APPENDIX ‘A’

GEOTECHNICAL REPORT

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Pembina Highway and Bishop Grandin Boulevard Interchange Southwest Corner Slope Failure

Slope Stability Assessment Report

Prepared for:
Cameron Ward, P. Eng.
Bridge Projects Engineer
City of Winnipeg, Engineering Division
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106-1155 Pacific Avenue
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Project Number: 0015 034 00

Date: May 26, 2020 (2nd Revision)

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Quality Engineering | Valued Relationships

May 26, 2020 Our File No. 0015 034 00

Mr. Cameron Ward, P. Eng.
Bridge Project Engineer
City of Winnipeg, Engineering Division
Public Works Department
106-1155 Pacific Avenue
Winnipeg, MB, R3E 3P1

RE: Pembina Highway and Bishop Grandin Boulevard Interchange
Southwest Corner Slope Failure
Slope Stability Assessment Report (1st Revision)

TREK Geotechnical Inc. is pleased to submit a revised Final Report for the geotechnical investigation for the above noted project. Revisions include findings of hydro-excavation for utility locations and associated changes to the report recommendations, as well as further information on the suspected triggering event.

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	February 18, 2020	Final Report
1	MVH	May 18, 2020	Revised Final Report
2	MVH	May 26, 2020	Revised Final Report

Authorization Signatures

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Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: 2020-05-26

Ken Skaftfeld, M.Sc., P.Eng.
Senior Geotechnical Engineer

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Executive Summary

During the week of October 14, 2019, the City of Winnipeg Public Works Department observed an instability of the south slope of the Bishop Grandin Boulevard underpass on Pembina Highway. The instability 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 event with over 35 cm of snow, sleet and rain within 2 days; the instability was observed within a few days after this storm. It is likely that the accumulation of soil moisture through September combined with the October 11th storm triggered the instability.

A slope stability analysis calibrated to match observed zones of movement from monitoring instrumentation was used to develop options for remedial works. Rockfill ribs combined with a trench drain at the toe of slope form the recommended and most cost-effective alternative to address the instability. The total estimated construction cost for this alternative (excluding contingency, engineering, administration and taxes) is approximately [REDACTED]

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

1. Confirm the availability of existing CCTV sewer inspections and perform additional inspections to confirm the condition of the land drainage sewer.
2. Consult with the City of Winnipeg Water and Waste Department to determine an appropriate connection location and detail to discharge the trench drain into the land drainage sewer, and confirm that the proximity of the works to the existing LDS is acceptable.
3. Confirm construction schedule and requirements for traffic management in consultation with Traffic Services. Construction of rockfill ribs in the summer would be favorable, when the ground is unfrozen and the effects of snow melt on surface and groundwater conditions has subsided, and when potential impacts to traffic will not be exacerbated by icy road conditions.
4. Confirm anticipated construction access and traffic control requirements. We anticipate the park area upslope of the failure (within the SB-EB loop) will be used for staging and laydown of equipment and materials. Otherwise, all work is expected to be completed working from the toe of slope off the roadway without major access ramps.

1.0 Introduction

This report summarizes the results of the geotechnical investigation and provides geotechnical recommendations for the design of slope stabilization works to address instabilities that occurred on the southwest corner of the interchange at Pembina Highway and Bishop Grandin Boulevard. The terms of reference of the work are included in our proposal to Mr. Cameron Ward, P.Eng. of the City of Winnipeg (COW) dated October 25, 2019. The scope of work includes a visual assessment of the existing site conditions, subsurface investigations, monitoring, and the preliminary design of slope stabilization works and associated Class 3 construction cost estimate.

2.0 Background

During the week of October 14, 2019, the City of Winnipeg Public Works Department observed a slope instability on the south slope of the Bishop Grandin Boulevard underpass of Pembina Highway, just west of the Pembina Highway bridge and just east of the SB-EB ramp onto Bishop Grandin. Photo 1 shows the instability head scarp. The site location and plan view extents of the instability are shown in Figure 01. An assessment of the existing slope instability is required, in order to identify suitable stabilization options and develop a preliminary design for stabilization works at the site.

Photo 1 (2019-10-21) Looking East at Head Scarp (Pembina Highway bridge in background)

The instability 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; the instability was observed within a few days after the storm. 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 the slopes of the grade separation as follows. In 2005, two shallow, saturation-induced instabilities were repaired near the CN Letellier bridge over Bishop Grandin. The "SE Quadrant" instability was located on the south slope and approximately 50 to 100 m east of the Letellier bridge, along the EB to SB/NB ramp off Bishop Grandin. The "NW Quadrant" instability was located on the north slope approximately 15 to 70 m west of the Letellier Bridge. The repair involved fully excavating the slide mass, placement and compaction of Class C granular backfill to restore the slope, and the installation of a trench drain near the slope crest. All previous instabilities are believed to have been triggered by high degree of saturation of the slope as a result from high precipitation events and groundwater seepage. Record drawings for the stabilization works are included in Appendix A.

3.0 Field Program

3.1 Site Conditions

A site reconnaissance was completed by Brodie Blight, EI of TREK on October 21, 2019. The ground surface is grass covered and slopes from the crest (Elev. 233.3 m ±) to the south curb of Bishop Grandin (Elev. 227.1 m ±) at approximately 4H:1V (Horizontal to Vertical). At the time of the site visit, a 0.8 m high head scarp and various tension cracks were observed that run approximately 22 m parallel to Bishop Grandin Blvd. The head scarp (tension cracks) is located just downslope of the slope crest, while a toe bulge (upthrust zone) is present just above the slope toe, extending onto concrete paving adjacent to the roadway. The limits of the tension cracks are shown on Figure 01. Concrete (suspected to be abandoned piles) was visible at four locations within instability area. Based on the visual assessment, the slope instability does not pose an imminent risk to public or road safety. Photographs from the site reconnaissance are included in Appendix B.

3.2 Site Survey

A topographic survey was performed at the site on October 31 and November 5, 2019 by TREK. Test holes and instrumentation locations and elevations, topography and relevant site features were measured as part of the survey. Site features and contour elevations generated from the survey are shown on Figure 01 and cross-sections of the existing conditions are shown on Figure 02 and 03.

3.3 Sub-surface Investigation

A sub-surface investigation was undertaken on November 5, 2019 under the supervision of TREK personnel to determine the soil stratigraphy and groundwater conditions at the site. Test holes HA19-01 to HA19-04 were advanced using a 50 mm hand auger at the locations within the instability shown on Figure 01.

HA19-01, -02, -03 and -04 were drilled to respective depths of 3.1 m, 3.7 m, 4.5 m and 3.9 m below ground surface. A standpipe was installed in each test hole (SP-01 to -04). The standpipes consist of 25 mm diameter PVC pipes installed to the bottom of the test holes, except in HA19-01 and -02 where the standpipes were installed to approximately 0.3 m above the bottom due to squeezing of the hole.

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 C.

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 stiff and of high plasticity and the silty clay is generally firm and of high plasticity. A zone of soft silty clay of higher moisture content was encountered in all test holes; at 1.5 m below ground surface in upper slope test holes (HA19-01 and -03) and at 1.1 m below ground surface in lower slope test holes (HA19-02 and -04). The silty clay becomes firm to stiff below 2.1 m and 1.5 m depth in HA19-03 and -04 respectively.

3.3.2 Groundwater and Sloughing Conditions

Seepage and squeezing was observed in all test holes at depths ranging from 1.2 m to 2.4 m below ground surface. No sloughing was observed. Table 1 summarizes the measured water levels in the standpipes.

Table 1 - Groundwater Monitoring Results

Date (yyyy-mm-dd)	Elevation (m)			
	SP-01 (HA19-01)	SP-02 (HA19-02)	SP-03 (HA19-03)	SP-04 (HA19-04)
2019-11-05 (approximately 1 hour after installation)	229.05	225.47	228.93	227.55
2019-11-12	228.89	227.76	229.29	227.77
2019-11-19	228.80	227.80	229.20	228.05
2019-12-07	228.78	227.79	229.20	227.89
2020-02-21	228.48	227.10	228.79	227.77
2020-04-20	228.41	226.90	228.68	227.76

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

The standpipes were also used to monitor for shear movements. If differential shear movement (shear plane) develops within the depth of the standpipe, the relatively flexible PVC standpipe will deform with the surrounding soil, whereas a stiff steel pipe lowered within the standpipe will encounter resistance at the depth of movement, and or may be impassable for larger movements.

A galvanized steel pipe (3.3 m long) was lowered into each standpipe to detect zones of differential shear movements. Table 2 summarizes the depth to which the pipe was lowered in each standpipe for each monitoring event. Slight resistance was encountered in 1.5 m in SP-02 following the initial baseline reading, otherwise the steel pipe was lowered to the bottom of standpipe without resistance.

Table 2 - Slope Movement Monitoring Results

Date (yyyy-mm-dd)	Depth Lowered Below Ground (m)			
	SP-01 (HA19-01)	SP-02 (HA19-02) Note 1	SP-03 (HA19-03)	SP-04 (HA19-04)
Bottom of pipe depth	**2.8**	**3.4**	**4.5**	**3.9**
2019-11-05 (approximately 1 hour after installation)	2.8	3.4	4.5	3.9
2019-11-12	2.8	3.4 (1.5)	4.5	3.9
2019-11-19	2.8	3.4 (1.5)	4.5	3.9
2019-12-07	2.8	3.4 (1.5)	4.5	3.9
2020-02-21	1.2	3.4	0.7	1.3
2020-04-20	1.2	3.4	0.6	1.3

Note 1: Slight resistance encountered at 1.5 m below ground where noted.

3.4 Underground Utilities

Underground utilities present within the instability area include a 200 mm (8”) high-pressure gas line running in a general north-south direction near the western edge of the instability, a 600 mm diameter land drainage sewer (LDS) running parallel to Bishop Grandin Boulevard near the toe of the instability at the north edge of the site, and street-light cable running along the slope crest and parallel to the Pembina Highway bridge along the south and east edges of the site (beyond the extent of the instability), respectively. The locations and depths of the gas line and LDS were determined by hydro-excavation at five locations as shown on Figure 01.

Manitoba Hydro was consulted regarding precautions required for construction near the gas line. A letter from Manitoba Hydro with mitigative measures required during investigations and construction is attached in Appendix A.

4.0 Slope Stability Analysis

Slope stability analysis was performed to back-analyse the pre-failure slope geometry and evaluate the existing (post-failure) geometry and slope stabilization works. 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 instability initiates just downslope of the slope crest 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 and a loss of soil suction resulting from prolonged periods of high precipitation. This type of instability is often localized in extent 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 groundwater level was represented using a static piezometric line, and a zone of residual soils was included within the interpreted depth of the instability.

Cross-section 1 is located through the middle of the instability, as shown on Figure 01, and was assumed to represent a critical cross-section for analysis. The soil stratigraphy assumed in the model is based on TREK's test holes, which are shown in cross-section on Figure 01. Zones of soft clay, measured groundwater levels, and the observed zone of movement in TH19-02 are also shown in cross-section on Figure 01.

Groundwater conditions were represented in the model using a static piezometric line at a depth that approximates the groundwater level elevations observed in the standpipe piezometers. It should be noted that this groundwater level is considered representative of shallower slip surfaces (similar to the observed instability), however would be considered conservative for analysis of deep-seated (global) slip surfaces.

The material parameters assumed in the model for each soil unit are summarized in Table 3 below and represent assumed 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 soft clay, the interpreted depth of movement, and the critical slip surface geometry determined from the back-analysis case. 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. Preliminary sensitivity analyses were performed to examine the impact of deeper residual clay zones and it was determined that residual clay extending deeper would result in factors of safety less than unity and slip surfaces that do not match the geometry of the observed instability.

Table 3 - Material Parameters used in Slope Stability Analysis

Material	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (degrees)
Silty Clay	17.5	5	15
Residual Clay	17.5	2	12
Rockfill Ribs (2:1 ratio)	18.3	1.3	23

<u>Design Criteria</u>

A minimum factor of safety of 1.30 was selected for design of slope stabilization works, applied to the observed (back-analysed) slip surface, with no reduction to the stability of an overall global slip surface.

4.2 Analysis Results

The results of the analyses are summarized in Table 4 and are shown on Figures C-01 to C-10 (as referenced in Table 4) which are included in Appendix D, and are discussed in the following sections.

Table 4 - Summary of Calculated Factors of Safety

Stability Case	Slip Surface	Factor of Safety (Change from Baseline)	Figure No. (Appendix D)
Back-Analysis (Pre-Failure Geometry)	Critical + Observed Global	1.00 (baseline) 1.19 (baseline)	D-01
Back-Analysis (Existing / Post-Failure Geometry)	Critical + Observed Global	1.12 (+12%) 1.23 (+3%)	D-02
Rockfill Ribs (2:1 ratio) and Final Grade Restoration (4H:1V)	Observed Critical + Global	1.31 (+31%) 1.20 (+1%)	D-03

4.2.1 Back-Analysis

The back-analysis was performed on both an assumed pre-failure and surveyed post-failure (existing) slope geometry. The calculated factor of safety along the critical slip surface within the zone of residual clay is 1.00 (Figure D-01) for pre-failure geometry, whereas the critical factor of safety increases to 1.12 for the post-failure geometry (Figure D-02). The factor of safety along the critical global (deep-seated) slip surface ranges from 1.19 to 1.23 for pre- and post- failure back-analyses.

4.2.2 Slope Stabilization Measures

Slope stabilization alternatives considered included (in order of increasing cost) drainage improvements (e.g. French drains), rockfill shear keys and rockfill ribs. Based on preliminary analyses (not reported herein), drainage improvements and rockfill shear keys are not considered adequate. Drainage improvements alone do not provide sufficient stability improvements and may be subject to clogging and reduced performance in the long-term, whereas rockfill shear keys (located in the lower toe) will not address the potential for shorter (upper-bank) translational slip surfaces from developing in the future. As such, rockfill ribs are considered the preferred alternative for slope stabilization given that they improve stability both in the lower and mid bank areas, provide mechanical stabilization and provide drainage enhancement as a secondary benefit.

Rockfill ribs installed at a 2:1 replacement ratio in plan view (e.g. 1.5 m wide with 3.0 m clear spacing between ribs) and a base width of 8 m satisfy the design stability targets (Figure D-03). The calculated factors of safety with rockfill ribs and regrading to pre-existing grades (4H:1V) increases to 1.31 (+31%) for the observed slip surface and to 1.20 (+1%) for the critical deep-seated (global) slip surface.

4.2.3 Recommendations

Rockfill ribs satisfy the target factor of safety of 1.30 for the critical slip surface and provide a marginal benefit to global stability. The selected piezometric line is considered conservative for deep-seated slip surfaces, as noted previously. It should be noted that all of the observed instabilities at the grade separation were of similar geometry to the shallow instability observed at the current site; no deep-seated global instabilities have been observed at the grade separation. Since it is difficult to predict any reductions in groundwater levels associated with the rockfill ribs, the piezometric conditions considered with rockfill ribs were not changed from the back-analysis and the analysis is therefore considered to be conservative.

The recommended layout and geometry of the stabilization works is shown on Figure 02. A longitudinal trench drain at the toe of the slope is also recommended to collect any accumulated seepage within the ribs and discharge into the existing land drainage sewer. Due to the presence of the gas line, rockfill ribs on either side of the gas line were enlarged to maintain the overall target improvement to stability, and the trench drain will need to be hydro-excavated within 1 m of the gas line. The grading of the trench drain and subdrain pipe should be determined in detailed design once the outlet location is confirmed. Due to uncertainty in the depth of the slip surface, the base of the ribs should be confirmed by TREK during construction, and the ribs should extend a minimum of 0.5 m below the confirmed slip surface.

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

1. Confirm the availability of existing CCTV sewer inspections and consider performing additional inspections to confirm the condition of the land drainage sewer.
2. Consult with the City of Winnipeg Water and Waste Department to determine an appropriate connection location and detail to discharge the trench drain into the land drainage sewer, and to confirm the extent of the proposed stabilization works is acceptable (the rockfill ribs extend in close proximity to the existing LDS).
3. Confirm construction schedule and requirements for traffic management in consultation with Traffic Services. Construction of rockfill ribs in the summer would be favorable, when the ground is unfrozen and the effects of snow melt on surface and groundwater conditions has subsided, and when potential impacts to traffic will not be exacerbated by icy road conditions.

4. Confirm anticipated construction access and traffic control requirements. We anticipate the park area upslope of the failure (within the SB-EB loop) will be used for staging and laydown of equipment and materials. Otherwise, all work is expected to be completed working from the toe of slope off the roadway without major access ramps.

5.0 Cost Estimates

Table 5 summarizes a Class 3 cost estimate for the construction of rockfill ribs. 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. As requested by Public Works, the estimated construction costs have been added to the "Basis of Estimate Capital Cost Detail" worksheet provided by the City (Appendix E). We have reviewed the City's estimates for contingencies, engineering and traffic services, and find the estimates to be reasonable.

Table 5 - Class 3 Cost Estimate

Item	Units	Est. Qty	Unit Price	Subtotal
Mob/Demob	L.S.	1		
Site Access (incl. traffic control, remove / re-install traffic barriers)	L.S.	1		
Hydro-Excavation (for Trench Drain)	L.S.	1		
Waste Excavation (Rockfill Ribs and Trench Drain)	m^3	350		
Supply and Compact Rockfill (Rockfill Ribs)	tonne	540		
Supply and Place Free Draining Granular (Trench Drain)	tonne	30		
Supply and Place Geotextile (Trench Drain)	sq.m	150		
Supply and Place Perforated Subdrain Pipe c/w Filter Sock	L.m.	40		
Regrading to Final (incl. clay cap)	m^2	870		
Connection to LDS	L.S.	1		
Erosion Control Blanket	m^2	870		
Topsoil and Seed	m^2	870		
Class 3 Cost Estimate (excluding Contingency, Engineering and Administration Costs)				

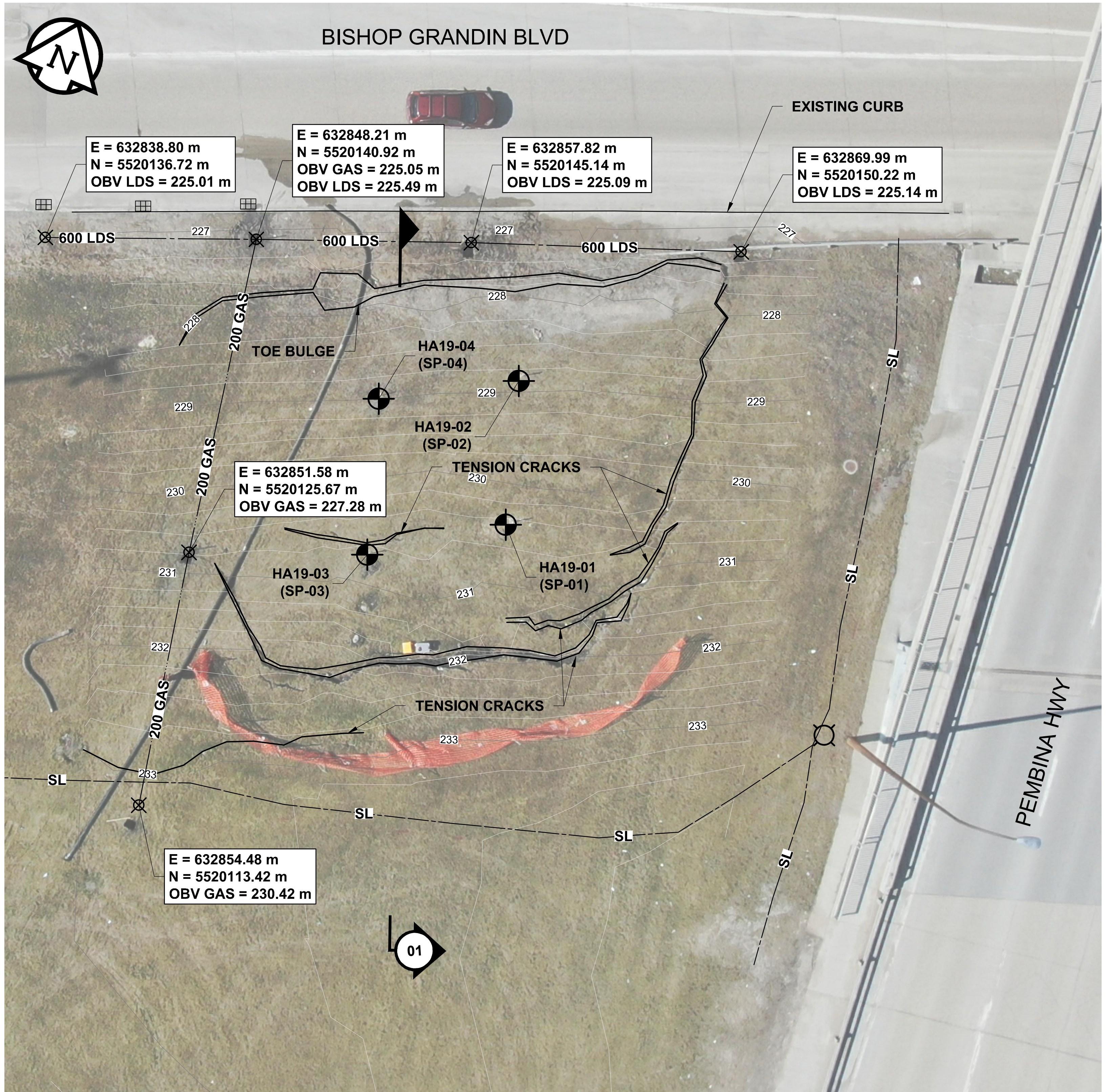
6.0 Closure

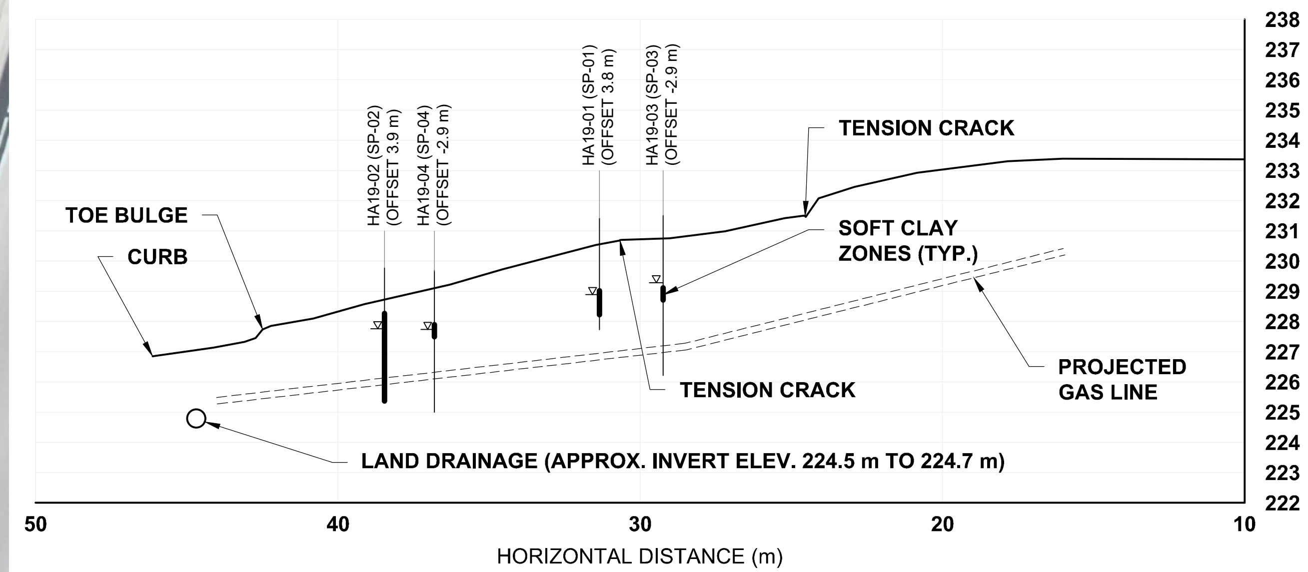
The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation and laboratory testing). Soil conditions are natural deposits that can be 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.

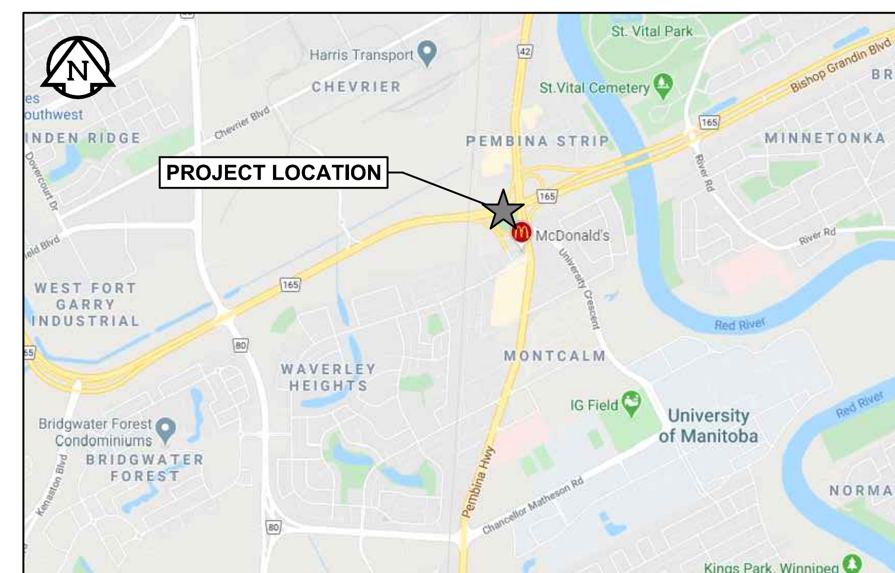
This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of the City of Winnipeg (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties,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

Figures





CROSS SECTION 01



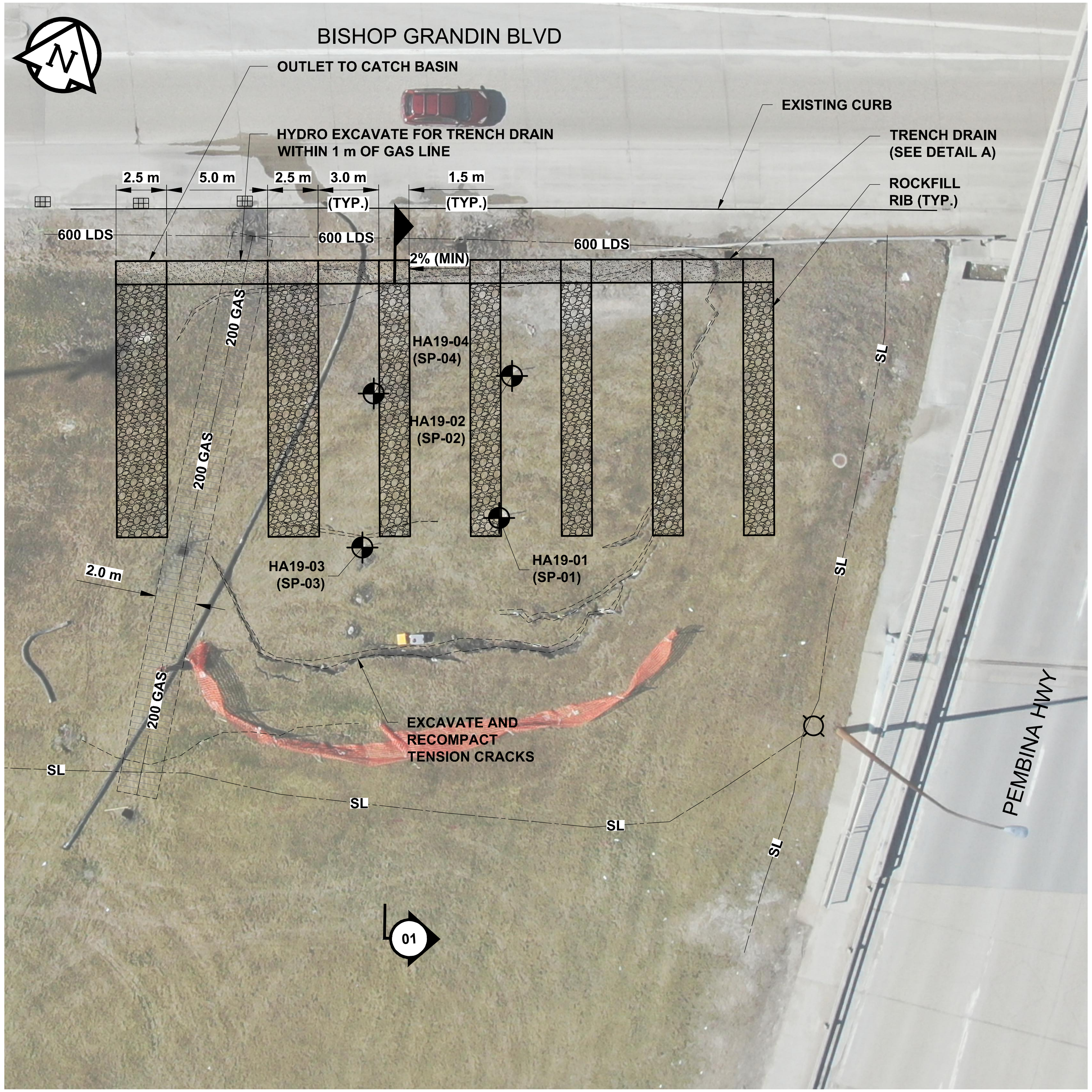
KEY PLAN
SCALE N.T.S.

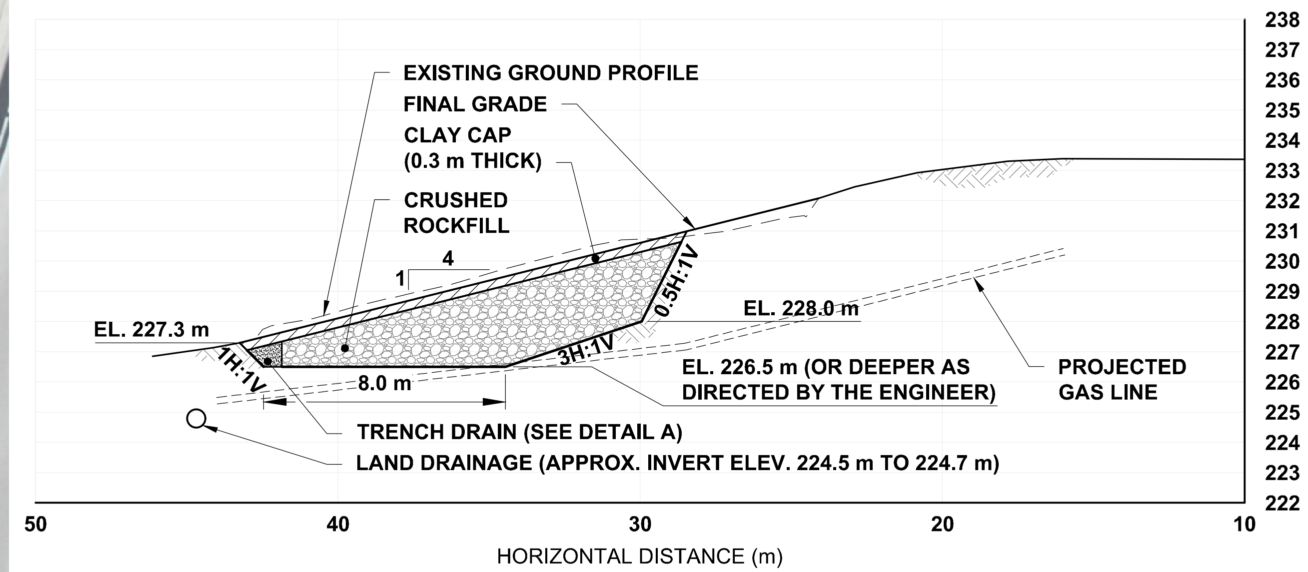
0 5 10 15 m
SCALE = 1 : 250 (279 mm x 432 mm)

LEGEND:
- TEST HOLE (TREK, NOVEMBER 5, 2019)
- LIGHT STANDARD
- CATCH BASIN
- SL — POWER LINE
- 200 GAS — GAS LINE
- 600 LDS — LAND DRAINAGE SEWER

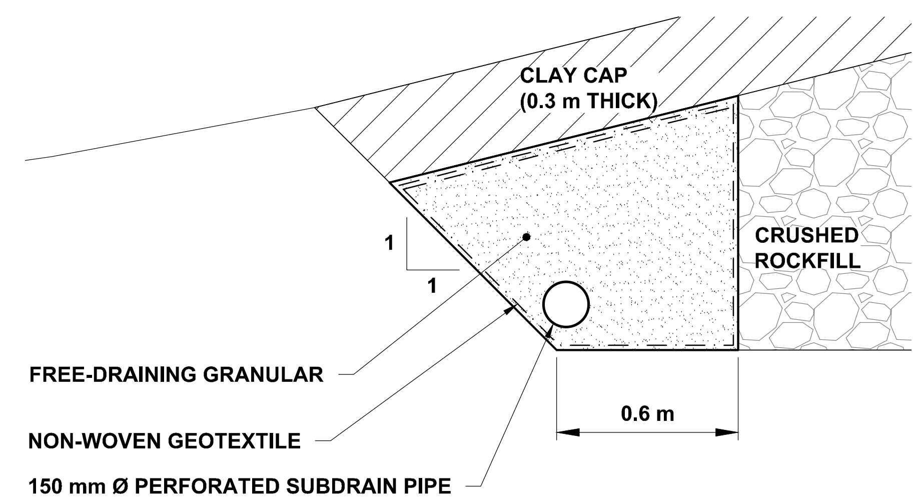
NOTES:
1. AERIAL IMAGE ON APRIL 29, 2020
2. GROUND TOPOGRAPHY SURVEYED ON OCTOBER 31, 2019

Figure 01
Existing Conditions





CROSS SECTION 01
(TYPICAL CROSS SECTION)



DETAIL A
SCALE 1:25

0 5 10 15 m
SCALE = 1 : 250 (279 mm x 432 mm)

LEGEND:
- TEST HOLE (TREK, NOVEMBER 5, 2019)
- LIGHT STANDARD
- CATCH BASIN
- SL — POWER LINE
- 200 GAS — GAS LINE
- 600 LDS — LAND DRAINAGE SEWER

NOTES:
1. AERIAL IMAGE ON APRIL 29, 2020

Figure 02
Rockfill RIbs
Plan, Typical Cross Section and Detail A

Sub-Surface Logs

TREK GEOTECHNICAL

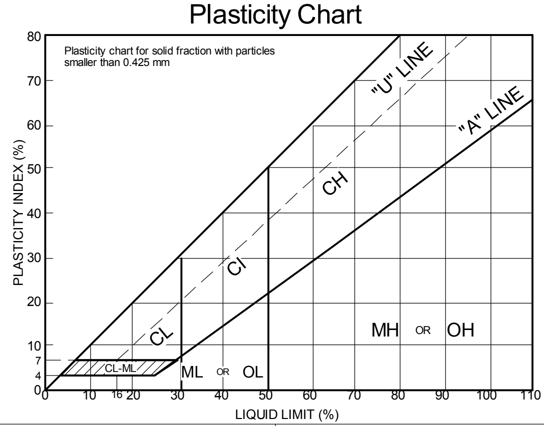
EXPLANATION OF FIELD AND LABORATORY TESTING

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 Classification	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	

Plasticity Chart



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

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

* 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

TREK GEOTECHNICAL

Sub-Surface Log

Client:	City of Winnipeg	**Project Number:**	0015 034 00
Project Name:	Slope Failure Pembina and Bishop	**Location:**	UTM 14U, 5520133.463m N, 632864.958m E
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	230.52 m
Method:	50 mm Hand Auger	**Date Drilled:**	November 5, 2019

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

Elevation (m) | Depth (m) | Soil Symbol | Standpipe | MATERIAL DESCRIPTION | Sample Type | Sample Number | Bulk Unit Wt (kN/m^3) 16 17 18 19 20 21 | Particle Size (%) 0 20 40 60 80 100 | PL MC LL 0 20 40 60 80 100 | Undrained Shear Strength (kPa) Test Type △ Torvane △ ✚ Pocket Pen. ✚ ⊠ Qu ⊠ ○ Field Vane ○ 0 50 100 150 200 250

Depth: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0
Elevation: 230.1, 227.4

CLAY (FILL) - silty, trace sand, trace gravel (<5 mm diam.), some organics and trace rootlets to 0.2 m depth, silt seam (100 mm thick) at 0.3 m depth
- dark brown, brown below 0.2 m depth, moist, stiff
- high plasticity

CLAY - silty, trace sand, trace gravel (<5 mm diam.), trace silt inclusions (<5 mm diam.), trace oxidation
- brown
- moist, firm
- high plasticity

- soft to firm below 1.5 m

- wet, soft below 2.1 m

- moist below 2.3 m

Sample Numbers: G01, G02, G03, G04, G05, G06

END OF TEST HOLE AT 3.1 m IN CLAY
Notes:
1. Seepage observed between 2.1 m and 2.3 m below ground surface.
2. Squeezing observed below 2.1 m depth.
3. Test Hole open to 2.8 m depth upon completion of drilling.
4. Standpipe SP-01 installed at 2.8 m below ground surface. Groundwater level at 1.5 m below ground surface 5.5 hours after SP-01 installed.
5. Test Hole backfilled with sand pack from 2.8 m to 0.2 m below ground surface and topped with bentonite chips.

Logged By: Beta Taryana **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

Sub-Surface Log

TREK GEOTECHNICAL

Client:	City of Winnipeg	**Project Number:**	0015 034 00
Project Name:	Slope Failure Pembina and Bishop	**Location:**	UTM 14U, 5520140.176m N, 632862.623m E
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	228.87 m
Method:	50 mm Hand Auger	**Date Drilled:**	November 5, 2019

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

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number
		CLAY (FILL) - silty, trace sand, trace gravel (<5 mm diam.), some organics and trace rootlest to 0.2 m depth - dark brown, brown below 0.2 m depth, moist, firm to stiff - high plasticity	Grab	G07
228.5	0.5	CLAY - silty, trace sand, trace gravel (<5 mm diam.), trace silt inclusions (<5 mm diam.), trace oxidation - brown - moist, firm - high plasticity	Grab	G08
	1.0	- silt laminations (2 mm thick every 3 mm), soft to firm below 0.6 m		
		- moist to wet below 1.2 m		
	1.5	- soft below 1.5 m	Grab	G09
	2.0		Grab	G10
	2.5	- moist below 2.4 m		
	3.0		Grab	G11
225.2	3.5			

Bulk Unit Wt (kN/m^3): 16 17 18 19 20 21
Particle Size (%): 0 20 40 60 80 100
PL MC LL: 0 20 40 60 80 100

Undrained Shear Strength (kPa): 0 50 100 150 200 250
Test Type: △ Torvane △; ✚ Pocket Pen. ✚; ⊠ Qu ⊠; ○ Field Vane ○

END OF TEST HOLE AT 3.7 m IN CLAY
Notes:
1. Seepage observed between 1.2 m and 2.4 m below ground surface.
2. Squeezing observed below 1.2 m depth.
3. Test Hole open to 3.4 m depth upon completion of drilling.
4. Standpipe SP-02 installed at 3.4 m below ground surface. SP-02 was dry measured 2.5 hours after SP-02 installed.
5. Test Hole backfilled with sand pack from 3.4 m to 0.2 m below ground surface and topped with bentonite chips.

Logged By: Beta Taryana **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

Sub-Surface Log

TREK GEOTECHNICAL

Client:	City of Winnipeg	**Project Number:**	0015 034 00
Project Name:	Slope Failure Pembina and Bishop	**Location:**	UTM 14U, 5520129.21m N, 632859.326m E
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	230.82 m
Method:	50 mm Hand Auger	**Date Drilled:**	November 5, 2019

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

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	MATERIAL DESCRIPTION	Sample Type	Sample Number	Bulk Unit Wt (kN/m^3) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○ — 0 50 100 150 200 250
				CLAY (FILL) - silty, trace sand, trace gravel (<5 mm diam.), some organics and trace rootlest to 0.2 m depth - dark brown, brown below 0.2 m depth, moist, stiff - high plasticity				
230.4				CLAY - silty, trace sand, trace gravel (<5 mm diam.), trace silt inclusions (<5 mm diam.), trace oxidation - brown - moist, firm - high plasticity - silt seam (75 mm thick) at 0.6 m				
	0.5							
	1.0							
	1.5			- wet, soft below 1.7 m				
	2.0			- moist, firm below 2.1 m				
	2.5			- firm to stiff below 2.6 m				
	3.0							
	3.5							
	4.0							
226.3								

END OF TEST HOLE AT 4.5 m IN CLAY
Notes:
1. Seepage and squeezing observed between 1.7 m and 2.1 m below ground surface.
2. Test Hole open to 4.5 m depth upon completion of drilling.
3. Standpipe SP-03 installed at 4.5 m below ground surface. Groundwater level at 1.9 m below ground surface 1 hour after SP-03 installed.
4. Test Hole backfilled with sand pack from 4.5 m to 0.3 m below ground surface and topped with bentonite chips.

Logged By: Beta Taryana **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Client:	City of Winnipeg	**Project Number:**	0015 034 00
Project Name:	Slope Failure Pembina and Bishop	**Location:**	UTM 14U, 5520136.331m N, 632856.781m E
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	228.99 m
Method:	50 mm Hand Auger	**Date Drilled:**	November 5, 2019

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

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	MATERIAL DESCRIPTION	Sample Type	Sample Number	Bulk Unit Wt (kN/m^3) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○ 0 50 100 150 200 250
				CLAY (FILL) - silty, trace to some sand, trace gravel (<5 mm diam.), some organics and trace rootlest to 0.2 m depth - dark brown, brown below 0.2 m depth, moist, stiff - high plasticity				
228.6	0.5			CLAY - silty, trace sand, trace gravel (<5 mm diam.), trace silt inclusions (<5 mm diam.), trace oxidation - brown - moist, firm - high plasticity				
	1.0			- soft below 1.1 m - wet below 1.2 m				
	1.5			- moist, firm to stiff below 1.5 m				
	2.0							
	2.5							
	3.0							
225.1	3.5							

END OF TEST HOLE AT 3.9 m IN CLAY

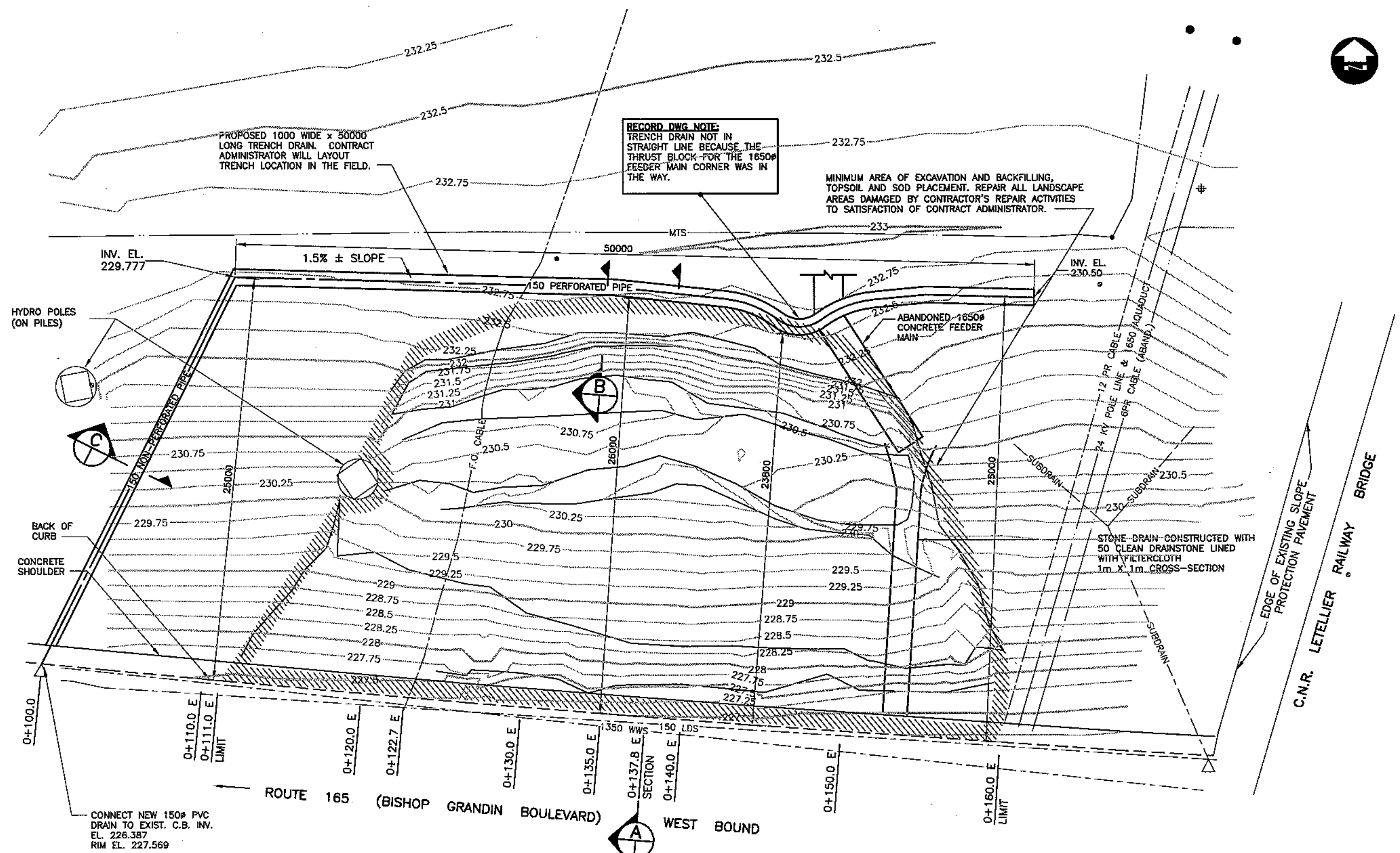
Notes:
1. Seepage and squeezing observed between 1.2 m and 1.5 m below ground surface.
2. Test Hole open to 3.9 m depth upon completion of drilling.
3. Standpipe SP-04 installed at 3.9 m below ground surface. Groundwater level at 1.5 m below ground surface 30 minutes after SP-04 installed.

Logged By: Beta Taryana **Reviewed By:** Ken Skaftfeld **Project Engineer:** Michael Van Helden

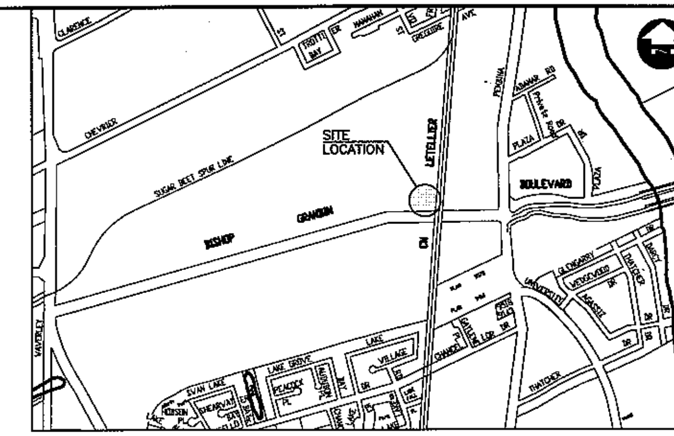
Appendix A

Existing Information

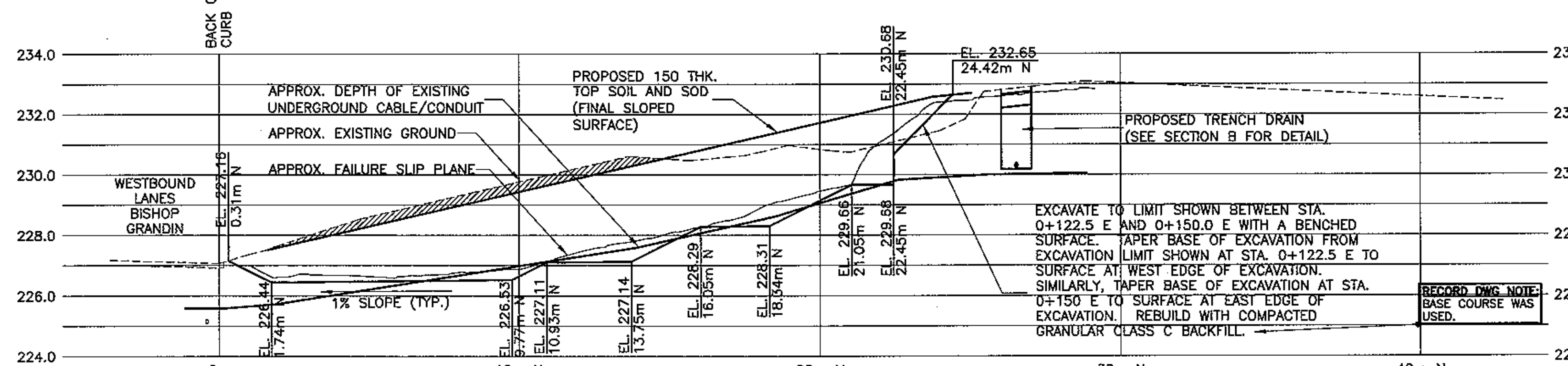
WO 101-84



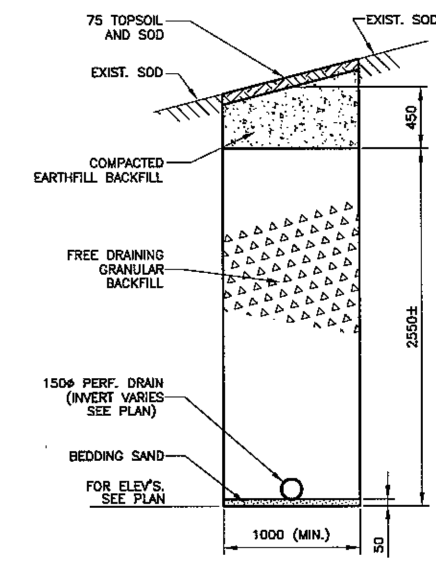
PLAN
1: 150



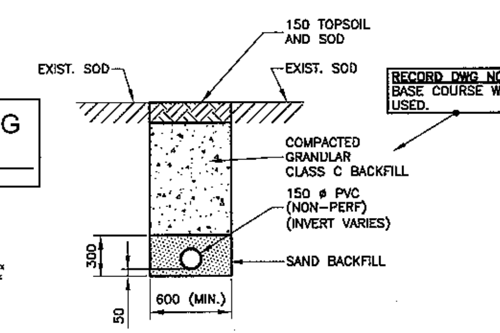
LOCATION PLAN



SECTION AT STA. 0+137.8 E (A)
1: 100



SECTION (B)
1: 25



SECTION (C)
1: 25

PROPOSED TRENCH
AS SHOWN

RECORD DRAWING
ORIGINAL SIGNED BY: M.R. DOUCET 02/14/06
APPROVED BY: DATE:

BENCH MARK
84R629 — C.N.R. LETELLIER SUBD. & CHANCELLOR DR., TBLT. ON TOP OF 0.05m DIA. x 2.4m IRON PIPE, ON S.L. OF CHANCELLOR DR. & 22.5m W. OF C.L. OF RAILWAY TRACK ON C.N.R. LETELLIER SUBD., OR 45m W. OF W.L. C.N.R. LETELLIER SUBD. & ON S.L. OF CHANCELLOR DR.

PROVINCE OF MANITOBA — ORIGINAL STAMPED BY A.D. GOULD SEPTEMBER 2005 — REGISTERED PROFESSIONAL ENGINEER

WARNING

CONTRACTOR TO OBTAIN UTILITY CLEARANCES PRIOR TO COMMENCING EXCAVATION.

UNDERGROUND INFORMATION SHOWN ON THIS DRAWING IS BASED ON INFORMATION RECEIVED FROM THE CITY OF WINNIPEG UNDERGROUND STRUCTURES AND MAY NOT BE ENTIRELY ACCURATE OR COMPLETE.

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

APEGM
Certificate of Authorization
Dillon Consulting Limited
No. 1789 Expiry: April 30, 2006

B.M. 78-047
ELEV. 232.905m

NO.	REVISIONS	DATE	BY
3	RECORD DRAWING	02/10/06	M.R.D.
2	ISSUED FOR CITY TENDER	08/31/05	R.A.W.
1	ISSUED FOR CITY REVIEW	05/08/05	R.A.W.

DESIGNED BY: A.D.G./R.A.W.
DRAWN BY: A.J.P./S.K.B.
CHECKED BY: R.A.W.
APPROVED BY:
SCALE: HORZ. AS SHOWN VERT.
DATE: 08/31/05
AUTHORIZED BY: DATE:
ORIGINAL SIGNED BY B.A. NEIRINCK 02/13/06
CITY BRIDGE ENGINEER

DILLON CONSULTING

ENGINEER'S SEAL: PROVINCE OF MANITOBA — ORIGINAL STAMPED BY R.A. WIEBE AUGUST 2005 — REGISTERED PROFESSIONAL ENGINEER

CONSULTANT PROJECT NO. 05-4421-1001

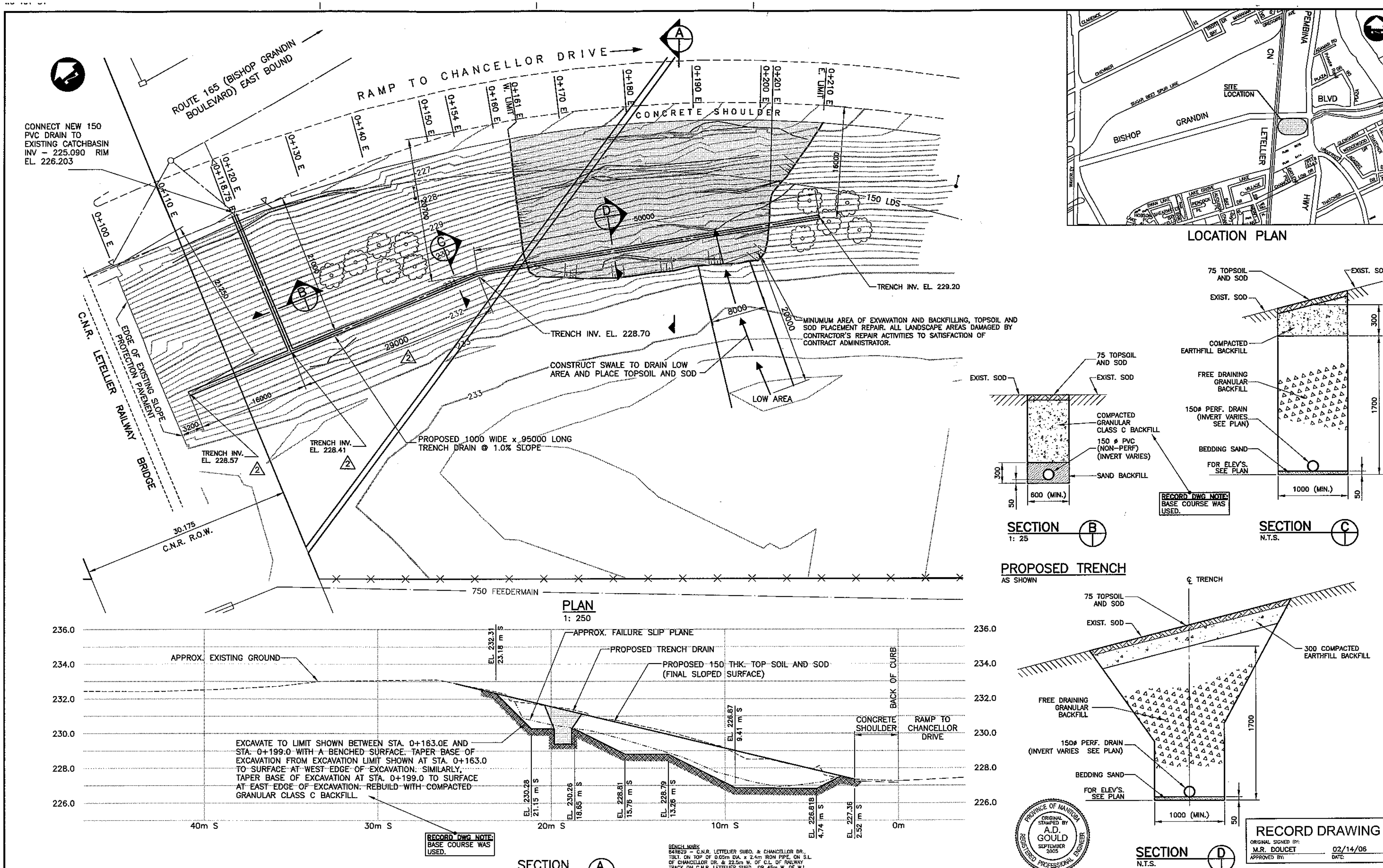
THE CITY OF WINNIPEG
PUBLIC WORKS DEPARTMENT
Winnipeg

2005 BRIDGE MAINTENANCE
ROUTE 165 UNDERPASS UNDER CNR LETELLIER SUBDIVISION-N.W. QUADRANT
SLOPE FAILURE REPAIR

PLAN, SECTIONS AND DETAILS

CITY DRAWING NUMBER U230-05-01-AC
SHEET 1 OF 2

4DDILLON ACAD FILE: G:\CAD\034421\SLOPE FAILURE\RECORD DWGS\NORTH\CN_BISHOP_GRANDIN.DWG 10/07/05



BENCH MARK
84R629 – C.N.R. LETTELIER SUBD. & CHANCELLOR DR., TBLT. ON TOP OF 0.05m DIA. x 2.4m IRON PIPE, ON S.L. OF CHANCELLOR DR. & 22.5m W. OF C.L. OF RAILWAY TRACK ON C.N.R. LETTELIER SUBD., OR 45m W. OF W.L. C.N.R. LETTELIER SUBD. & ON S.L. OF CHANCELLOR DR.

PROVINCE OF MANITOBA ORIGINAL STAMPED BY A.D. GOULD SEPTEMBER 2005 REGISTERED PROFESSIONAL ENGINEER

RECORD DRAWING
ORIGINAL SIGNED BY: M.R. DOUCET 02/14/06
APPROVED BY: DATE:

WARNING

CONTRACTOR TO OBTAIN UTILITY CLEARANCES PRIOR TO COMMENCING EXCAVATION.

UNDERGROUND INFORMATION SHOWN ON THIS DRAWING IS BASED ON INFORMATION RECEIVED FROM THE CITY OF WINNIPEG UNDERGROUND STRUCTURES AND MAY NOT BE ENTIRELY ACCURATE OR COMPLETE.

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

APEGM
Certificate of Authorization
Dillon Consulting Limited
No. 1789 Expiry: April 30, 2006

B.M. 76-047
ELEV. 232.905m

NO.	REVISIONS	DATE	BY
3	RECORD DRAWING	02/10/06	M.R.D.
2	RELOCATED LATERAL DRAIN	10/20/05	R.A.W.
1	ISSUED FOR TENDER	08/31/05	R.A.W.

DESIGNED BY: A.D.G./R.A.W.
DRAWN BY: A.J.P./S.K.B.
CHECKED BY: R.A.W.
APPROVED BY:
SCALE: HORZ. VERT. AS SHOWN
DATE: 08/31/05
AUTHORIZED BY: ORIGINAL SIGNED BY B.A. NEIRINCK DATE: 02/13/06
CITY BRIDGE ENGINEER

DILLON CONSULTING

ENGINEER'S SEAL
PROVINCE OF MANITOBA ORIGINAL STAMPED BY R.A. WIEBE AUGUST 2005 REGISTERED PROFESSIONAL ENGINEER

CONSULTANT PROJECT NO. 05-4421-1001

THE CITY OF WINNIPEG
PUBLIC WORKS DEPARTMENT

2005 BRIDGE MAINTENANCE
ROUTE 165 UNDERPASS UNDER
CNR LETELLIER SUBDIVISION–S.E. QUADRANT
SLOPE FAILURE REPAIR

PLAN, SECTIONS AND DETAILS

CITY DRAWING NUMBER U230-05-02-AC
SHEET 2 OF 2

DILLON ACAD FILE: S:\CAD\054421\SLOPE FAILURE\RECORD DWGS\CN_BISHOP_GRANDIN.DWG 11/22/05

360 Portage Ave (18) ♦ Winnipeg, Manitoba Canada • R3C 0G8
P: (204) 360-4170 C: (204) 479-2850
E: agreaves@hydro.mb.ca

3/20/2020

MH Gas File # 2020-0062

Michael Van Helden
TREK Geotechnical Inc.
1712 St. James Street
Winnipeg, Manitoba R3H 0L3

Dear Michael Van Helden:

Re: Slope Failure Pembina and Bishop - Gas line location

Manitoba Hydro (Gas) has reviewed the request submitted by TREK Geotechnical for information on the 219.1 mm steel gas main impacted by the slope failure at the Bishop Grandin and Pembina interchange (south slope, west of the bridge). The following parameters shall be adhered to for investigative digs around this natural gas main. **Please note that this letter is to provide information on investigative digs only and does not consider the slope failure remediation, which should be resubmitted to gasdesign@hydro.mb.ca once finalized.** Please ensure that all requirements are communicated to your contractor.

1. **Natural Gas Record Drawings**
   - Unfortunately, there is no alignment distances for this gas main available in Manitoba Hydro's eGIS system so it is difficult to determine the accuracy of both TREK's and the City of Winnipeg's survey of the main. Soft digging will need to be conducted to confirm location, as per the requirements listed below. An as-built of the gas main is attached, however.
   - CAUTION: Large diameter gas main present.
   - Yellow lines represent energized gas mains.
   - Purple dashed lines represent abandoned gas mains.

2. **Special Concerns**

   Upon review, it was noted that proposed investigative digs for slope stabilization works at Bishop Grandin and Pembina Hwy impact a large diameter distribution pressure 219.1 mm steel gas main. A Manitoba Hydro High Pressure Safety Watch may be required for all construction activities within 1.0 m of this gas main. All excavations within 1.0 m of any natural gas main must be completed by hand or Hydro-excavation. During construction, gas mains should not be undermined or exposed past the 3 o'clock and 9 o'clock positions on the cross section of the pipe.

Please locate any mains within 1.0 m or underneath the proposed construction, and investigate by hand or soft-digging to determine depth of cover and location in relation to both existing and proposed grades. Note that all locating and soft-digging requirements listed below are to be upheld.

For consideration in future remediation work at this location, if it is determined that a final minimum depth of cover of 900 mm for the 219.1 mm steel distribution main cannot be maintained, then relocations or lowerings may be required. Contact Andrew Greaves at agreaves@hydro.mb.ca or (204) 360-4170 to discuss options pertaining to lowerings or relocations. Additionally, a minimum separation of 300 mm from gas mains must be maintained for any new underground structure installations. If an underground structure must be installed with less than the minimum separation, an underground rigid foam barrier shall be placed over the main for protection. Submit plans for barrier installation to GasDesign@hydro.mb.ca if this is required.

3. **219.1 mm Distribution Pressure Natural Gas Main**
   - Proposed slope failure remediation occurs over an existing steel 219.1 mm distribution pressure natural gas main. A Manitoba Hydro Safety Watch may be required if any excavations are within 1.0 m of the 219.1 mm natural gas main.
   - Contact "Click before you dig" a minimum of 2 weeks prior to any work commencing within 1.0 m of the 219.1 mm distribution pressure natural gas main to arrange for the pipeline to be properly located and marked by Manitoba Hydro personnel at **ClickBeforeYouDigMB.com or Call 1-800-940-3447**. Upon receiving clearances, the excavator will be provided with the phone number of the appropriate District in order to coordinate a Manitoba Hydro Safety Watch, if required.
   - A minimum 900 mm of cover shall be maintained in all areas where highway rated equipment will be crossing, traveling or compacting over the 219.1 mm gas main. Vibratory compaction cannot be used over or within 1.0 m of a main.
   - If highway rated equipment must cross, travel, or compact over the gas main with less than the minimum depth of cover, earth bridging or steel plates shall be placed over the main and extend a minimum of 1.0 m on either side at each crossing location. If equipment heavier than highway rated load cross the main, then submit construction plans to GasDesign@hydro.mb.ca.
   - When working with less than minimum cover, a minimum 300 mm of granular material shall be bladed into place with tracked equipment offset from the pipeline. Then static compaction equipment would be allowed and built up in layers until minimum cover is achieved.
   - Once the pipeline depth and location has been confirmed by hand or hydro-excavation, the safety watcher may authorize the limited use of mechanical excavation. A smooth edged bucket must be used for excavations within 1.0 m of the main.
   - Subbase material shall be bladed into place as opposed to being end dumped over the 219.1 mm gas main in areas with less than the minimum cover.
   - Caution must be used to ensure the integrity of the pipeline coating. Any damages to the coating must be reported to and repaired at no cost by Manitoba Hydro prior to backfilling.

4. **Insufficient Cover**
   - Absolutely no work including concrete cutting or pavement breaking may occur over the pipeline (regardless of size) until depth of cover is determined and a safety watch is on site.

5. **Rockfill Rib Installation for Slope Stabilization**
   - Proposed excavations for slope stabilization installations appear to be within 1.0 m of a gas main in which case will require exposure to be completed by hand or Hydro-excavation. Caution must be used when working in the vicinity of the natural gas mains at these locations.
   - A minimum separation of 300 mm from gas mains must be maintained for any new underground structure installations. If an underground structure must be installed with less than the minimum separation, an underground rigid foam barrier shall be placed over the main for protection. Submit plans for barrier installation to GasDesign@hydro.mb.ca.

6. **General:**
   - Please note that the requirements of Manitoba Hydro's Safe Excavation and Safety Watch guidelines shall apply. All natural gas pipelines and service lines must be properly located and marked by Manitoba Hydro personnel. This can be arranged by visiting **ClickBeforeYouDigMB.com or call 1-800-940-3447.** Construction operations are not to commence unless these conditions are adhered to.
   - All excavations within 1.0 m of any natural gas main must be completed by hand or Hydro-excavation.
   - All construction operations within the vicinity of natural gas pipelines are to take place in a manner so as not to damage or cause detriment to the integrity of the natural gas pipeline. Any damages to the coating must be reported to and repaired at no cost by Manitoba Hydro prior to backfilling.

Manitoba Hydro believes that there should be no problem with this work however; Manitoba Hydro makes no representations or warranties in that regard.

Please note that all construction drawings requiring review or approval must be mailed to Gas Design, 360 Portage Ave (18) Winnipeg, Manitoba, R3C 0G8. If you wish to send construction drawings electronically, they may be sent to GasDesign@hydro.mb.ca.

If you have any questions or comments, please contact the undersigned.

Regards,

Andrew Greaves, P.Eng.
Gas Design Engineer – City of Winnipeg
Manitoba Hydro - Gas Design
360 Portage Ave (18), Wpg. MB., R3C 0G8
P: (204) 360-4170 C: (204) 479-2850
Email: agreaves@hydro.mb.ca

AG/DF

Cc: Larry Tole, Gas Distribution MTCE – Sutherland Ave, Manitoba Hydro
Robert Morrison, Damage Prevention – Sutherland Ave, Manitoba Hydro
Aaron Dueck, District Service Worker – Henlow Bay, Manitoba Hydro
Brian Jensen, Gas Distribution MTCE – Sutherland Ave, Manitoba Hydro
Aldo Garofalo, Gas Distribution MTCE – Sutherland Ave, Manitoba Hydro

Appendix B

Site Photographs

IMG_6923

IMG_6924

IMG_6925

IMG_6926

IMG_6927

IMG_6928

IMG_6929

IMG_7244

IMG_7245

IMG_7246

IMG_7247

IMG_7248

IMG_7249

IMG_7250

IMG_7251

IMG_7252

IMG_7253

IMG_8808

IMG_8810

IMG_8811

IMG_8817

IMG_8818

IMG_8819

IMG_8820

IMG_8821

IMG_8822

IMG_8823

IMG_8824

IMG_8825

Photo 1. Looking west, hydro-excavation preparation

Photo 2. Looking west, hydro-excavation at the toe

Photo 3. Land drainage sewer (LDS), obvert at 2.0 m below surface

Photo 4. Looking west, hydro-excavation at the toe, east of instability area

Photo 5. Looking east, hydro-excavation at the cress

Photo 6. High pressure gas line at the cress, obvert at 2.7 m below surface

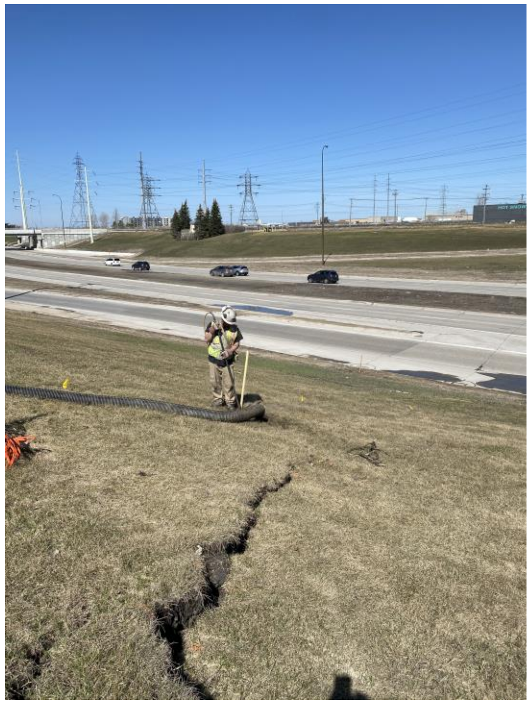


Photo 7. Looking west, hydro-excavation at mid bank

Photo 8. Aerial photograph of site condition during hydro-excavation work

Appendix C

Laboratory Testing Results

MEMORANDUM

Date	November 19, 2019
To	Beta Taryana, TREK Geotechnical
From	Angela Fidler-Kliewer, TREK Geotechnical
Project No.	0015-034-00
Project	Slope Failure Pembina and Bishop
Subject	Laboratory Testing Results – Lab Req. R19-254
Distribution	Michael Van Helden

Attached are the laboratory testing results for the above noted project. This report includes moisture content determinations and Atterberg limits.

Regards,

Angela Fidler-Kliewer, C.Tech.

Attach.

Review Control:

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

Lab Requisition

TREK GEOTECHNICAL
1712 St. James Street
Winnipeg, Manitoba R3H 0L3
T 204.975.9433 F 204.975.9435

PROJECT: Slope Failure Pembina and Bishop PROJECT NO: 0015 034 00

CLIENT: City of Winnipeg FIELD TECHNICIAN: Beta Taryana

TEST HOLE NUMBER	SAMPLE NUMBER	Sample Start Depth (ft)	Sample End Depth (ft)		MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS				Soil Description/ Comments
HA19-01	G01	0.0	0.5		X										CLAY (FILL)
HA19-01	G02	0.5	1.0		X										CLAY
HA19-01	G03	1.0	1.3		X										SILT SEAM
HA19-01	G04	2.0	3.0		X		X								CLAY
HA19-01	G05	5.0	6.0		X										CLAY
HA19-01	G06	7.0	8.0		X										CLAY
HA19-02	G07	0.0	0.5		X										CLAY (FILL)
HA19-02	G08	2.0	3.0		X		X								CLAY
HA19-02	G09	5.0	6.0		X										CLAY
HA19-02	G10	7.0	8.0		X										CLAY
HA19-02	G11	10.0	11.0		X										CLAY

REQUESTED BY: Beta Taryana REPORT TO: Michael Van Helden

REQUISTION DATE: Nov 13, 2019 DATE REQUIRED: Nov 20, 2019

COMMENTS:

REQUISITION NO. R19-254

SHEET 1 OF 1

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. 0015-034-00
Client City of Winnipeg
Project Slope Failure Pembina and Bishop

Sample Date 05-Nov-19
Test Date 13-Nov-19
Technician SB

Test Hole	HA19-01	HA19-01	HA19-01	HA19-01	HA19-01	HA19-01
Depth (m)	0.0 - 0.2	0.2 - 0.3	0.3 - 0.4	0.6 - 0.9	1.5 - 1.8	2.1 - 2.4
Sample #	G01	G02	G03	G04	G05	G06
Tare ID	P11	N03	A51	E136	E92	A36
Mass of tare	8.4	8.5	8.7	8.3	8.6	8.3
Mass wet + tare	183.1	147.2	149.4	376.3	155.7	156.4
Mass dry + tare	139.9	106.7	112.3	254.7	99.8	97.1
Mass water	43.2	40.5	37.1	121.6	55.9	59.3
Mass dry soil	131.5	98.2	103.6	246.4	91.2	88.8
Moisture %	32.9%	41.2%	35.8%	49.4%	61.3%	66.8%

Test Hole	HA19-02	HA19-02	HA19-02	HA19-02	HA19-02	
Depth (m)	0.0 - 0.2	0.6 - 0.9	1.5 - 1.8	2.1 - 2.4	3.0 - 3.4	
Sample #	G07	G08	G09	G10	G11	
Tare ID	D45	Z25	N12	Z18	H67	
Mass of tare	8.6	8.4	8.9	8.9	8.5	
Mass wet + tare	170.8	363.0	176.7	164.3	155.9	
Mass dry + tare	130.0	242.6	114.1	106.6	106.7	
Mass water	40.8	120.4	62.6	57.7	49.2	
Mass dry soil	121.4	234.2	105.2	97.7	98.2	
Moisture %	33.6%	51.4%	59.5%	59.1%	50.1%	

TREK GEOTECHNICAL
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Atterberg Limits
ASTM D4318-10e1

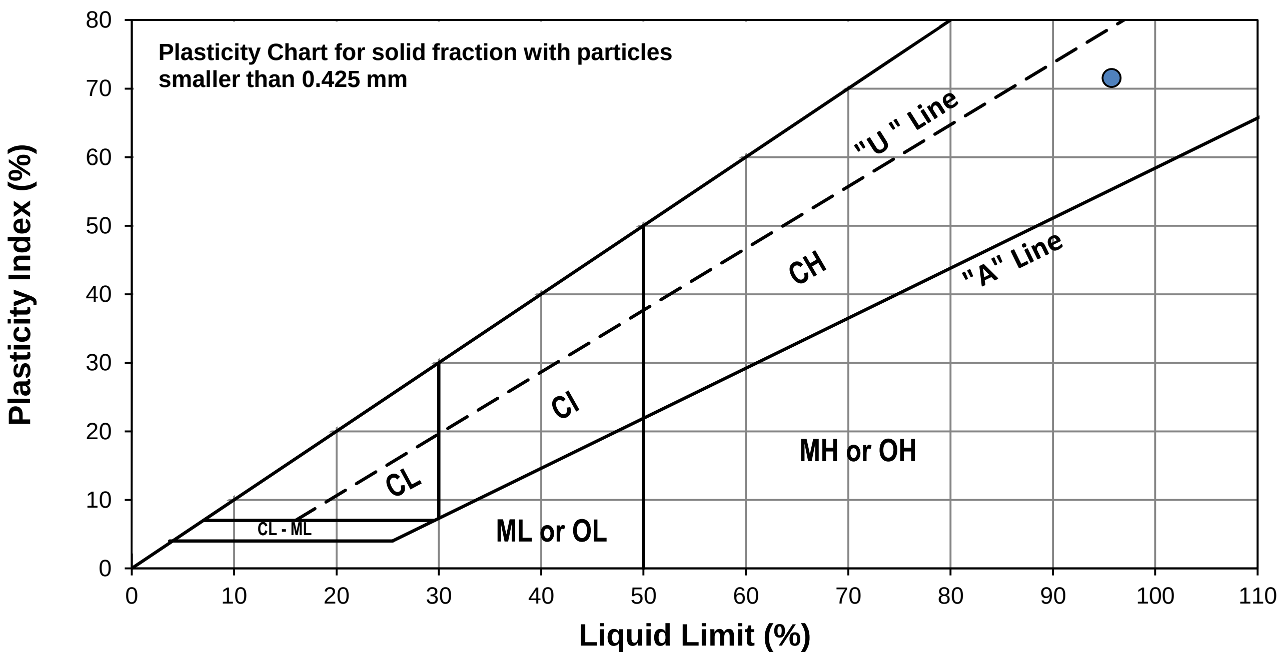
CERTIFIED BY CCIL Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

Project No.	0015-034-00
Client	City of Winnipeg
Project	Slope Failure Pembina and Bishop
Test Hole	HA19-01
Sample #	G04
Depth (m)	0.6 - 0.9
Sample Date	05-Nov-19
Test Date	18-Nov-19
Technician	SB

Liquid Limit	96
Plastic Limit	24
Plasticity Index	72

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	22	27	33		
Mass Wet Soil + Tare (g)	20.677	20.477	21.378		
Mass Dry Soil + Tare (g)	17.371	17.427	17.890		
Mass Tare (g)	13.972	14.210	14.119		
Mass Water (g)	3.306	3.050	3.488		
Mass Dry Soil (g)	3.399	3.217	3.771		
Moisture Content (%)	97.264	94.809	92.495		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.096	14.172			
Mass Wet Soil + Tare (g)	20.658	21.470			
Mass Dry Soil + Tare (g)	19.370	20.056			
Mass Water (g)	1.288	1.414			
Mass Dry Soil (g)	5.274	5.884			
Moisture Content (%)	24.422	24.031			

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Atterberg Limits
ASTM D4318-10e1

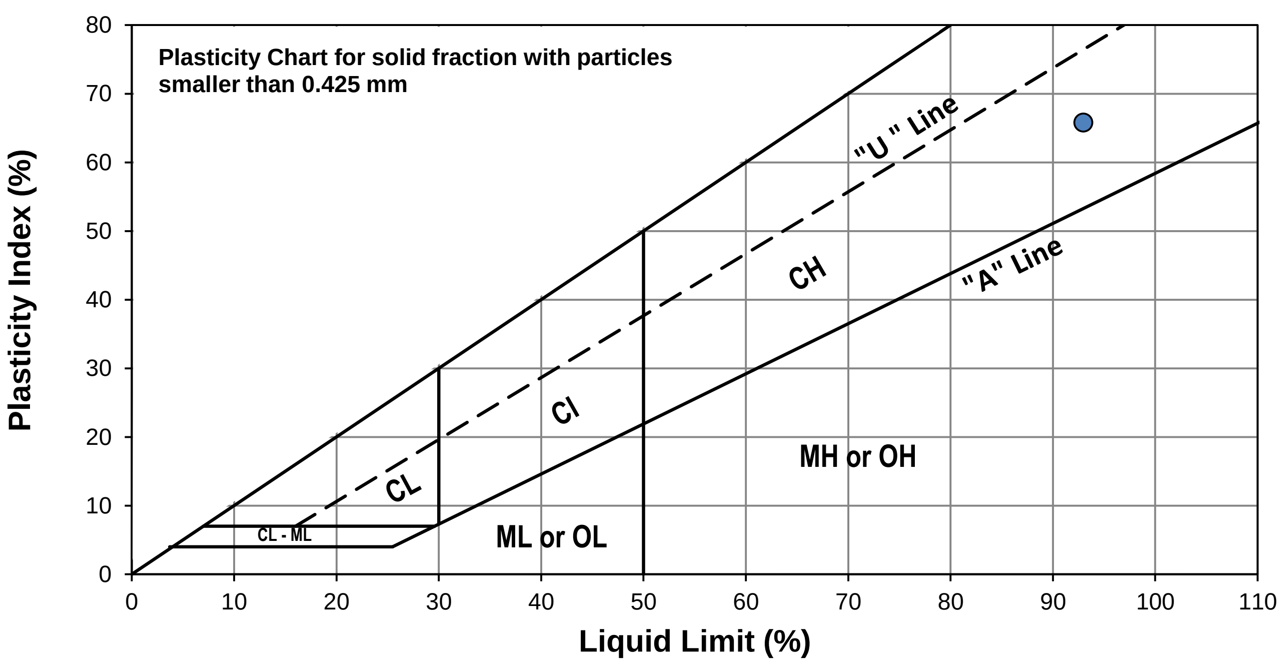
CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

Project No.	0015-034-00
Client	City of Winnipeg
Project	Slope Failure Pembina and Bishop
Test Hole	HA19-02
Sample #	G08
Depth (m)	0.6 - 0.9
Sample Date	05-Nov-19
Test Date	15-Nov-19
Technician	SB

Liquid Limit	93
Plastic Limit	27
Plasticity Index	66

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	19	28	35		
Mass Wet Soil + Tare (g)	21.538	20.423	21.956		
Mass Dry Soil + Tare (g)	17.930	17.391	18.158		
Mass Tare (g)	14.157	14.093	13.923		
Mass Water (g)	3.608	3.032	3.798		
Mass Dry Soil (g)	3.773	3.298	4.235		
Moisture Content (%)	95.627	91.935	89.681		

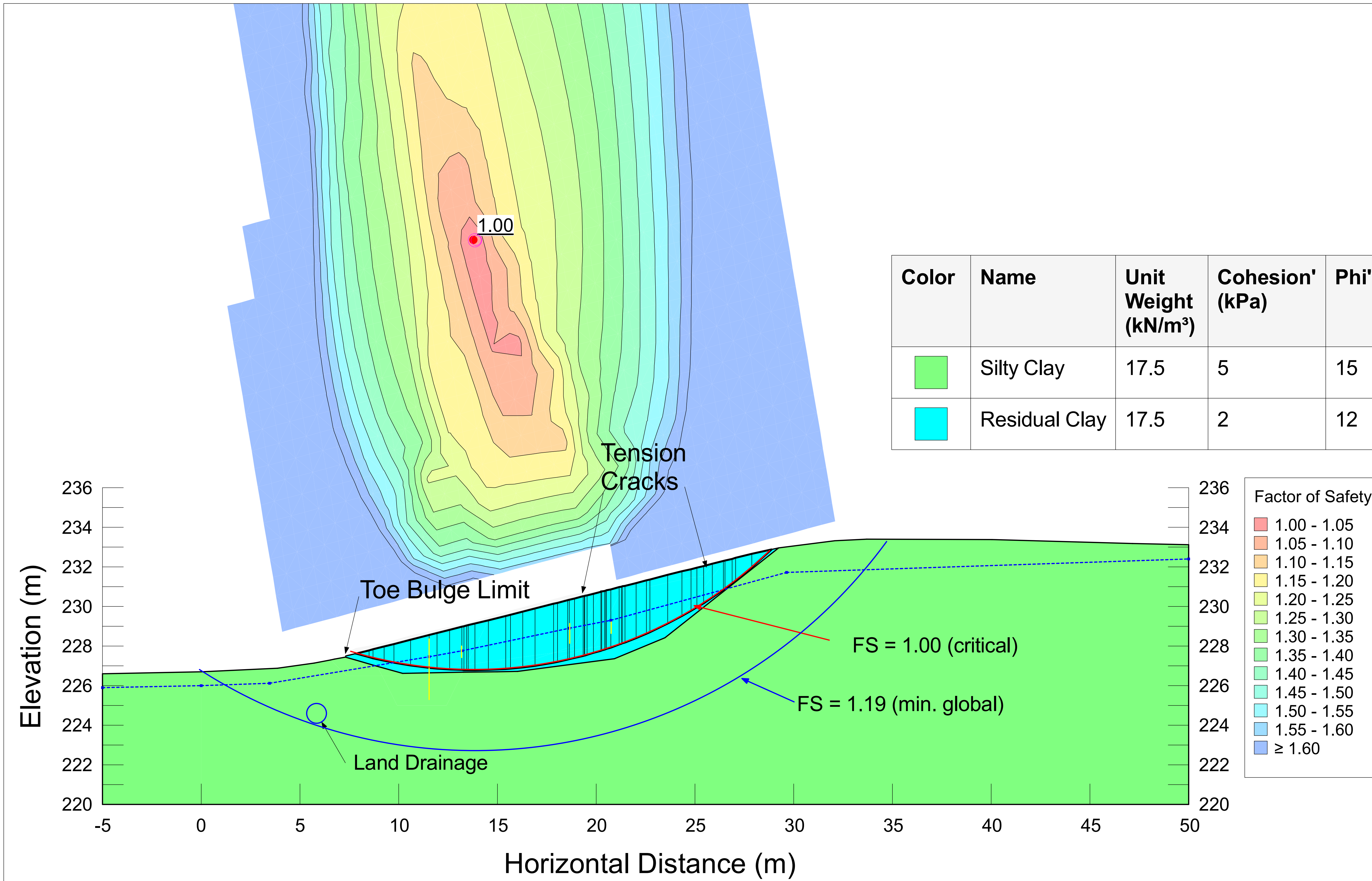


Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.283	13.875			
Mass Wet Soil + Tare (g)	22.830	19.989			
Mass Dry Soil + Tare (g)	21.006	18.680			
Mass Water (g)	1.824	1.309			
Mass Dry Soil (g)	6.723	4.805			
Moisture Content (%)	27.131	27.242			

Appendix D

Slope Stability Analysis Results

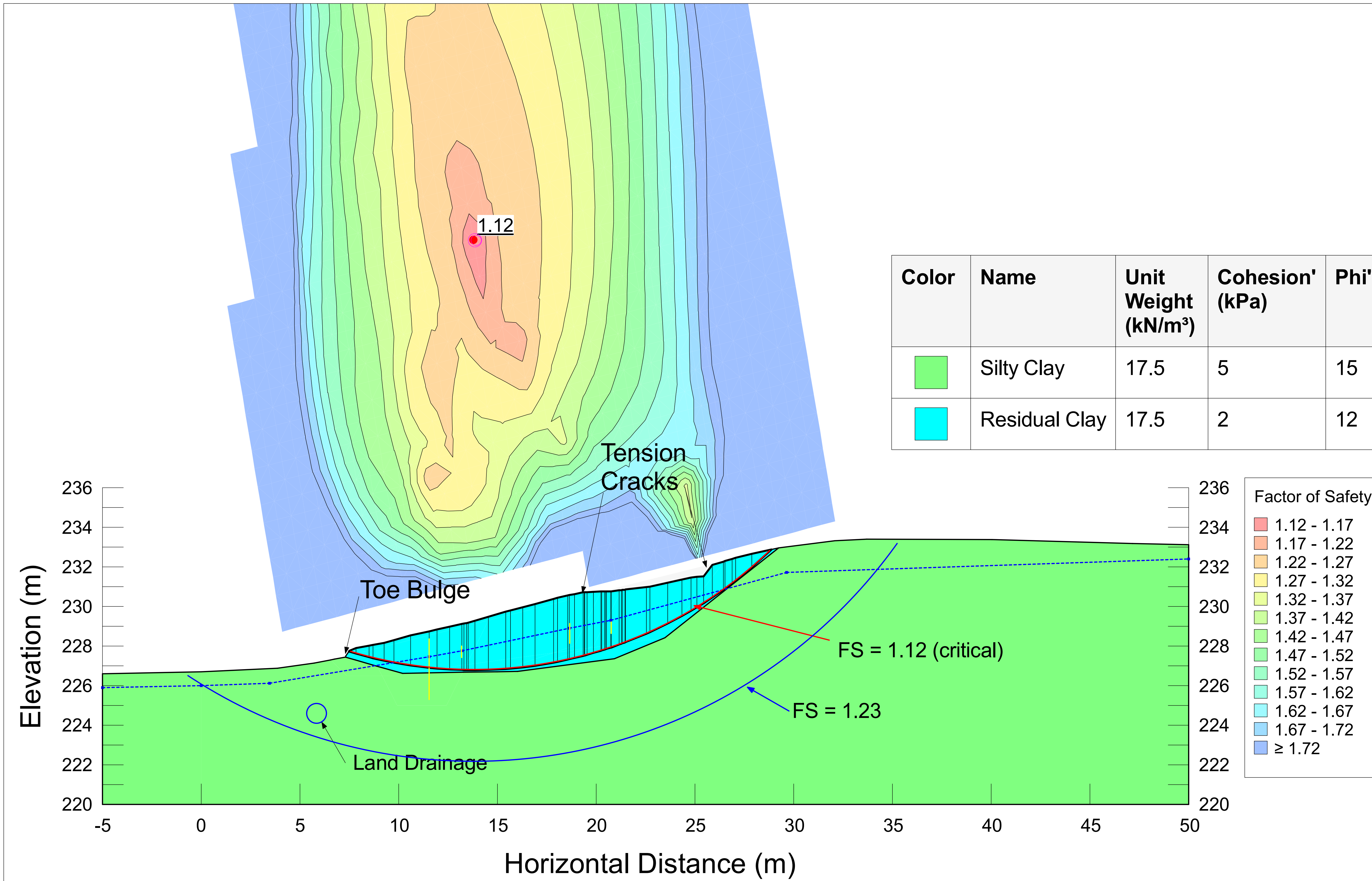


Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Silty Clay	17.5	5	15
	Residual Clay	17.5	2	12

Tabloid (279mm x 432mm)
SAVED: 2020-02-11 9:49:34 AM
FILE NAME: M006 - XS01 (former XS03).gsz
SCALE: 1:200 (279mm x 432mm)

Figure D-01
Cross-Section 01
Back-Analysis (Pre-Failure Conditions)

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Silty Clay	17.5	5	15
	Residual Clay	17.5	2	12



Tabloid (279mm x 432mm)
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Figure D-02
Cross-Section 01
Back-Analysis (Existing Conditions)

Tabloid (279mm x 432mm)

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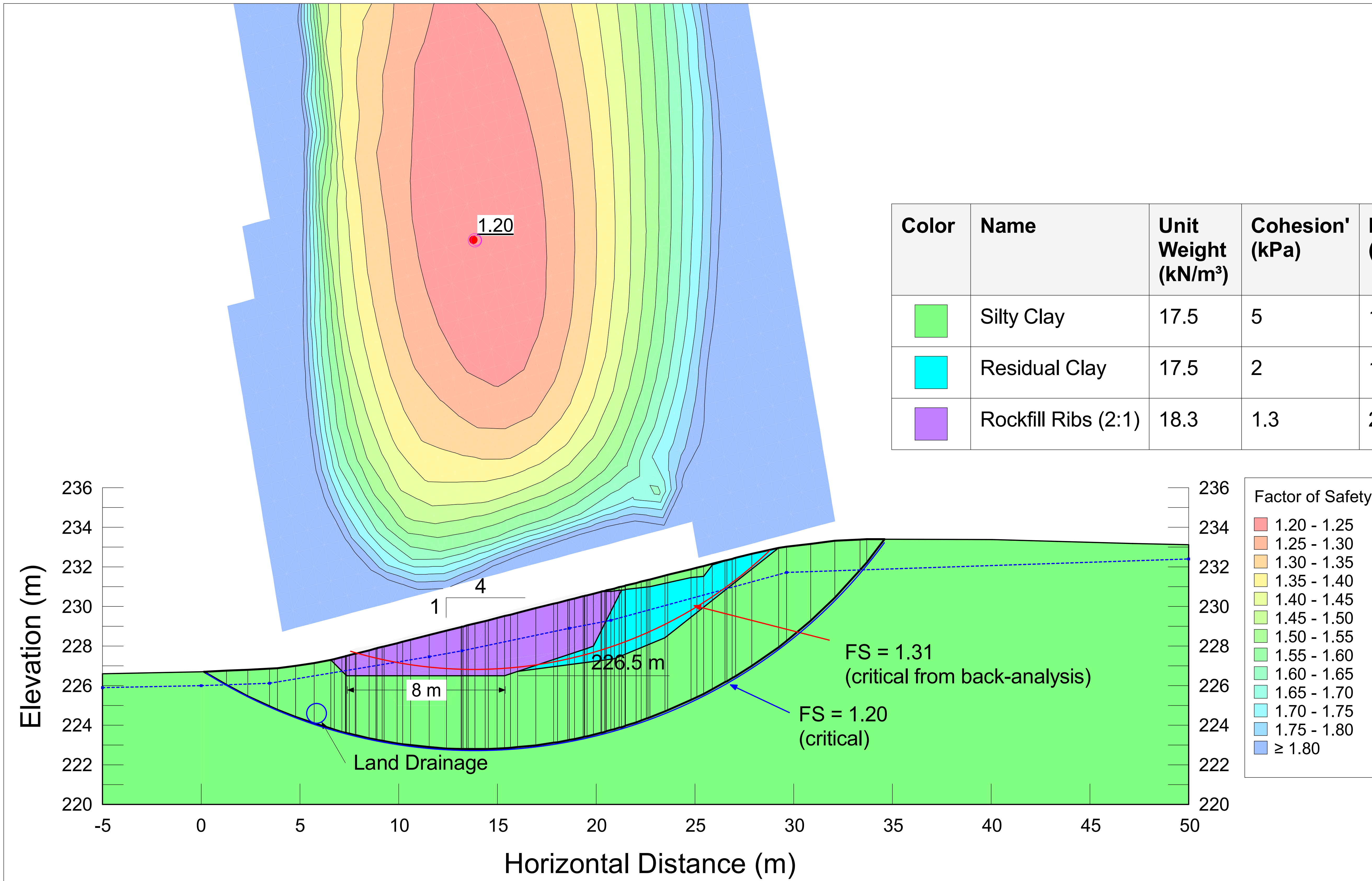

Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Silty Clay	17.5	5	15
	Residual Clay	17.5	2	12
	Rockfill Ribs (2:1)	18.3	1.3	23

SCALE: 1:200 (279mm x 432mm)

Figure D-03
Cross-Section 01
Rockfill Ribs

Appendix E

Basis of Estimate Capital Detail Worksheet