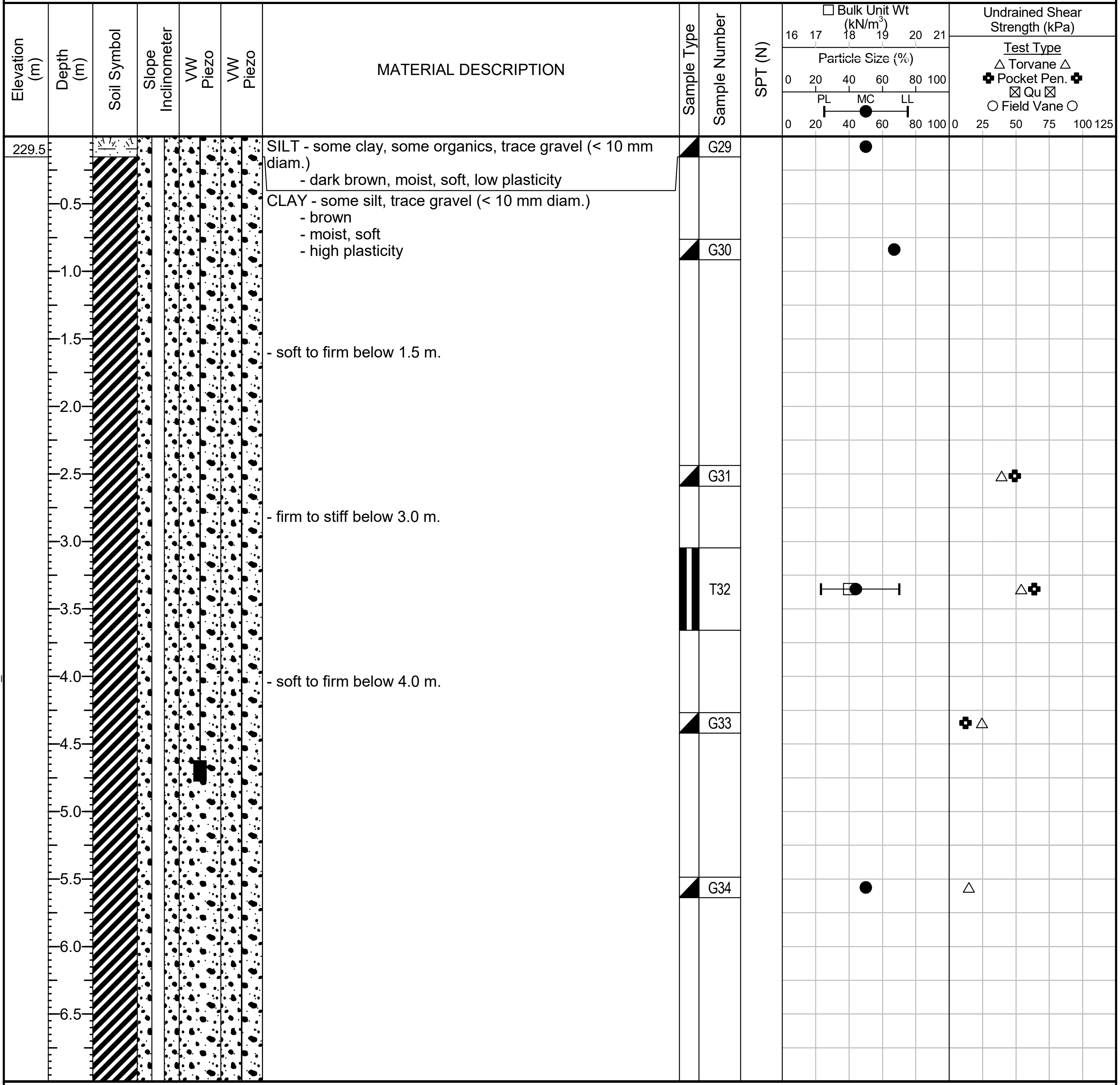
Test Hole TH20-03

Client: City of Winnipeg
Project Number: 0015-037-00
Project Name: Lagimodiere Blvd Slope Failures (CN Pond)
Location:
Contractor: Maple Leaf Drilling
Ground Elevation: 229.65 m -
Method: 125 mm Solid Stem Augers / HQ Coring, Acker Renegade Track Mount
Date Drilled: May 7, 2020

Sample Type: ◣ Grab (G) ◨ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ◫ Core (C)

Particle Size Legend: ▥ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ▱ Cobbles ■ Boulders

Backfill Legend: ■ Bentonite ▩ Cement ▨ Drill Cuttings ⁘ Filter Pack Sand ⁘ Grout ▩ Slough



SILT - some clay, some organics, trace gravel (< 10 mm diam.)
- dark brown, moist, soft, low plasticity

CLAY - some silt, trace gravel (< 10 mm diam.)
- brown
- moist, soft
- high plasticity

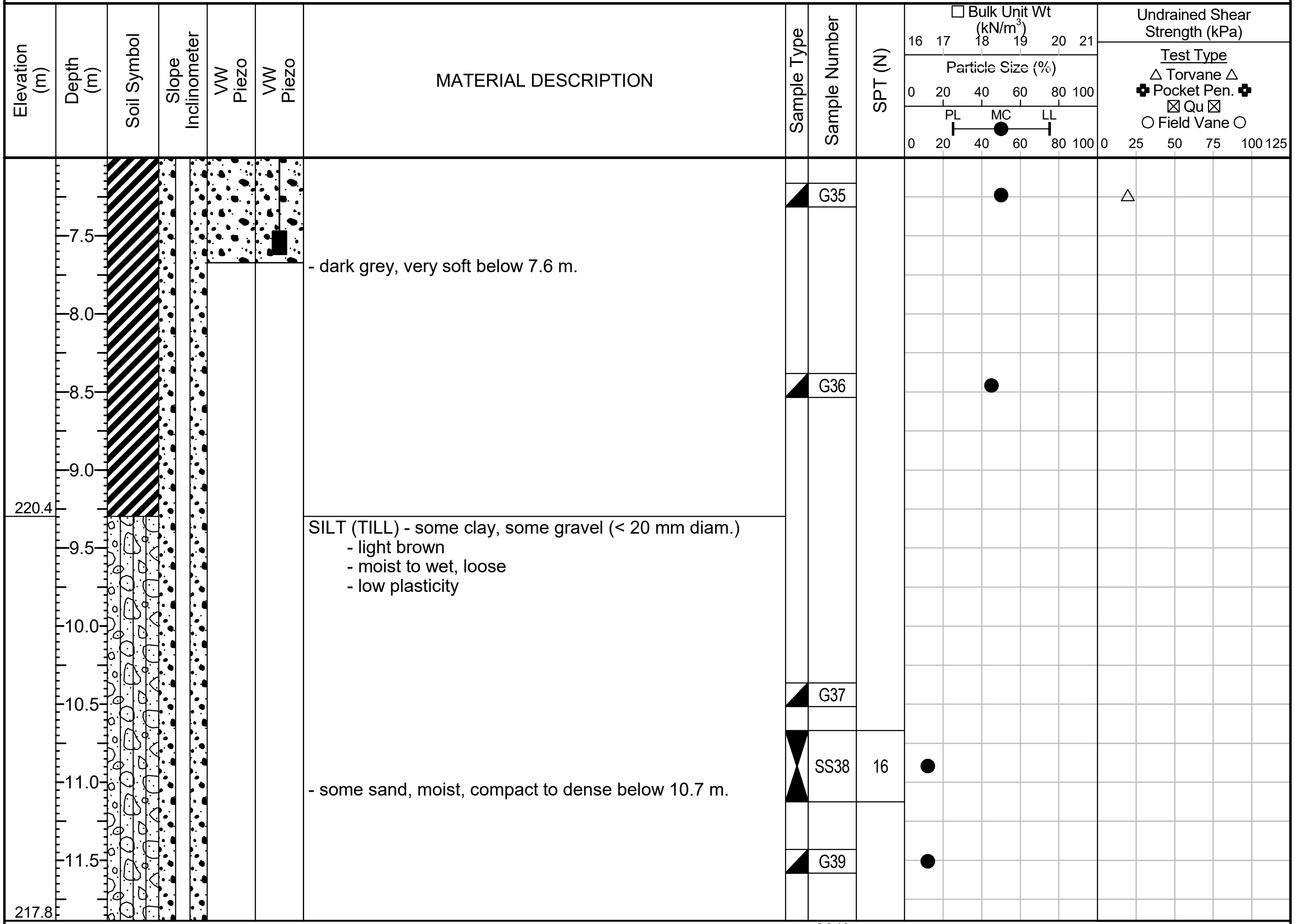
- soft to firm below 1.5 m.

- firm to stiff below 3.0 m.

- soft to firm below 4.0 m.

Logged By: Ruslan Amarasinghe
Reviewed By: N.J Ferreira
Project Engineer: Michael Van Helden

Sub-Surface Log



- dark grey, very soft below 7.6 m.

SILT (TILL) - some clay, some gravel (< 20 mm diam.)
- light brown
- moist to wet, loose
- low plasticity

- some sand, moist, compact to dense below 10.7 m.

END OF TEST HOLE AT 11.9 m IN SILT (TILL).

Notes:
1) Power auger refusal at 11.9 m depth below ground surface.
2) Seepage and sloughing observed 9.3 m below ground surface.
3) SI20-03 installed to 11.9 m depth below ground surface.
4) Vibrating wire (VW) piezometers VW20-03A (S/N: 1901577) and VW20-03B (S/N: 1901579), respectively, were installed at 4.6 m and 7.5 m below ground surface in a companion test hole approximately 0.8 m North of TH20-03.
5) SI20-03 and the VW companion test hole were backfilled with bentonite cement grout.

Logged By: Ruslan Amarasinghe **Reviewed By:** N.J Ferreira **Project Engineer:** Michael Van Helden

Appendix A

Site Photos

IMG_0333   2020/04/01 09:05:01

IMG_0335   2020/04/01 09:05:15

IMG_0336 2020/04/01 09:06:59

IMG_0337 2020/04/01 09:07:08

IMG_0339 2020/04/01 09:07:11

IMG_0340 2020/04/01 09:08:25

IMG_0341 2020/04/01 09:09:02

IMG_0342 2020/04/01 09:09:19

IMG_0343 2020/04/01 09:09:33

IMG_0346 2020/04/01 09:09:54

IMG_0348 2020/04/01 09:10:06

Appendix B

Laboratory Testing Results

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

MEMORANDUM

Date	May 21, 2020
To	Ruslan Amarasinghe , TREK Geotechnical
From	Angela Fidler-Kliewer, TREK Geotechnical
Project No.	0015-037-00
Project	Lagimodiere Blvd Slope Failure
Subject	Laboratory Testing Results – Lab Req. R20-084
Distribution	Ryan Belbas, Jashan Bhullar

Attached are the laboratory testing results for the above noted project. This report includes moisture content determinations, Atterberg limits, Visual classification and bulk unit weights on Shelby tube samples.

Regards,

Angela Fidler-Kliewer, C.Tech.

Attach.

Review Control:

Prepared By: HS	*Reviewed By:* AFK	*Checked By:* NJF

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT City of Winnipeg

PROJECT NAME Lagimodiere Blvd Slope Failure

PROJECT NO: 0015-037-00

FIELD TECHNICIAN: ~~Jashandeep Singh Bhullar~~ Ruslan / Jenna

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/Comments
TH20-01	G01	0.0 - 1.0													SILT
TH20-01	G02	2.5 - 3.0													|
TH20-01	G03	4.5 - 5.0		X											CLAY
TH20-01	G04	7.5 - 8.0		X											
TH20-01	T05	10.0 - 12.0			X	X									See Page 2 *
TH20-01	G06	13.0 - 13.5													
TH20-01	G07	16.0 - 16.5		X											
TH20-01	G08	18.0 - 18.5		X											
TH20-01	G09	23.5 - 24.0		X											
TH20-01	G10	27.5 - 28.0													
TH20-01	G11	29.0 - 29.5		X		X									
TH20-01	G12	32.5 - 33.0													TRANSITION ZONE
TH20-01	G13	33.0 - 33.5		X											+
TH20-01	SS14	35.0 - 36.5		X											SILT (TILL)
TH20-01	G15	37.5 - 38.0		X											|
TH20-01	SS16	39.0 - 40 ~~40.0 - 41.5~~		X											
TH20-02	G17	1.0 - 1.5													SILT
TH20-02	G18	4.0 - 4.5		X											CLAY
TH20-02	G19	7.5 - 8.0		X											
TH20-02	G20	13.0 - 13.5													
TH20-02	T21	15.0 - 17.0			X	X									See page 2 *
TH20-02	G22	19.0 - 19.5		X											
TH20-02	G23	23.0 - 23.5		X											
TH20-02	G24	27.5 - 28.0		X											TRANSITION ZONE
TH20-02	G25	33.0 - 33.5													SILT (TILL)
TH20-02	SS26	35.0 - 36.5		X											
TH20-02	G27	39.5 - 40.0													|
TH20-02	SS28	40.0 - 40.5		X											
TH20-03	G29	0.0 - 0.5		X											SILT
TH20-03	G30	2.5 - 3.0		X											CLAY
TH20-03	G31	8.0 - 8.5													
TH20-03	T32	10.0 - 12.0			X	X									See Page 2 *
TH20-03	G33	14.0 - 14.5													
TH20-03	G34	18.0 - 18.5		X											
TH20-03	G35	23.5 - 24.0		X											

REQUESTED BY: Jashandeep Singh Bhullar **REPORT TO:** Ruslan/Ryan Belbas/Jashan

REQUISITION DATE: May-13-2020 **DATE REQUIRED:** May 20, 2020

COMMENTS:

REQUISITION NO. R20-084

PAGE 1 OF 2

TREK LABORATORY REQUISITION LOGS 2020-05-11 LAGIMODIERE BLVD SLOPE FAILURE 0_A_JSB 0015-037-00.GPJ TREK GEOTECHNICAL.GDT 12/5/20

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT City of Winnipeg
PROJECT NAME Lagimodiere Blvd Slope Failure
PROJECT NO: 0015-037-00
FIELD TECHNICIAN: ~~Jashandeep Singh Bhullar~~ Ruslan / Jenna

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/Comments
TH20-03	G36	27.5 - 28.0		X											CLAY
TH20-03	G37	34.0 - 34.5													SILT (TILL)
TH20-03	SS38	35.0 - 36.5		X											
TH20-03	G39	37.5 - 38.0		X											
TH20-03	SS40	39.0 - 39.0													No Recovery

- For Shelby tubes please do Visual, Pocket pentrometer, Torvane moisture Content and Bulk Unit weight.

NO Qu.

- Jashan Bhullar.

Jashan Bhullar.

REQUESTED BY: Jashandeep Singh Bhullar **REPORT TO:** Ruslan / Ryan Belbas /
REQUISITION DATE: May-13-2020 **DATE REQUIRED:** May 20, 2020
COMMENTS:

REQUISITION NO.

PAGE 2 OF 2

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No. 0015-037-00
Client City of Winnipeg
Project Lagimodiere Blvd Slope Failure

Sample Date 06-May-20
Test Date 19-May-20
Technician HS

Test Hole	TH20-01	TH20-01	TH20-01	TH20-01	TH20-01	TH20-01
Depth (m)	1.4 - 1.5	2.3 - 2.4	4.9 - 5.0	5.5 - 5.6	7.2 - 7.3	8.8 - 9.0
Sample #	G03	G04	G07	G08	G09	G11
Tare ID	W76	AB80	W22	H35	F132	D21
Mass of tare	8.5	6.6	8.5	8.5	8.6	8.6
Mass wet + tare	217.7	258.7	189.6	186.9	231.9	427.1
Mass dry + tare	146.7	182.1	134.9	134.5	154.9	336.3
Mass water	71.0	76.6	54.7	52.4	77.0	90.8
Mass dry soil	138.2	175.5	126.4	126.0	146.3	327.7
Moisture %	51.4%	43.6%	43.3%	41.6%	52.6%	27.7%

Test Hole	TH20-01	TH20-01	TH20-01	TH20-01	TH20-02	TH20-02
Depth (m)	10.1 - 10.2	10.7 - 11.1	11.4 - 11.6	11.7 - 12.2	1.2 - 1.4	2.3 - 2.4
Sample #	G13	SS14	G15	SS16	G18	G19
Tare ID	Z72	H2	E85	A100	H74	W18
Mass of tare	8.8	8.4	8.7	8.8	8.7	8.4
Mass wet + tare	263.2	176.9	353.1	117.0	210.5	255.4
Mass dry + tare	232.9	157.4	317.8	103.3	143.7	179.3
Mass water	30.3	19.5	35.3	13.7	66.8	76.1
Mass dry soil	224.1	149.0	309.1	94.5	135.0	170.9
Moisture %	13.5%	13.1%	11.4%	14.5%	49.5%	44.5%

Test Hole	TH20-02	TH20-02	TH20-02	TH20-02	TH20-02	TH20-03
Depth (m)	5.8 - 5.9	7.0 - 7.2	8.4 - 8.5	10.7 - 11.1	12.2 - 12.3	0.0 - 0.2
Sample #	G22	G23	G24	SS26	SS28	G29
Tare ID	A103	AB71	D29	P06	C17	F17
Mass of tare	8.7	6.8	8.4	8.6	8.6	8.7
Mass wet + tare	240.1	305.6	254.6	166.3	153.7	178.6
Mass dry + tare	164.4	220.2	187.6	150.1	141.5	122.2
Mass water	75.7	85.4	67.0	16.2	12.2	56.4
Mass dry soil	155.7	213.4	179.2	141.5	132.9	113.5
Moisture %	48.6%	40.0%	37.4%	11.4%	9.2%	49.7%

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Moisture Content Report
ASTM D2216-10

Project No. 0015-037-00
Client City of Winnipeg
Project Lagimodiere Blvd Slope Failure

Sample Date 06-May-20
Test Date 19-May-20
Technician HS

Test Hole	TH20-03	TH20-03	TH20-03	TH20-03	TH20-03	TH20-03
Depth (m)	0.8 - 0.9	5.5 - 5.6	7.2 - 7.3	8.4 - 8.5	10.7 - 11.1	11.4 - 11.6
Sample #	G30	G34	G35	G36	SS38	G39
Tare ID	E3	AB01	Z58	K7	H12	F103
Mass of tare	8.6	6.8	8.6	8.7	8.5	8.8
Mass wet + tare	253.1	245.0	202.6	262.0	244.0	376.1
Mass dry + tare	155.0	165.6	137.6	182.9	218.0	338.2
Mass water	98.1	79.4	65.0	79.1	26.0	37.9
Mass dry soil	146.4	158.8	129.0	174.2	209.5	329.4
Moisture %	67.0%	50.0%	50.4%	45.4%	12.4%	11.5%

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Atterberg Limits
ASTM D4318-10e1

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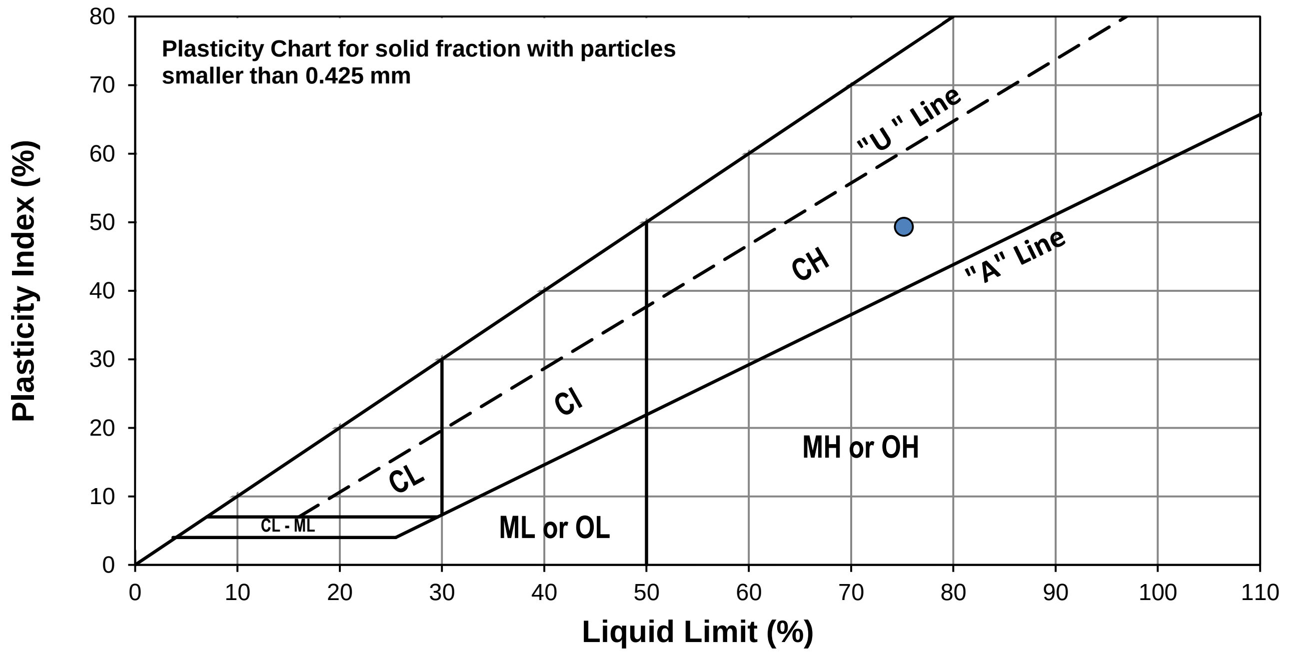
Project No.	0015-037-00
Client	City of Winnipeg
Project	Lagimodiere Blvd Slope Failure
Test Hole	TH20-01
Sample #	T05
Depth (m)	3.0 - 3.7
Sample Date	06-May-20
Test Date	19-May-20
Technician	HS

Liquid Limit	75
Plastic Limit	26
Plasticity Index	49

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	17	27	33		
Mass Wet Soil + Tare (g)	25.656	30.776	21.492		
Mass Dry Soil + Tare (g)	20.684	23.754	18.427		
Mass Tare (g)	14.165	14.404	14.300		
Mass Water (g)	4.972	7.022	3.065		
Mass Dry Soil (g)	6.519	9.350	4.127		
Moisture Content (%)	76.269	75.102	74.267		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.413	14.110			
Mass Wet Soil + Tare (g)	22.270	21.851			
Mass Dry Soil + Tare (g)	20.647	20.268			
Mass Water (g)	1.623	1.583			
Mass Dry Soil (g)	6.234	6.158			
Moisture Content (%)	26.035	25.706			

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Atterberg Limits
ASTM D4318-10e1

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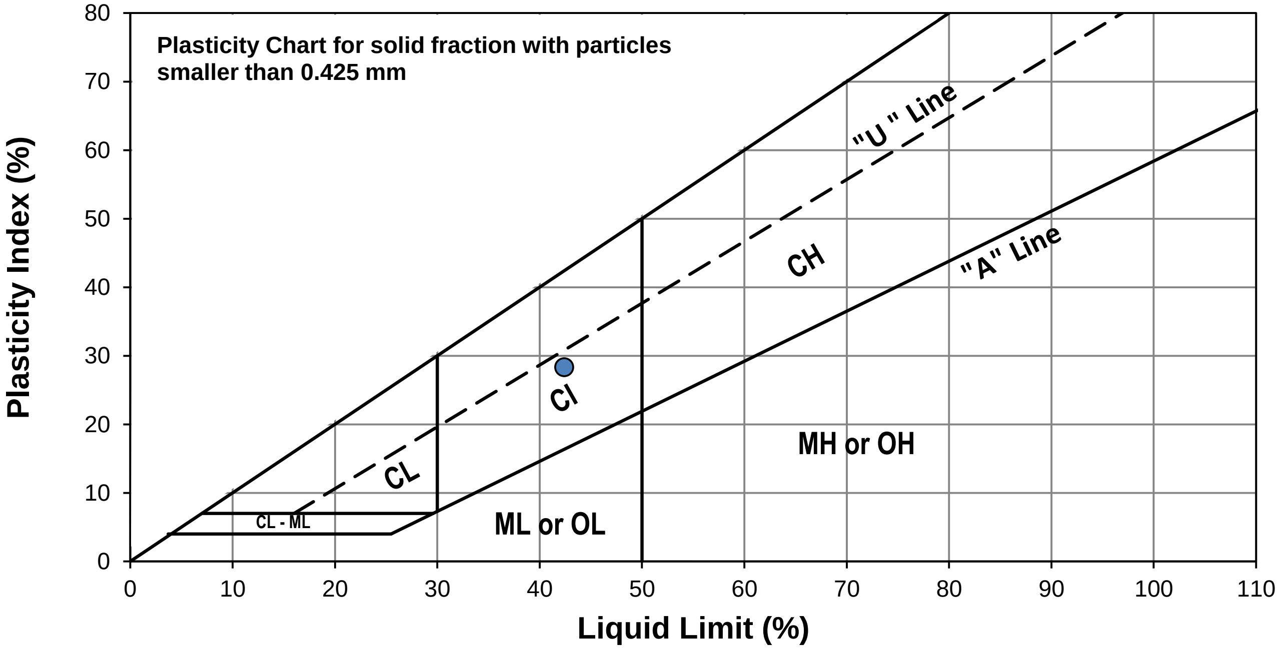
Project No.	0015-037-00
Client	City of Winnipeg
Project	Lagimodiere Blvd Slope Failure
Test Hole	TH20-01
Sample #	G11
Depth (m)	8.8 - 9.0
Sample Date	06-May-20
Test Date	19-May-20
Technician	HS

Liquid Limit	42
Plastic Limit	14
Plasticity Index	28

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	18	25	31		
Mass Wet Soil + Tare (g)	27.747	26.117	28.659		
Mass Dry Soil + Tare (g)	23.615	22.591	24.427		
Mass Tare (g)	14.261	14.240	14.213		
Mass Water (g)	4.132	3.526	4.232		
Mass Dry Soil (g)	9.354	8.351	10.214		
Moisture Content (%)	44.174	42.222	41.433		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.401	14.309			
Mass Wet Soil + Tare (g)	22.984	22.311			
Mass Dry Soil + Tare (g)	21.932	21.313			
Mass Water (g)	1.052	0.998			
Mass Dry Soil (g)	7.531	7.004			
Moisture Content (%)	13.969	14.249			

Atterberg Limits
ASTM D4318-10e1

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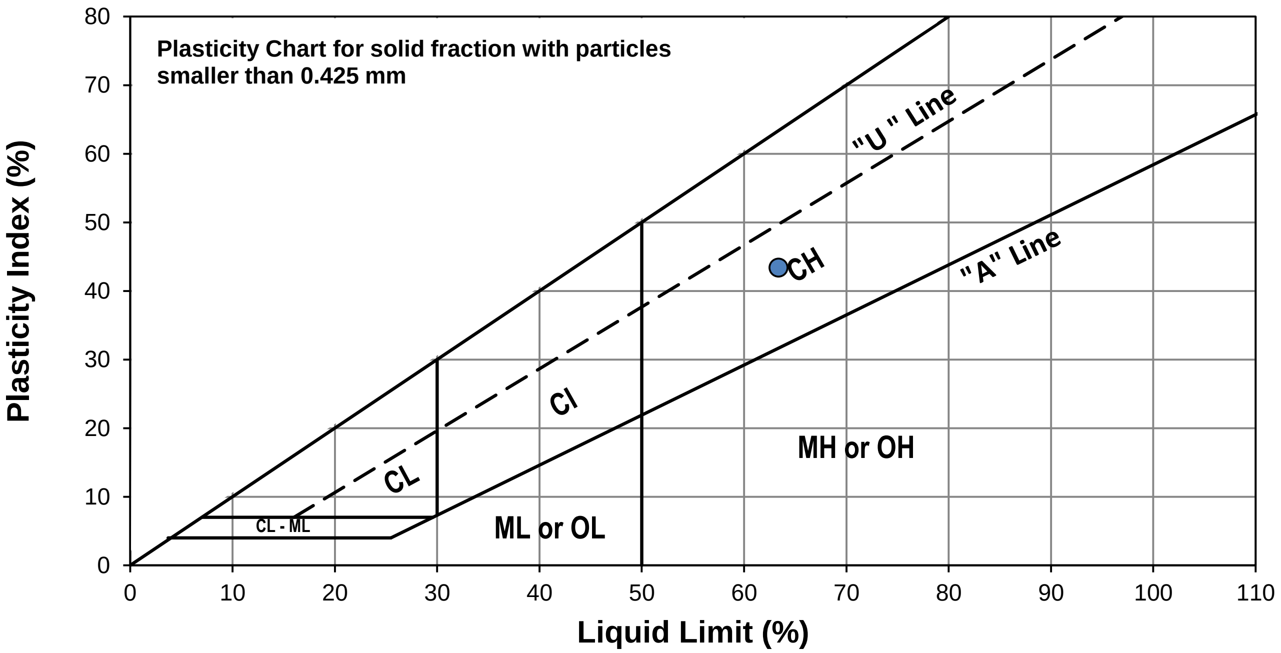
Project No.	0015-037-00
Client	City of Winnipeg
Project	Lagimodiere Blvd Slope Failure
Test Hole	TH20-02
Sample #	T21
Depth (m)	4.6 - 5.2
Sample Date	06-May-20
Test Date	19-May-20
Technician	HS

Liquid Limit	63
Plastic Limit	20
Plasticity Index	43

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	16	21	27		
Mass Wet Soil + Tare (g)	24.801	27.725	27.860		
Mass Dry Soil + Tare (g)	20.577	22.405	22.643		
Mass Tare (g)	14.247	14.203	14.320		
Mass Water (g)	4.224	5.320	5.217		
Mass Dry Soil (g)	6.330	8.202	8.323		
Moisture Content (%)	66.730	64.862	62.682		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.002	14.211			
Mass Wet Soil + Tare (g)	22.433	22.494			
Mass Dry Soil + Tare (g)	21.023	21.122			
Mass Water (g)	1.410	1.372			
Mass Dry Soil (g)	7.021	6.911			
Moisture Content (%)	20.083	19.852			

Atterberg Limits
ASTM D4318-10e1

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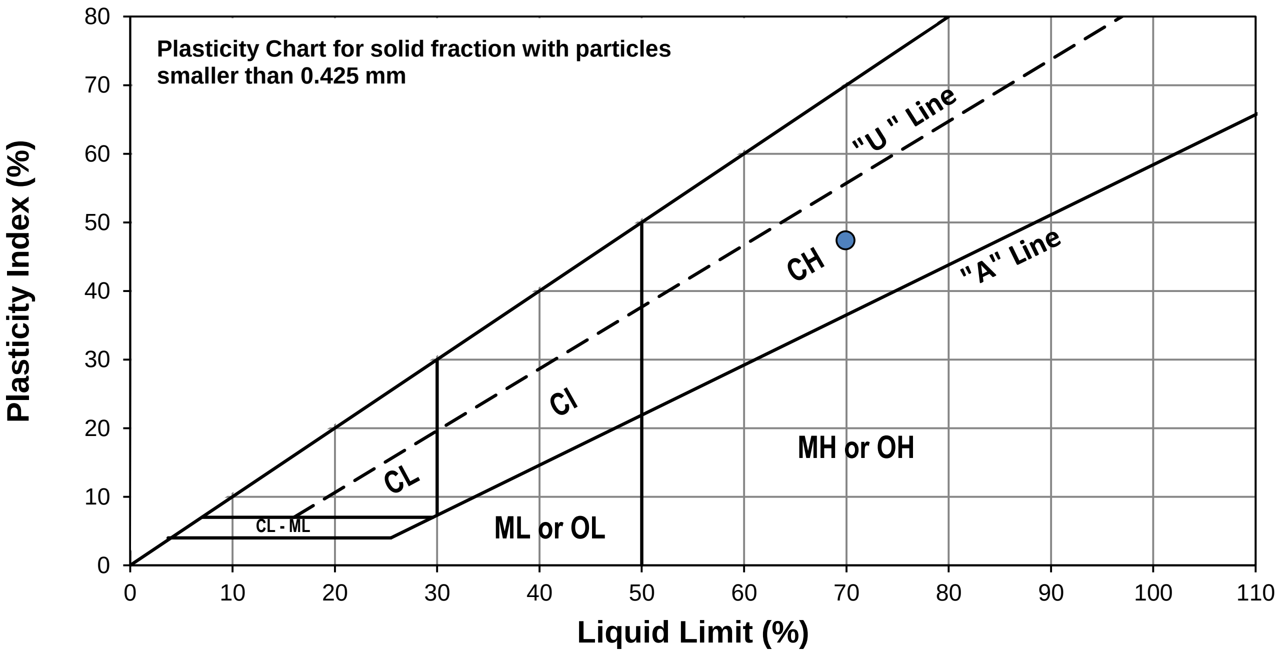
Project No.	0015-037-00
Client	City of Winnipeg
Project	Lagimodiere Blvd Slope Failure
Test Hole	TH20-03
Sample #	T32
Depth (m)	3.0 - 3.7
Sample Date	06-May-20
Test Date	19-May-20
Technician	HS

Liquid Limit	70
Plastic Limit	23
Plasticity Index	47

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	18	25	34		
Mass Wet Soil + Tare (g)	26.042	24.003	31.355		
Mass Dry Soil + Tare (g)	21.116	19.983	24.383		
Mass Tare (g)	14.245	14.233	14.166		
Mass Water (g)	4.926	4.020	6.972		
Mass Dry Soil (g)	6.871	5.750	10.217		
Moisture Content (%)	71.693	69.913	68.239		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.136	13.768			
Mass Wet Soil + Tare (g)	21.702	20.536			
Mass Dry Soil + Tare (g)	20.310	19.292			
Mass Water (g)	1.392	1.244			
Mass Dry Soil (g)	6.174	5.524			
Moisture Content (%)	22.546	22.520			

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Shelby Tube Visual

Project No.	0015-037-00
Client	City of Winnipeg
Project	Lagimodiere Blvd Slope Failure
Test Hole	TH20-01
Sample #	T05
Depth (m)	3.0 - 3.7
Sample Date	06-May-20
Test Date	14-May-20
Technician	HS

Tube Extraction

Recovery (mm) 760 (overpush)

Bottom - 3.8 m	3.54 m	3.44 m	3.22 m	3.10 m **Top - 3 m**
Keep	Bulk	PP TV Moisture Content Atterberg Limits	Visual	Toss
270 mm	100 mm	220 mm	120 mm	50 mm

Visual Classification

Material	Clay
Composition	silty
trace silt inclusions (<10 mm diam.)	
Color	mottled brown
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	blocky
Gradation	

Torvane

Reading	0.70
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	68.7

Pocket Penetrometer

Reading	**1**	1.75
	2	1.70
	3	1.70
	Average	1.72
Undrained Shear Strength (kPa)		84.2

Moisture Content

Tare ID	F32
Mass tare (g)	8.3
Mass wet + tare (g)	488.7
Mass dry + tare (g)	335.7
Moisture %	46.7%

Unit Weight

Bulk Weight (g)		566.0
Length (mm)	**1**	76.82
	2	76.99
	3	77.20
	4	76.77
Average Length (m)		0.077
Diam. (mm)	**1**	71.89
	2	71.53
	3	71.97
	4	72.10
Average Diameter (m)		0.072
Volume (m^3)		3.12E-04
Bulk Unit Weight (kN/m^3)		17.8
Bulk Unit Weight (pcf)		113.2
Dry Unit Weight (kN/m^3)		12.1
Dry Unit Weight (pcf)		77.1

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Shelby Tube Visual

Project No.	0015-037-00
Client	City of Winnipeg
Project	Lagimodiere Blvd Slope Failure
Test Hole	TH20-02
Sample #	T21
Depth (m)	4.6 - 5.2
Sample Date	06-May-20
Test Date	14-May-20
Technician	HS

Tube Extraction

Recovery (mm) 730

Bottom - 5.3 m 5.10 m 5.00 m 4.93 m 4.89 m **Top - 4.6 m**

Keep	Bulk	PP TV Moisture Content Visual Atterberg Limits	Visual	Toss Slough
200 mm	100 mm	70 mm	40 mm	320 mm

Visual Classification

Material	Clay
Composition	silty
trace sand	
trace gravel (<10 mm diam.)	
trace silt inclusions (<10 mm diam.)	
Color	grey
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	-
Gradation	

Torvane

Reading	0.55
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	53.9

Pocket Penetrometer

Reading	**1**	1.20
	2	1.20
	3	1.30
	Average	1.23
Undrained Shear Strength (kPa)		60.5

Moisture Content

Tare ID	P28
Mass tare (g)	8.6
Mass wet + tare (g)	499.9
Mass dry + tare (g)	357.7
Moisture %	40.7%

Unit Weight

Bulk Weight (g)		704.5
Length (mm)	**1**	93.70
	2	93.37
	3	94.10
	4	93.95
Average Length (m)		0.094
Diam. (mm)	**1**	70.95
	2	71.57
	3	71.44
	4	70.99
Average Diameter (m)		0.071
Volume (m^3)		3.74E-04
Bulk Unit Weight (kN/m^3)		18.5
Bulk Unit Weight (pcf)		117.7
Dry Unit Weight (kN/m^3)		13.1
Dry Unit Weight (pcf)		83.6

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Shelby Tube Visual

Project No.	0015-037-00
Client	City of Winnipeg
Project	Lagimodiere Blvd Slope Failure
Test Hole	TH20-03
Sample #	T32
Depth (m)	3.0 - 3.7
Sample Date	06-May-20
Test Date	14-May-20
Technician	HS

Tube Extraction

Recovery (mm) 690

Bottom - 3.7 m | 3.45 m | 3.30 m | 3.22 m | 3.15 m | **Top - 3 m**

Keep	Bulk	PP TV Moisture Content Visual Atterberg Limits	Visual	Toss Slough
290 mm	150 mm	80 mm	70 mm	100 mm

Visual Classification

Material	Clay
Composition	silty
trace silt inclusions (<10 mm diam.)	
Color	grey
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	-
Gradation	

Torvane

Reading	0.55
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	53.9

Pocket Penetrometer

Reading	**1**	1.20
	2	1.40
	3	1.30
	Average	1.30
Undrained Shear Strength (kPa)		63.7

Moisture Content

Tare ID	E13
Mass tare (g)	8.8
Mass wet + tare (g)	504.3
Mass dry + tare (g)	353.9
Moisture %	43.6%

Unit Weight

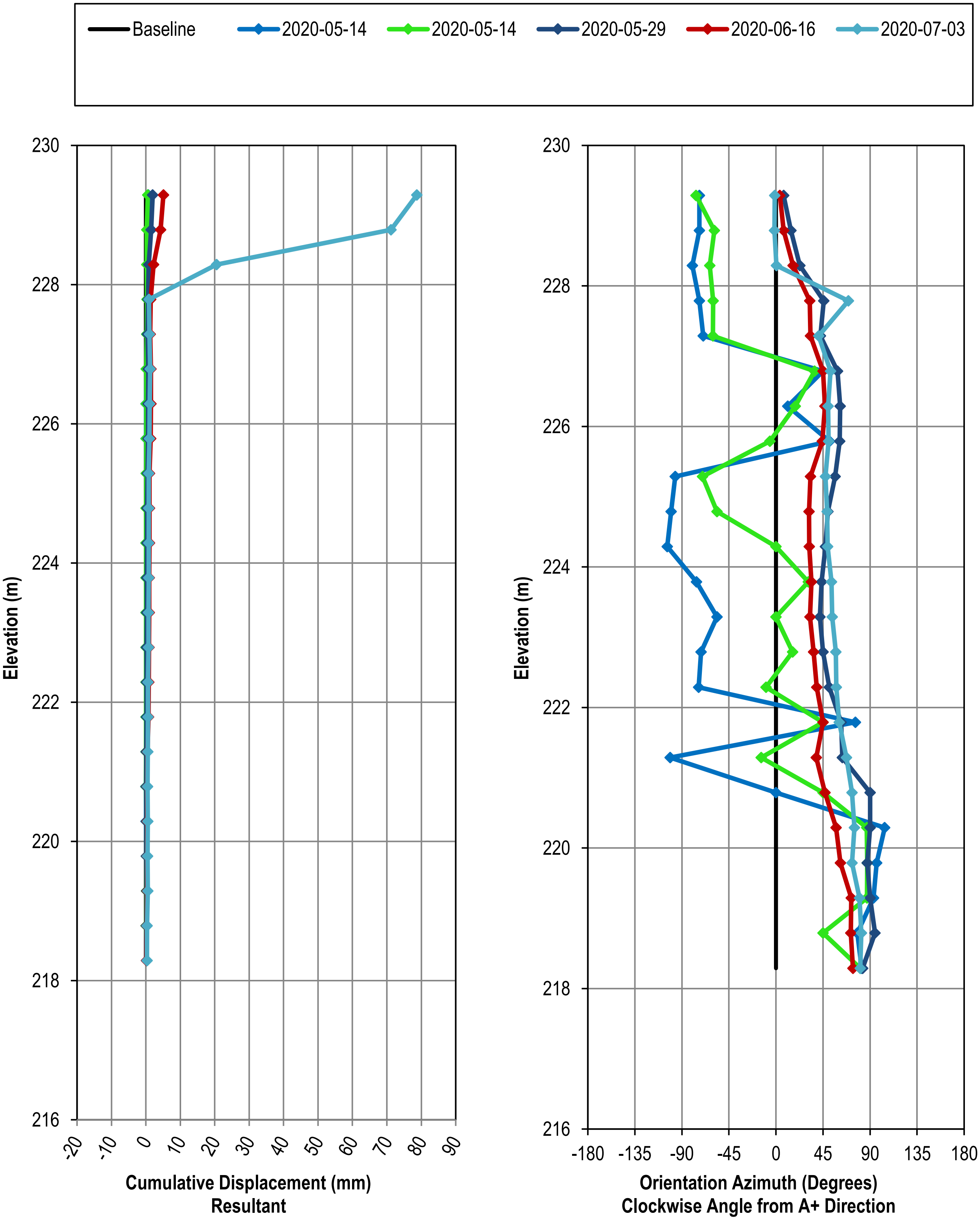
Bulk Weight (g)		1015.5
Length (mm)	**1**	138.08
	2	138.83
	3	138.25
	4	138.49
Average Length (m)		0.138
Diam. (mm)	**1**	71.57
	2	71.41
	3	71.49
	4	71.25
Average Diameter (m)		0.071
Volume (m^3)		5.55E-04
Bulk Unit Weight (kN/m^3)		18.0
Bulk Unit Weight (pcf)		114.3
Dry Unit Weight (kN/m^3)		12.5
Dry Unit Weight (pcf)		79.6

Appendix C

Slope Inclinometer Monitoring Results

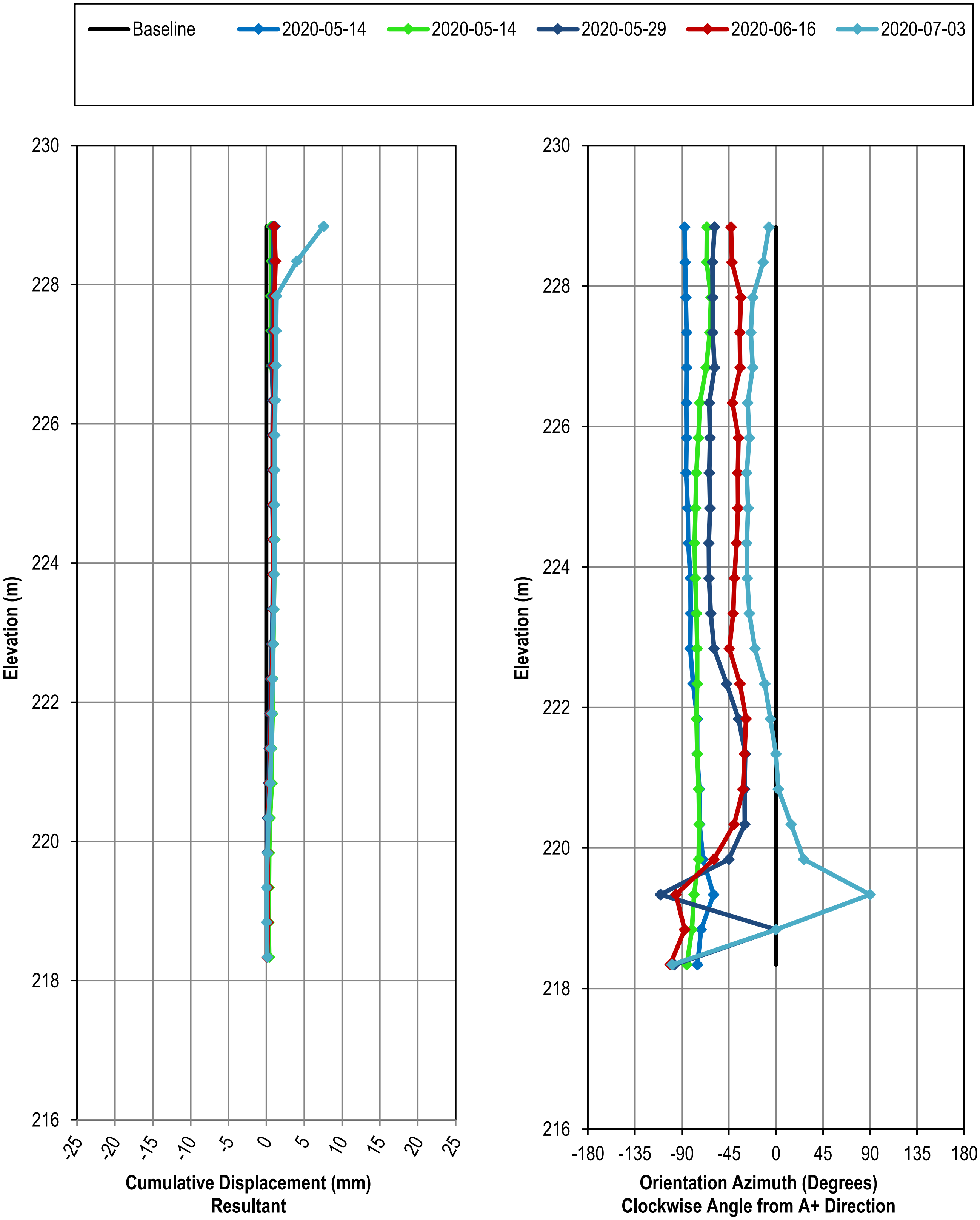
SLOPE INCLINOMETER DATA PLOTS

SI20-01



SLOPE INCLINOMETER DATA PLOTS

SI20-03



Appendix D

Slope Stability Analysis Results

Tabloid (279mm x 432mm)

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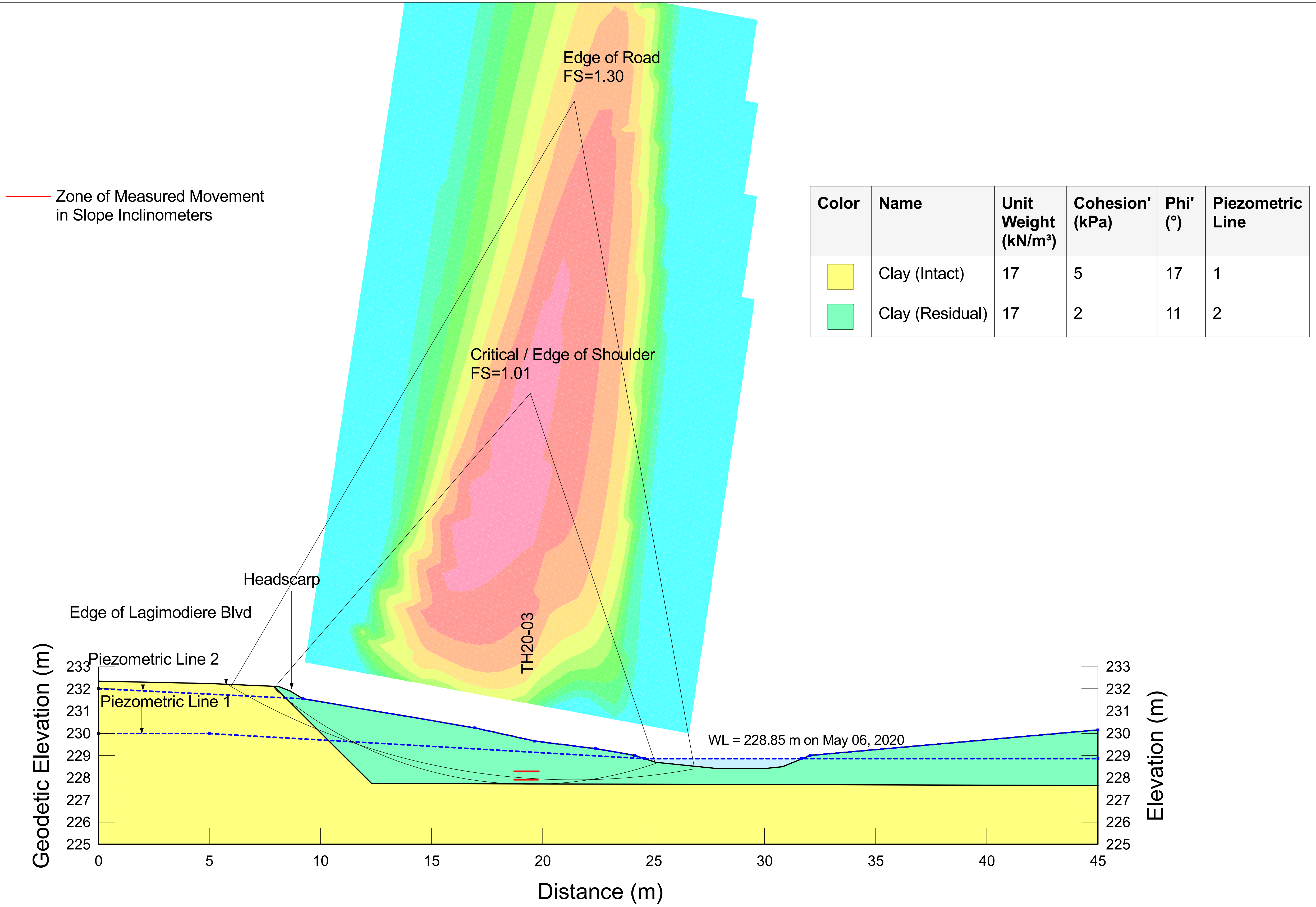

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟨	Clay (Intact)	17	5	17	1
🟩	Clay (Residual)	17	2	11	2

FILE PATH: Z:\Projects\0015 City of Winnipeg\0015 037 00 Lagimodiere Slope Failure CN Pond\2 Design\2.7 Modelling\0015-037-00 DD018.gsz

Figure D-01
Cross-Section A
Back-Analysis (Post-Failure Geometry)

0015 037 00
City of WInnipeg
Lagimodiere Blvd Slope Failures (CN Pond)

Tabloid (279mm x 432mm)

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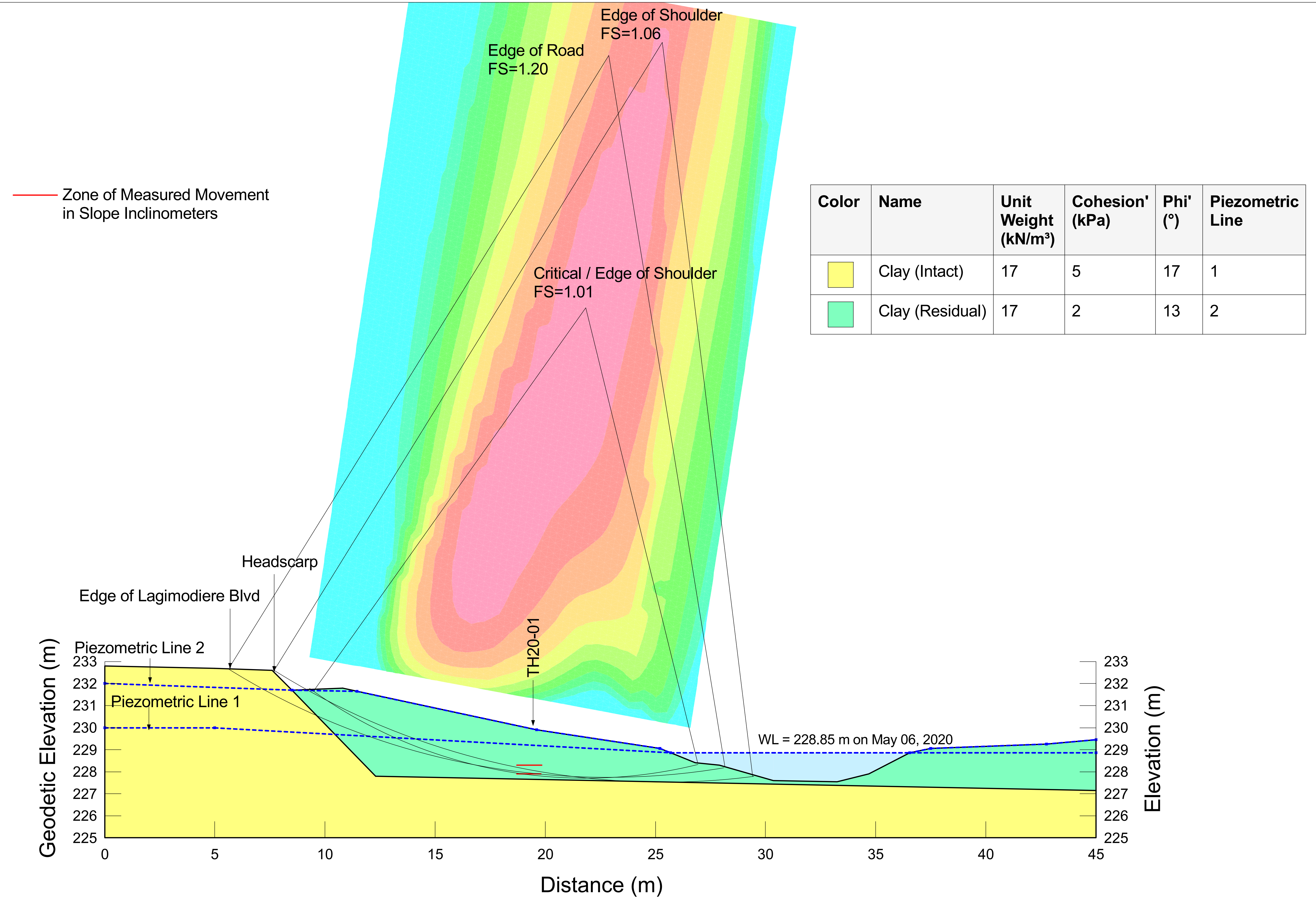

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟨	Clay (Intact)	17	5	17	1
🟩	Clay (Residual)	17	2	13	2

FILE PATH: Z:\Projects\0015 City of Winnipeg\0015 037 00 Lagimodiere Slope Failure CN Pond\2 Design\2.7 Modelling\0015-037-00 DD008.gsz

Figure D-02
Cross-Section C
Back-Analysis (Post-Failure Geometry)

0015 037 00
City of WInnipeg
Lagimodiere Blvd Slope Failures (CN Pond)

Tabloid (279mm x 432mm)

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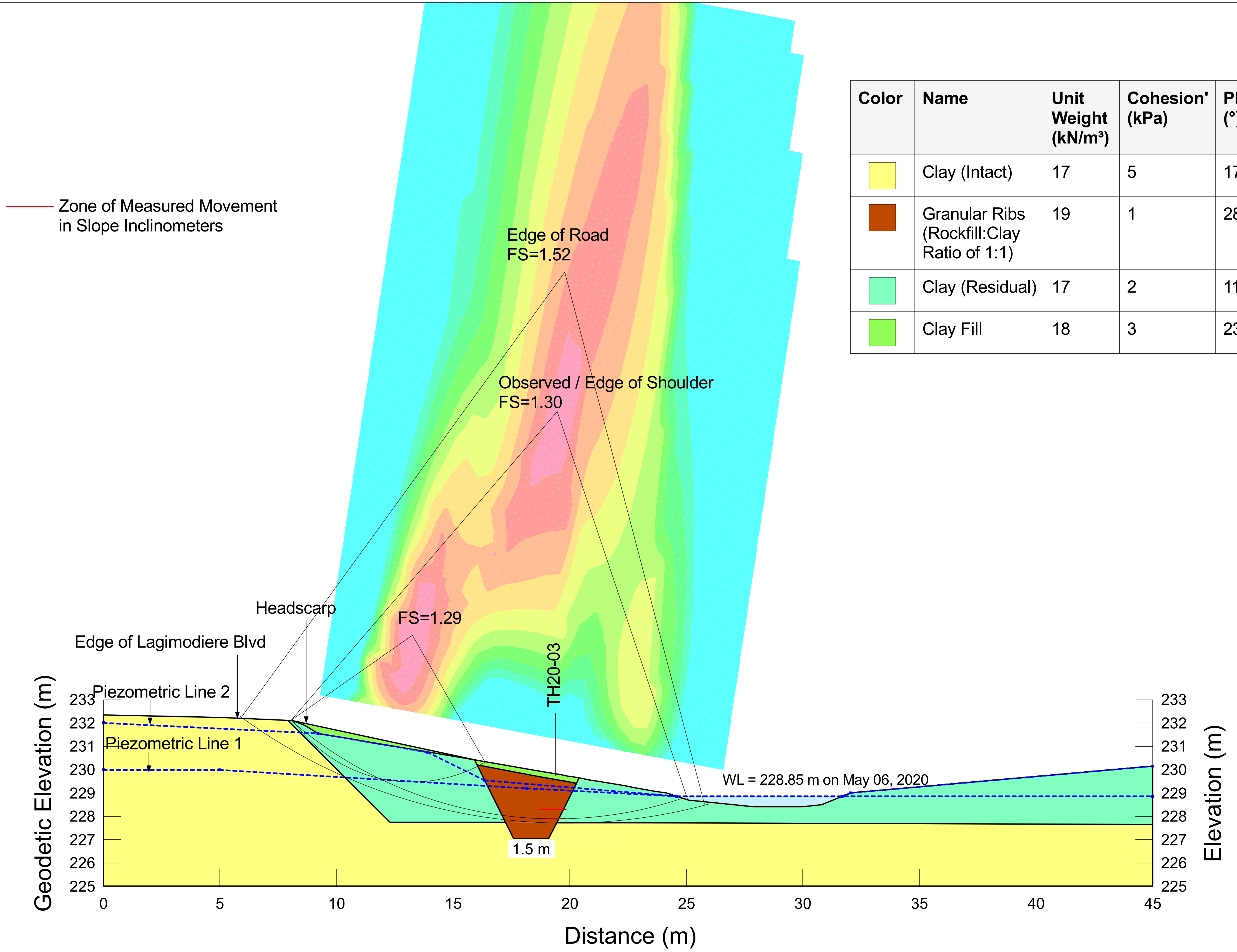
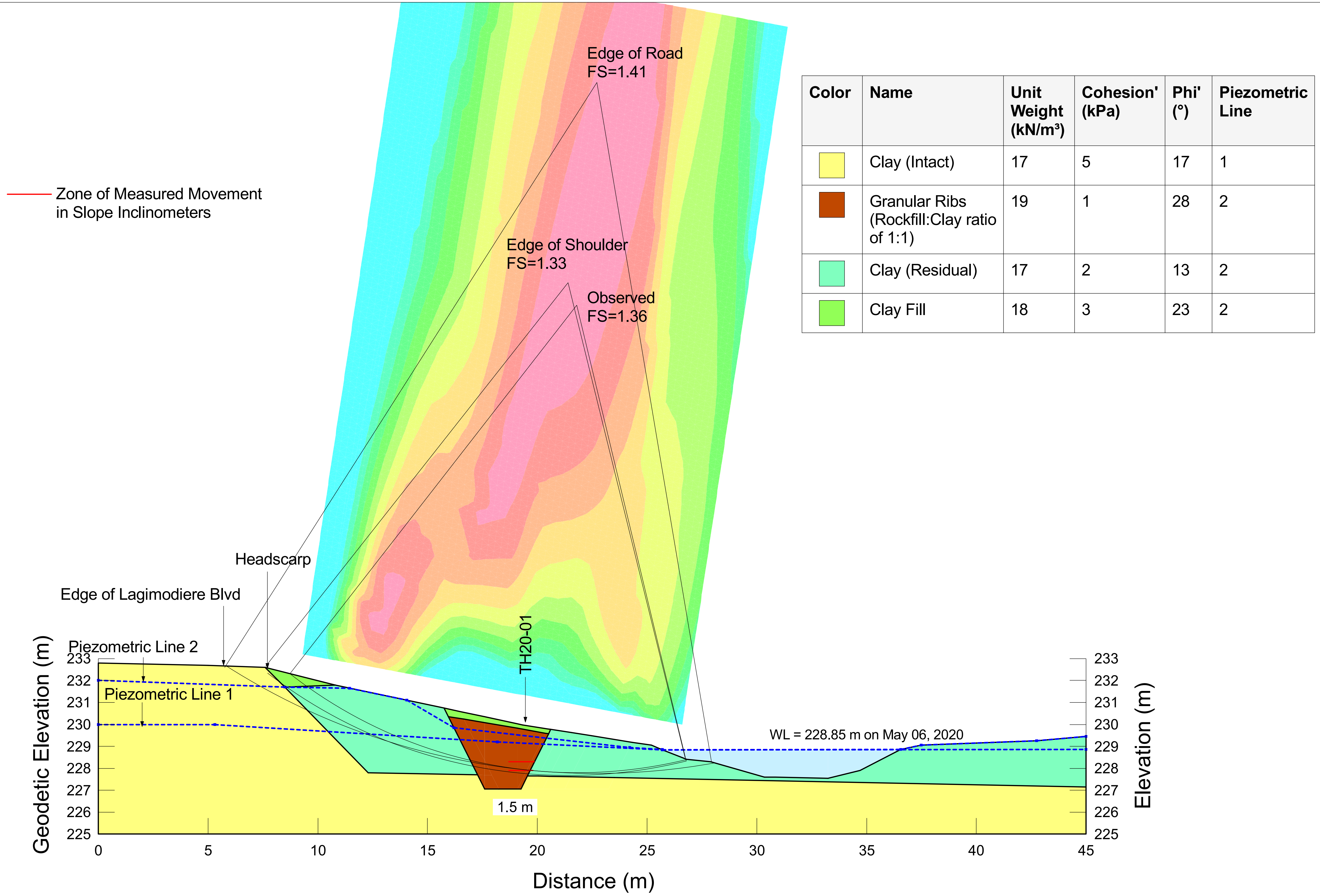


Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟨	Clay (Intact)	17	5	17	1
🟫	Granular Ribs (Rockfill:Clay Ratio of 1:1)	19	1	28	2
🟩	Clay (Residual)	17	2	11	2
🟩	Clay Fill	18	3	23	2

FILE PATH: Z:\Projects\0015 City of Winnipeg\0015 037 00 Lagimodiere Slope Failure CN Pond\2 Design\2.7 Modelling\0015-037-00 DD016.gsz

Figure D-03
Cross-Section A
Rockfill Ribs (1:1 Replacement Ratio) and Regrading to Original Grades

0015 037 00
City of WInnipeg
Lagimodiere Blvd Slope Failures (CN Pond)



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟨	Clay (Intact)	17	5	17	1
🟫	Granular Ribs (Rockfill:Clay ratio of 1:1)	19	1	28	2
🟩	Clay (Residual)	17	2	13	2
🟩	Clay Fill	18	3	23	2

FILE PATH: Z:\Projects\0015 City of Winnipeg\0015 037 00 Lagimodiere Slope Failure CN Pond\2 Design\2.7 Modelling\0015-037-00 DD006.gsz

Figure D-04
Cross-Section C
Rockfill Ribs (1:1 Replacement Ratio) and Regrading to Original Grades

Tabloid (279mm x 432mm)
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SCALE: 1:180 (279mm x 432mm)

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟨	Clay (Intact)	17	5	17	1
🟫	Granular Toe Berm	20	0	45	2
🟩	Clay (Residual)	17	2	11	2
🟩	Clay Fill	18	3	23	2

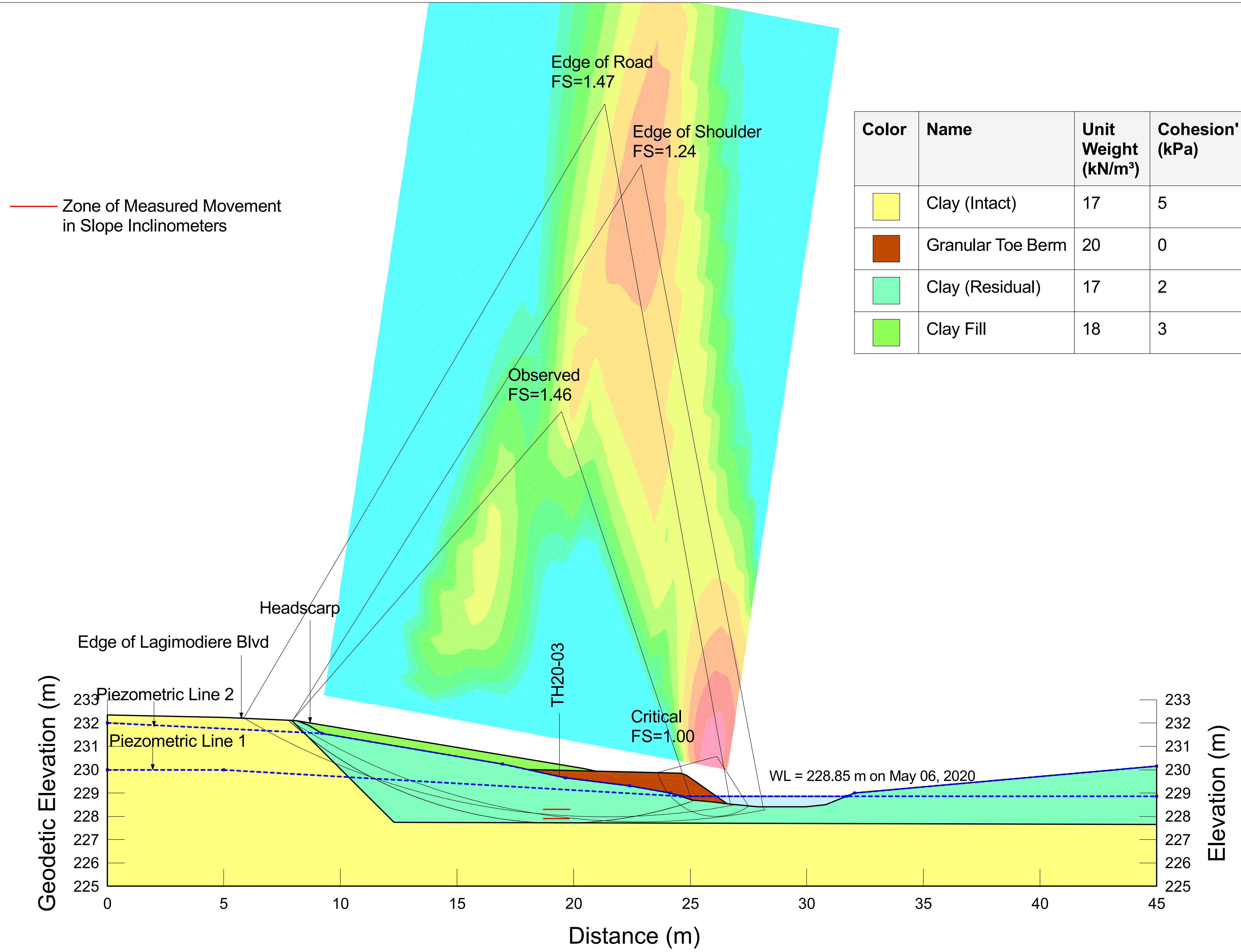

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Figure D-05
Cross-Section A
Rockfill Toe Berm and Slope Flattening (6.3H:1V Upslope of Berm)

Tabloid (279mm x 432mm)

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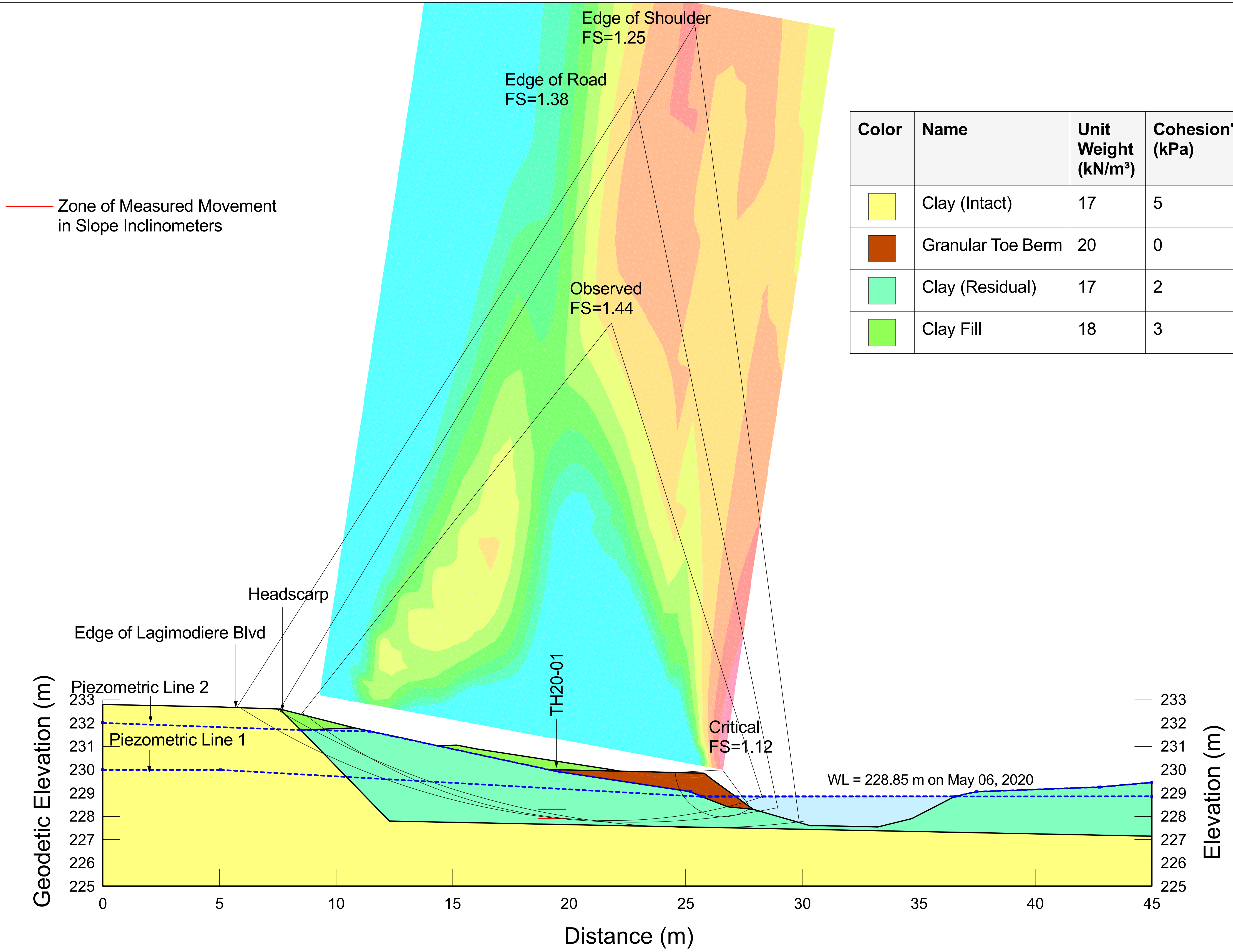

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟨	Clay (Intact)	17	5	17	1
🟫	Granular Toe Berm	20	0	45	2
🟦	Clay (Residual)	17	2	13	2
🟩	Clay Fill	18	3	23	2

FILE PATH: Z:\Projects\0015 City of Winnipeg\0015 037 00 Lagimodiere Slope Failure CN Pond\2 Design\2.7 Modelling\0015-037-00 DD007.gsz

Figure D-06
Cross-Section C
Rockfill Teo Berm and Slope Flattening (6.3H:1V Upslope of Berm)

Appendix E

Basis of Estimate Capital Detail Worksheet

Basis of Estimate Capital Cost Detail

Investment Title	**Slope Stabilization - Lagimodiere Blvd at CN Pond - Elizabeth Rd to Betournay St**
BC ID	**0**
Is this a Major Capital project?	**No**
Estimate Date	**August 6, 2020**
In Service Year	**2020**
Class of Estimate	**Class 3**

ESTIMATE DETAIL

		Cost Escalation / Capital Inflation	3%	3%	3%	3%	3%	3%	
		Estimate Year	**Year Project Work Undertaken**						
		2020							**Total**
Construction/Equipment Costs	% of Const.	($000's)							
Stabilization - Rockfill Ribs - Failed Areas	83%	$185	$0	$0	$0	$0	$0	$0	$0
Stabilization - Rockfill Ribs - Unfailed Areas	17%	$39	$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
Construction Costs Sub-total	100%	**$224**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Consultant Costs (Internal & External)	% of Const	($000's)							
PD	16%	$36	$0	$0	$0	$0	$0	$0	$0
DD	4%	$10	$0	$0	$0	$0	$0	$0	$0
CA	9%	$20	$0	$0	$0	$0	$0	$0	$0
PCS	2%	$5	$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
Consultant Costs Sub-total	32%	**$71**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Construction & Consultant Sub-total		**$295**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Utility Costs	% C&C	($000's)							
Hydro - pole replacement	3%	$10	$0	$0	$0	$0	$0	$0	$0
Communication - MTS	0%	$0	$0	$0	$0	$0	$0	$0	$0
Communication - Shaw	0%	$0	$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
Utility Costs Sub-total	3%	**$10**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Other Costs	% C&C	($000's)							
Land Acquisition	0%		$0	$0	$0	$0	$0	$0	$0
Insurance	0%		$0	$0	$0	$0	$0	$0	$0
CN Work Permits	3%	$10	$0	$0	$0	$0	$0	$0	$0
Traffic Services Allowance	3%	$10	$0	$0	$0	$0	$0	$0	$0
Other Costs Sub-total	7%	**$20**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Project Costs before Contingencies Sub-total		**$325**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Contingencies Costs	% Proj Cost	($000's)							
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
	0%		$0	$0	$0	$0	$0	$0	$0
Contingencies Costs Sub-total	0%	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Project Sub-total before Administrative Charges Subtotal		**$325**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
							% increase from base		0%

Administrative Charges Detail

Administrative Charges (* consult department Finance)									
Departmental Staff	2.00%	$7	$0	$0	$0	$0	$0	$0	$0
Corporate Admin (max $100,000)	1.25%	$4	$0	$0	$0	$0	$0	$0	$0
Municipal Accommodations charges (if delivering the project)	0.00%	$0	$0	$0	$0	$0	$0	$0	$0
Research (SMIR) (Construction Only, only applies to Public Works)	0.00%	$0	$0	$0	$0	$0	$0	$0	$0
Corporate Interest	2.00%	$7	$0	$0	$0	$0	$0	$0	$0
		$0	$0	$0	$0	$0	$0	$0	$0
		$0	$0	$0	$0	$0	$0	$0	$0
Administrative Charges Sub-total	-	**$17**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Project Sub-total before Interest Charges Sub-total		**$342**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
TOTAL CAPITAL PROJECT COST		**$342**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**