APPENDIX C – RIVERBANK CONDITION ASSESSMENT AND FUNCTIONAL DESIGN REPORT

St. Boniface Rivertrail
Tree Top Lookout and Sidewalk Expansion

Riverbank Condition Assessment and Functional Design Report
FINAL

KGS Group 15-0107-008
January 2016

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January 26, 2016

File No. 15-0107-008

City of Winnipeg
Planning, Property and Development
Unit 15 – 30 Fort Street
Winnipeg, Manitoba
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ATTENTION: Mr. Kendall Thiessen, P.Eng.
Riverbank Management Engineer

RE: St. Boniface Rivertrail Tree Top Lookout and Sidewalk Expansion
Riverbank Condition Assessment and Functional Design
Summary Report – Final

Dear Mr. Thiessen:

Please find attached three (3) hardcopies of the KGS Group summary report for the proposed St. Boniface Rivertrail Tree Top Lookout and Sidewalk Expansion works along Taché Avenue in Winnipeg, Manitoba.

KGS Group was retained by the City of Winnipeg to complete a riverbank condition assessment and functional design of riverbank stability improvement works along the Red River as part of the proposed St. Boniface Rivertrail Tree Top Lookout and Sidewalk Expansion works. This report also summarizes our structural findings to date regarding the proposed works. The attached summary report complete with functional level design drawings and preliminary construction cost estimates are suitable for immediate follow up to detailed design and preparation of associated regulatory and construction documents.

If you have any further questions or require additional information please do not hesitate to contact the undersigned.

Yours truly,

Bruno Pierre Arpin, P. Eng.
Geotechnical Engineer

BPA/jr
Enclosure

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1.0 INTRODUCTION

KGS Group was retained by the City of Winnipeg to complete a preliminary riverbank condition assessment, functional design of riverbank stability improvement works along the east bank of the Red River, and foundation assessment and functional structural design for the proposed St. Boniface Rivertrail Tree Top Lookout and sidewalk expansion. The scope of work completed as part of this assignment included:

- Reviewed findings from the 2014/2015 riverbank investigation, instrumentation and monitoring completed at the proposed project site. Findings from this program were summarized in the KGS Group letter report titled, “Saint-Boniface Rivertrail along Taché Avenue Preliminary Field Investigations, Instrumentation and Monitoring Summary Geotechnical Report of Findings – FINAL,” dated April 28, 2015.

- Completion of a topographic survey of the existing riverbank and a bathymetric survey of the river channel extending out beyond the channel thalweg.

- Completion of a two-dimensional slope stability analysis on two (2) select representative cross sections of the bank to assess the existing conditions. At each section, the impact of the proposed Tree Top Lookout and sidewalk expansion was evaluated and alternate riverbank stability improvement and erosion control works were assessed.

- Completion of a foundation assessment which included all necessary parameters for design of the foundations, and includes preliminary foundation alternatives for both the Tree Top Lookout and the sidewalk expansion.

- Completion of a functional level structural design of the Tree Top Lookout and sidewalk expansion structures.

- Completion of a functional level construction cost estimate, including a 25% contingency, for all design options considered for riverbank stabilization works and for functional structural design options.

- Preparation of this summary report detailing results of the preliminary riverbank condition assessment, functional design of riverbank stability improvement works, foundation assessment, functional level structural design, cost estimate and construction recommendations.

This functional level report is suitable for immediate follow-up to detailed design, preparation of construction documents (i.e. construction drawings and technical specifications) and submission in support of regulatory approvals.

2.0 BACKGROUND

The site of the proposed St. Boniface Rivertrail extends approximately 500 m along an outside bend on the east bank of the Red River between Esplanade Riel and Rue Despins, where Taché Avenue extends along the top of bank and also acts as a City of Winnipeg Primary Dike. Records indicate that this section of riverbank has experienced historic riverbank instability and active shoreline erosion which lead to construction of various riverbank stabilization and erosion protection works along select sections of riverbank over the last 50 years. The works have slowed the rate at which useable land has been lost and have protected critical infrastructure such as Taché Avenue. The proposed Tree Top Lookout and sidewalk expansion would span along the riverbank on the riverside of the existing retaining wall structure supporting Taché Avenue as shown in plan on Drawing G03 and the conceptual sketches produced by Scatliff+Miller+Murray in August 2015, which are included in Appendix A.

Further, the “Go… to the Waterfront” report prepared by Scatliff+Miller+Murray in 2014/2015 has recently been adopted and approved by City Council as “A Guideline for Waterfront Development” in Winnipeg. This document provides a vision for Winnipeg’s waterfront and describes various features along the Red River within the St. Boniface and Forks Precinct. Amongst these are the Taché Promenade and the Tree Top Lookout which could become the catalyst for a resurgence of development along the east shore of the Red River, aligning with such initiatives as the renovations to the St. Boniface Cathedral Precinct in celebration of its Bicentennial (2018).

The April 28, 2015 KGS Group letter report titled, “Saint-Boniface Rivertrail along Taché Avenue Preliminary Field Investigations, Instrumentation and Monitoring Summary Geotechnical Report of Findings – FINAL,” was also reviewed for additional background information regarding the previously constructed riverbank works, site stratigraphy, groundwater conditions and recent monitoring of geotechnical instrumentation.

2.1 PREVIOUS RIVERBANK STABILITY AND EROSION PROTECTION WORKS

Various riverbank stability and erosion improvement works have been constructed along this section of riverbank. Referencing the April 2015 KGS Group letter report, the site has been divided into the following seven (7) reaches based on the existing works:

Reach 1 – At the downstream extent of the site at Esplanade Riel, a riprap erosion protection blanket and rockfill columns were constructed in 2001 along 150 m± of riverbank in conjunction with the Esplanade Riel Project.

Reach 2 – Upstream of Esplanade Riel and downstream of Ave De La Cathédrale, approximately 75 m of riverbank is unprotected.

Reach 3 – Off the end of the Ave De La Cathédrale Right-of-Way, approximately 65 m of riverbank stability improvement works consisting of rockfill columns and a riprap blanket were constructed in 2009 to protect a City of Winnipeg outfall.

Reach 4 – Along the shoreline at the Taché Dock structure a rockfill riprap blanket and toe berm were constructed along approximately 65 m of riverbank in 1983.

Reach 5 – Immediately upstream of the Taché Dock riprap blanket and toe berm, approximately 25 m of riverbank is unprotected.

Reach 6 – An approximately 145 m long retaining wall structure along Taché Avenue was constructed downstream of Rue Despins in the 1970’s. Mid bank offloading and shoreline erosion protection works were completed at that time. These works were completed following a large slope failure that encroached onto Taché Avenue.

Lower bank rockfill columns were subsequently installed in 1999 along the shoreline parallel to the Taché Avenue retaining wall structure. Based on Waterway Permit No. 120/1999, it is known that fifty-five (55) 3.01 m diameter rockfill columns were installed in two (2) rows and spaced 5 m on centre along 145 m of the lower riverbank. City of Winnipeg records also indicate that additional riprap erosion protection (i.e. approximately 330 m^3 at 0.3 m± thick) was placed along the shoreline area in 1999 in conjunction with the construction of the rockfill columns. It is also understood that maintenance and upgrades to the retaining wall have been completed by the City of Winnipeg over the years.

Reach 7 – Adjacent to Rue Despins, approximately 45 m of riverbank stability improvement works consisting of rockfill columns and a riprap blanket were constructed in 2009 to protect the City of Winnipeg Despins Flood Pumping Station.

The Tree Top Lookout and sidewalk expansion are proposed to be located in Reach 6 and may extend onto Reach 5 and therefore these sections are the focus of this functional design report.

2.2 STRATIGRAPHY

KGS Group completed a geotechnical drilling, soil sampling and laboratory testing program in March and April 2014 as summarized in the April 2015 KGS Group letter report. The drilling program consisted of drilling five (5) test holes to power auger refusal in the underlying till. In each test hole, one (1) slope inclinometer was installed to monitor potential bank movements and pneumatic piezometers were installed in both the clay and till strata to monitor piezometric pressures in the bank.

Diagnostic laboratory testing was performed on select soil samples to determine the relevant engineering properties, including moisture content, Atterberg Limit tests, and grain size analyses. Test hole locations are shown on Drawing G02. Test hole logs including laboratory testing results are included in Appendix B.

2.2.1 Reach 5 – 25 m± Unprotected Section of Bank

In general, the stratigraphy is interpreted to consist of silty clay of lacustrine origin overlying clay till and silt till. At the upper / mid bank area (TH14-03), clayey silt fill was encountered overlying the lacustrine silty clay while in the mid / lower bank area (TH14-04), topsoil and clayey silt were encountered overlying the lacustrine silty clay.

Clayey Silt Fill – Clayey silt fill was encountered at the upper / mid bank area from ground surface to a depth of 1.5 m±. The clayey silt fill was brownish tan in colour, moist, compact to dense, and of low to intermediate plasticity. The undrained shear strength of the fill, estimated from the Field Torvane, was 65 kPa.

Topsoil – Topsoil was encountered at the mid / lower bank area from ground surface to a depth of 0.6 m±. The topsoil was black, damp, and contained trace fine grained gravel and trace cobbles.

Clayey Silt (ML) – An approximately 0.3 m thick layer of clayey silt was encountered at the mid /lower bank area directly below the topsoil and extended to a depth of 0.9 m±. The clayey silt was tan in colour, damp to moist, crumbly, of low plasticity, and contained trace amounts of clay.

Lacustrine Silty Clay (CH) – Underlying the clayey silt fill at the upper / mid bank area and the clayey silt deposit at the mid / lower bank area was silty clay of lacustrine origin. The silty clay was brown to grey in colour, moist, firm to stiff in consistency, of high plasticity, and contained trace silt nodules, trace gypsum and trace oxidation. Atterberg Limit testing on a sample from El. 223.7 m measured a Liquid Limit of 93% and a Plasticity Index of 67%. When measured from a sample at El. 217.6 m, a Liquid Limit of 75% and a Plasticity Index of 55% was measured classifying this material as CH. Undrained shear strengths estimated by the Field Torvane decreased with depth and ranged between 5 and 60 kPa. Moisture content within the clay generally increased with depth and ranged from 34 to 62%.

Clay Till – Clay till was encountered below the lacustrine silty clay at El. 215.1 to 216.1 m, and extended to El. 214.6 to 215.5 m. The clay till was greyish tan in colour, moist to wet, soft to very soft, of low to intermediate plasticity and contained varying amounts of silt, sand and gravel.

Silt Till – Silt till was encountered below the clay till and extended to power auger refusal at El. 213.7 to 214.0 m. The silt till was tan in colour, moist, dense to very dense, and contained varying amounts of sand and gravel. A Standard Penetration Test (SPT) performed in the silt till reached refusal with an uncorrected blow counts (N) of greater than 50 over 0.30 m.

2.2.2 Reach 6 – 145 m± Section of Bank with Rockfill Columns and Riprap

In general, the stratigraphy is interpreted to consist of silty clay of alluvial origin overlying a thin clayey silt layer, lacustrine silty clay, clay till and silt till. At the upper mid bank area (TH14-02), clay fill and clayey sand with gravel was encountered overlying the alluvial silty clay.

Clay Fill – Clay fill was encountered at the upper mid bank area and extended from ground surface to a depth of 1.8 m±. The clay fill was brown and black in colour, damp to moist, stiff, of intermediate plasticity, and contained trace organics and trace fine grained gravel. The undrained shear strength as estimated from one test with the Field Torvane was 85 kPa.

Clayey Sand with Gravel Fill (SC) – Clayey sand with gravel was encountered at the upper mid bank area and extended to a depth of 4.7 m± . The clayey sand with gravel was black in colour, moist to wet, and loose. The moisture content was 34% at 4.6 m± depth.

Alluvial Silty Clay (CH) – Silty clay of alluvial origin was encountered from ground surface at the lower mid bank area, and below the clayey sand with gravel at the upper mid bank area. The alluvial silty clay was brown to grey in colour, damp to moist, firm to stiff, of high plasticity, and contained trace organics and trace sand. Atterberg Limit testing on a sample from El. 220.5 m (TH14-01) measured a Liquid Limit of 76% and a Plasticity Index of 52%, resulting in a material classification of CH. Undrained shear strengths estimated by the Field Torvane decreased with depth and ranged between 46 and 90 kPa. Moisture contents within the alluvial silty clay generally did not vary with depth and ranged between 32% and 36%.

Silt (ML) / Clayey Silt (CL-CI) – A 0.5 m± thick layer of silt / clayey silt was encountered below the alluvial silty clay at El. 219.3 to 220.9 m. The silt was tan to grey in colour, moist, firm, and of low to intermediate plasticity. Undrained shear strengths estimated by the Field Torvane range from 45 to 50 kPa. Moisture content in the clayey silt was measured to be 34%.

Lacustrine Silty Clay (CH) – Underlying the silt / clayey silt layer was a deposit of lacustrine silty clay. The silty clay was brown to grey in colour, moist, firm to stiff, of high plasticity, and contained trace silt nodules. Atterberg Limit testing on a sample from El. 218.2 m measured a Liquid Limit of 75% and a Plasticity Index of 55%. Undrained shear strengths estimated by the

Field Torvane decreased with depth and ranged between 30 and 50 kPa. Moisture content within the clay generally increased with depth and ranged from 52 to 58%.

Clay Till – Clay till was encountered below the lacustrine silty clay at El. 216.6 m in TH14-02, and extended to El. 215.7 m. The clay till was grey in colour, moist to wet, firm, and contained some fine grained gravel and coarse grained sand.

Silt Till – Silt till was encountered underlying the lacustrine silty clay in TH14-01 and the clay till in TH14-02, and extended to power auger refusal at El. 215.1 to 215.4 m. The silt till was grey to tan in colour, moist, compact to very dense, and contained varying amounts of sand and gravel. A Standard Penetration Test performed in the silt till in TH14-01 recorded uncorrected blows (N) of 26 over 0.30 m while uncorrected blow counts (N) of greater than 50 were recorded at TH14-02.

2.3 GROUNDWATER CONDITIONS

Based on monitoring of eight (8) pneumatic piezometers installed in the clay and till strata in TH14-01 to TH14-04, groundwater elevations ranged from El. 223.5 to 226.6 m in the clay and from El. 224.2 to 226.0 m in the till between April 2014 and December 2015. Piezometric monitoring results are summarized in Appendix C.

There appears to be a slight downward hydraulic gradient through the massive clay strata down to the till. It would also appear based on monitoring data that till piezometric pressures respond to changing river levels such that an upward hydraulic gradient can occur at depth near the clay/till interface with rising river levels (i.e. spring freshet).

2.4 SLOPE INCLINOMETER DATA

The April 2015 letter report summarized the slope inclinometer monitoring data for the five (5) slope inclinometers installed during the 2014 drilling program as well as ongoing monitoring from previously installed slope inclinometers at the Cathédrale Outfall and Despins Flood Pumping Station sites. The slope inclinometers installed in TH14-01 to TH14-04 have been read a total of nine (9) times since the baseline readings following installation, most recently in

December 2015. The slope inclinometer monitoring plots are attached in Appendix D and results for Reaches 5 and 6 are summarized below:

Reach 5 – 25 m± unprotected section of bank – Based on mid bank monitoring data collected from TH14-04, approximately 20 mm of cumulative shear displacement has occurred between installation in April 2014 and December 2015 at El. 227.0 m±. This measured bank movement is relatively shallow and occurs within a thin (0.5 m±) layer of clayey silt at a depth of 0.7 m± below ground surface. Approximately 15 mm of the total 20 mm cumulative shear displacement occurred between December 2014 and December 2015, showing that movement of the lower slope is ongoing.

Based on upper bank monitoring data collected from TH14-03, no measureable upper bank movement has occurred since installation.

Reach 6 – 145 m± section of bank with rockfill columns and riprap blanket – Based on upper mid bank monitoring data collected from TH14-02, approximately 6 mm of cumulative shear displacement has occurred between installation in April 2014 and December 2015 at El. 220.5 m±. This measured bank movement is relatively deep and occurs within a thin (0.5 m±) layer of clayey silt at a depth of 5.9 m± below ground surface.

Based on lower mid bank monitoring data collected from TH14-01, approximately 9 mm of cumulative shear displacement has occurred since installation in April 2014 at El. 218.5 m±. This measured bank movement is similarly deep and occurs directly below a thin 0.5 m± thick layer of silt at a depth of 7.6 m± below ground surface. The majority of the movement occurred from September to December 2014, and from September to December 2015 (i.e. river drawdown periods). Approximately 4.5 mm of the total 9 mm cumulative shear displacement occurred during the fall 2015 river drawdown period.

Two (2) slope inclinometers within Reach 7 (Despins Flood Pumping Station Site, adjacent to Reach 6) were read most recently in December 2015. Based on mid bank monitoring data collected from SI09-01 (between the mid bank and lower bank rockfill columns), no measureable mid bank movement has occurred within the 2014/2015 monitoring period. Based on upper bank monitoring data collected from SI-03, approximately 4 mm of cumulative shear displacement occurred between May and December 2015 at a shallow depth of 2 m± below grade.

2.5 SITE TOPOGRAPHY

The 2011 LiDAR data which was used to generate the topography at the site in the April 2015 report has been supplemented with topographic and bathymetric surveys completed by KGS Group in May 2015. The revised topographic and bathymetric contours are shown in plan on Drawing G02. These contours were used to generate representative cross sections for the slope stability modeling. As shown on Drawing G03, Cross Section A is located within the unprotected area of Reach 5 (referred to as Area 2), and Cross Section C is located within the previously stabilized area of Reach 6 (referred to as Area 1). Cross Sections A and C are shown on the stability analysis output sections provided in Appendix E. The stability Cross Sections A and C are also shown outlining the recommended works on Drawing G04.

3.0 RIVERBANK STABILITY ASSESSMENT

A slope stability assessment was performed at two (2) representative cross sections (Section A in Area 2 and Section C in Area 1) to estimate the existing stability conditions, with the model calibrated by a back analysis of the existing geometry along Section A. Remedial works were then assessed to determine their improvement to the stability to meet the Factor of Safety (FS) criteria of 1.5 or 1.3 under normal conditions. To clarify, it is known that both Areas 1 and 2 have at one point been in a quasi-stable state (i.e. FS ≈ 1.0). Area 1 has benefited from some bank stabilization efforts in the past, whereas Area 2 has not. Both sections have been designed to a FS of 1.5, corresponding to a 50% increase in stability from said historic quasi-stable state, and as such it is anticipated that Area 1 will require less stabilization works to achieve the design FS criteria.

The geotechnical criteria used by KGS Group for this project were:

- A minimum FS of 1.5 under normal steady state conditions, corresponding to a 50% increase in stability compared to no stabilization works (criteria defined by the City of Winnipeg for bank stability within the limits of structures and for all Primary Dikes).
- A minimum FS of 1.3 under normal steady state conditions was also evaluated (30% increase in stability compared to no stabilization works) in the case that no structures are constructed.
- A minimum FS of 1.2 under the extreme condition of a fully saturated bank plus river drawdown to the Unregulated Winter River Level (UWRL).

The stability analysis was conducted using the two-dimensional computer modeling software Slope/W developed by GeoSlope International Ltd. of Calgary, Alberta. The model is capable of analyzing numerous iterations of both circular and composite slip surface to identify the analytically worse-case slip surface. The Morgenstern-Price Method of Slices with a half sine wave inter-slice force function was applied to all calculations reported herein. Static groundwater conditions were assumed in the analyses.

Numerical modeling was completed based upon the direct stratigraphic input from the test hole logs, riverbank and river bottom geometry as surveyed, and the measured groundwater and river levels.

3.1 EXISTING CONDITIONS BACK ANALYSIS

The existing conditions were initially modeled at Section A with clay soil properties as calculated from a detailed back analysis previously completed by KGS Group along the same outside bend for Reach 3 (Ave de la Cathédrale Outfall site) and Reach 7 (Rue Despins Flood Pumping Station site). It was known that the FS along these sections was near unity (1.0) due to the historic headscarps and monitored riverbank movements. In this analysis the portion of the riverbank located upslope of the headscarp (i.e. top of bank area) was assigned intact (non-failed) shear strengths, and the areas downslope of the headscarp were modeled on the basis of residual (failed) shear strengths.

The model for Section A was then calibrated by performing a sensitivity analysis on the residual shear strength parameters for the lacustrine silty clay. The sensitivity analysis was performed under the conditions of the Regulated Summer River Level (RSRL) of El. 223.7 m and groundwater levels of El. 226.0 m in the upper bank and El. 225.0 m in the lower bank, which are representative of normal conditions and correspond to measured groundwater levels at Section A during the period of measured bank movement. A slightly different groundwater level of El. 226.0 m in both the upper and lower bank was applied to the Section C model based on the piezometric monitoring results for that location.

Assuming a factor of safety near unity (1.0) for a lower bank slip (representative of observed bank movement at Section A) and a global slip (representative of observed bank movement at Section C), the residual shear strength parameters for the lacustrine silty clay were determined to be $\Phi'_r = 12°$ and $c'_r = 3.5$ kPa. The same residual strength parameters were used for Section C, including the upper alluvial silty clay encountered at Section C as the plasticity of the two clays were found to be similar based on the investigations completed by KGS Group in 2014. At the upper bank area where there was no evidence of ongoing movements, KGS Group assumed intact effective shear strength parameters of $\Phi' = 15°$ and $c' = 5$ kPa for the silty clay. These values are consistent with extensive triaxial based measurements of fully softened shear strengths of Lake Agassiz clays, as well as the stability analyses previously completed by KGS Group in the adjacent riverbank sections.

In the upper bank area at Section C, 1.8 m± of clay fill above 2.9 m± of clayey sand with gravel was encountered in test hole TH14-02. These materials were not encountered in any of the other test holes drilled by KGS Group. In a report titled, "Geotechnical Report on Riverbank Stability – Tache Avenue" prepared by A. Dean Gould, dated November 1998, a "gravelly fill" was also encountered at two test holes drilled in the upper bank within the limits of the retaining wall area. The material was believed by Gould to be imported and placed either during the construction of Taché Ave or during remedial works, and was incorporated into the stability analysis completed under that assignment. After reviewing all of the available background information, no definable limits could be associated with the granular material encountered in this area. KGS Group evaluated the stability at Section C both with and without the granular detail due to the uncertainty of its geometry and extent along the riverbank. For the analysis including the granular material, material type and elevations were used from the KGS Group test hole TH14-02, while the geometry of the detail was approximated from the stability analysis completed by A. Dean Gould in 1998. Due to the uncertainty associated with the granular detail, KGS Group recommends that the stability results not including the granular material be used to evaluate the existing riverbank stability.

It is understood that the existing lower bank rockfill columns at Section C (Area 1) may not have been vibro-compacted during installation. As discussed in Thiessen (2010), the method proposed by Maksimovic (1996) produces non-linear strength envelopes that fit the measured strengths of local (Winnipeg and surrounding area) crushed limestone rockfill reasonably well. Utilizing the figure provided in Thiessen (2010), which uses Maksimovic's method, the range of the secant friction angle for loose rockfill was estimated along the length of the column. Under the minimum and maximum expected normal stresses for the existing rockfill columns, the estimated friction angle ranges from approximately 45° to 55°. Therefore, an average friction angle of 50° over the length of the columns was used in the analyses for the existing rockfill columns.

The soil shear strength parameters used in the stability analysis are summarized in Table 1. Tables 2 and 3 present the estimated FS for the existing site conditions and recommended works at Sections C and A, respectively. The slip surfaces analyzed include: a global slip surface originating at or near the top of bank area and exiting near the toe of the bank (SS1), an upper bank slip surface (SS2), a lower bank slip surface (SS3), and a mid bank slip surface

(SS4). An additional block slip surface (SS5) was analyzed at Section C which may be representative of the observed movement at that location, as the movement was recorded close to the near-horizontal silt layer. All slip surfaces were analyzed under both normal conditions (i.e. normal groundwater levels and the Regulated Summer River Level) and an extreme design condition (i.e. fully saturated bank and the Unregulated Winter River Level). Each slip surface analyzed is shown in cross section on the GeoStudio output provided in Appendix E.

3.1.1 Area 1 Back Analysis (Section C)

The existing conditions model of Section C included previously constructed riverbank stabilization works including the retaining wall with upper bank offloading, lower bank rockfill columns, and a riprap blanket along the toe of the riverbank. The rockfill columns were modeled with a 2.85 m effective width, as calculated from the record drawing provided by the City of Winnipeg. The estimated FS for the existing conditions at Section C, with and without the granular detail, are shown on Table 2.

Section C is within the limits of both the proposed Tree Top Lookout and sidewalk expansion structures. Based on the existing conditions analysis under normal conditions with no granular detail, the global (SS1), upper bank (SS2), mid bank (SS4), and block slip (SS5) surfaces do not meet the minimum FS criteria of 1.5. Similarly, the same slip surfaces do not meet a minimum FS of 1.2 under the extreme condition. The lower bank slip surface (SS3) met the FS criteria due to the presence of the existing lower bank rockfill columns and riprap blanket.

3.1.2 Area 2 Back Analysis (Section A)

The estimated FS for the existing conditions at Section A are shown on Table 3. Section A is currently unprotected, and within the limits of the proposed sidewalk expansion. Based on the back analysis for existing conditions and measured slope movements, the bank is currently at a FS near unity (1.0) under normal conditions. Under the extreme design condition of a fully saturated bank and river drawdown to the UWRL, the estimated FS of the bank was less than 1.0 (approximately 0.75). The existing conditions at Section A therefore do not meet the minimum FS criteria.

3.2 RIVERBANK STABILIZATION ANALYSIS

Analyses of potential riverbank stabilization options were carried out under both the normal and extreme design conditions for Sections A and C. The analyses generally included the addition of rockfill riprap, rockfill columns, and a sheetpile retaining wall adjacent to Taché Ave (required for the sidewalk expansion). Sensitivity analyses were performed on the effective width of the rockfill columns and the offset of the rockfill columns along the bank as compared to the Taché Ave centreline to determine the most economical way to meet the Factor of Safety criteria.

3.2.1 Area 1 (Section C)

Riprap Erosion Protection and Rockfill Columns

In order to further protect again lower bank erosion, it was determined that the existing riprap blanket should be upgraded. The recommended upgrades consist of increasing the thickness of the riprap blanket to 0.6 m, extending the blanket up the bank to El. 225.0 m±, and extending the blanket approximately 10 m past the UWRL (El. 222.0 m) into the river channel. The proposed upgraded riprap would be placed directly on top of the bank below the UWRL, and subcut 0.6 m into the bank above the UWRL so that it sits flush with the original bank surface. Upgrading of the existing riprap blanket results in an estimated 5% to 6% increase in global stability, 6 to 11% increase in lower bank stability, and an increase of 21% to mid bank stability.

In order to achieve the FS criteria, an analysis was carried out for the inclusion of a second set of rockfill columns in the mid bank. A sensitivity analysis was performed on both the rockfill column width and offset from the Taché Ave centreline. A 2 m effective width was the minimum width considered in the analyses as anything narrower is generally not as effective. Sensitivity plots for both the global circular and block slips are shown on Figures 1 and 2 below.

FIGURE 1
SENSITIVITY ON MID BANK ROCKFILL COLUMN EFFECTIVE WIDTH AND OFFSET (SECTION C) – GLOBAL CIRCULAR SLIP SURFACE

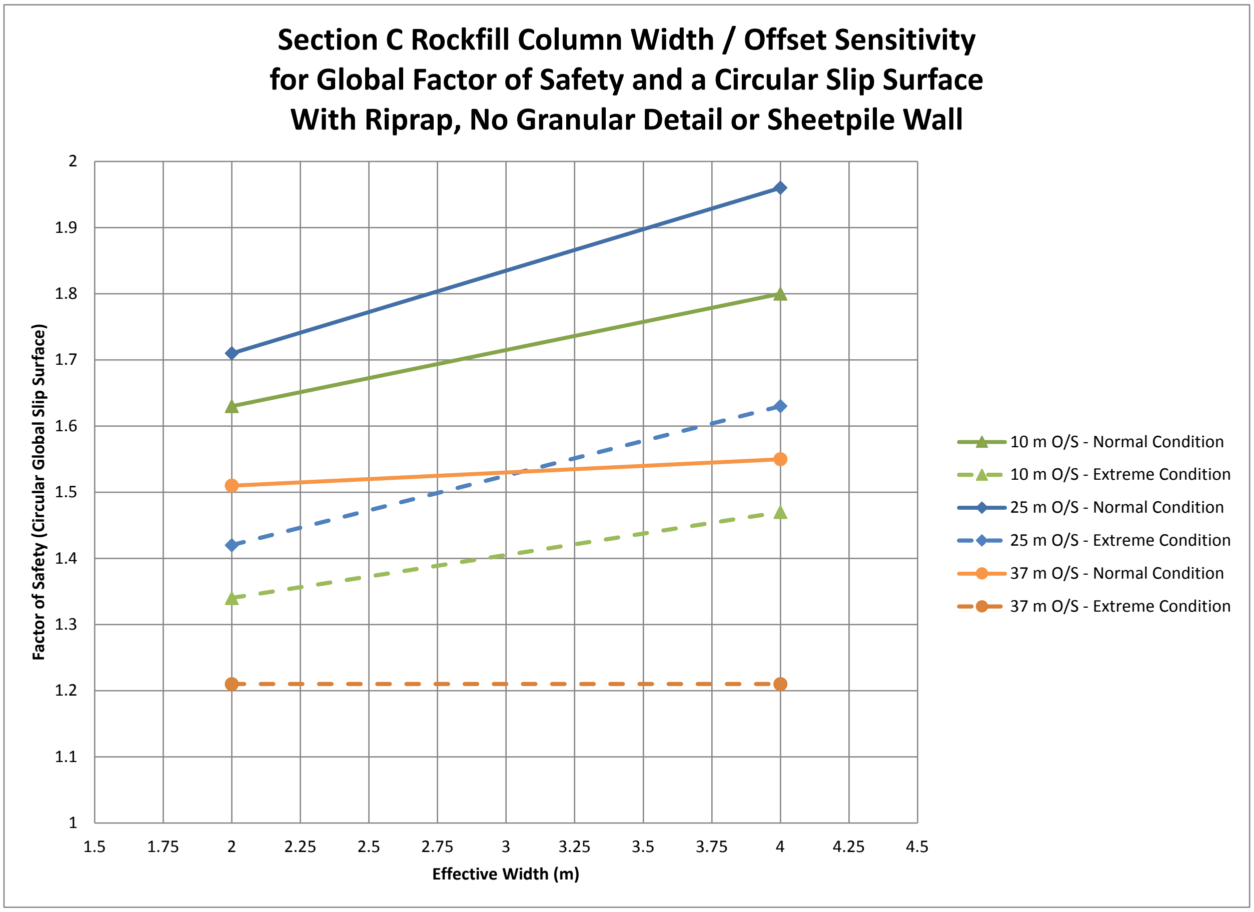
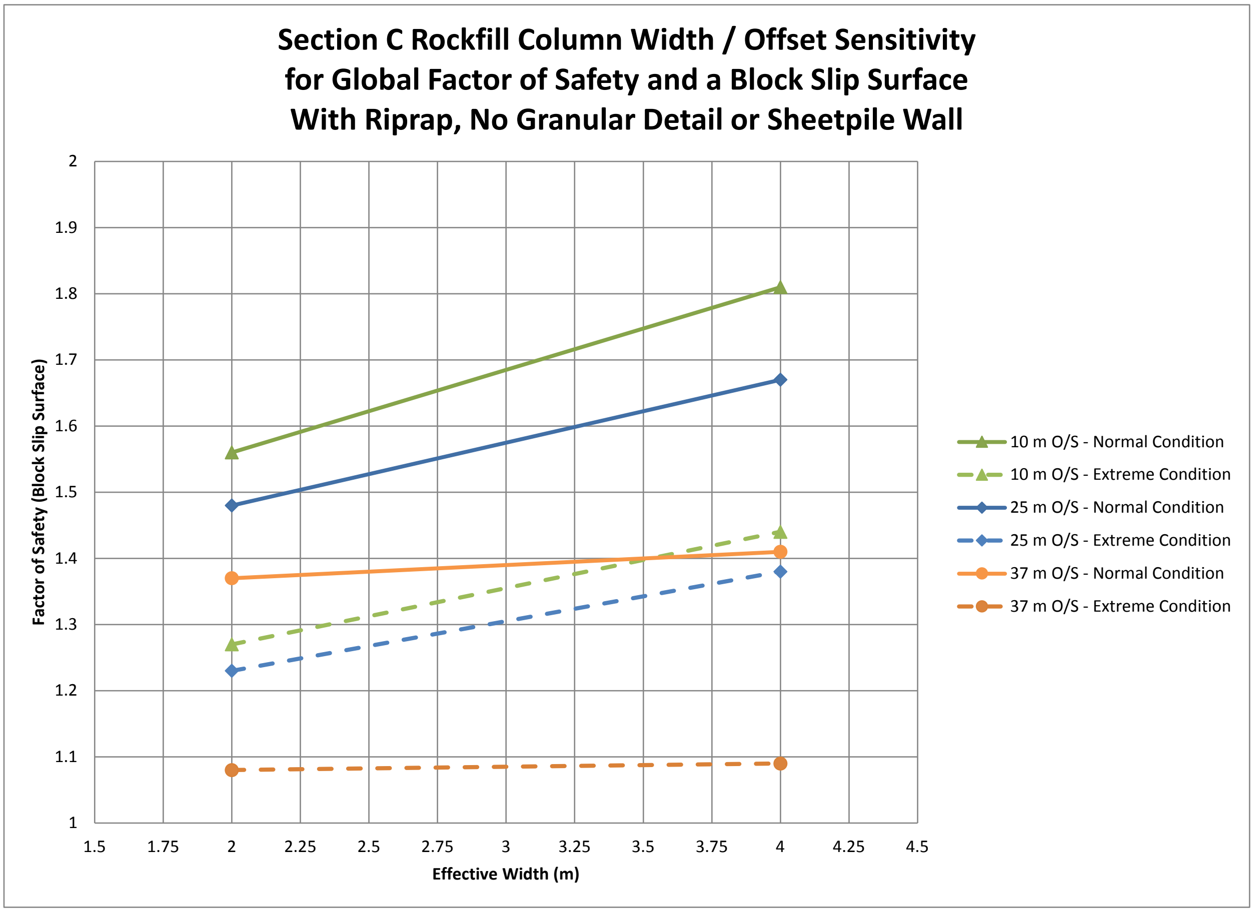


FIGURE 2
SENSITIVITY ON MID BANK ROCKFILL COLUMN EFFECTIVE WIDTH AND OFFSET (SECTION C) – BLOCK SLIP SURFACE



As shown on Figure 1, the minimum effective width of 2 m meets the FS criteria for a global circular slip surface (SS1) under both normal and extreme conditions anywhere in the offset range analyzed. However, as shown on Figure 2, a 2 m effective width rockfill column only meets the FS criteria for a block slip surface under both conditions at a 10 m or 25 m offset (for 25 m offset the estimated FS under the normal condition is 1.48). Based on the sensitivity analysis, ground elevation contours, existing trees, and proposed Tree Top Lookout location, the best option was determined to be 2 m effective width rockfill columns at a 25 m offset from the Taché Ave centreline in Area 1.

To achieve a FS criteria of 1.3 under normal conditions and 1.2 under extreme conditions, the additional set of rockfill columns would still be required in the mid bank to address the potential block slip surface SS5 (estimated Factors of Safety of 1.27 and 1.06 under each condition respectively after including an upgraded riprap blanket). The construction of mid bank rockfill columns will help to address ongoing bank movement that has been measured at Section C, despite construction of lower bank rockfill columns.

The estimated mid bank FS with 2 m effective width rockfill columns at a 25 m offset under normal conditions was 1.43 (i.e. did not meet the minimum FS criteria of 1.5). Given that the majority of the bank in the Tree Top Lookout area will have maintained mature tree growth, a stability analysis was completed with a 1 m deep tree root system in the approximate limits of existing tree growth. The analysis consisted of increasing the cohesion, c' within this region to 15 kPa for the upper 1 m of soil. The tree root system in combination with the upgraded riprap blanket increased the estimated mid bank FS to 1.59 under normal conditions. The assumption of an established tree root system in this area was considered reasonable due to the planned Tree Top Lookout having trees surrounding the structure, and therefore the mid bank FS meets the criteria. Note that the maintenance of an established tree root system would not be as critical if a FS of 1.3 was adopted (i.e. if the Tree Top Lookout is not constructed), as this criteria was met without the inclusion of a tree root system in the stability model (FS = 1.43).

Sheetpile / Sidewalk Expansion

The estimated upper bank FS (SS2) with 2 m effective width rockfill columns at a 25 m offset was 1.12 under normal conditions and < 1 (0.73) under the extreme condition of full bank saturation. The critical upper bank slip enters within the Taché Ave Right-of-Way and exits on the river side of the existing retaining structure. It should be noted that no contribution to stability has been assumed from the existing timber piles below Taché Ave.

In the assessment for the proposed sidewalk expansion, it was determined that the best option was to install sheetpiling adjacent to the existing walkway, backfilling between the sheetpile wall and Taché Ave, and constructing an at-grade active transportation path that meets the required width of 4 m. The use of a sheetpile retaining wall to expand the existing sidewalk will require additional works (i.e. reconstruction of the existing sidewalk, installation of a drainage system behind the sheetpile, utility relocation, etc.). However, the construction of a sheetpile wall will provide a long term benefit to the existing flood protection infrastructure along Taché Ave, which currently does not meet the City of Winnipeg's stability criteria. Using sheetpiling to cut off potential slope failures from encroaching onto Taché Ave will increase the stability of the City of Winnipeg Primary Dike, and allow it to meet the City of Winnipeg's criteria of a FS of 1.5 for primary dikes.

A sensitivity analysis was performed on the sheetpile depth to determine the embedment depth required to achieve a global FS of 1.5 (normal conditions) and 1.2 (extreme condition) against a slip originating within Taché Ave and extending below the sheetpile. The required depth based on the analysis was approximately 1 m above the till. The sheetpile should therefore be directly embedded into the till, which will avoid loading the riverbank from backfill behind the sheetpile wall.

An analysis was completed including the sheetpile embedded into the till unit, the 2 m effective width rockfill columns at a 25 m offset, and the upgraded riprap blanket, which resulted in an increase to both global and upper bank stability. In particular, the estimated upper bank (SS2) FS under normal and extreme conditions was increased to 2.93 and 2.35, respectively.

If the sidewalk expansion is not constructed the sheetpile wall does not need to be installed to construct the Tree Top Lookout, as the potential upper bank slip is generally outside the limits of the Tree Top Lookout. However, stability considerations would have to be taken into account at the final design stage at the Tree Top Lookout tie in locations to address potential upper bank slips in those specific locations and achieve a FS of 1.5 (e.g. localized rockfill column installation).

The estimated Factors of Safety for the recommended works for Area 1 are shown on Table 2. Representative GeoStudio cross-sections for Section C are provided in Appendix E.

3.2.2 Area 2 (Section A)

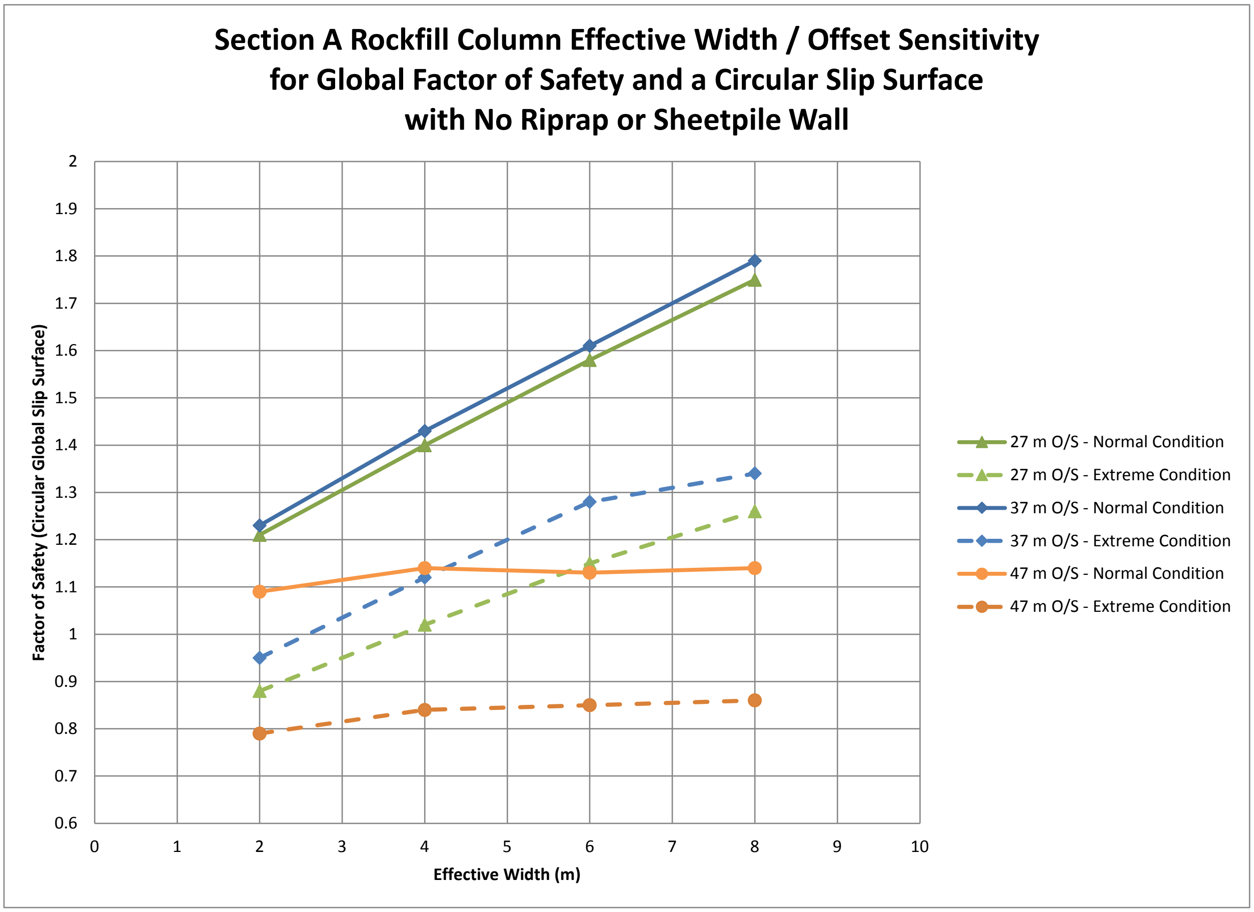
Riprap Erosion Protection and Rockfill Columns

To address potential retrogressive failures originating from the lower bank a riprap erosion protection blanket should be constructed. The lower bank is steeper along this section than in Area 1. In order to provide a smooth, consistent final riprap surface between Area 1 and the

Taché Dock, it was decided to place the riprap to El. 225.0 m at the control line shown on Drawing G04 (approximately 37.6 m offset from Taché Ave centreline), and sloped down at 4.5H:1V until it reaches the channel bottom. The riprap should then extend along the channel bottom at 0.6 m thick to the same offset from Taché Ave as the adjacent riprap blankets (minimum of 10 m past the UWRL).

Rockfill columns are required at Area 2 to stabilize the riverbank and achieve the target Factors of Safety. A sensitivity analysis was performed on the rockfill column effective width and offset from the Taché Ave centreline to determine the approximate total effective width required to achieve the target FS for global stability. A sensitivity plot showing the estimated global FS versus rockfill column effective width and offset is shown on Figure 3 below.

FIGURE 3
SENSITIVITY ON ROCKFILL COLUMN EFFECTIVE WIDTH AND OFFSET (SECTION A) – GLOBAL CIRCULAR SLIP SURFACE



As shown on Figure 3, the minimum total effective width to achieve a global FS of 1.5 under normal conditions and 1.2 under the extreme condition is 5 m, with an optimal offset of approximately 37 m from the Taché Ave centreline. Note that to achieve a FS criteria of 1.3 under normal conditions (i.e. if the sidewalk expansion is not constructed in this area), a 3 m total effective width would be required for global stability, as shown on Figure 3.

In order to address potential slip surfaces in both the upper and lower bank, a split column configuration was determined to be appropriate. A 3 m effective width rockfill column was selected for the lower bank in order to resist global and lower bank movement, which is slightly larger the existing lower bank columns previously installed in Area 1. The 3 m effective width column was set at a 44 m offset from the Taché Ave centreline, which is approximately halfway between the RSRL and UWRL and comparable with the existing columns offset at Area 1.

A set of 2 m effective width rockfill columns was added to the mid bank to achieve a total effective width of 5 m, and to help address potential upper and mid bank slip surfaces. A sensitivity analysis was performed on the offset of the 2 m effective width rockfill columns from the Taché Ave centreline in order to optimize their location. The offset range analyzed was determined based on the location of the analytically highest shear stress along the critical upper and mid bank slip surfaces after including the 3 m effective width lower bank columns and riprap blanket. Based on the sensitivity analyses and the ground elevation contours in Area 2, it was determined that a 28 m offset was optimal for the mid bank columns. The inclusion of the lower and mid bank rockfill columns and riprap blanket result in an estimated FS of 1.58 for global stability (SS1), 1.53 for upper bank stability (SS2), 1.71 for lower bank stability (SS3), and 1.56 for mid bank stability (SS4). All of the potential slip surfaces also have an estimated FS greater than 1.2 under the extreme condition, except for SS2 (upper bank) which was estimated at 1.16.

Sheetpile / Sidewalk Expansion

Since Section A is within the limits of the proposed sidewalk expansion, a stability model was run with the option of a sheetpile wall to achieve the 4 m active transportation path width. As with Section C, installing the sheetpile provides additional benefit by increasing the stability of the City of Winnipeg Primary Dike (Taché Ave) such that it meets a FS of 1.5 under normal conditions and 1.2 under extreme conditions. Expanding the existing sidewalk through use of a sheetpile wall also ensures that the sidewalk elevation will be above the Flood Protection Level (FPL), consistent with Area 1. The wall will also provide the opportunity for the City of Winnipeg to change the grades of the upper bank along Area 2 (i.e. offloading) for planting or other development opportunities, if required.

Alternatively, the City of Winnipeg could select not to install the sheetpile wall along this section and instead proceed with an at-grade path option. Since no additional fill can be added to the bank, this would require excavation of the upper bank and the use of a mechanically stabilized earth (MSE) wall system along Taché Ave. This approach would result in a lower path elevation that could result in periodic flooding of the pathway during elevated river levels, and a corresponding loss of use to the public.

With sheetpiling driven into till, the upper and lower bank rockfill columns and an optimized riprap blanket, the estimated upper bank (SS2) FS under the extreme condition is increased to 1.20, therefore meeting the criteria of 1.2.

If the sidewalk expansion is not constructed in Area 2, the sheetpile and mid bank rockfill columns are not required in order to achieve a global FS of 1.3 under normal conditions (SS1 = 1.36). The lower bank FS is also estimated to be above 1.3 under normal conditions (SS3 = 1.48). However, upper (SS2) and mid bank (SS4) stability does not achieve a FS of 1.3 (estimated 14% and 22% increase to stability with riprap and lower bank columns, respectively). The potential slip surfaces under the extreme condition of full bank saturation do not meet a FS of 1.2, but have increased stability from the existing conditions (estimated 43% increase in global stability, 19% in upper bank stability, 55% in lower bank stability, and 30% in mid bank stability). The movement measured in Area 2 was at the mid/lower bank, and therefore an estimated 55% increase in lower bank stability from the riprap and lower bank columns is beneficial. Since the slope inclinometer monitoring data at Area 2 has recorded nominal signs of upper bank movement, constructing only the lower bank rockfill columns and riprap would still be beneficial since they provide an increase to stability at the upper/mid bank. However, it should be noted that with a similar level of stabilization works at Area 1 (riprap blanket and 2.85 m effective width lower bank rockfill columns) ongoing slope movement has been measured at both the upper and mid/lower bank. With that in mind, optimization of the recommended bank stabilization works should be considered during the final detailed design. If it can be demonstrated by means of additional stability modelling and analysis that opportunities exist to further optimize the recommended bank stabilization works such that existing trees can be salvaged or otherwise, it may be desirable to do so. Further, should some acceptable degree of compromise be considered by the City of Winnipeg with respect to the established design criteria, there may in turn also exist opportunities to minimize risk while working within the constraints of a future budget.

The estimated Factors of Safety for the recommended works for Area 2 are shown on Table 3. Representative GeoStudio cross-sections for Section A are provided in Appendix E.

3.3 RECOMMENDED RIVERBANK STABILIZATION WORKS

Based on the riverbank stability assessment performed by KGS Group, the following riverbank stabilization works are recommended to achieve the minimum Factors of Safety criteria at Areas 1 and 2. Drawing G03 shows the recommended works in plan, and identifies the approximate limits of Area 1 and Area 2. The recommended works are shown in cross section on Drawing G04.

Area 1 – Section of Bank with Existing Rockfill Columns and Riprap Blanket

- Top up the existing riprap blanket by 0.3 m (total thickness of 0.6 m±). The approximate limits of the existing riprap blanket are shown on Drawing G02. Place 0.6 m thick riprap above the existing limit of the riprap blanket to a top elevation of El. 225.0 m± (subcut into the bank). Place 0.6 m thick riprap below the existing riprap blanket to approximately 10 m beyond the UWRL (El. 222.0 m).

- Construct two rows of 2.1 m diameter rockfill columns along the mid bank, offset 25 m from the centreline of Taché Ave, with a 3.33 m centre-to-centre spacing along the bank and 2.3 m centre-to-centre spacing between the two rows.

- To construct the sidewalk expansion and increase stability of the Taché Ave Primary Dike, install a sheetpile wall into the till, offset 4 m from the riverside of Taché Ave. If the sidewalk expansion is not constructed, stability improvements should be considered at the final design stage for the upper bank and at the Tree Top Lookout tie in locations to address potential upper bank localized instability.

- Maintain tree growth within the mid and lower bank. This is not critical if a lower FS criteria of 1.3 under normal conditions is adopted instead of 1.5 (i.e. if the Tree Top Lookout is not constructed).

Area 2 – Unprotected Section of Bank

- Construct a new riprap blanket. In order to provide a smooth, consistent final riprap surface between Area 1 and the Taché Dock, the riprap should be placed to El. 225.0 m at the control line shown on Drawings G03 and G04 (approx. 37.6 m offset from Taché Ave centreline), and sloped down at 4.5H:1V until it reaches the channel bottom. The riprap should then extend along the channel bottom at 0.6 m thick to the same offset from Taché Ave as the adjacent riprap blankets (minimum of 10 m beyond the UWRL).

- Construct two rows of 3.05 m diameter rockfill columns along the lower bank (between the existing lower bank columns in Area 1 and the Taché Dock), offset 44 m from the centreline of Taché Ave, with a 4.62 m centre-to-centre spacing along the bank and 3.25 m centre-to-centre spacing between the two rows.

- To achieve a FS of 1.5 under normal conditions, construct two rows of 2.1 m diameter rockfill columns along the mid bank (between the Area 1 mid bank columns and the Taché Dock). The columns should be offset 28 m from the centreline of Taché Ave, with a 3.33 m centre-to-centre spacing along the bank and 2.3 m centre-to-centre spacing between the two rows.

- To construct the sidewalk expansion and increase stability of the Taché Ave Primary Dike, install a sheetpile wall into the till, offset 4 m from the riverside of Taché Ave.

Note that if it is decided to only proceed with erosion protection (i.e. riprap blanket) and no stabilization works, the riverbank would not meet generally accepted minimum FS for stability for construction of the Tree Top Lookout or sidewalk expansion structures. The riprap blanket would minimize the potential for retrogressive slope failures at the lower bank caused by ongoing erosion. The addition of a riprap blanket does not detrimentally impact bank stability based on the stability analyses. A nominal increase to stability would be expected at Areas 1 and 2, but this will not meet the FS criteria.

4.0 FOUNDATION ASSESSMENT

The sidewalk expansion is proposed to consist of a sheetpile wall driven into till, with an at-grade pathway between Taché Ave and the wall. It is recommended that the sheetpiling be driven into the till based on the results of the stability analysis such that no additional load is placed on the riverbank from backfill placed behind the sheetpile, especially since ongoing bank movements have been recorded in this area. Below the path structure granular backfill with a subdrain will allow the retaining wall to drain. Drain holes will be provided through the sheetpiling to allow water to drain onto the riverbank from behind the wall. Details on the sidewalk expansion are included in Section 5.

The Tree Top Lookout is proposed to consist of an elevated sidewalk above the riverbank at an elevation matching the existing Taché Ave sidewalk, and supported on deep end bearing piles. Deep end bearing piles are suitable for this application as they distribute the loads from the structure to the underlying till or bedrock. Friction piles and shallow foundations are not suitable for the Tree Top Lookout as additional loading of the overburden soils may detrimentally impact slope stability at this site.

Although Reach 6 of the bank includes previously constructed riverbank stability improvement works (bank offloading, rockfill columns, and riprap), additional works are recommended (mid bank rockfill columns, a riprap top-up, and a sheetpile wall), because if not then ongoing small displacements are likely to occur which will horizontally load the piles. This must be considered in design of the foundation and in selection of the preferred foundation system. For reference, bridge sites in the City of Winnipeg often have riverbank stabilization works increase the FS to 1.5 similar to this site, and have end bearing piles for the bridge abutments and piers on the riverbank.

The foundation considerations described in this report follow the Limit State Design (LSD) Guidelines. Limit State Design requires consideration of two (2) main groups loading states: Ultimate Limit States and Serviceability Limit States. The Ultimate Limit States (ULS) are primarily concerned with collapse mechanisms of the structure and safety, and the Serviceability Limit States (SLS) present conditions or mechanisms that restrict or constrain the intended use, function or occupancy of the structure under expected service or working loads. For foundation design, each loading state prescribes Geotechnical Resistance Factors (Φ) that are based upon the method used to evaluate pile capacity to obtain the Factored Serviceability Limit State (SLS) and Factored Ultimate Limit State (ULS) pile capacity values. A Geotechnical Resistance Factor (Φ) of 0.4 has been applied to the factored ULS and SLS values presented below.

4.1 DEEP FOUNDATION ALTERNATIVES FOR THE TREE TOP LOOKOUT

End bearing deep foundations are recommended at this site to transfer loads to the underlying till and/or bedrock, so as to not apply additional loads to the overburden soils and decrease riverbank stability. Precast concrete piles have a very low resistance to bending, which may be of concern at this site due to ongoing riverbank slope creep and potential ice loading on the proposed Tree Top Lookout structure. Driven steel piles are not generally used for light to medium loads like those proposed at this site, and are less economical than cast-in-place concrete piles. Therefore, the recommended foundation type for the Tree Top Lookout is cast-in-place concrete piles end bearing on competent silt till.

4.2 CAST-IN-PLACE CONCRETE END BEARING PILES

Belled or straight shaft cast-in-place end bearing concrete piles, bearing on undisturbed, dense silt till should be used to support the foundation loads of the proposed Tree Top Lookout structure. The recommended factored end-bearing values for Limit State Design of the piles are as shown on Table 4.

For cast-in-place concrete end bearing piles downhole inspection of the bearing surface by experienced geotechnical personnel is required to ensure that the specific bearing capacity is achieved. The base of the piles must be mechanically cleaned prior to placement of concrete to obtain a sound bearing surface and ensure that all deleterious material has been removed from the bearing surface. With the potential presence of cobbles, boulders, and/or granular layers within the till, caving at the bell roofs should be expected resulting in difficulty maintaining the integrity of the bell even where the pile holes are sleeved.

The potential exists for squeezing of the borehole during installation of the cast-in-place concrete piles at this site. Temporary steel sleeves should be used as required during pile installation in an effort to maintain the drill shaft in a clean and dry state. The concrete should be poured as soon as practical following drilling of each shaft. Should heavy groundwater inflow be encountered, concrete placement should be completed using tremie or pump-in methods. Drilling and concrete placement for the piles should be inspected by experienced geotechnical personnel to verify the soil conditions and proper installation of the piles.

Additional recommendations for the design and construction of the piles are provided below:

- The spacing between adjacent piles should be a minimum of 3 pile diameters (or bell diameter, if applicable), as measured from centre to centre.
- Temporary steel sleeves should be available for cast-in-place piles in the event that groundwater seepage or sloughing of the piles holes is encountered during pile installation.
- Detailed construction records and full time inspection by experienced geotechnical personnel is recommended throughout construction of foundations to ensure that the design capacities indicated in this report are achieved.
- It is recommended that all concrete piles utilize CSA Type 50 sulphate resistant cement.
- The sizing and reinforcement of the cast-in-place concrete end bearing piles should take into account the horizontal loading and bending due to ice loading on the Tree Top Lookout structure, as described in Section 5.

5.0 FUNCTIONAL STRUCTURAL DESIGN

Reference Drawing S01 for the structural concept design of the Tree Top Lookout and sidewalk expansion.

5.1 TREE TOP LOOKOUT

The Tree Top Lookout is a steel framed elevated walkway supported on steel pipe columns and concrete cast-in-place piles end bearing on till. The columns and piles are designed to support vertical loads and are sufficiently robust to resist the impact forces of drifting ice. Riprap at the base of the columns provides erosion protection. The walkway steel framing consists of square “capital” frames above each column which support longitudinal and transverse channels spanning between the frames. All steel components are to be galvanized.

5.2 SIDEWALK EXPANSION

The existing sidewalk consists of a structural slab supported on timber piles spaced at 500 mm on centre and precast concrete driven piles at 7000 mm on centre. The timber piles were originally provided to stabilize the upper bank. The existing slab is to be removed and the existing piles are to remain. The proposed reconstruction components will include a slab / asphalt on grade; steel sheet piles driven to till; a concrete cap beam; and an integrated handrail / guardrail.

The integrated handrail / guardrail along the expanded sidewalk will be dual-purpose for both pedestrians and vehicles, as opposed to the handrail along the Tree Top Lookout which is solely for pedestrians, and is reflected in the unit pricing included in the cost estimate shown on Table 5.

6.0 FUNCTIONAL LEVEL CONSTRUCTION COST ESTIMATE

In KGS Group's and Scatliff+Miller+Murray's initial assignment, potential riverbank works were reviewed at a high level and order of magnitude costs on a per metre basis were developed and provided to the City of Winnipeg. These figures represented a preliminary estimate of the cost to achieve a Factor of Safety (FS) of 1.3 for bank stability.

Under the current assignment, the City of Winnipeg has defined the Factor of Safety criteria as 1.5 under normal conditions for riverbank stability within the limits of structures. The estimated construction costs provided below represent the estimated costs necessary to achieve this FS of 1.5. If the City of Winnipeg decides to not construct the proposed structures within an area, a lower minimum FS of 1.3 would be required for bank stability, as defined by the City of Winnipeg.

The proposed Tree Top Lookout is located within Area 1 (section with existing lower bank stabilization works), and the proposed sidewalk expansion spans across both Areas 1 and 2. The bank at Area 1, which includes existing lower bank stabilization works constructed to arrest slope failures experienced in the past, continued to record ongoing bank movement throughout the 2014/2015 monitoring period. Movement has also been observed within the lower bank at Area 2. Ongoing movement over the design life of the project may be such that damage/maintenance becomes an issue. Further bank stabilization works are recommended to achieve the minimum FS criteria of 1.5 and minimize riverbank movement to improve long term performance of the proposed structures, as well as increase the stability of the Taché Ave Primary Dike such that it meets the City of Winnipeg's minimum FS criteria of 1.5.

The functional level construction cost estimate for the recommended riverbank stabilization and functional level structural design options is provided on Table 5. Note that the proposed works have been broken up into four (4) categories, and each has their own line item for mobilization and demobilization. The sum of the mobilization / demobilization costs is considered representative of the total for the entire project. However, some potential savings could be expected due to shared mobilization / demobilization costs should all four (4) components of the project be completed concurrently. The total estimated construction cost provided includes a 25% contingency applied to the summation of all four (4) categories of work.

The estimated construction cost for riverbank stabilization works in Area 1 (section with existing lower bank rockfill columns and riprap blanket) is $1,244,550. The construction cost estimated for riverbank stabilization works in Area 2 (section with no existing rockfill columns between Area 1 and the Taché Dock) is $956,850. These estimated costs include all recommended stabilization works to achieve a minimum FS of 1.5. If the sidewalk expansion is not constructed and a target global FS of 1.3 (i.e. 30% increase in global stability) is adopted at Area 2 as opposed to 1.5, the mid bank rockfill columns are not required and the estimated cost is reduced to approximately $527,600 (includes estimated reduction in revegetation costs). Note that a 30% increase in stability is not achieved for the potential upper and mid bank slip surfaces without the installation of mid bank columns.

The estimated construction cost for the Tree Top Lookout is $1,201,725, which includes all recommended construction works as well as the architectural components (i.e. light fixtures, custom IPE bench and interpretive features, and the “Guiding Light” sculpture). If it is decided to proceed with only the Tree Top Lookout and not the sidewalk expansion, additional stabilization works would be required at the Tree Top Lookout tie in locations to Taché Ave to address potential stability concerns at the upper bank (between Taché Ave and the mid bank rockfill columns), as there would be no sheetpile contributing to upper bank stability. Alternate works could include the installation of rockfill columns around the tie in locations to provide a FS of 1.5 for the structure.

The estimated construction cost to construct the sidewalk expansion with sheetpiling over the entire 184 m length is $2,070,355. Note that instead of the asphalt pathway considered in this estimate, the City could consider a more decorative paving option, such as a concrete pathway with integrated soldier course paving stone on both sides (estimated to cost approximately $75,000 more than the asphalt paving option). If the City of Winnipeg selects not to install the sheetpile wall within Area 2 the estimated cost of the sidewalk expansion would be reduced. However, expanding the sidewalk to a 4 m width in this segment using an at-grade option would require excavation of the upper bank and use of a mechanically stabilized earth (MSE) wall system along the edge of Taché Ave. This option would result in a lower path elevation which will be susceptible to periodic flooding of the path, and would not provide a stability benefit to the Taché Ave Primary Dike.

The total estimated construction cost for all of the project components with a 25% contingency is $6,841,850 (excluding applicable taxes). This includes riverbank stabilization to an estimated FS of 1.5 along both Areas 1 and 2, the Tree Top Lookout, and an expanded sidewalk complete with sheetpile retaining wall along the entire length. The City of Winnipeg may choose to only select certain components of the recommended works to be constructed based on available funding.

Indirect costs that the City of Winnipeg should also consider include final design, regulatory approvals, contract administration, and construction inspection services. The magnitude of these costs will vary based on the project components that the City of Winnipeg decides to proceed with.

7.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

Construction considerations include safe development of construction access, riprap placement, mechanical reinforcement of the riverbank by the construction of rockfill columns, riverbank regrading and drainage improvements, deep foundation construction, construction of the structural Tree Top Lookout and sidewalk expansion, re-vegetation and the overall sequence of the work.

7.1 CONSTRUCTION SEQUENCE

In terms of riverbank stability, the most critical time will be during the construction of the works and the concern typically begins with construction access development. Sequencing of the work must be carefully developed to minimize the possibility of any aspect of the construction activities causing riverbank movements. Generally, some small movements may occur during construction but proper construction staging will result in successful construction with minimal movement. The riverbank stabilization works must be completed prior to the construction of any foundation and structural works related to the Tree Top Lookout and sidewalk expansion. The works should generally follow the sequence outlined below:

- Access ramp construction.
- Riprap blanket construction.
- Rockfill column construction.
- Riverbank regrading / drainage swale construction.
- Tree Top Lookout and sidewalk expansion construction including foundation and structural works.

7.2 CONSTRUCTION ACCESS

In any riverbank stabilization project, construction access must achieve some temporary improvement to bank stability before the actual work begins. An access ramp to the lower and mid bank areas should be constructed by excavation only and no fill should be placed on the bank. Stockpiling of material on the riverbank will have a detrimental impact on riverbank stability and in turn may initiate slope movements. Stockpiling of materials should be limited to a designated area sufficiently offset at a safe distance beyond the top of the riverbank. Prior to the construction of an access ramp, the contractor should develop a site access plan approved by an experienced geotechnical engineer.

7.3 ROCKFILL RIPRAP

The proposed riprap will be placed along the shoreline and will extend out into the river channel below the river ice to protect the lower toe of the slope, and is positive to lower bank stability.

The riprap will be placed directly on the channel bottom below the UWRL and will extend out into the channel approximately 10 m±. Upslope of the UWRL, the riprap will be subcut and placed flush with the existing riverbank surface in Area 1. For Area 2, the final riprap surface has been designed to provide a continuous, smooth blanket between Area 1 and the Taché Dock, and as a result some areas will not be subcut. The riprap blanket will be blended in at the upstream and downstream limits with the existing riprap. The edge of the riprap blanket will be placed with a 5H:1V transition or taper to allow for a smooth flow transition and no increase in turbulent flow along the shoreline.

Selection of the 5H:1V transition or taper for the edges of new riprap blankets is based on previous analysis by KGS Group hydraulic engineers from past erosion protection projects we have designed on both the Red and Assiniboine Rivers. The assessments were performed using the methods and procedures outlined in the U.S. Army Corps of Engineers Waterway Experimental Station “Stream Investigation and Streambank Stabilization Handbook” dated October 1997. Our results indicate that a 5H:1V transition between the existing river bottom and the proposed riprap will not cause any increase in turbulent flow along the shoreline and therefore will not accelerate the ongoing natural shoreline erosion downstream of this site.

7.4 ROCKFILL COLUMNS

Rockfill columns are constructed by drilling a shaft down through the clay into the underlying till and backfilling the hole with rockfill. Sleeving of individual column excavations may be required due to the potential for squeezing or slumping of the side walls in the deep excavation. As excavation for each column progresses, the excavated materials are to be immediately disposed of off-site; however suitable clay may be stockpiled and used as the clay cap over the columns. Once excavated to the required depths (i.e. a minimum of 0.6 m into competent till), the columns must be immediately backfilled with suitable rockfill. Careful inspection by experienced and qualified geotechnical engineering inspectors is required to ensure an adequate depth and diameter of excavation is achieved prior to proceeding with backfilling activities.

Rockfill placed in the columns should be vibro-compacted to full-depth to ensure that the overall density of the backfill material is increased by an estimated 10% to 15% along the entire depth of the column. Increased rockfill density results in increased rockfill shear strength at small strain and the density achieved during installation of rockfill columns has a significant impact on the movement required to mobilize the shearing resistance.

A total of 115 rockfill columns are recommended to be constructed in the mid bank area with 2 rows of 2.1 m diameter columns over approximately 192 m of riverbank. A total of 24 rockfill columns are recommended to be constructed in the lower bank area in Area 2 with 2 rows of 3.05 m diameter columns over approximately 56 m of riverbank. The rockfill columns should be excavated a minimum of 0.6 m into competent till.

7.5 RIVERBANK REGRADING / DRAINAGE IMPROVEMENTS

Minor regrading of the riverbank should be performed including the excavation of drainage swales to promote positive drainage of overland flow of water to the Red River and prevent ponding of water along the riverbank. Regrading of the riverbank should be performed by excavation only and all excavated material should be removed from site. Fill must not be placed on the riverbank to regrade the bank.

7.6 FOUNDATION CONSTRUCTION

The deep end-bearing foundation for the Tree Top Lookout should be constructed following completion of riverbank stabilization works. The piles should be installed consistent with recommendations made in Section 4.

7.7 TREE TOP LOOKOUT CONSTRUCTION

The proposed Tree Top Lookout is a steel framed structure supported on steel pipe columns and concrete cast-in-place piles end bearing on till. The columns and piles have been designed to account for both vertical loads and horizontal loads due to river ice. The steel components should be galvanized to protect against weathering effects. Additional considerations for the Tree Top Lookout are included in Section 5.

7.8 SIDEWALK EXPANSION CONSTRUCTION

The sidewalk expansion is proposed to consist of a sheetpile driven into till, with an at-grade pathway between Taché Ave and the sheetpile wall. The sheetpiles should be driven such that a 4 m offset is provided between the back of the existing Taché Ave curb and the road-side of the sheetpile. The sheetpile should be driven first, followed by excavation of the existing sidewalk and retaining wall. The subgrade behind the sheetpile should be prepared and backfilled with granular material to allow drainage behind the wall. A weeping tile subdrain and drainage outlets through the sheetpile should be provided to allow drainage onto the river side of the structure. The structure of the active transportation pathway will consist of 75 mm thick asphalt pavement, 50 mm of crushed limestone base course, 150 mm of 50 mm limestone sub-base, geogrid, and geotextile fabric above the granular backfill. Relocation of the existing electrical line and three (3) light standards along the riverside of Taché Ave will be required to install the sheetpile. Details for the sidewalk expansion are provided on Drawing G05. Additional structural considerations for the sidewalk expansion are included in Section 5.

7.9 RE-VEGETATION

The bank should be re-vegetated along its entire length where the natural vegetation has been disturbed. Re-vegetation with natural grasses and trees will establish a root mass near ground surface which will minimize the likelihood of shallow slope failures and sloughing of the riverbank as well as to control groundwater levels near ground surface. Re-vegetation should be undertaken in the spring / summer when conditions are optimal.

8.0 RECOMMENDATIONS

The proposed St. Boniface Rivertrail Tree Top Lookout and sidewalk expansion extends along an outside bend on the east bank of the Red River, between Rue Despins and the Taché Dock along Taché Avenue. Records indicate that this section of riverbank has experienced historic riverbank instability and active shoreline erosion, and various riverbank stabilization and erosion protection works have been constructed in the past along select sections of the riverbank.

KGS Group performed a preliminary riverbank condition assessment, functional design of riverbank stability improvement works, and foundation assessment and functional structural design for the proposed St. Boniface Rivertrail Tree Top Lookout and sidewalk expansion. A functional level construction cost estimate was also completed including a 25% contingency for the recommended riverbank stabilization works and functional structural design options.

Based on the assessment performed by KGS Group, the following recommendations are made to meet a minimum FS of 1.5:

- Riverbank stability improvement works at Area 1, consisting of:
  - Top up and expand the limits of the existing riprap blanket.
  - Construct two rows of 2.1 m diameter rockfill columns along the mid bank.
  - To construct the sidewalk expansion and increase stability of the Taché Ave Primary Dike, install a sheetpile wall in the upper bank. If the sidewalk expansion is not constructed, additional stability improvements should be addressed during final design to address upper bank stability at Tree Top Lookout tie in locations.
  - Maintain tree growth within the mid and lower bank. Maintaining tree growth is not as critical if the Tree Top Lookout is not constructed.

- Riverbank stability improvement works at Area 2, including:
  - Construct a new riprap blanket.
  - Construct two rows of 3.05 m diameter rockfill columns along the lower bank.
  - Install two rows of 2.1 m diameter rockfill columns along the mid bank.
  - To construct the sidewalk expansion and increase stability of the Taché Ave Primary Dike, install a sheetpile wall in the upper bank.

- Minor regrading of the riverbank should be performed to promote positive drainage of surface water to the Red River and prevent ponding of water along the riverbank.

- Cast-in-place reinforced concrete piles end bearing on competent silt till are recommended as the foundation type for the Tree Top Lookout.

- The recommended Tree Top Lookout structure is a steel framed elevated walkway supported on steel pipe columns as described in Section 5.

- The sheetpile should be installed at a 4 m offset from the riverside of Taché Ave for the proposed sidewalk expansion. The existing sidewalk and retaining structure should be removed, and the sheetpile backfilled with granular with a subdrain system.

- Construct an asphalt at-grade active transportation pathway between Taché Ave and the sheetpile. Note that a more decorative option such as concrete with inlayed paving stone could be constructed at an additional cost.

- Re-vegetation of all areas along the bank affected by the construction activities.

- The riverbank stability improvement works should be completed prior to the Tree Top Lookout and sidewalk expansion.

- It may be impractical to protect some of the existing instrumentation along the riverbank from damage during construction. Replacement instrumentation should be installed at the end of construction and monitored biannually for a minimum of three (3) years after construction.

- Full-time inspection by qualified personnel should be completed during construction, including both the riverbank stabilization and structural works.

Additional recommendations for further review during final design include:

- The proposed location of the mid bank rockfill columns in Area 2 will require the removal of nearly all the trees in Area 2. If the City of Winnipeg wishes to retain the mid bank trees, the locations of the rockfill columns could be adjusted and re-evaluated with respect to the stability criteria.

- Further optimization of the currently proposed footprint of the stabilization works could be assessed during final design such that the effective footprint of the works is minimized, or additionally identified constraints are considered.

- Construction access, construction methods, and equipment selection should consider as a priority the retention and protection of existing trees.

- It may be desirable to remove additional trees than those required by construction. This should be evaluated during final design so that the tree removal can be integrated with the removals already required.

- Full or partial closure of Taché Ave will be required during construction of the sheetpile and sidewalk expansion. A traffic management plan should be developed to allow continued access during construction, with specific consideration regarding access to the St. Boniface Hospital.

- Potential path upgrading options south of the project limits exist to better connect the new 4 m wide active transportation pathway to the existing Rivertrail infrastructure.

Options include expanding the existing path west of the Despins FPS to be 4 m wide, and/or constructing a new concrete sidewalk along the east side of the Despins FPS.

- Investigations of the condition of the existing infrastructure and utilities along Taché Ave should be completed for final design, such as evaluating the condition of any catch basins and piping, and determining where to relocate utilities affected by the work.

9.0 STATEMENT OF LIMITATIONS AND CONDITIONS

9.1 THIRD PARTY USE OF REPORT

This report has been prepared for the City of Winnipeg to whom this report has been addressed and any use a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

9.2 GEOTECHNICAL INVESTIGATION STATEMENT OF LIMITATIONS

The geotechnical investigation findings and recommendations of this report were prepared in accordance with generally accepted professional engineering principles and practice. The findings and recommendations are based on the results of field and laboratory investigations, combined with an interpolation of soil and groundwater conditions found at and within the depth of the test holes drilled by KGS Group at this site. If conditions encountered during construction appear to be different from those shown by the test holes drilled by KGS Group or if the assumptions stated herein are not in keeping with the design, this office should be notified in order that the recommendations can be reviewed and modified if necessary.

9.3 CAPITAL COST ESTIMATE STATEMENT OF LIMITATIONS

The cost estimates included with this report have been prepared by KGS Group using its professional judgment and exercising due care consistent with the level of detail required for the stage of the project for which the estimate has been developed. These estimates represent KGS Group's opinion of the probable costs and are based on factors over which KGS Group has no control. These factors include, without limitation, site conditions, availability of qualified labour and materials, present workload of the Bidders at the time of tendering and overall market conditions. KGS Group does not assume any responsibility to the Client, in contract, tort or otherwise in connection with such estimates and shall not be liable to the Client if such estimates prove to be inaccurate or incorrect.

TABLES

TABLE 1
MATERIAL PROPERTIES FOR STABILITY ANALYSIS

MATERIAL	FRICTION ANGLE, Φ' (DEGREES)	COHESION, c' (kPa)	UNIT WEIGHT, γ (kN/m^3)
Lacustrine Silty Clay (Residual)	12	3.5	17.5
Alluvial Silty Clay (Residual)	12	3.5	17.5
Silty Clay (Intact)	15	5	17.5
Silt / Clayey Silt / Clayey Silt Fill	20	4	18
Till	40	20	20
Riprap	40	0	20
Rockfill Column	50	0	20
Clay Fill	15	5	18
Clayey Sand with Gravel	35	0	17.5

TABLE 2
SUMMARY OF TWO DIMENSIONAL FACTORS OF SAFETY
SECTION C (AREA 1)

CASE	DESIGN CONDITION	POTENTIAL SLIP SURFACE (1)	RIVER LEVEL (2)	GROUNDWATER LEVEL (m) (3)	NO GRANULAR DETAIL		WITH GRANULAR DETAIL	
					ESTIMATED FACTOR OF SAFETY	CHANGE (%)	ESTIMATED FACTOR OF SAFETY	CHANGE (%)
Back Analysis Existing Bank	Normal	SS1 (Global)	RSRL	Normal	1.36	-	1.38	-
		SS2 (Upper)	RSRL	Normal	1.12	-	1.34	-
		SS3 (Lower)	RSRL	Normal	1.57	-	1.57	-
		SS4 (Midbank)	RSRL	Normal	1.19	-	1.19	-
		SS5 (Block)	RSRL	Normal	1.21	-	1.22	-
	Extreme	SS1	UWRL	Fully Saturated	1.13	-	1.17	-
		SS2	UWRL	Fully Saturated	<1 (0.73)	-	<1 (0.92)	-
		SS3	UWRL	Fully Saturated	1.43	-	1.43	-
		SS4	UWRL	Fully Saturated	1.14	-	1.14	-
		SS5	UWRL	Fully Saturated	1.00	-	1.01	-
Riprap Top-Up + 2 m Effective Width Rockfill Column at 25 m Offset	Normal	SS1	RSRL	Normal	1.71	26%	1.73	26%
		SS2	RSRL	Normal	1.12	0%	1.34	0%
		SS3	RSRL	Normal	1.66	6%	1.66	6%
		SS4	RSRL	Normal	1.43	21%	1.43	21%
		SS5	RSRL	Normal	1.48	22%	1.49	23%
	Extreme	SS1	UWRL	Fully Saturated	1.42	25%	1.48	27%
		SS2	UWRL	Fully Saturated	<1 (0.73)	0%	<1 (0.92)	0%
		SS3	UWRL	Fully Saturated	1.59	11%	1.59	11%
		SS4	UWRL	Fully Saturated	1.38	21%	1.39	22%
		SS5	UWRL	Fully Saturated	1.23	23%	1.26	25%
Riprap Top-Up + 1 m Deep Tree Root System in Mid Bank	Normal	SS1	RSRL	Normal	1.43	6%	1.46	6%
		SS2	RSRL	Normal	1.12	0%	1.34	0%
		SS3	RSRL	Normal	1.86	19%	1.86	19%
		SS4	RSRL	Normal	1.59	34%	1.59	34%
		SS5	RSRL	Normal	1.27	5%	1.28	5%
	Extreme	SS1	UWRL	Fully Saturated	1.19	5%	1.22	5%
		SS2	UWRL	Fully Saturated	<1 (0.73)	0%	<1 (0.92)	0%
		SS3	UWRL	Fully Saturated	1.73	21%	1.73	21%
		SS4	UWRL	Fully Saturated	1.55	37%	1.55	37%
		SS5	UWRL	Fully Saturated	1.06	5%	1.06	5%
Riprap Top-Up + Sheetpile + 2 m Effective Width Rockfill Column at 25 m Offset	Normal	SS1	RSRL	Normal	2.40	76%	2.42	75%
		SS2	RSRL	Normal	2.93	162%	3.42	155%
		SS3	RSRL	Normal	1.66	6%	1.66	6%
		SS4	RSRL	Normal	1.43	21%	1.43	21%
		SS5	RSRL	Normal	N/A	-	N/A	-
	Extreme	SS1	UWRL	Fully Saturated	1.91	68%	1.92	65%
		SS2	UWRL	Fully Saturated	2.35	220%	3.23	251%
		SS3	UWRL	Fully Saturated	1.59	11%	1.59	11%
		SS4	UWRL	Fully Saturated	1.39	22%	1.39	22%
		SS5	UWRL	Fully Saturated	N/A	-	N/A	-

Notes:

1. SS1 = Global Slip (enter at/near crest of bank*, exit at/near toe of bank or within rockfill column near toe)
   SS2 = Upper Bank Slip (enter at/near crest of bank*, exit within midslope)
   SS3 = Lower Bank Slip (enter within midslope, exit at/near toe of bank)
   SS4 = Midbank Slip (enter and exit within midslope)
   SS5 = Critical Global or Upper Bank Block Slip**
   *With the sheetpile, global and upper bank slips were taken as entering in the upper bank area (upslope of TH14-02)
   **Block slips not valid with a sheetpile

2. UWRL - Unregulated Winter River Level (El. 222.0 m)
   RSRL - Regulated Summer River Level (El. 223.7 m)

3. Normal Groundwater Level = El. 226.0 m
   Fully Saturated Groundwater Level = Groundwater level at ground surface

4. Grey highlight = Factor of Safety does not meet criteria (1.5 normal condition / 1.2 extreme condition)

TABLE 3
SUMMARY OF TWO DIMENSIONAL FACTORS OF SAFETY
SECTION A (AREA 2)

CASE	DESIGN CONDITION	POTENTIAL SLIP SURFACE (1)	RIVER LEVEL (2)	GROUNDWATER LEVEL (m) (3)	ESTIMATED FACTOR OF SAFETY	CHANGE (%)
Back Analysis Existing Bank	Normal	SS1 (Global)	RSRL	Normal	≈1 (0.99)	-
		SS2 (Upper)	RSRL	Normal	1.06	-
		SS3 (Lower)	RSRL	Normal	1.04	-
		SS4 (Midbank)	RSRL	Normal	1.05	-
	Extreme	SS1	UWRL	Fully Saturated	<1 (0.73)	-
		SS2	UWRL	Fully Saturated	<1 (0.76)	-
		SS3	UWRL	Fully Saturated	<1 (0.76)	-
		SS4	UWRL	Fully Saturated	<1 (0.75)	-
4.5H:1V Riprap + 3 m Effective Width Rockfill Column at 44 m Offset	Normal	SS1	RSRL	Normal	1.36	37%
		SS2	RSRL	Normal	1.21	14%
		SS3	RSRL	Normal	1.48	42%
		SS4	RSRL	Normal	1.28	22%
	Extreme	SS1	UWRL	Fully Saturated	1.04	43%
		SS2	UWRL	Fully Saturated	<1 (0.90)	19%
		SS3	UWRL	Fully Saturated	1.17	55%
		SS4	UWRL	Fully Saturated	≈1 (0.98)	30%
4.5H:1V Riprap + 3 m Eff. Width Rockfill Column at 44 m Offset + 2 m Eff. Width Rockfill Column at 28 m Offset	Normal	SS1	RSRL	Normal	1.58	59%
		SS2	RSRL	Normal	1.53	45%
		SS3	RSRL	Normal	1.71	65%
		SS4	RSRL	Normal	1.56	48%
	Extreme	SS1	UWRL	Fully Saturated	1.21	65%
		SS2	UWRL	Fully Saturated	1.16	53%
		SS3	UWRL	Fully Saturated	1.32	75%
		SS4	UWRL	Fully Saturated	1.29	72%
4.5H:1V Riprap + 3 m Eff. Width Rockfill Column at 44 m Offset + 2 m Eff. Width Rockfill Column at 28 m Offset + Sheetpile	Normal	SS1	RSRL	Normal	1.68	69%
		SS2	RSRL	Normal	1.64	55%
		SS3	RSRL	Normal	1.74	67%
		SS4	RSRL	Normal	1.56	49%
	Extreme	SS1	UWRL	Fully Saturated	1.30	77%
		SS2	UWRL	Fully Saturated	1.20	58%
		SS3	UWRL	Fully Saturated	1.33	76%
		SS4	UWRL	Fully Saturated	1.29	71%

Notes:

1. SS1 = Global Slip (enter at/near crest of bank, exit at/near toe of bank) *
   SS2 = Upper Bank Slip (enter at/near crest of bank, exit within midslope) *
   SS3 = Lower Bank Slip (enter within midslope, exit at/near toe of bank)
   SS4 = Midbank Slip (enter and exit within midslope)
   * With sheetpile, global and upper bank slip were taken entering in upper slope between sheetpile and TH14-03

2. UWRL - Unregulated Winter River Level (El. 222.0 m)
   RSRL - Regulated Summer River Level (El. 223.7 m)

3. Normal Groundwater Level = El. 226.0 m in the upper bank and El. 225.0 m in the lower bank
   Fully Saturated Groundwater Level = Groundwater level at ground surface

4. Grey highlight = Factor of Safety does not meet criteria (1.5 normal condition / 1.2 extreme condition)

TABLE 4
LIMIT STATE DESIGN END BEARING VALUES FOR CAST-IN-PLACE CONCRETE PILES UNDER COMPRESSIVE LOADING

DEPTH BELOW GRADE	SERVICEABILITY LIMIT STATE (SLS) VALUE (kPa)	ULTIMATE LIMIT STATE (ULS) VALUE (kPa)
End Bearing on Competent Silt Till	720	900

TABLE 5
FUNCTIONAL LEVEL CONSTRUCTION COST ESTIMATE

ITEM	DESCRIPTION	UNIT	APPROXIMATE QUANTITY	UNIT PRICE	AMOUNT
Riverbank Stabilization - Area 1 (Protects Approximately 135 L.m. of Riverbank to Est. FS of 1.5)					
Section with existing lower bank rockfill columns and riprap blanket					
1	Mobilization and Demobilization	Lump Sum	1	$100,000	$100,000
2	Installation of Silt Fence	L.m.	140	$25	$3,500
3	Tree Removal				
	i) 50 mm to 250 mm Diameter	Each	24	$400	$9,600
	ii) Greater than 250 mm to 500 mm Diameter	Each	5	$600	$3,000
	iii) Greater than 500 mm Diameter	Each	1	$1,200	$1,200
4	Riprap	Tonne	3,500	$45	$157,500
5	2 m Effective Width Mid Bank Rockfill Columns (R.C.) - 2 Rows of 40 R.C. per Row (2.13 m Diameter):				
	i) Shaft Drilling	L.m.	940	$500	$470,000
	ii) Rockfill Backfill	Tonne	6,725	$50	$336,250
	iii) Sleeving	Each	80	$1,000	$80,000
6	Bank Regrading for Positive Overland Drainage	Lump Sum	1	$10,000	$10,000
7	Revegetation (Topsoil and Seeding)	m^2	2,175	$20	$43,500
8	Tree Planting Allowance	Lump Sum	1	$30,000	$30,000
Sub-Total - Riverbank Stabilization - Area 1 (Excluding Taxes)					$1,244,550
Riverbank Stabilization - Area 2 (Protects Approximately 60 L.m. of Riverbank to Est. FS of 1.5)					
Section with no existing rockfill columns or riprap					
9	Mobilization and Demobilization	Lump Sum	1	$100,000	$100,000
10	Installation of Silt Fence	L.m.	60	$25	$1,500
11	Tree Removal				
	i) 50 mm to 250 mm Diameter	Each	5	$400	$2,000
	ii) Greater than 250 mm to 500 mm Diameter	Each	4	$600	$2,400
	iii) Greater than 500 mm Diameter	Each	1	$1,200	$1,200
12	Riprap	Tonne	2,200	$45	$99,000
13	3 m Effective Width Lower Bank Rockfill Columns (R.C.) - 2 Rows of 12 R.C. per Row (3.05 m Diameter):				
	i) Shaft Drilling	L.m.	225	$500	$112,500
	ii) Rockfill Backfill	Tonne	3,280	$50	$164,000
	iii) Sleeving	Each	24	$1,000	$24,000
14	2 m Effective Width Mid Bank Rockfill Columns (R.C.) - 1 Row of 18 R.C., 1 Row of 17 R.C. (2.13 m Diameter):				
	i) Shaft Drilling	L.m.	445	$500	$222,500
	ii) Rockfill Backfill	Tonne	3,175	$50	$158,750
	iii) Sleeving	Each	35	$1,000	$35,000
15	Bank Regrading for Positive Overland Drainage	Lump Sum	1	$5,000	$5,000
16	Revegetation (Topsoil and Seeding)	m^2	950	$20	$19,000
17	Tree Planting Allowance	Lump Sum	1	$10,000	$10,000
Sub-Total - Riverbank Stabilization - Area 2 (Excluding Taxes)					$956,850

TABLE 5
FUNCTIONAL LEVEL CONSTRUCTION COST ESTIMATE
(CONTINUED)

ITEM	DESCRIPTION	UNIT	APPROXIMATE QUANTITY	UNIT PRICE	AMOUNT
Tree Top Lookout (Approximately 100 L.m. Long Structure)					
Including "Guiding Light" sculpture					
18	Mobilization and Demobilization	Lump Sum	1	$50,000	$50,000
19	Tree Removal				
	i) 50 mm to 250 mm Diameter	Each	17	$400	$6,800
	ii) Greater than 250 mm to 500 mm Diameter	Each	5	$600	$3,000
	iii) Greater than 500 mm Diameter	Each	1	$1,200	$1,200
20	Cast-in-Place Reinforced Concrete Pile (Below Grade)				
	i) 36" Diameter	Each	9	$25,600	$230,400
	ii) 30" Diameter	Each	6	$22,200	$133,200
21	Steel Pipe Column (20" Diameter)	Each	15	$5,000	$75,000
22	Riprap Fill (Tree Top Lookout Foundations)	Tonne	65	$45	$2,925
23	Tree Top Lookout Structure				
	i) Walkway Support Frames	Each	15	$5,000	$75,000
	ii) Walkway Channel Framing	Lump Sum	1	$65,000	$65,000
	iii) Decking (Combination of Timber and Pavers or Asphalt)	m^2	360	$375	$135,000
	iv) Anodized Aluminum Hand Rail	L.m.	200	$400	$80,000
24	Revegetation (Topsoil and Seeding)	m^2	610	$20	$12,200
25	Tree Planting Allowance	Lump Sum	1	$23,000	$23,000
26	Architectural Components				
	i) Light Fixtures	Each	6	$14,000	$84,000
	ii) Custom IPE Bench and Interpretive Features Allowance	Lump Sum	1	$25,000	$25,000
	iii) "Guiding Light" Sculpture	Lump Sum	1	$200,000	$200,000
Sub-Total - Tree Top Lookout (Excluding Taxes)					$1,201,725
Sidewalk Expansion (Approximately 184 L.m. of Expanded Sidewalk)					
27	Mobilization and Demobilization	Lump Sum	1	$50,000	$50,000
28	Tree Removal				
	i) 50 mm to 250 mm Diameter	Each	15	$400	$6,000
	ii) Greater than 250 mm to 500 mm Diameter	Each	2	$600	$1,200
	iii) Greater than 500 mm Diameter	Each	1	$1,200	$1,200
29	Utility Relocation	Lump Sum	1	$150,000	$150,000
30	Sheetpile Installation (Founded on Competent Silt Till)	L.m.	184	$6,750	$1,242,000
31	Excavation and Removals				
	i) Earthfill Backfill	m^3	625	$40	$25,000
	ii) Structural Concrete Sidewalk, Beam, Pile Cap and Curb	m^3	175	$100	$17,500
	iii) Paving Stone Sidewalk	m^2	405	$45	$18,225
	iv) Concrete Barrier Curb	L.m.	35	$20	$700
	v) Corrugated Steel Skirting	L.m.	95	$100	$9,500
	vi) Existing Guardrail	L.m.	182	$100	$18,200
32	Subdrain for Sheetpile Wall	L.m.	185	$140	$25,900
33	Sheetpile Granular Backfill	Tonne	2,050	$45	$92,250
34	Sheetpile Concrete "Cap" Beam	L.m.	184	$850	$156,400
35	Active Transportation Pathway				
	i) Non-Woven Geotextile	m^2	1,750	$4	$7,000
	ii) Geogrid	m^2	740	$7	$5,180
	iii) 50 mm Crushed Limestone Sub-Base	Tonne	260	$45	$11,700
	iv) Crushed Limestone Base Course	m^3	40	$130	$5,200
	v) Type 1A Asphalt Pavement	Tonne	135	$200	$27,000
36	Installation of New Integrated Handrail / Guardrail	L.m.	184	$700	$128,800
37	Revegetation (Topsoil and Seeding)	m^2	920	$20	$18,400
38	Tree Planting Allowance	Lump Sum	1	$18,000	$18,000
39	Signage and Wayfinding Allowance	Lump Sum	1	$35,000	$35,000
Sub-Total - Sidewalk Expansion (Excluding Taxes)					$2,070,355
Sub-Total - Riverbank Stabilization - Area 1 with Existing Bank Works (Excluding Taxes)					$1,244,550
Sub-Total - Riverbank Stabilization - Area 2 with No Existing Bank Works (Excluding Taxes)					$956,850
Sub-Total - Tree Top Lookout (Excluding Taxes)					$1,201,725
Sub-Total - Sidewalk Expansion (Excluding Taxes)					$2,070,355
Sub-Total - Construction Cost (Excluding Taxes)					$5,473,480
Contingency at 25%					$1,368,370
TOTAL ESTIMATED CONSTRUCTION COST (EXCLUDING TAXES)					**$6,841,850**

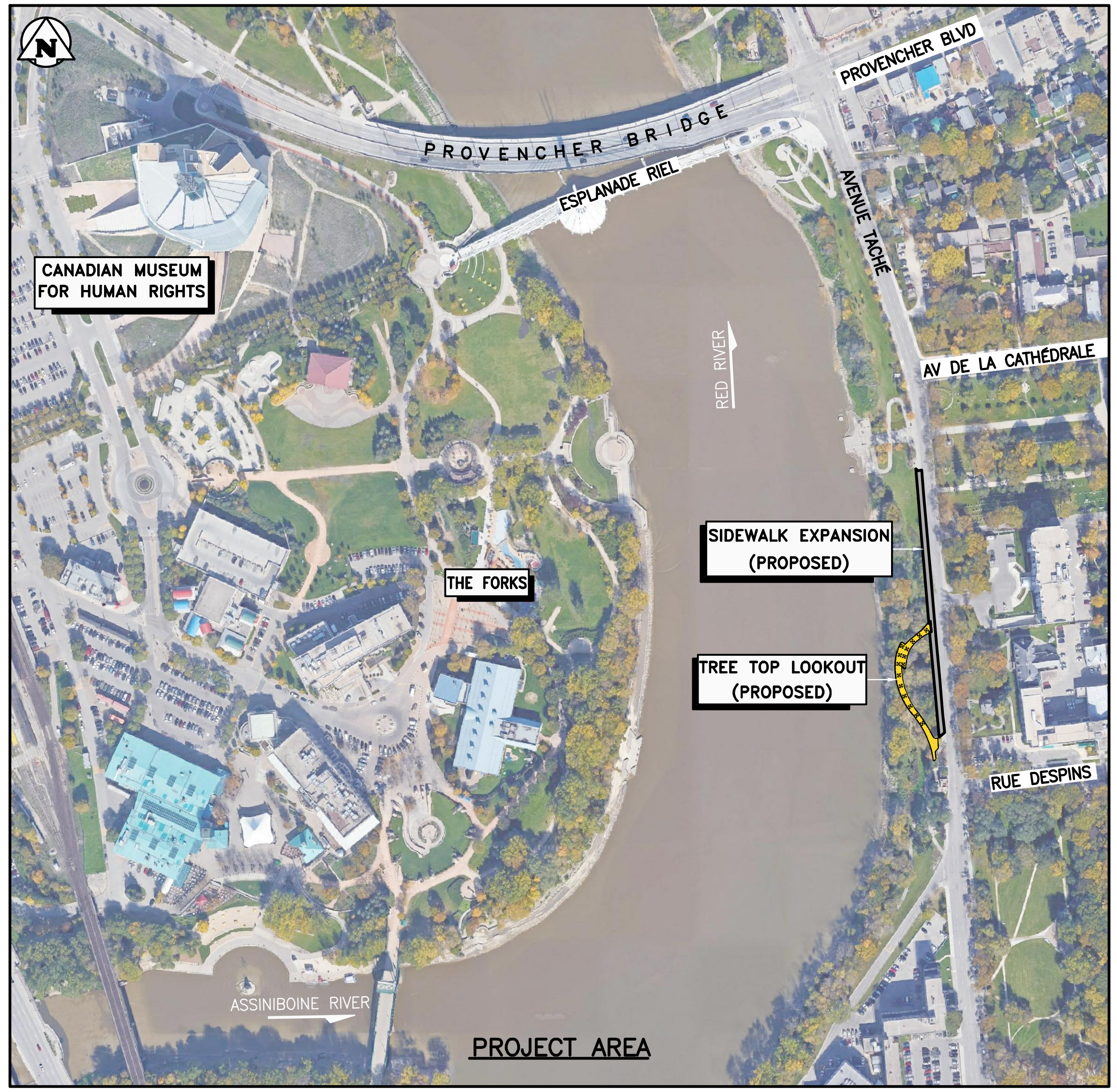
DRAWINGS

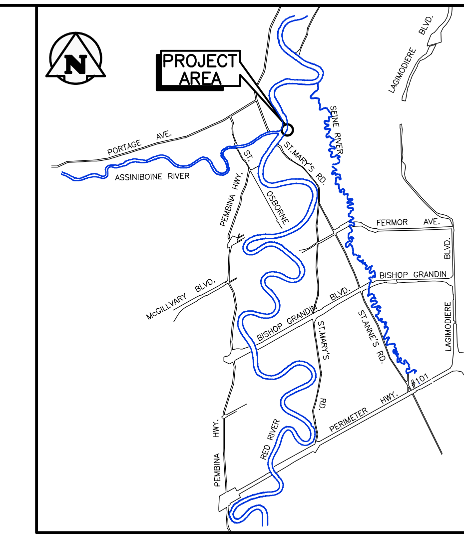
CITY OF WINNIPEG

ST. BONIFACE RIVERTRAIL

TREE TOP LOOKOUT AND SIDEWALK EXPANSION

ST. BONIFACE, WINNIPEG, MB





KEY MAP

LIST OF DRAWINGS:

DRAWING NO. **DRAWING TITLE:**

GEOTECHNICAL

DRAWING NO.	DRAWING TITLE
15-0107-008_G01.DWG	COVER SHEET AND LIST OF DRAWINGS
15-0107-008_G02.DWG	EXISTING SITE CONDITIONS (2015)
15-0107-008_G03.DWG	WORKS PLAN
15-0107-008_G04.DWG	WORKS SECTIONS
15-0107-008_G05.DWG	DETAILS

STRUCTURAL

DRAWING NO.	DRAWING TITLE
15-0107-008_S01.DWG	STRUCTURAL PLAN, SECTIONS AND DETAILS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK
0	16/01/26	ISSUED WITH FINAL REPORT	GCB	BPA

REVISIONS / ISSUE

CLIENT: Winnipeg

PROJECT:
ST. BONIFACE RIVERTRAIL
TREE TOP LOOKOUT AND SIDEWALK EXPANSION
ST. BONIFACE, WINNIPEG, MB

DWG. DESCRIPTION:
COVER SHEET AND LIST OF DRAWINGS

AUTHENTICATION FOR CURRENT REVISION

ENG. STAMP

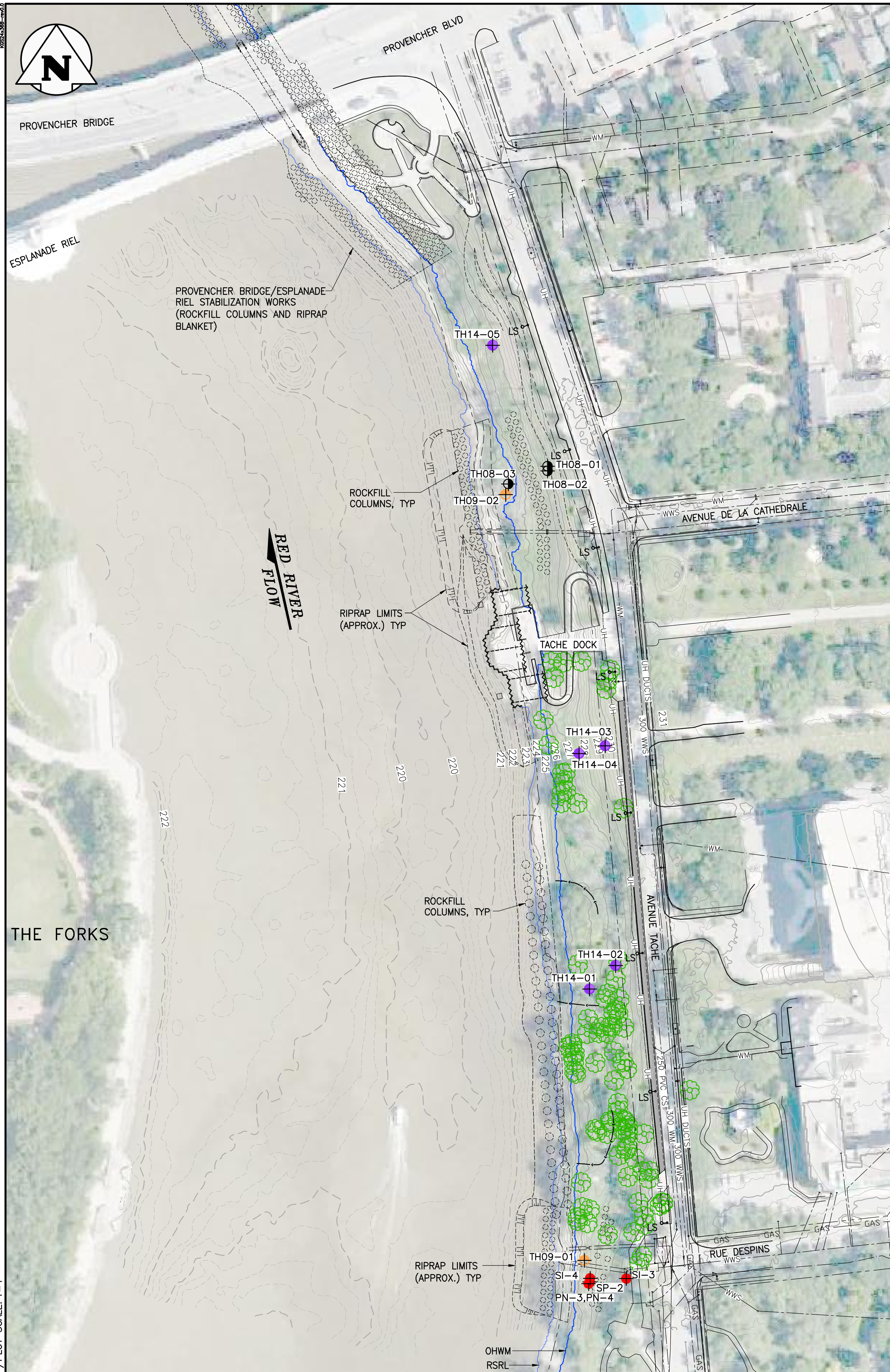
APEGM
Certificate of Authorization
KGS Group
No. 245

KGS GROUP
CONSULTING ENGINEERS

DESIGN BY:	GCB	DATE (YY/MM/DD):	15/07/22
DESIGN CHECK:	BPA	DATE:	16/01/26
DRAWN BY:	ESm	DATE:	15/07/22
DWG CHECK:	js	DATE:	16/01/26

DWG. NO.: 15-0107-008 G01 REV: 0

FileName: \\k-file-4\p-data\Projects\2015\15-0107-008\Dwg\Geo\15-0107-008_G01.dwg - Tab: G01 Plotted By: rmeilleur 16/01/27 [Wed 2:28pm]
24"x36"/PLOT SCALE: 1=1



GENERAL PLAN
SCALE: 1:1000 (24"x36")

DETAILED PLAN
SCALE: 1:500 (24"x36")

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

LEGEND:

231	GROUND CONTOURS (IN METRES)
220	BATHYMETRY CONTOURS (IN METRES)
RSRL	REGULATED SUMMER RIVER LEVEL (EL 223.75m)
OHWM	ORDINARY HIGH WATER MARK (EL 225.50m)
	PROPERTY LIMITS
WM	WATER MAIN
WWS	SEWER LINE
GAS	GAS LINE
UH	UNDERGROUND HYDRO LINE
	EXISTING SHEET PILING WITH UNDERGROUND TIE RODS (DILLON, 1983)
	EXISTING TREES
LS	EXISTING LIGHT STANDARD
	EXISTING SWALE
SI-3	TEST HOLE (KGS GROUP, 2004)
TH08-01	TEST HOLE (KGS GROUP, 2008)
TH09-01	TEST HOLE (KGS GROUP, 2009)
TH14-01	TEST HOLE (KGS GROUP, 2014)

REFERENCES:

08-0107-12_01 TO 09	KGS GROUP DRAWINGS (CITY OF WINNIPEG LD-5238 TO LD-5246)
9177-02 D-1 TO D-3	DILLON DRAWINGS
99-6738-02 SHTS. 1-8 (1540-99)	DILLON RECORD DRAWINGS
4084-003-01 DWG. S-1 S-2, A-1, A-2 AND A-4	UMA DRAWINGS

PROPERTY LIMITS DELINEATION

DELINEATION OF PROPERTY LIMITS AS SHOWN ON THIS DRAWING DOES NOT REPRESENT A "LEGAL SURVEY". KGS GROUP MAKES NO REPRESENTATION OR WARRANTY AS TO THE ACCURACY OF PROPERTY LIMITS DELINEATED ON THIS DRAWING, NOR ON THE DIMENSIONAL ACCURACY OF DRAWING FEATURES RELATIVE TO THOSE PROPERTY LIMITS.

UTILITIES/UNDERGROUND STRUCTURES

LOCATION OF UNDERGROUND STRUCTURES AS SHOWN ARE BASED ON THE BEST INFORMATION AVAILABLE BUT NO GUARANTEE IS GIVEN THAT ALL EXISTING UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL SERVICES MUST BE OBTAINED BY THE CONTRACTOR FROM THE INDIVIDUAL UTILITIES BEFORE PROCEEDING WITH CONSTRUCTION.

25 0 25 50 75m
SCALE: 1:1000 METRIC 24"x36"
1:2000 METRIC 11"x17"

10 0 10 20 30 40m
SCALE: 1:500 METRIC 24"x36"
1:1000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK
0	16/01/26	ISSUED WITH FINAL REPORT	GCB	BPA

REVISIONS / ISSUE

CLIENT: Winnipeg

PROJECT:
ST. BONIFACE RIVERTRAIL
TREE TOP LOOKOUT AND SIDEWALK EXPANSION
ST. BONIFACE, WINNIPEG, MB

DWG. DESCRIPTION:
EXISTING SITE CONDITIONS (2015)

AUTHENTICATION FOR CURRENT REVISION

ENG. STAMP

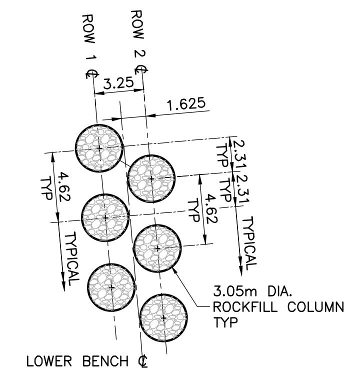
APEGM
Certificate of Authorization
KGS Group
No. 245

KGS GROUP CONSULTING ENGINEERS

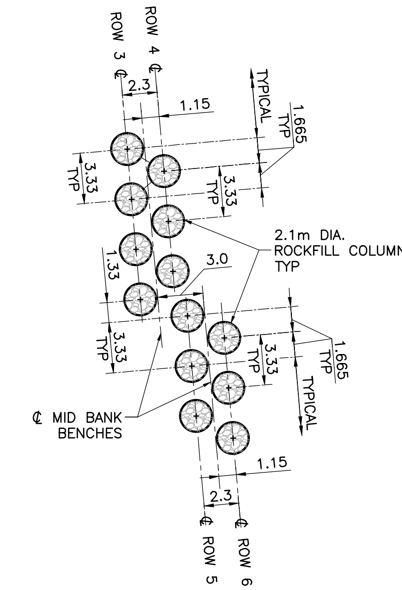
DESIGN BY: GCB	DATE (YY/MM/DD): 15/07/22
DESIGN CHECK: BPA	DATE: 16/01/26
DRAWN BY: PEC	DATE: 15/07/22
DWG CHECK: JS	DATE: 16/01/26

DWG. NO. 15-0107-008 G02 REV: 0

FileName: \\k-file-4\p-data\Projects\2015\15-0107-008\Dwg\Geo\15-0107-008_G02.dwg – Tab: G02 Plotted By: rmeilleur 16/01/27 [Wed 2:28pm]
24"x36"/PLOT SCALE 1=1



1 LOWER BANK ROCKFILL COLUMN DETAILS
SCALE: 1:500 (24x36)



2 MID BANK ROCKFILL COLUMN DETAILS
SCALE: 1:500 (24x36)

LEGEND:

- 231 GROUND CONTOURS (IN METRES)
- 220 BATHYMETRY CONTOURS (IN METRES)
- RSRL REGULATED SUMMER RIVER LEVEL (EL 223.75m)
- OHWM ORDINARY HIGH WATER MARK (EL 225.50m)
- UWRL UNREGULATED WINTER RIVER LEVEL (EL 222.0m)
- PROPERTY LIMITS
- WM WATER MAIN
- WWS SEWER LINE
- GAS GAS LINE
- UH UNDERGROUND HYDRO LINE
- EXISTING SHEET PILING WITH UNDERGROUND TIE RODS (DILLON, 1983)
- EXISTING TREES
- LS EXISTING LIGHT STANDARD
- EXISTING ROCKFILL COLUMNS
- NEW ROCKFILL COLUMNS
- SI-3 TEST HOLE (KGS GROUP, 2004)
- TH08-01 TEST HOLE (KGS GROUP, 2008)
- TH09-01 TEST HOLE (KGS GROUP, 2009)
- TH14-01 TEST HOLE (KGS GROUP, 2014)

NOTES:

1. ROCKFILL COLUMNS TO BE COORDINATED WITH TREE TOP LOOKOUT FOUNDATIONS IN OVERLAPPING AREAS. MINOR MODIFICATIONS TO ROCKFILL COLUMN POSITIONS MAY BE REQUIRED TO ACCOMMODATE FOUNDATION ELEMENTS.
2. RIPRAP (MINIMUM 0.6m THICK) TO SLOPE DOWN AT 4.5H:1V FROM EL 225.0m CONTROL LINE SHOWN IN THIS AREA.

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

5 0 5 10 15 20m
SCALE: 1:250 METRIC 24"x36"
1:500 METRIC 11"x17"

10 0 10 20 30 40m
SCALE: 1:500 METRIC 24"x36"
1:1000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK
0	16/01/26	ISSUED WITH FINAL REPORT	GCB	BPA

REVISIONS / ISSUE

CLIENT: Winnipeg

PROJECT:
ST. BONIFACE RIVERTRAIL
TREE TOP LOOKOUT AND SIDEWALK EXPANSION
ST. BONIFACE, WINNIPEG, MB

DWG. DESCRIPTION:
WORKS PLAN

AUTHENTICATION FOR CURRENT REVISION
ENG. STAMP

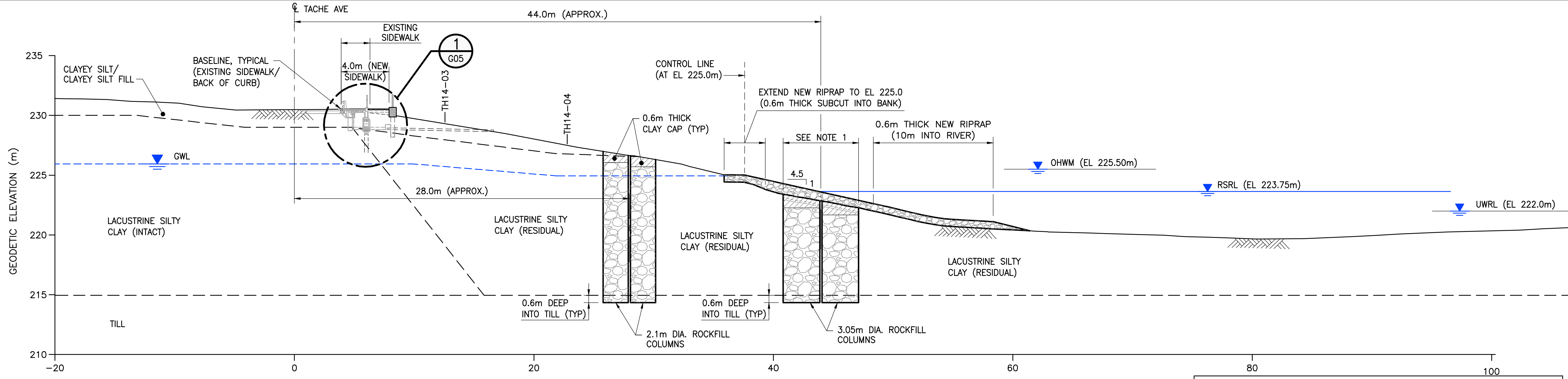
APEGM
Certificate of Authorization
KGS Group
No. 245

KGS GROUP CONSULTING ENGINEERS

DESIGN BY:	GCB	DATE (YY/MM/DD):	15/07/22
DESIGN CHECK:	BPA	DATE:	16/01/26
DRAWN BY:	ESm	DATE:	15/07/22
DWG CHECK:	jS	DATE:	16/01/26

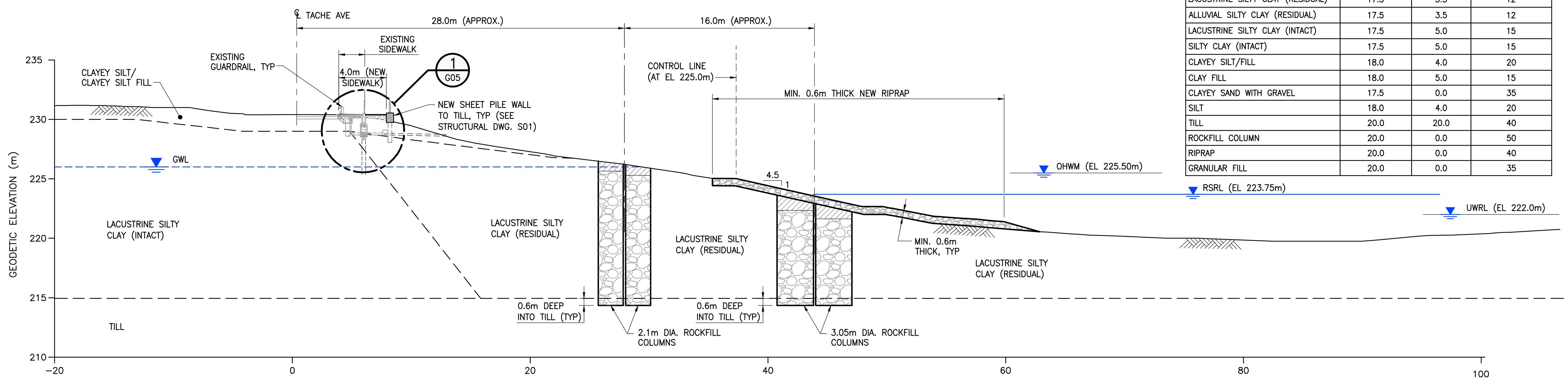
DWG. NO. 15-0107-008 G03 REV: 0

FileName: \\k-file-4\p-data\Projects\2015\15-0107-008\Dwg\Geo\15-0107-008_G03.dwg - Tab: G03 Plotted By: rmeilleur 16/01/27 [Wed 2:29pm]
24"x36"/PLOT SCALE 1=1

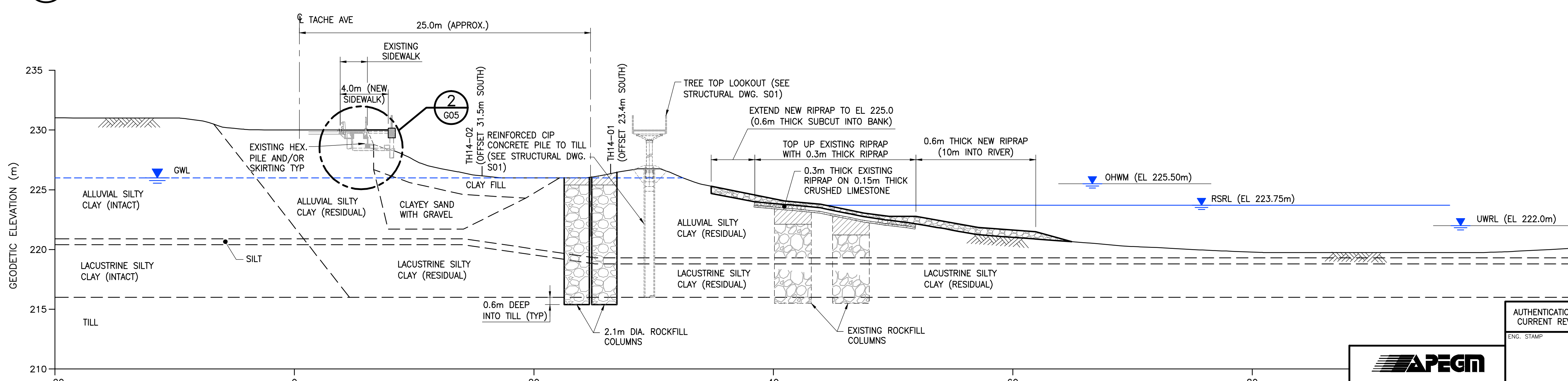


A SECTION
G03
SCALE: 1:200 (24"x36")

MATERIAL PROPERTIES			
NAME	UNIT WEIGHT (kN/m³)	COHESION (kPa)	PHI (DEGREE "°")
LACUSTRINE SILTY CLAY (RESIDUAL)	17.5	3.5	12
ALLUVIAL SILTY CLAY (RESIDUAL)	17.5	3.5	12
LACUSTRINE SILTY CLAY (INTACT)	17.5	5.0	15
SILTY CLAY (INTACT)	17.5	5.0	15
CLAYEY SILT/FILL	18.0	4.0	20
CLAY FILL	18.0	5.0	15
CLAYEY SAND WITH GRAVEL	17.5	0.0	35
SILT	18.0	4.0	20
TILL	20.0	20.0	40
ROCKFILL COLUMN	20.0	0.0	50
RIPRAP	20.0	0.0	40
GRANULAR FILL	20.0	0.0	35



B SECTION
G03
SCALE: 1:200 (24"x36")



C SECTION
G03
SCALE: 1:200 (24"x36")

LEGEND:

RSRL	REGULATED SUMMER RIVER LEVEL (EL 223.75m)
OHWM	ORDINARY HIGH WATER MARK (EL 225.50m)
UWRL	UNREGULATED WINTER RIVER LEVEL (EL 222.0m)

NOTES:

1. AREA OF EXISTING RIPRAP SHALL BE REMOVED WHERE NEW ROCKFILL COLUMNS ARE TO BE CONSTRUCTED. THESE AREAS SHALL BE RE-BUILT WITH MINIMUM 0.6m THICK NEW RIPRAP ONCE ROCKFILL COLUMNS ARE COMPLETED.

REFERENCES:

99-6738-02 SHTS. 1-8 DILLON RECORD DRAWINGS (1540-99)

4084-003-01 DWG. S-1 UMA DRAWINGS S-2, A-1 AND A-2

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

5 0 5 10 15m
SCALE: 1:200 METRIC 24"x36"
1:400 METRIC 11"x17"

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ST. BONIFACE RIVERTRAIL
TREE TOP LOOKOUT AND SIDEWALK EXPANSION
ST. BONIFACE, WINNIPEG, MB

DWG. DESCRIPTION:
WORKS SECTIONS

AUTHORIZATION FOR CURRENT REVISION
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KGS Group
No. 245

KGS GROUP CONSULTING ENGINEERS

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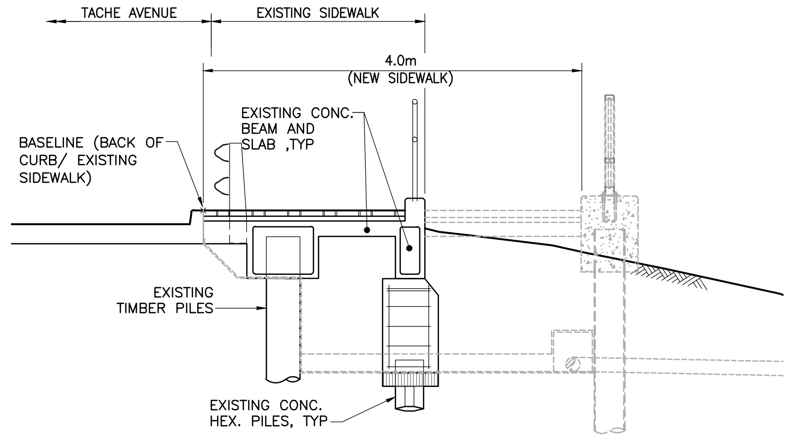
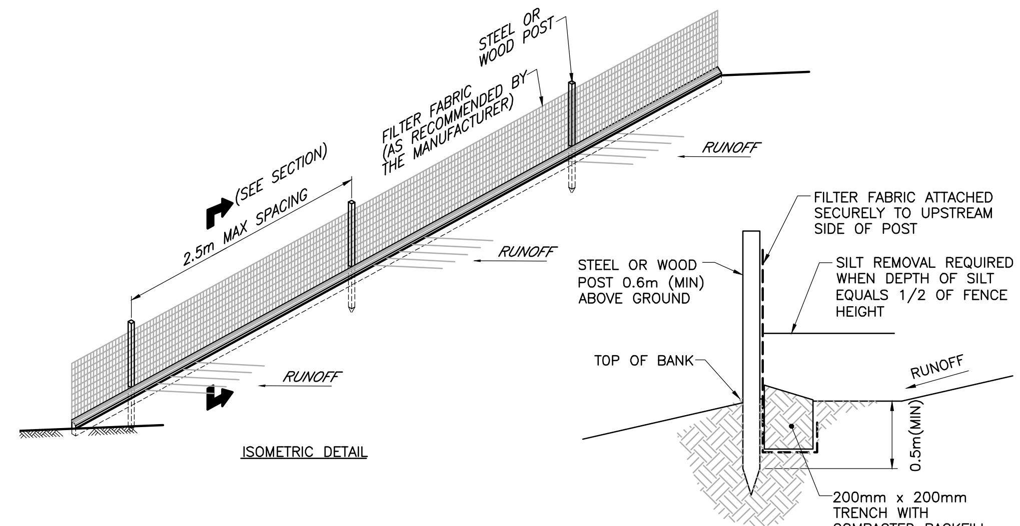
DESIGN CHECK:	BPA	DATE:	16/01/26
DRAWN BY:	ESm	DATE:	15/07/28
DWG CHECK:	jS	DATE:	16/01/26

DWG. NO. 15-0107-008 G04
REV. 0

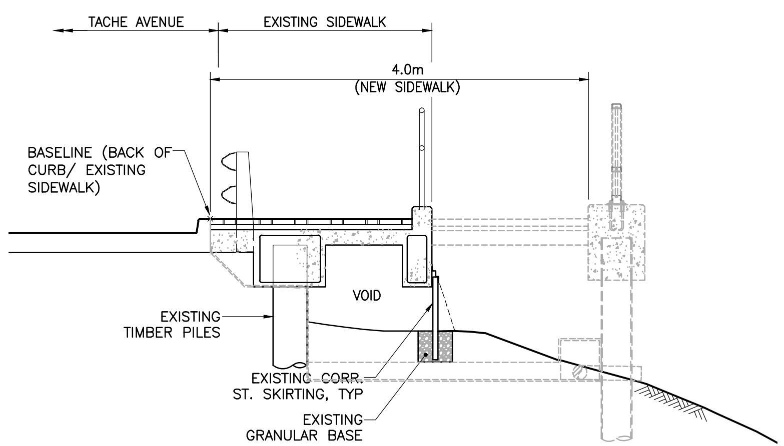
FileName: \\k-file-4\p-data\Projects\2015\15-0107-008\Dwg\Geo\15-0107-008_G04.dwg - Tab: G04 Plotted By: rmeilleur 16/01/27 [Wed 2:30pm]
24"x36"/PLOT SCALE: 1=1



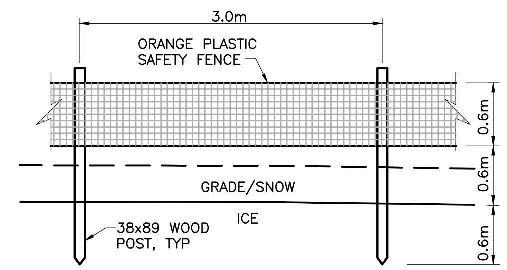
1 G04 TYPICAL EXISTING NONE SKIRTED SIDEWALK DETAIL
SCALE: 1:40 (24"x36")



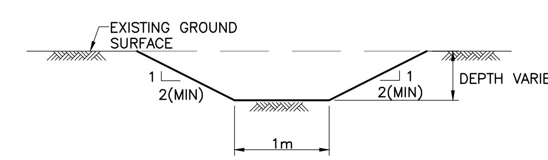
SILT FENCE DETAIL
NTS



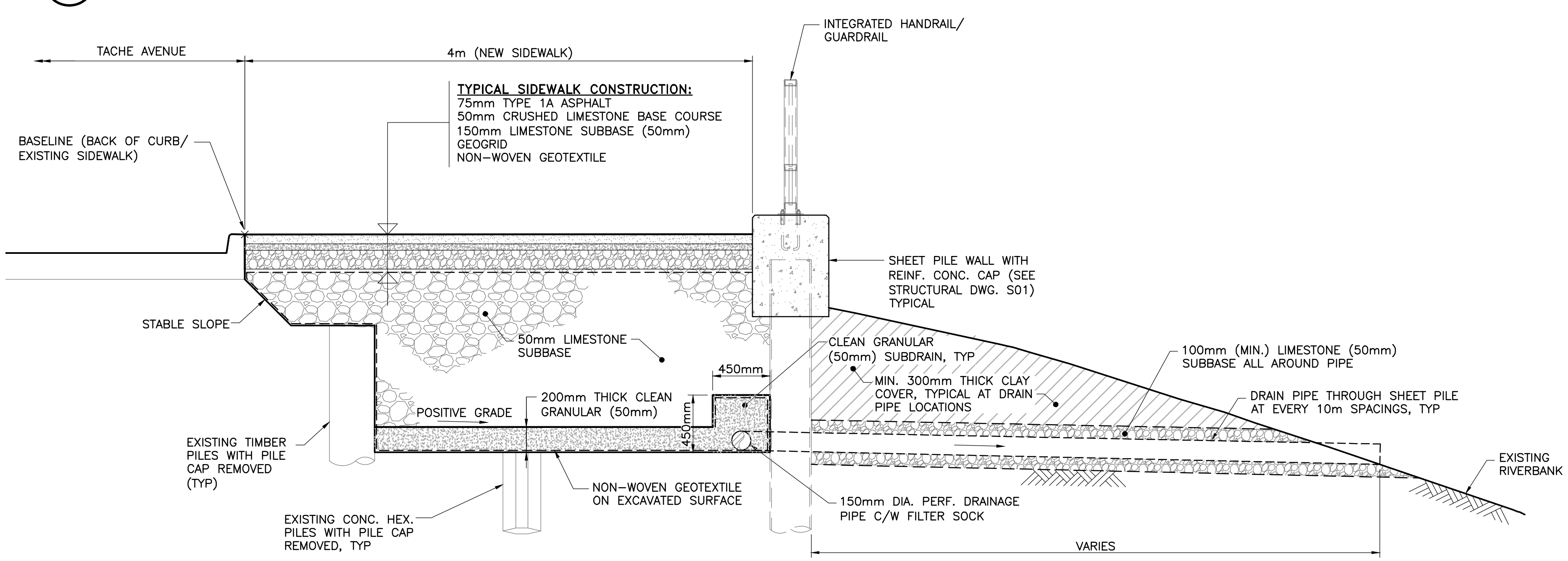
2 G04 TYPICAL EXISTING SKIRTED SIDEWALK DETAIL
SCALE: 1:40 (24"x36")



SAFETY AND ICE FENCE DETAIL
NTS



DRAINAGE SWALE DETAIL
N.T.S.



3 – TYPICAL NEW SIDEWALK CONSTRUCTION
SCALE: 1:25 (24"x36")

REFERENCES:

99-6738-02 SHTS. 1-8 DILLON RECORD DRAWINGS (1540-99)

4084-003-01 DWG. S-1 UMA DRAWINGS S-2, A-1 AND A-2

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

1 0 1 2 3m
SCALE: 1:40 METRIC 24"x36"
1:80 METRIC 11"x17"

.5 0 .5 1 1.5 2m
SCALE: 1:25 METRIC 24"x36"
1:50 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK
0	16/01/26	ISSUED WITH FINAL REPORT	GCB	BPA

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ST. BONIFACE RIVERTRAIL
TREE TOP LOOKOUT AND SIDEWALK EXPANSION
ST. BONIFACE, WINNIPEG, MB

DWG. DESCRIPTION:
DETAILS

AUTHENTICATION FOR CURRENT REVISION
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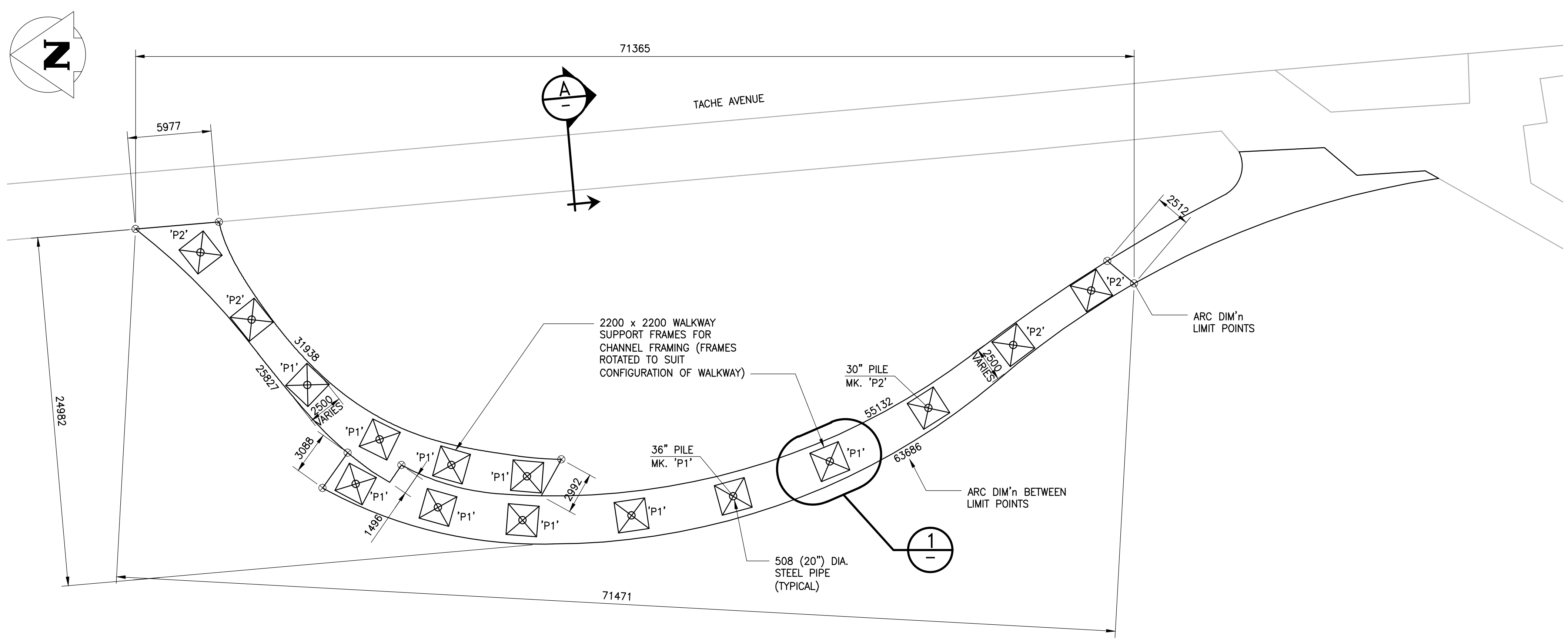
KGS Group
No. 245

KGS GROUP CONSULTING ENGINEERS

DESIGN BY:	GCB	DATE (YY/MM/DD):	15/07/22
DESIGN CHECK:	BPA	DATE:	16/01/26
DRAWN BY:	PEC/ESm	DATE:	15/07/22
DWG CHECK:	jS	DATE:	16/01/26

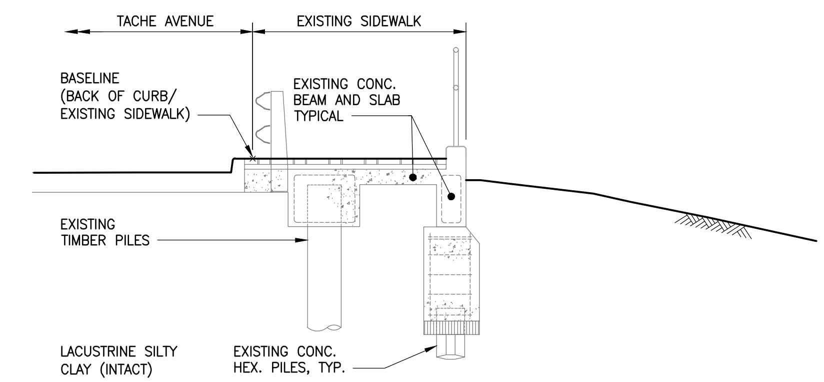
DWG. NO. 15-0107-008 G05 REV: 0

FileName: \\k-file-4\p-data\Projects\2015\15-0107-008\Dwg\Geo\15-0107-008_G05.dwg - Tab: G05 Plotted By: rmeilleur 16/01/27 [Wed 2:30pm]
24"x36"/PLOT SCALE: 1=1



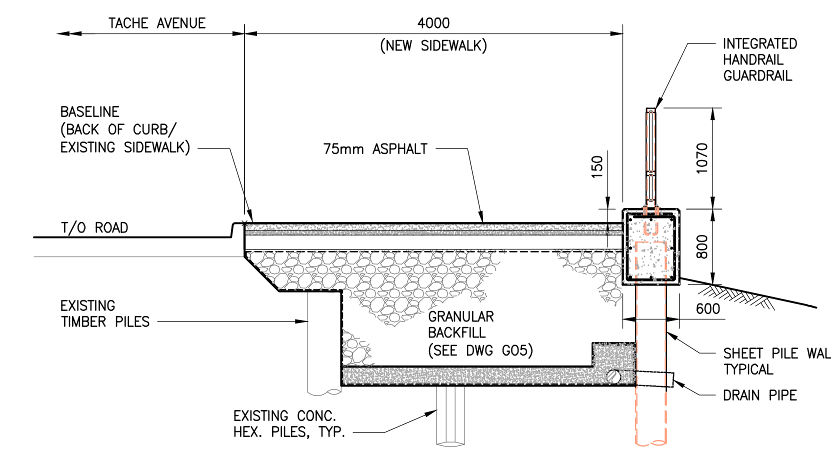
PLAN – TREE-TOP WALKWAY

SCALE: 1:200 (24x36)
1:400 (11x17)



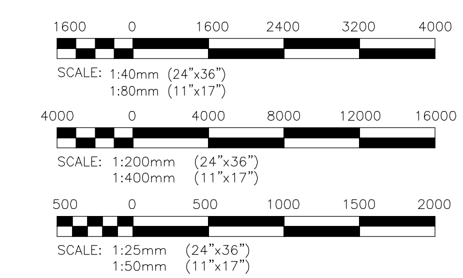
A – SECTION – EXISTING SIDEWALK

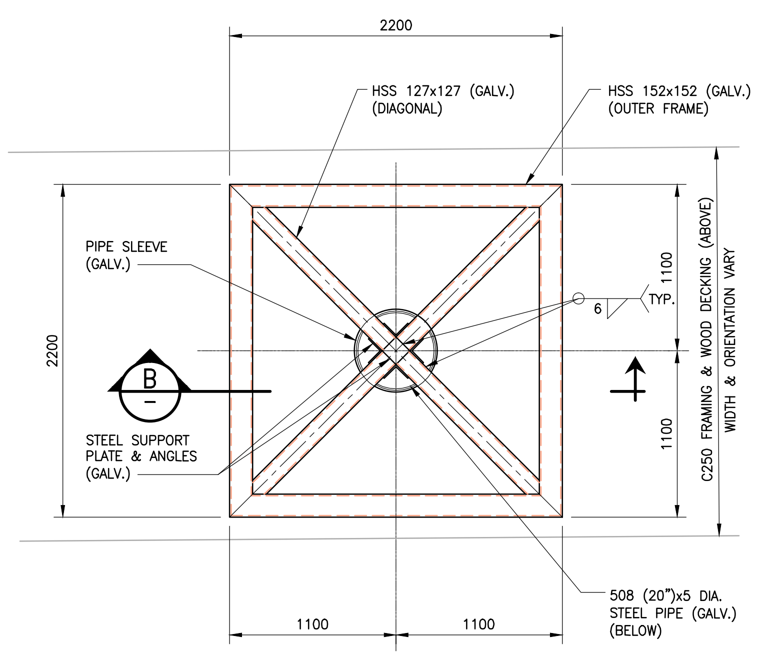
SCALE: 1:40 (24x36)
1:80 (11x17)



A – SECTION – RECONSTRUCTED SIDEWALK

SCALE: 1:40 (24x36)
1:80 (11x17)

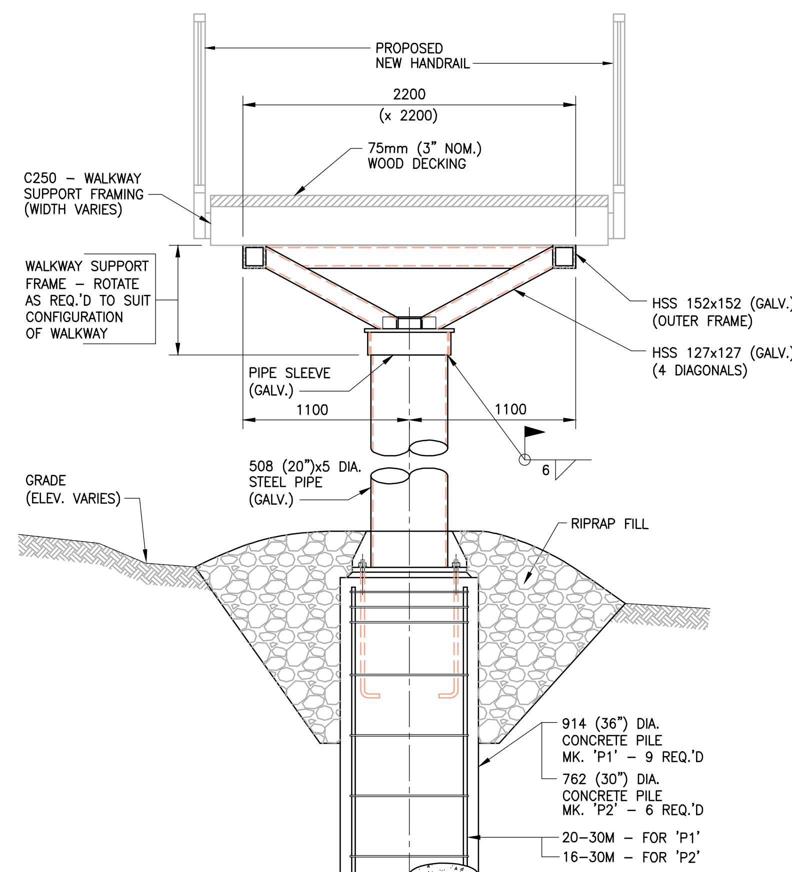




INSTALLATION NOTE:
ROTATE SUPPORT FRAME ON PIPE COLUMN AS REQ.'D TO SUIT CONFIGURATION OF WALKWAY. FIELD WELD PIPE SLEEVE TO COLUMN ONCE DESIRED LOCATION AND ANGLE ARE ESTABLISHED. ENTIRE FRAME TO REMAIN WITHIN OUTSIDE LIMITS OF 'C250' MEMBERS IN WALKWAY ABOVE.

1 – DETAIL PLAN – SUPPORT FRAME

SCALE: 1:25 (24x36)
1:50 (11x17)



B – SECTION

SCALE: 1:25 (24x36)
1:50 (11x17)

NO.	YY/MM/DD	DESCRIPTION	ISSUED BY	CHECK BY
0	16/01/26	ISSUED WITH FINAL REPORT	RJL	JMW

REVISIONS / ISSUE

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PROJECT:
ST. BONIFACE RIVERTRAIL
TREE TOP LOOKOUT AND SIDEWALK EXPANSION
ST. BONIFACE, WINNIPEG, MB

DWG. DESCRIPTION:
STRUCTURAL
PLAN, SECTIONS AND DETAILS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUTHENTICATION FOR CURRENT REVISION
ENG. STAMP

KGS GROUP
CONSULTING ENGINEERS

DESIGN BY:	RJL	DATE (YY/MM/DD):	15/08/25
DESIGN CHECK:	JMW	DATE:	16/01/27
DRAWN BY:	FBV	DATE:	15/08/25
DWG CHECK:	RJL	DATE:	16/01/27

DWG. NO. 15-0107-008 S01
REV: 0

FileName: \\k-file-4\p-data\Projects\2015\15-0107-008\Dwg\Struct\15-0107-008_S01 .dwg – Tab: S01 Plotted By: rmeilleur 16/01/27 [Wed 2:31pm]
24"x36" PLOT SCALE: 1"=1'

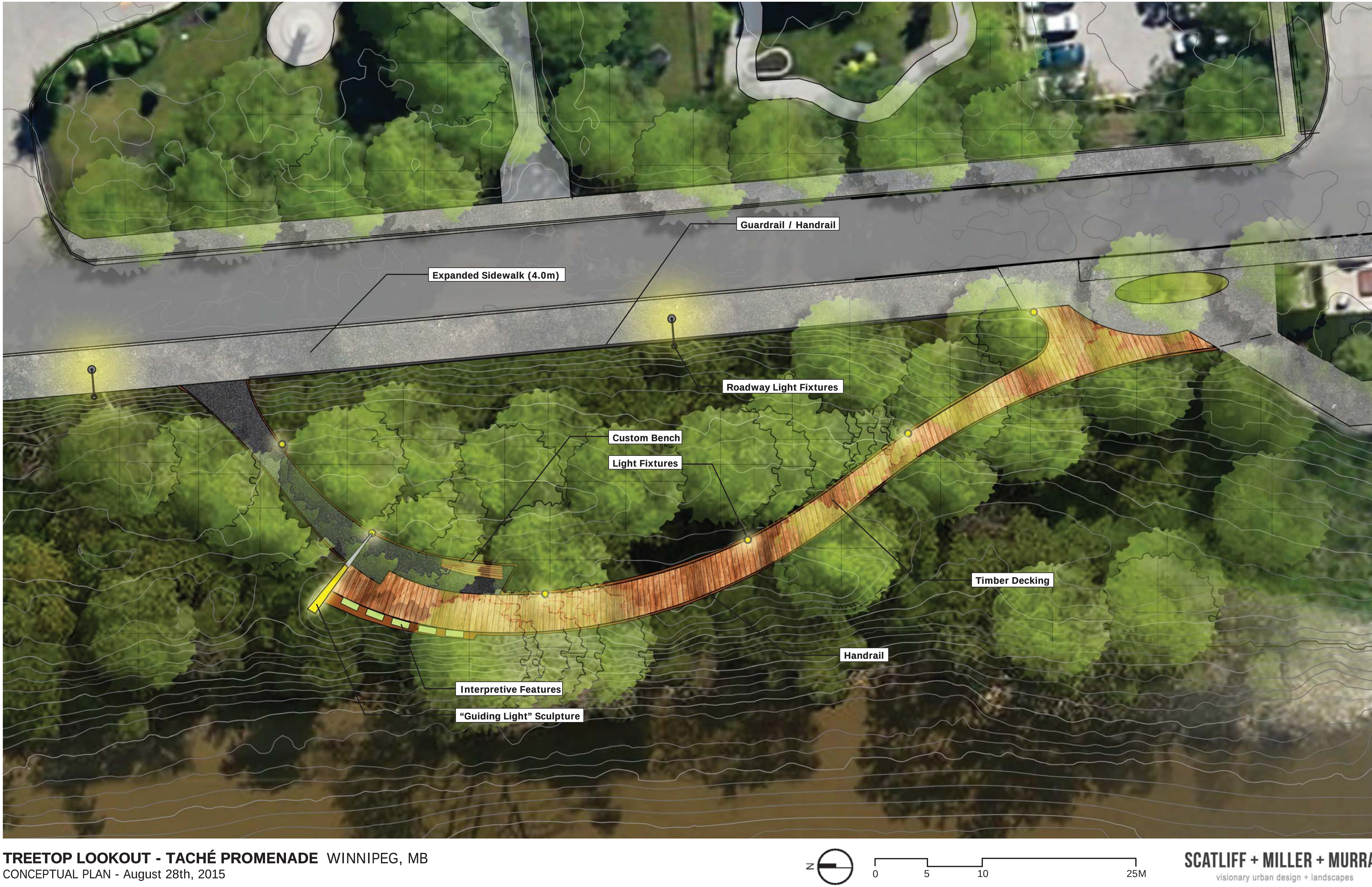
APPENDICES

APPENDIX A

CONCEPTUAL SKETCHES

Taché Promenade Conceptual Master Plan

SCATLIFF + MILLER + MURRAY



TREETOP LOOKOUT - TACHÉ PROMENADE WINNIPEG, MB
CONCEPTUAL PLAN - August 28th, 2015

SCATLIFF + MILLER + MURRAY
visionary urban design + landscapes

Perspective View: from the Tree Top Lookout toward Esplanade Riel and the Canadian Museum for Human Rights

SCATLIFF + MILLER + MURRAY

APPENDIX B

TEST HOLE LOGS

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH14-01**

CLIENT	CITY OF WINNIPEG	JOB NO.	14-0107-003
PROJECT	ST. BONIFACE RIVER TRAIL	GROUND ELEV.	226.12
SITE	TACHE AVENUE	TOP OF PVC ELEV.	
LOCATION	MID BANK	WATER ELEV.	
		DATE DRILLED	3/18/2014
DRILLING METHOD	200 mm ø Hollow Stem Auger, ACKER SS Drill Rig	UTM (m)	N 5,527,866 E 634,731

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE NUMBER
226.12	0	SILTY CLAY (CH) - Brown, damp, stiff, high plasticity, trace rootlets.		
		- No rootlets below 0.61 m.	0.9	S1
		- Increased silt content below 1.52 m.		
		- Blackish grey increasing moisture content, trace coarse grained sand, trace fine grained gravel below below 2.74 m. - No sand or gravel, blocky structure below 3.05 m.		S2
				S3
		- Grey, firm, not blocky below 3.96 m.		
		- Blocky below 4.57 m.		
		- Grain Size Distribution: Gravel (0.0%), Sand (1.7%), Silt (24.5%) & Clay (73.8%) at 5.49 m.		S4
		- Stiff below 6.10 m.	6.7	
219.3		SILT (ML) - Tan, moist, firm, low plasticity.		S5
218.8		LACUSTRINE SILTY CLAY (CH) - Brown, moist, stiff, high plasticity, trace silt nodules.		
		- Grey below 7.92 m.		S6
		- Firm below 8.38 m.		
				S7
216.2				

Column headings: ELEVATION (m); DEPTH (m) (ft); GRAPHICS; DESCRIPTION AND CLASSIFICATION; PIEZ. LOG; DEPTH (m); SAMPLE TYPE; NUMBER; RECOVERY %; SPT (N) blows/0.15 m ▲; DYNAMIC CONE (N) blows/ft △ (20 40 60); Cu POCKET PEN (kPa) ★; Cu TORVANE (kPa) ◆ (20 40 60 80); PL MC LL % (20 40 60 80)

SAMPLE TYPE: Auger Grab; Split Barrel; Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	B.P.ARPIN	7/11/14

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	PL — MC — LL % / Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆
216				**SILT TILL** - Light grey, moist, compact to dense, some medium to coarse grained sand, trace fine to coarse grained gravel.			Split Barrel	S8			MC ≈ 35
215.4		35		**AUGER REFUSAL at 10.67 m**		10.7	Split Spoon		0	39, 14, 12	
215	11										
214	12	40									
213	13										
		45									
212	14										
211	15	50									
210	16										
		55									
209	17										
208	18	60									
207	19										
		65									
206	20										
205	21	70									

Notes:
1. Drilled with solid stem auger from 0 to 1.52 m to prevent blockage in hollow stem.
2. Installed two RST flow-through P-100 pneumatic piezometers
   - (PN 035734) at 6.71 m below grade
   - (PN 035726) at 10.67 m below grade
3. Installed slope inclinometer at 10.67 m below grade with a 0.80 m stick up.
4. Backfilled with bentonite cement grout from 10.67 m to 0.91 m below grade, then bentonite chips from 0.91 m to grade.
5. Approximate bentonite-cement slurry mix (ratio by weight)
   - Water = 3.1 - 3.5 parts
   - Cement = 1.2 parts
   - Bentonite grout = 1 part

SAMPLE TYPE: Auger Grab | Split Barrel | Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	B.P.ARPIN	7/11/14

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH14-02**

CLIENT	CITY OF WINNIPEG	JOB NO.	14-0107-003
PROJECT	ST. BONIFACE RIVER TRAIL	GROUND ELEV.	226.39
SITE	TACHE AVENUE	TOP OF PVC ELEV.	
LOCATION	MID/UPPER BANK	WATER ELEV.	
DRILLING METHOD	200 mm ø Hollow Stem Auger, ACKER SS Drill Rig	DATE DRILLED	3/19/2014
		UTM (m)	N 5,527,875 E 634,742

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE NUMBER
	0	**CLAY FILL** - Brown and black, damp to moist, intermediate plasticity, stiff, trace organics, trace fine grained gravel		
		- Trace roots (10 - 15 mm diameter) at 1.22 m.		
224.6	1.8	**CLAYEY SAND WITH GRAVEL (SC)** - Black, moist to wet, loose, coarse grained sand, fine to coarse grained gravel, slight odour.	1.8	
		- Coarse grained gravel at 3.35 m.		
		- Grain Size Distribution: Gravel (16.7%), Sand (51.9%), Silt (18.1%) & Clay (13.3%) at 4.42 m.		S1
221.7	4.6	**SILTY CLAY (CH)** - Grey and black, moist, firm, high plasticity, trace organics, slight odour.	4.6	S2
220.9		**CLAYEY SILT (CL-CI)** - Tan and grey, moist, low to intermediate plasticity, slight odour.		S3
220.4		**LACUSTRINE SILTY CLAY (CH)** - Brown, moist, high plasticity, firm, trace silt nodules. - Grey below 6.10 m.		S4
		- Some to with silt below 8.69 m.		S5 S6
216.6	9.8	**CLAY TILL** - Grey, moist to wet, firm, some fine grained gravel and	9.1	S7

Column headings: PIEZ. LOG; SAMPLE TYPE; RECOVERY %; SPT (N) blows/0.15 m ▲; DYNAMIC CONE (N) blows/ft △ (20 40 60); Cu POCKET PEN (kPa) ★; Cu TORVANE (kPa) ◆ (20 40 60 80); PL MC LL % (20 40 60 80)

SAMPLE TYPE: Split Barrel; Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	S.REPA	B.P.ARPIN	7/11/14

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m	Cu / PL MC LL
			coarse grained sand.						
215.7		35			Split Barrel	S8			
	11		**SILT TILL** - Tan, moist, dense to very dense, some to wih fine grained gravel and coarse grained sand		Split Barrel	S9			
215.1				11.3	Split Spoon	S10	22	43, 50 * Refusal with 3 " left in 2nd set	
			AUGER REFUSAL at 11.28 m						

Notes:
1. Installed two RST flow-through P-100 pneumatic piezometers
   - (PN 035739) at 4.57 m below grade
   - (PN 035723) at 9.14 m below grade
2. Installed slope inclinometer at 11.28 m below grade with a 0.83 m stick up.
3. Backfilled with bentonite cement grout from 11.28 m to 1.80 m below grade, then bentonite chips from 1.80 m to grade.
4. Approximate bentonite-cement slurry mix (ratio by weight)
   - Water = 3.1 - 3.5 parts
   - Cement = 1.2 parts
   - Bentonite grout = 1 part
5. No sample was obtained from 0 m to 4.57 m and stratigraphy is projected from TH14-02A located 0.75 m North East.

SAMPLE TYPE: Split Barrel, Split Spoon

CONTRACTOR: Paddock Drilling Ltd. INSPECTOR: S.REPA APPROVED: B.P.ARPIN DATE: 7/11/14

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH14-02A**

CLIENT	CITY OF WINNIPEG	JOB NO.	14-0107-003
PROJECT	ST. BONIFACE RIVER TRAIL	GROUND ELEV.	226.39
		TOP OF PVC ELEV.	
SITE	TACHE AVENUE	WATER ELEV.	
LOCATION	MID/UPPER BANK 0.75 M EAST OF TH14-02	DATE DRILLED	3/18/2014
DRILLING METHOD	125 mm ø Solid Stem Auger, ACKER SS Drill Rig	UTM (m)	N 5,527,875 E 634,743

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
226.39	0	0	**CLAY FILL** - Brown and black, damp to moist, intermediate plasticity, stiff, trace organics, trace fine grained gravel		Auger Grab	S1			
					Auger Grab	S2			◆
			- Trace roots (10 - 15 mm diameter) at 1.22 m.						
224.6			**CLAYEY SAND WITH GRAVEL (SC)** - Black, moist to wet, loose, coarse grained sand, fine to coarse grained gravel, slight odour.		Auger Grab	S3			
					Auger Grab	S4			
221.8			- Grain Size Distribution: Gravel (16.7%), Sand (51.9%), Silt (18.1%) & Clay (13.3%) at 4.42 m.	4.6					

END TESTHOLE AT 4.57 M IN SILTY CLAY

Notes:
1. Hollow stem auger refusal at 1.22 m in sand and gravel fill.
2. Solid stem auger passes 1.22 m depth, end solid stem testhole at 4.57 m
3. Move testhole location 0.75 m NE, hollow stem refusal at 0.61 m.
4. Move testhole location 0.75 m SW from original location. Refer to TH14-02 logs.
5. Testhole backfilled with auger cuttings to grade.

SAMPLE TYPE: Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	S.REPA	B.P.ARPIN	7/11/14

KGS GROUP — **SUMMARY LOG**

REFERENCE NO.

HOLE NO. **TH14-03**

CLIENT	CITY OF WINNIPEG	JOB NO.	14-0107-003
PROJECT	ST. BONIFACE RIVER TRAIL	GROUND ELEV.	229.87
		TOP OF PVC ELEV.	
SITE	TACHE AVENUE	WATER ELEV.	
LOCATION	MID/UPPER BANK	DATE DRILLED	3/19/2014
DRILLING METHOD	200 mm ø Hollow Stem Auger, ACKER SS Drill Rig	UTM (m)	N 5,527,959 E 634,737

Column headings: ELEVATION (m) | DEPTH (m) (ft) | GRAPHICS | DESCRIPTION AND CLASSIFICATION | PIEZ. LOG | DEPTH (m) | SAMPLE TYPE | NUMBER | RECOVERY % | SPT (N) blows/0.15 m ▲; DYNAMIC CONE (N) blows/ft △ (20 40 60) | Cu POCKET PEN (kPa) ★; Cu TORVANE (kPa) ◆ (20 40 60 80); PL MC LL % (20 40 60 80)

Elevation (m)	Description and Classification	Depth (m)	Sample
	CLAYEY SILT FILL - Brownish tan, moist, low to intermediate plasticity, stiff.	0.6	S1 (Auger Grab), S2 (Auger Grab)
228.3	**LACUSTRINE SILTY CLAY (CH)** - Mottled grey and brown, moist, firm, high plasticity, trace gypsum and silt nodules		S3 (Split Barrel)
	- Stiff below 2.80 m.		S4 (Split Barrel)
	- Gypsum pockets at 3.65 m.		S5 (Split Barrel)
	- Gypsum pockets at 4.26 m.		
	- Trace oxidation below 4.57 m.		S6 (Split Barrel)
			S7 (Split Barrel)
	- Grey, no gypsum nodules, no oxidation below 7.57 m.		
	- Firm below 8.69 m.		S8 (Split Barrel)
		9.1	

Elevation scale: 229, 228, 227, 226, 225, 224, 223, 222, 221, 220. Depth scale (m): 1–9; (ft): 5, 10, 15, 20, 25, 30.

SAMPLE TYPE: Auger Grab | Split Barrel | Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	S.REPA	B.P.ARPIN	7/11/14

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH14-03**

Elevation (m)	Depth (m)	Description and Classification	Depth (m)	Sample	Recovery %	SPT (N) blows/0.15 m	PL / MC / LL, Cu Torvane
219	11	- Trace cobble (75 x 40 mm) at 10.67 m. - Trace fine grained gravel below 10.67 m.		S9			
218	12	- Trace coarse grained silty sand pocket (40 mm) at 11.58 m.	12.2	S10			
217	13			S11			
216	14						
215.1		**CLAY TILL** - Greyish tan, moist to wet, low to intermediate plasticity, soft, with fine grained gravel and coarse grained sand, some silt.		S12			
214.6	15	**SILT TILL** - Tan, moist, dense to very dense, with fine grained gravel and medium to coarse grained sand, trace coarse grained gravel.		S13			
214.0		**AUGER REFUSAL at 15.85 m**	15.8	S14	33	50 *Refusal with 4 " left in 1st set	

Notes:
1. Drilled with solid stem auger from 0 to 1.52 m to prevent blockage in hollow stem.
2. Installed two RST flow-through P-100 pneumatic piezometers
   - (PN 035725) at 9.14 m below grade
   - (PN 035722) at 12.19 m below grade
3. Installed slope inclinometer at 15.85 m below grade with a 0.76 m stick up.
4. Backfilled with bentonite cement grout from 15.85 m to 0.61 m and bentonite chips from 0.61 m to grade.
5. Approximate bentonite-cement slurry mix (ratio by weight)
   - Water = 3.1 - 3.5 parts
   - Cement = 1.2 parts
   - Bentonite grout = 1 part

SAMPLE TYPE: Auger Grab, Split Barrel, Split Spoon

CONTRACTOR: Paddock Drilling Ltd. | INSPECTOR: S.REPA | APPROVED: B.P.ARPIN | DATE: 7/11/14

GEOTECHNICAL-SOIL LOG U:\FMS\14-0107-003\ST. BONIFACE RIVERTRAIL LOGS.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH14-04**

CLIENT	CITY OF WINNIPEG	JOB NO.	14-0107-003
PROJECT	ST. BONIFACE RIVER TRAIL	GROUND ELEV.	227.72
		TOP OF PVC ELEV.	
SITE	TACHE AVENUE	WATER ELEV.	
LOCATION	MID BANK	DATE DRILLED	3/20/2014
DRILLING METHOD	125 mm ø Solid Stem Auger, ACKER SS Drill Rig	UTM (m)	N 5,527,956 E 634,727

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE TYPE / NUMBER
			TOPSOIL - Black, damp, trace organice clay, trace fine grained gravel, trace cobbles.		S1
227.1			**CLAYEY SILT (ML)** - Tan, damp to moist, crumbly, low plasticity, trace clay.		
226.8			**LACUSTRINE SILTY CLAY (CH)** - Brown, moist, firm, intermediate to high plasticity, trace silt nodules.	0.9	S2
					S3
			- Trace oxidation below 3.05 m.		
					S4
			- Stiff below 4.42 m. - Grey, trace to some silt nodules, no oxidation below 4.57 m.	4.6	
					S5
					S6
			- Firm below 8.38 m.		S7
			- Trace to some silt nodules below 9.14 m.	8.8	

Elevation scale: 227, 226, 225, 224, 223, 222, 221, 220, 219, 218. Depth (m): 1–9. Depth (ft): 5, 10, 15, 20, 25, 30.

Column headings: PIEZ. LOG; RECOVERY %; SPT (N) blows/0.15 m ▲; DYNAMIC CONE (N) blows/ft △ (20, 40, 60); Cu POCKET PEN (kPa) ★; Cu TORVANE (kPa) ◆ (20, 40, 60, 80); PL, MC, LL % (20, 40, 60, 80).

SAMPLE TYPE: Auger Grab; Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	S.REPA	B.P.ARPIN	7/11/14

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH14-04**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
						S8			
217		35	- Soft, some to with silt below 10.36 m.						
	11		- Very soft below 10.80 m.						
216.1 / 216			**CLAY TILL** - Greyish tan, moist, very soft, low to intermediate plasticity, some fine grained gravel, some coarse grained sand, some to with silt.			S9			
215.5	12	40	**SILT TILL** - Tan, moist, dense to very dense, some to with fine grained gravel, some to with medium to coarse grained sand, trace coarse grained gravel.						
215					12.8				
	13					S10			
214		45							
213.7	14		**AUGER REFUSAL at 14.02 m**		14.0	S11	44	24; 50; 50 * Refusal with 3 " left in 3rd set	
213									
	15								
		50							
212	16								
211		55							
	17								
210	18								
		60							
209	19								
208		65							
	20								
207	21								
		70							
206									

Notes:
1. Installed two RST flow-through P-100 pneumatic piezometers
   - (PN 035735) at 4.57 m below grade
   - (PN 035736) at 8.84 m below grade
2. Installed slope inclinometer at 12.80 m below grade with a 0.75 m stick up.
3. Backfilled with bentonite cement grout from 14.02 m to 0.91 m and bentonite chips from 0.91 to grade.
4. Approximate bentonite-cement slurry mix (ratio by weight)
   - Water = 3.1 - 3.5 parts
   - Cement = 1.2 parts
   - Bentonite grout = 1 part

SAMPLE TYPE: Auger Grab; Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	S.REPA	B.P.ARPIN	7/11/14

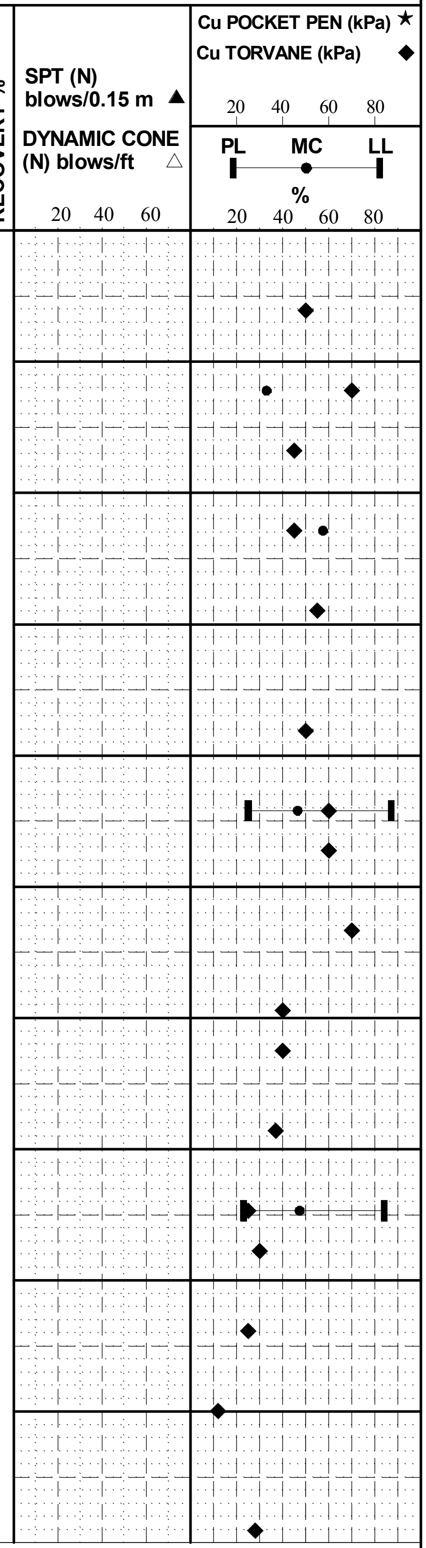
KGS GROUP SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH14-05**

CLIENT	CITY OF WINNIPEG	JOB NO.	14-0107-003
PROJECT	ST. BONIFACE RIVER TRAIL	GROUND ELEV.	227.85
SITE	TACHE AVENUE	TOP OF PVC ELEV.	
LOCATION	MID BANK	WATER ELEV.	
DRILLING METHOD	125 mm ø Solid Stem Auger, ACKER Track Mounted Rig	DATE DRILLED	4/1/2014
		UTM (m)	N 5,528,112 E 634,694

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE TYPE / NUMBER
227.85	0	**CLAY FILL** - Brown, damp, stiff, crumbly, intermediate plasticity, trace fine grained gravel, trace coarse grained sand.		
		- Damp to moist below 0.91 m.		S1
226.3		**LACUSTRINE SILTY CLAY (CH)** - Brown mottled with grey, moist, firm, high plasticity, trace silt nodules (1 - 3 mm), trace oxidation.		S2
		- Stiff, trace (1 -10 mm) silt nodules below 3.05 m.		
		- No oxidation below 4.11 m. - Grain Size Distribution: Gravel (0.3%), Sand (1.1%), Silt (27.7%) & Clay (70.9%) at 4.27 m. - Grey mottled with brown from 4.57 m to 5.03 m.		S3
		- Grey below 5.03 m.		
		- Firm below 5.64 m.		S4
		- Trace silt nodules (1 - 3 mm) below 6.10 m.	6.4	
		- Grain Size Distribution: Gravel (2.5%), Sand (5.7%), Silt (24.5%) & Clay (67.3%) at 7.32 m.		S5
				S6
		- Trace coarse grained sub rounded gravel (40 mm x 25 mm) at 9.45 m.		



SAMPLE TYPE: Auger Grab; Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	S.REPA	B.P.ARPIN	7/11/14

GEOTECHNICAL-SOIL LOG U:\FMS\14-0107-003\ST. BONIFACE RIVERTRAIL LOGS.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH14-05**

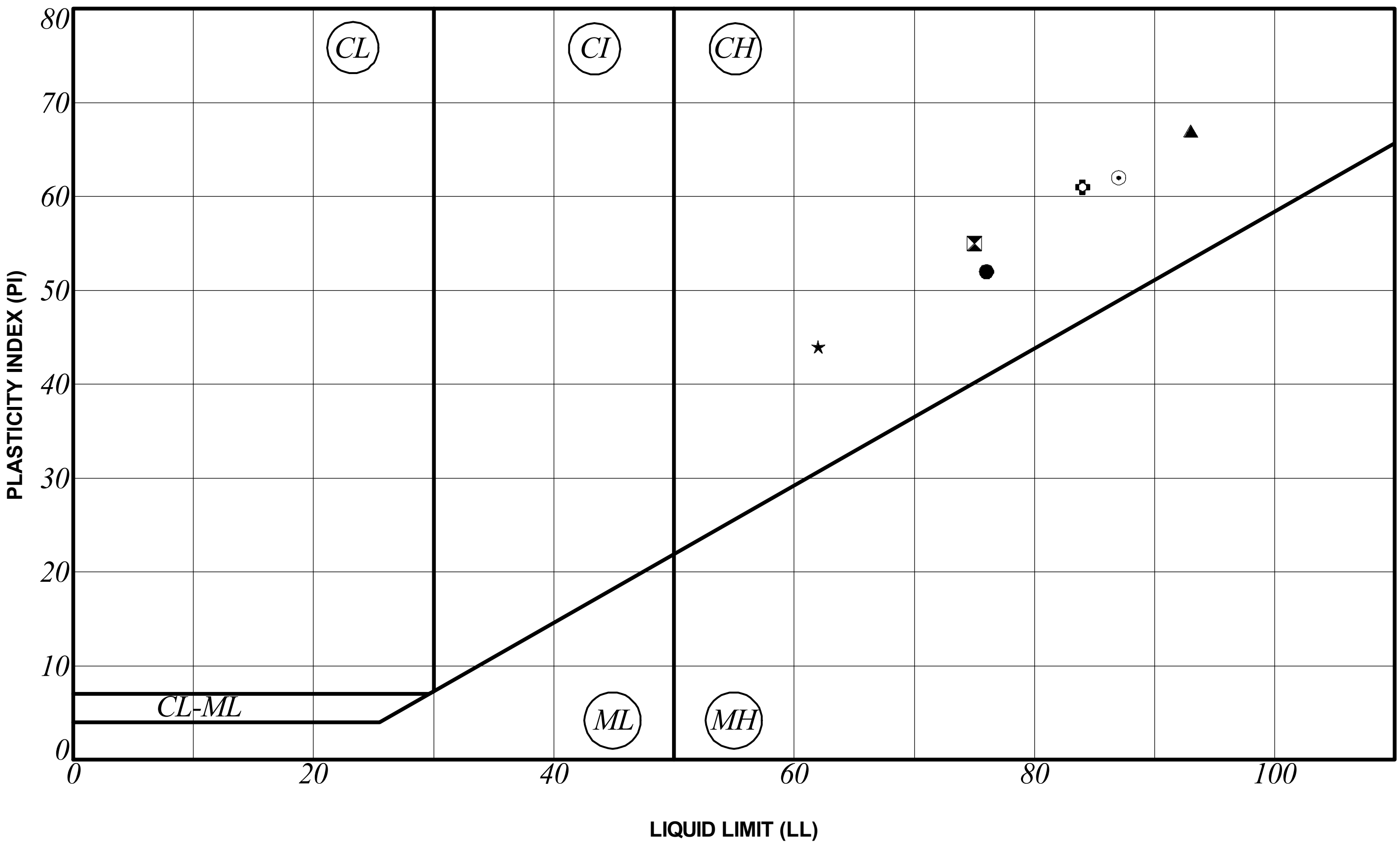
ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
			- Silt nodule diameter increases to (5 - 15 mm) below 10.06 m.		Auger Grab	S7			
217 / 216.9	11	35	- Some silt below 10.67 m.						
			CLAY TILL - Greyish tan, moist to wet, some fine grained to coarse grained gravel, trace fine grained gravel, some silt.		Auger Grab	S8			
216.1 / 216	12	40	**SILT TILL** - Tan, moist to damp, compact, with fine grained gravel, with medium to coarse grained sand, trace coarse grained gravel.	12.2	Auger Grab	S9			
215.5			**AUGER REFUSAL at 12.40 m**	12.4	Split Spoon	S10	50	8, 5, 5	

Notes:
1. Installed two RST flow-through P-100 pneumatic piezometers
   - (PN 035738) at 6.40 m below grade
   - (PN 035736) at 12.19 m below grade
2. Installed slope inclinometer at 12.40 m below grade with a 0.84 m stick up.
3. Backfilled with bentonite cement grout from 12.40 m to grade.
4. Approximate bentonite-cement slurry mix (ratio by weight)
   - Water = 3 parts
   - Cement = 1 part
   - Bentonite grout = 1.1 parts

Elevation scale: 215, 214, 213, 212, 211, 210, 209, 208, 207
Depth (m): 13, 14, 15, 16, 17, 18, 19, 20, 21
Depth (ft): 45, 50, 55, 60, 65, 70

SAMPLE TYPE: Auger Grab, Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	S.REPA	B.P.ARPIN	7/11/14



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	% SAND	% SILT	% CLAY	% MC	CLASSIFICATION
●	TH14-01	5.5	S4	76	24	52	1.7	24.5	73.8	36.1	CH
⧗	TH14-02	8.2	S5	75	20	55				57.5	CH
▲	TH14-04	3.8	S4	93	26	67				47.2	CH
★	TH14-04	9.9	S8	62	18	44				45.1	CH
☉	TH14-05	4.3	S3	87	25	62	1.1	27.7	70.9	46.5	CH
✿	TH14-05	7.3	S5	84	23	61	5.7	24.5	67.3	47.3	CH

Notes:
ML - Low Plasticity Silt
MH - High Plasticity Silt
CL-ML - Silty Clay
CL - Low Plasticity Clay
CI - Intermediate Plasticity Clay
CH - High Plasticity Clay
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index
MC - Moisture Content
NP - Non-Plastic

KGS GROUP

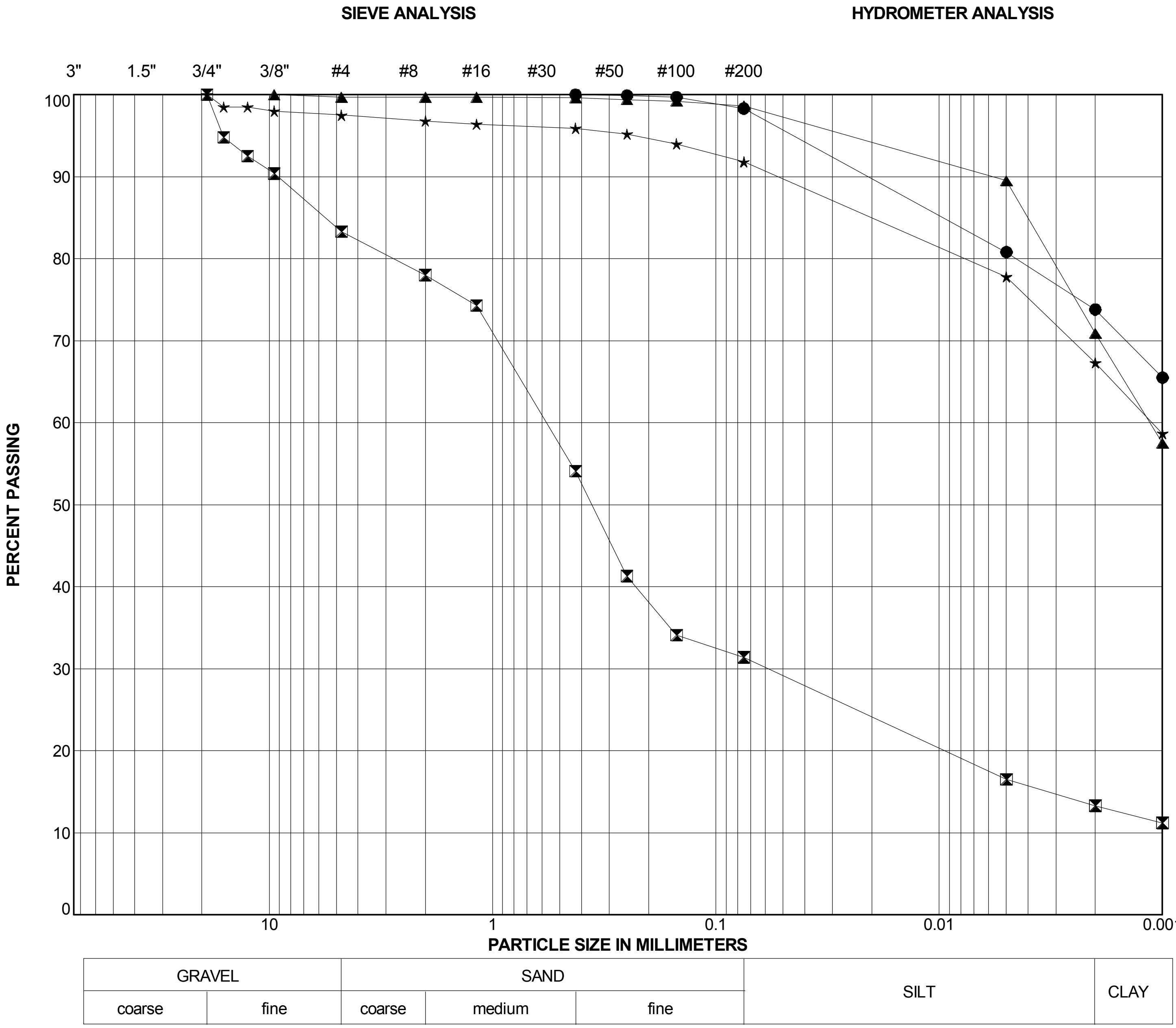
CITY OF WINNIPEG

ST. BONIFACE RIVER TRAIL

A-LINE PLOT

April 2014	**Figure 1**	**Page 1 of 1**

A-LINE PLOT \\K-FILE-5\U-USER\SREPA\FMS\14-0107-003\ST. BONIFACE RIVERTRAIL LOGS.GPJ



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	% GRAVEL	% SAND	% SILT	% CLAY	% SILT & CLAY	Cu	Cc	CLASSIFICATION
●	*TH14-01*	*5.5*	*S4*	*0.0*	*1.7*	*24.5*	*73.8*	*98.3*			*CH*
⧗	*TH14-02*	*4.4*	*S1*	*16.7*	*51.9*	*18.1*	*13.3*	*31.4*			*SC*
▲	*TH14-05*	*4.3*	*S3*	*0.3*	*1.1*	*27.7*	*70.9*	*98.6*			*CH*
★	*TH14-05*	*7.3*	*S5*	*2.5*	*5.7*	*24.5*	*67.3*	*91.8*			*CH*

KGS GROUP

CITY OF WINNIPEG

ST. BONIFACE RIVER TRAIL

GRAIN SIZE ANALYSES

April 2014	**Figure 2**	**Page 1 of 1**

SIEVE ANALYSIS \\K-FILE-5U-USER\SREPA\FMS\14-0107-003\ST. BONIFACE RIVERTRAIL LOGS.GPJ

APPENDIX C

PIEZOMETRIC MONITORING RESULTS

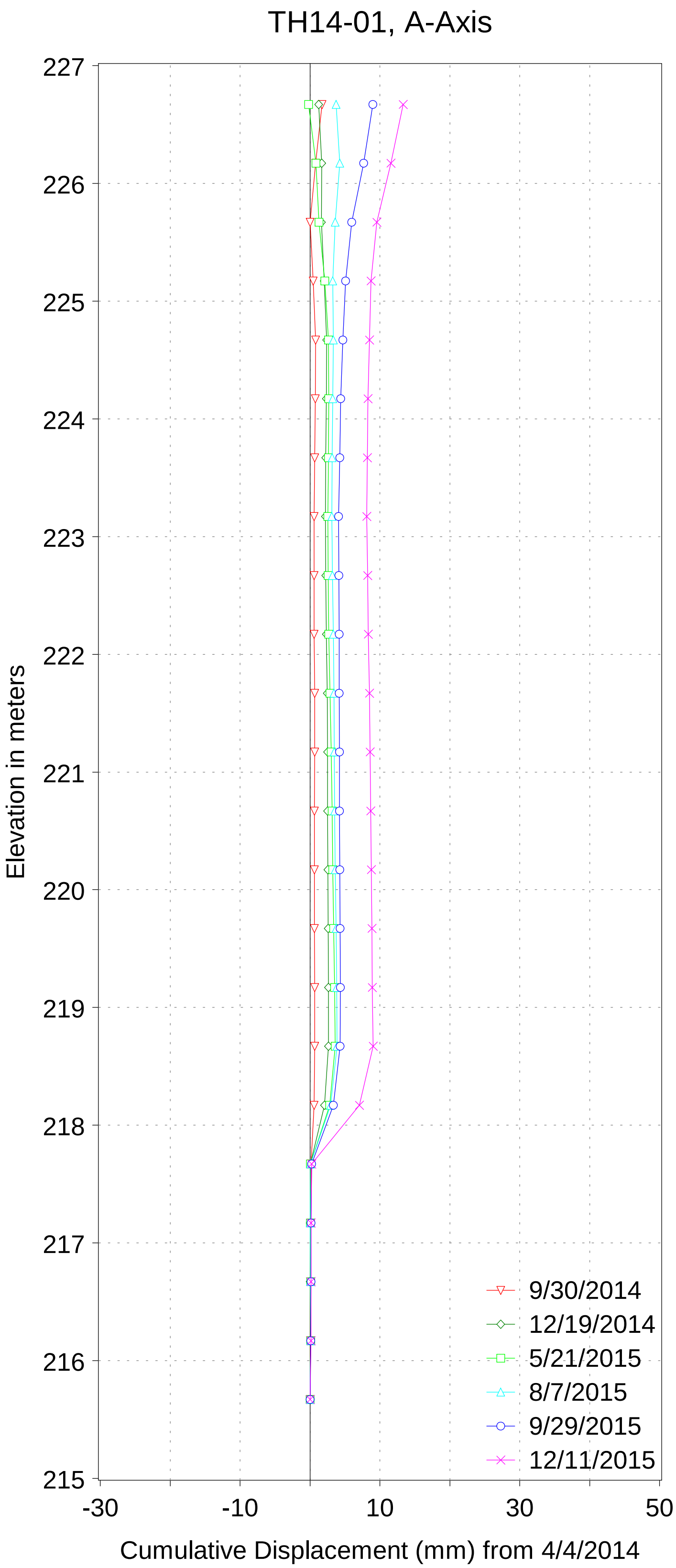
PIEZOMETRIC MONITORING RESULTS
ST. BONIFACE RIVER TRAIL
14-0107-003

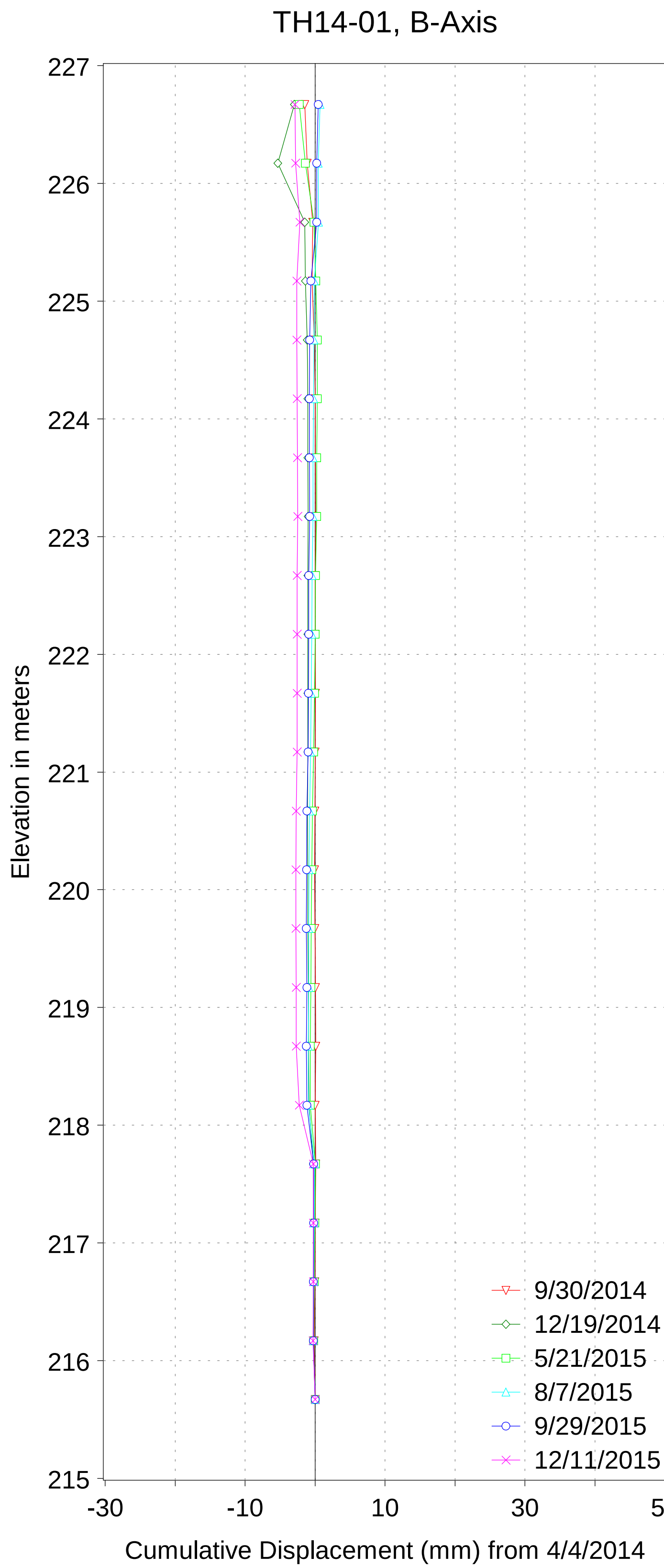
Test Hole:		**TH14-01**		**TH14-02**		**TH14-03**		**TH14-04**		**TH14-05**	
Ground Elevation (m):		**226.12**	**226.12**	**226.39**	**226.39**	**229.87**	**229.87**	**227.72**	**227.72**	**227.85**	**227.85**
Piezometer No.:		**35734**	**35726**	**35739**	**35723**	**35725**	**35722**	**35735**	**35736**	**35727**	**35738**
Top of Pipe Elevation (m):											
Tip Elevation (m):		**219.41**	**215.45**	**221.82**	**217.25**	**220.73**	**217.68**	**223.15**	**218.88**	**215.66**	**221.45**
Monitoring Zone:		**Clay**	**Clay Till**	**Clay**	**Clay**	**Clay**	**Clay**	**Clay**	**Clay**	**Till**	**Clay**
Date	**River Level (m)[1]**	**Piezometric Elevation (m)**									
4-Apr-14	222.45	223.99	224.23	223.87	224.10	225.24	225.02	223.72	223.45	Note (2)	Note (2)
8-Apr-14	222.35									222.54	226.04
12-May-14	226.36	226.50	225.82	225.32	225.43	226.25	225.79	225.16	224.66	Note (4)	226.75
26-Jun-14	226.57	Note (3)	Note (3)	225.17	225.71	226.18	225.65	225.16	224.66	Note (4)	Note (4)
16-Jul-14	226.05	226.64	225.96								
1-Aug-14	225.29	225.72	225.54	225.39	225.36	225.96	225.51	224.80	224.37	Note (4)	Note (4)
30-Sep-14	223.71	224.71	224.64	225.03	225.08	225.82	225.30	224.94	224.23	Note (4)	Note (4)
17-Dec-14	222.79	224.86	224.92	224.95	226.41	225.82	226.21	224.44	224.37	Note (4)	Note (4)
21-May-15	226.07	226.51	225.61	224.88	225.15	226.33	225.65	224.94	224.16	226.30	226.04
7-Aug-15	223.72	225.14	224.50	Note (4)	224.94	225.96	225.44	224.80	224.23	225.31	Note (4)
29-Sep-15	223.69	224.35	224.23		224.66	226.25	225.44				
6-Nov-15	222.30			224.45				224.87	223.87	224.67	226.75
11-Dec-15	222.34	224.35	224.50	224.52	224.94	226.04	225.16	224.73	223.80	224.31	Note (4)

Notes.
(1). River level measured at James Ave pumping station
(2). Installation had not been completed by this date.
(3). Casing below water level
(4). Erroneous reading

APPENDIX D

SLOPE INCLINOMETER MONITORING DATA



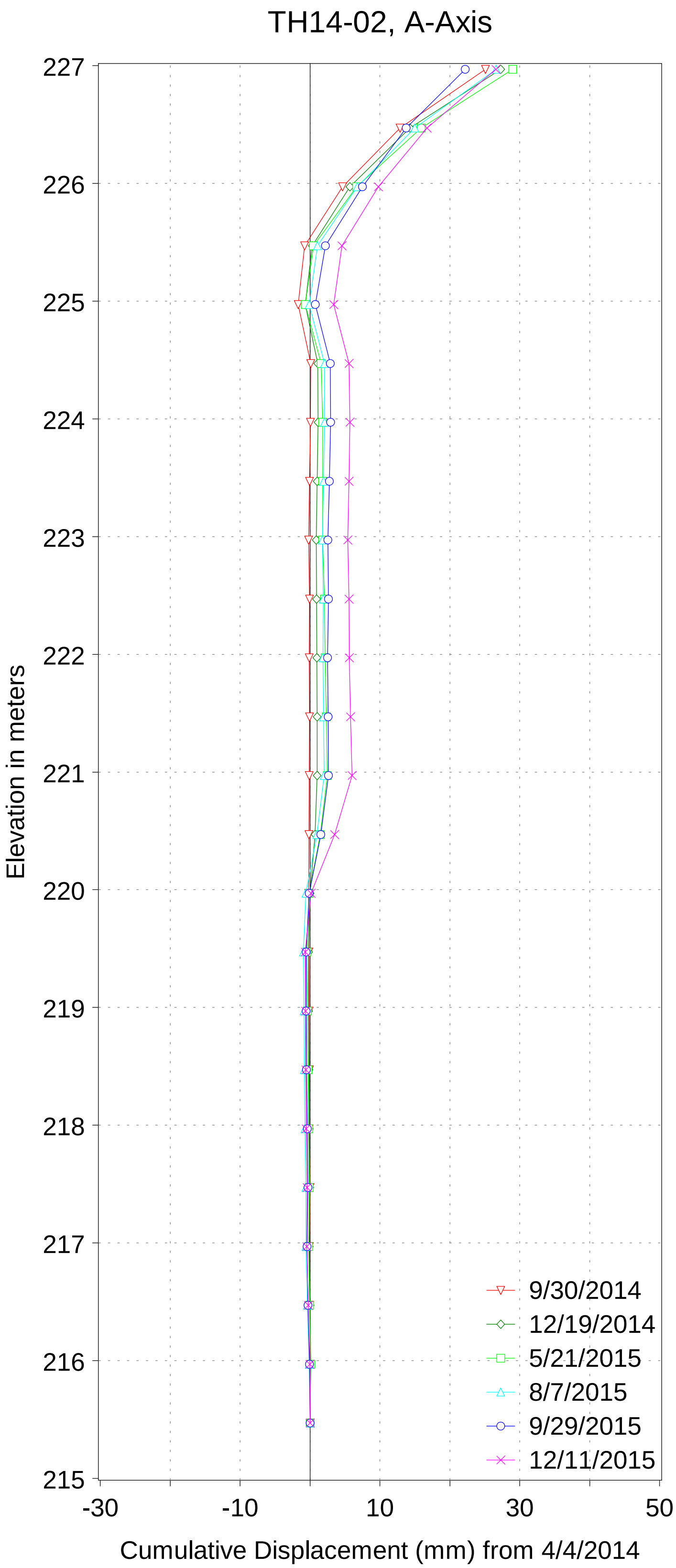


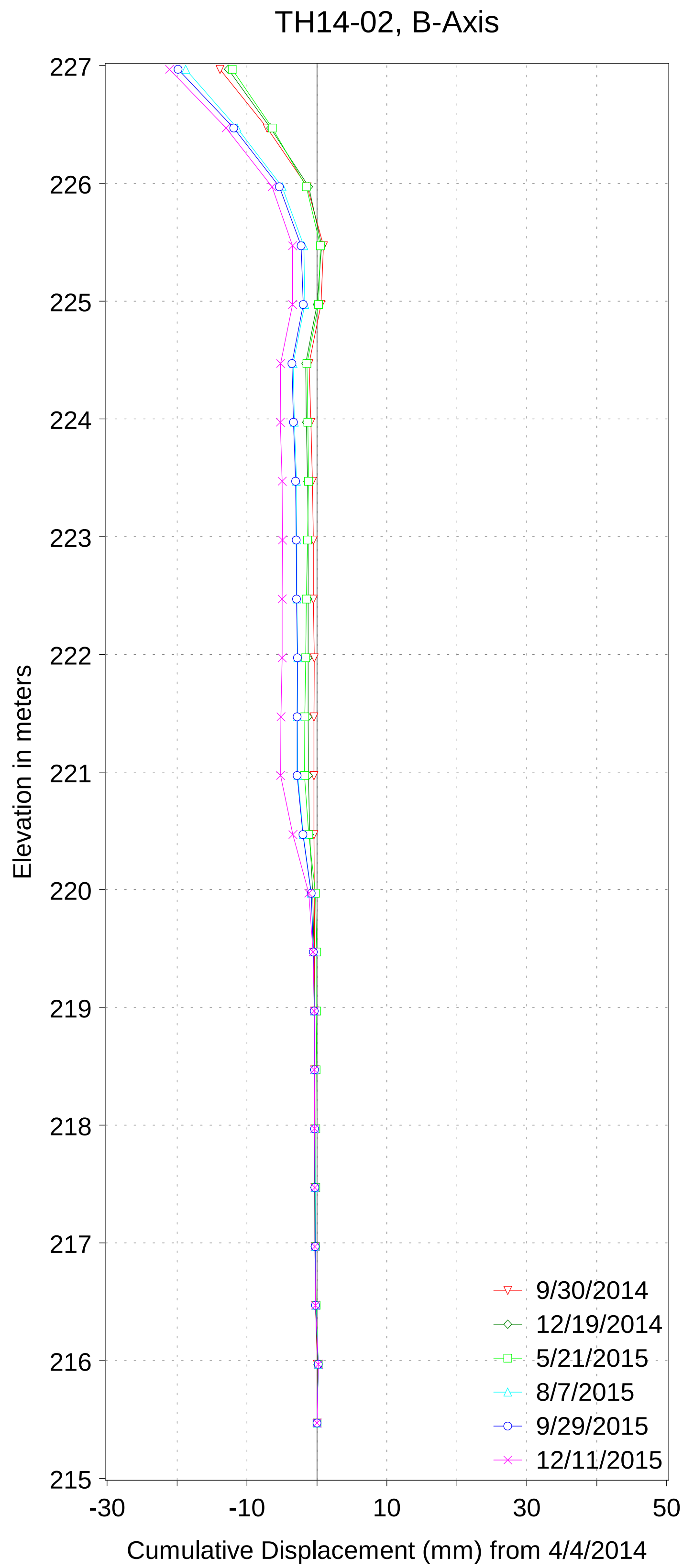
KGS GROUP

14-0107-003

St. Boniface River Trail

TH14-01



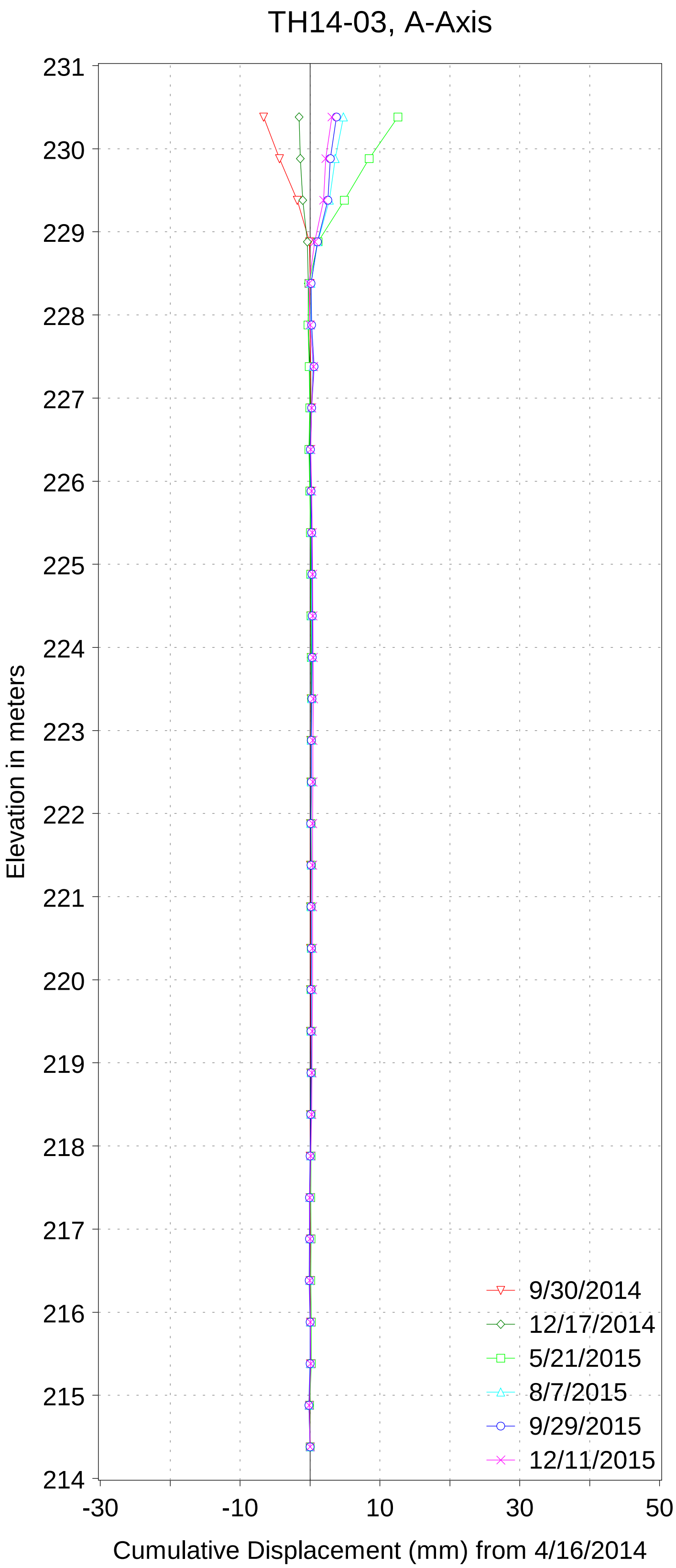


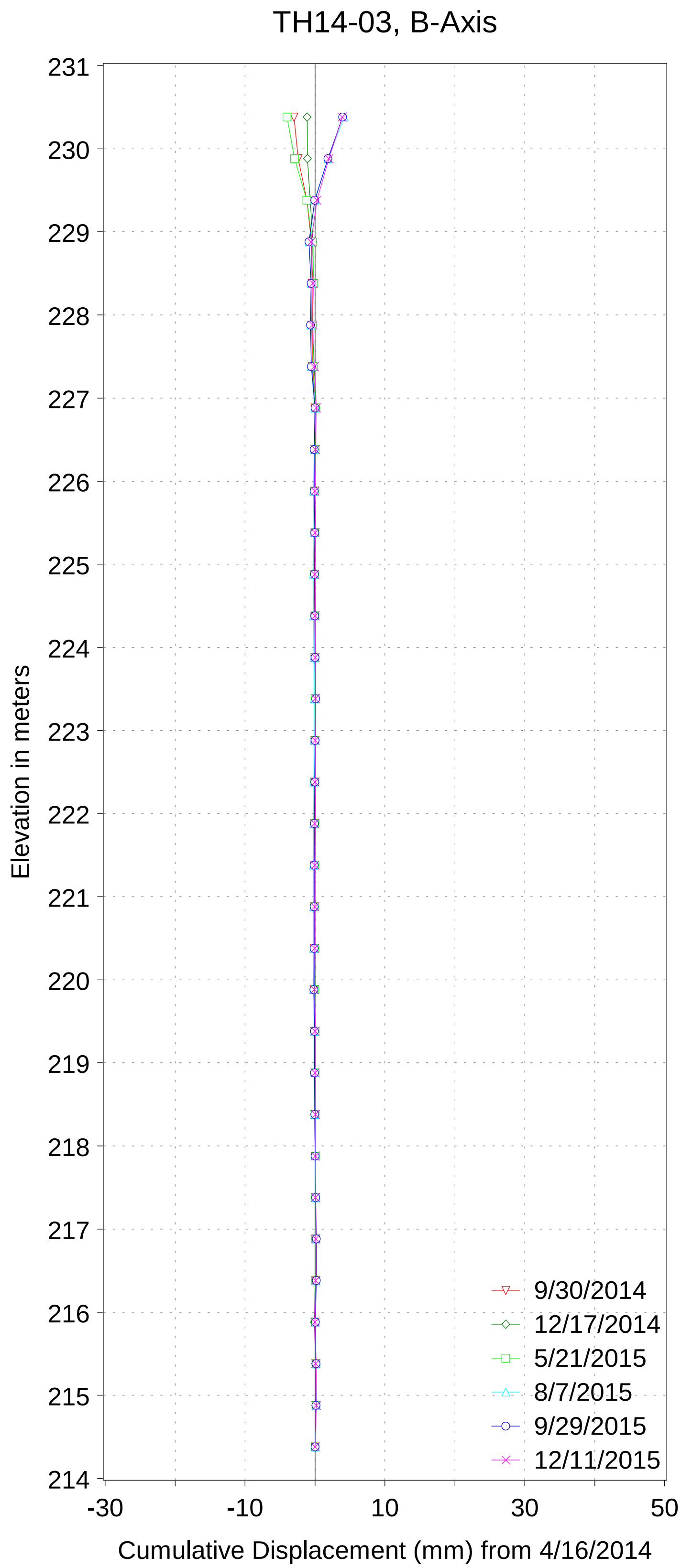
KGS GROUP

14-0107-003

St. Boniface River Trail

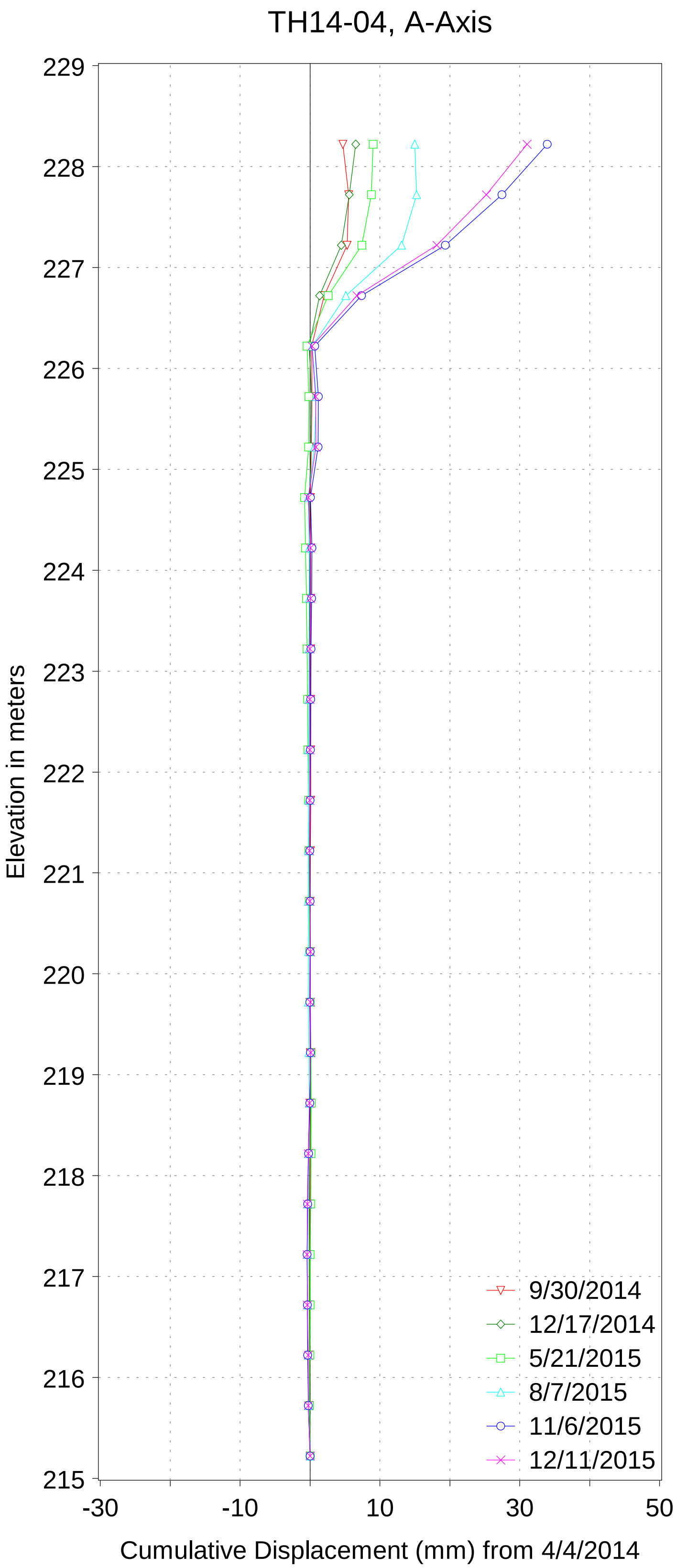
TH14-02

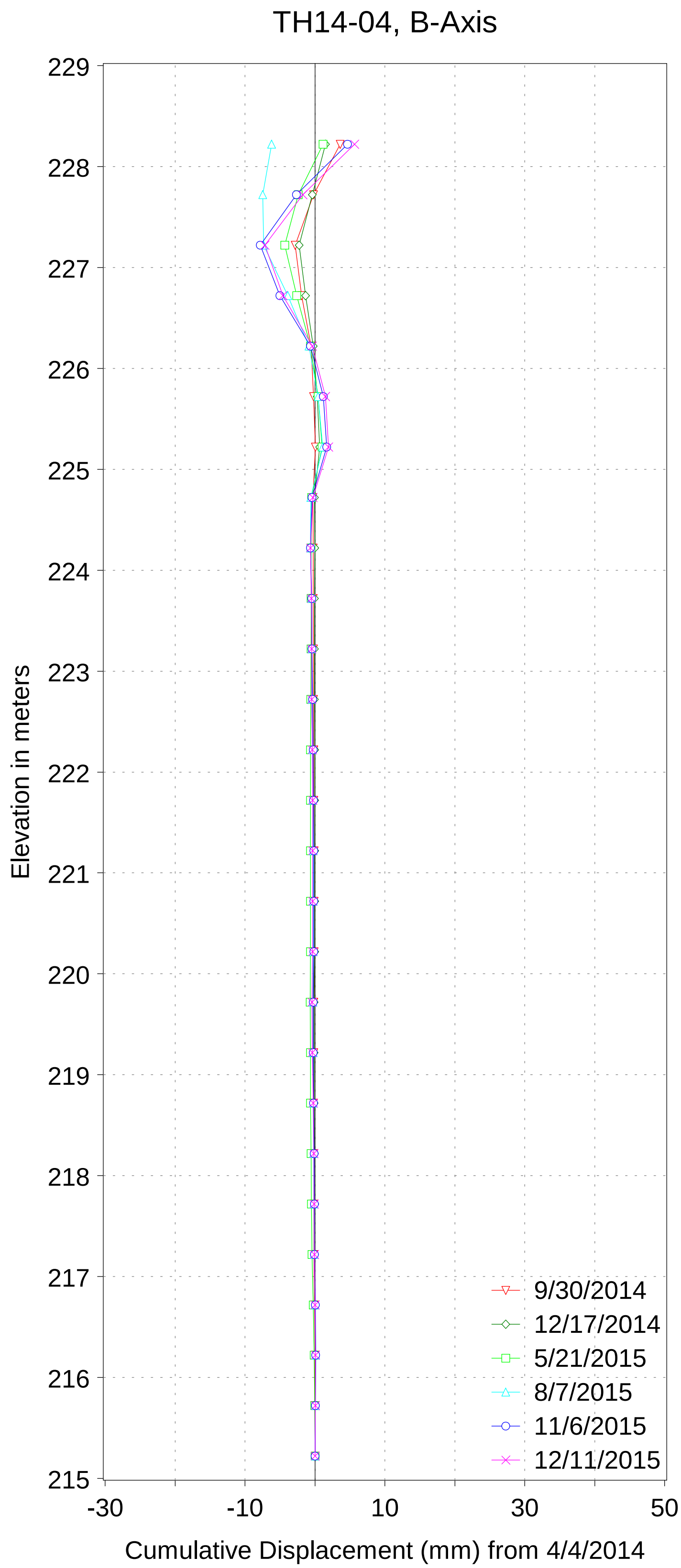




KGS GROUP

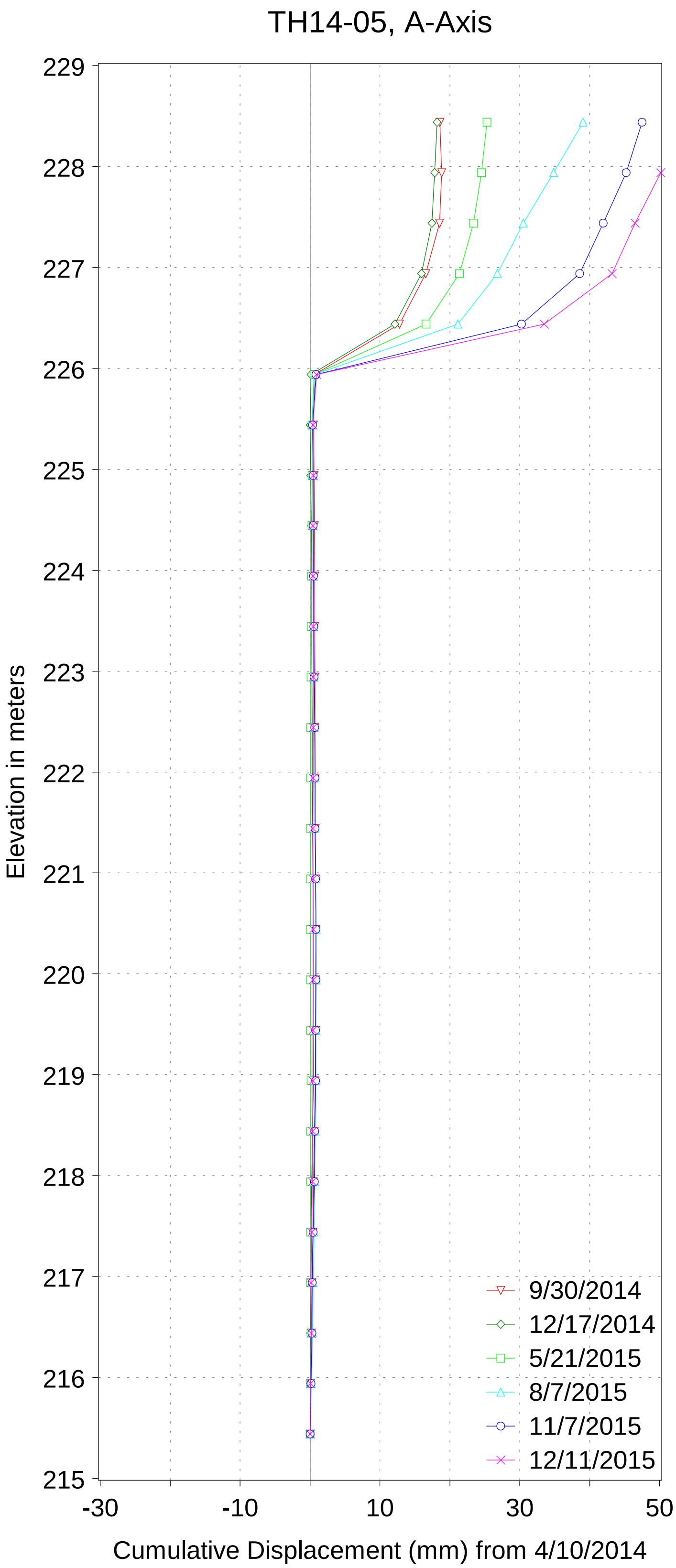
14-0107-003
St. Boniface River Trail
TH14-03

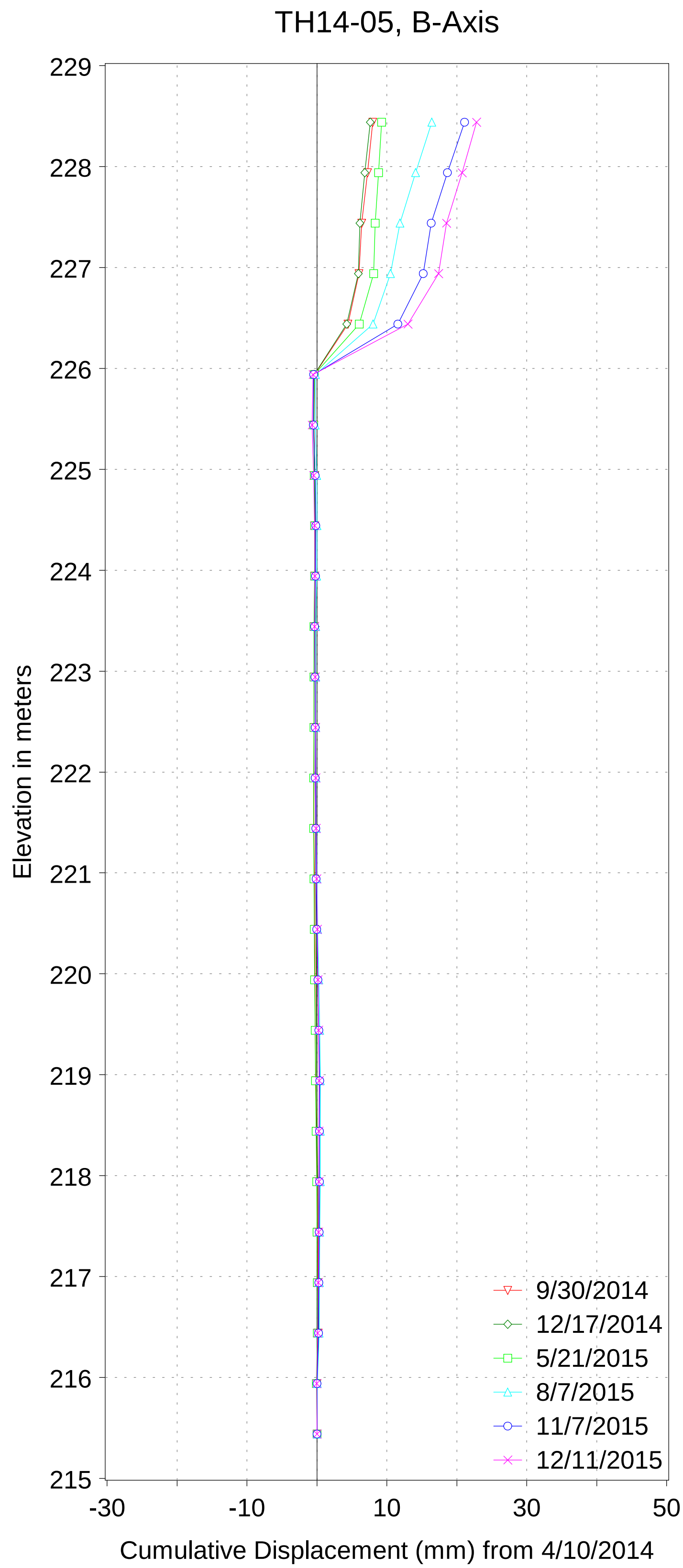




KGS GROUP

14-0107-003
St. Boniface River Trail
TH14-04





KGS GROUP

14-0107-003

St. Boniface River Trail

TH14-05

APPENDIX E

GEOSTUDIO OUTPUT SECTIONS

AREA 1 - SECTION C

Existing Condition - Back Analysis

Slip Surfaces:

SS1 - Global Slip

SS2 - Upper Bank Slip

SS3 - Lower Bank Slip

SS4 - Midbank Slip

SS5 - Block Slip

Name: Lacustrine Clay (Residual)
Unit Weight: 17.5 kN/m³
Cohesion': 3.5 kPa
Phi': 12 °

Name: Silty Clay (Residual)
Unit Weight: 17.5 kN/m³
Cohesion': 3.5 kPa
Phi': 12 °

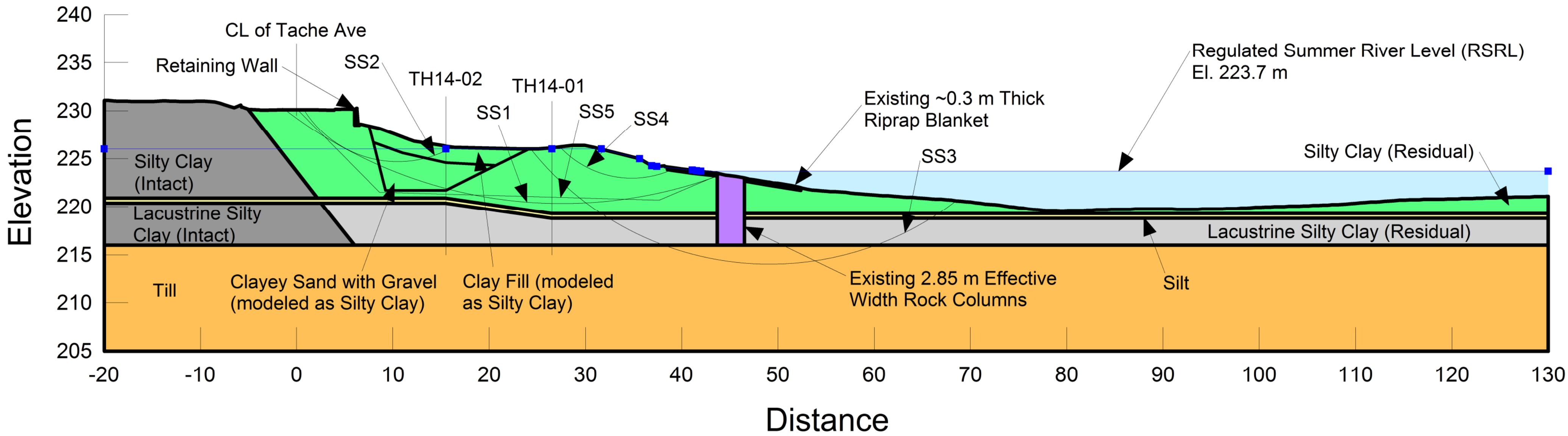
Name: Lacustrine Clay (Intact)
Unit Weight: 17.5 kN/m³
Cohesion': 5 kPa
Phi': 15 °

Name: Silt
Unit Weight: 18 kN/m³
Cohesion': 4 kPa
Phi': 20 °

Name: Till
Unit Weight: 20 kN/m³
Cohesion': 20 kPa
Phi': 40 °

Name: Riprap
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 40 °

Name: Rock Column
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 50 °



AREA 1 - SECTION C

Upgraded 0.6 m Thick Riprap Blanket

2 m Effective Width Rockfill Column at 25 m Offset from Tache Ave CL

Sheetpile 4 m Offset from Tache Ave Curb

Normal Steady State Conditions

Slip Surfaces:
SS1 - Global Slip
SS2 - Upper Bank Slip
SS3 - Lower Bank Slip
SS4 - Midbank Slip

Name: Lacustrine Clay (Residual)
Unit Weight: 17.5 kN/m³
Cohesion': 3.5 kPa
Phi': 12 °

Name: Silty Clay (Residual)
Unit Weight: 17.5 kN/m³
Cohesion': 3.5 kPa
Phi': 12 °

Name: Lacustrine Clay (Intact)
Unit Weight: 17.5 kN/m³
Cohesion': 5 kPa
Phi': 15 °

Name: Silt
Unit Weight: 18 kN/m³
Cohesion': 4 kPa
Phi': 20 °

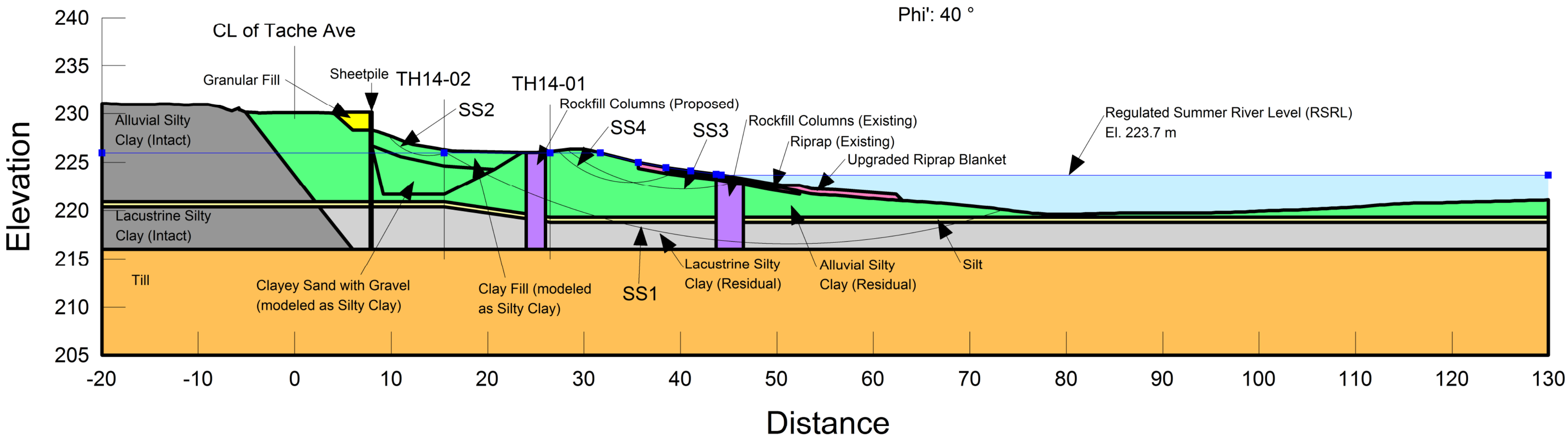
Name: Till
Unit Weight: 20 kN/m³
Cohesion': 20 kPa
Phi': 40 °

Name: Riprap
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 40 °

Name: Rock Column
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 50 °

Name: Granular Fill
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 35 °

Name: Sheetpile
Model: Bedrock (Impenetrable)



AREA 2 - SECTION A

Existing Condition - Back Analysis

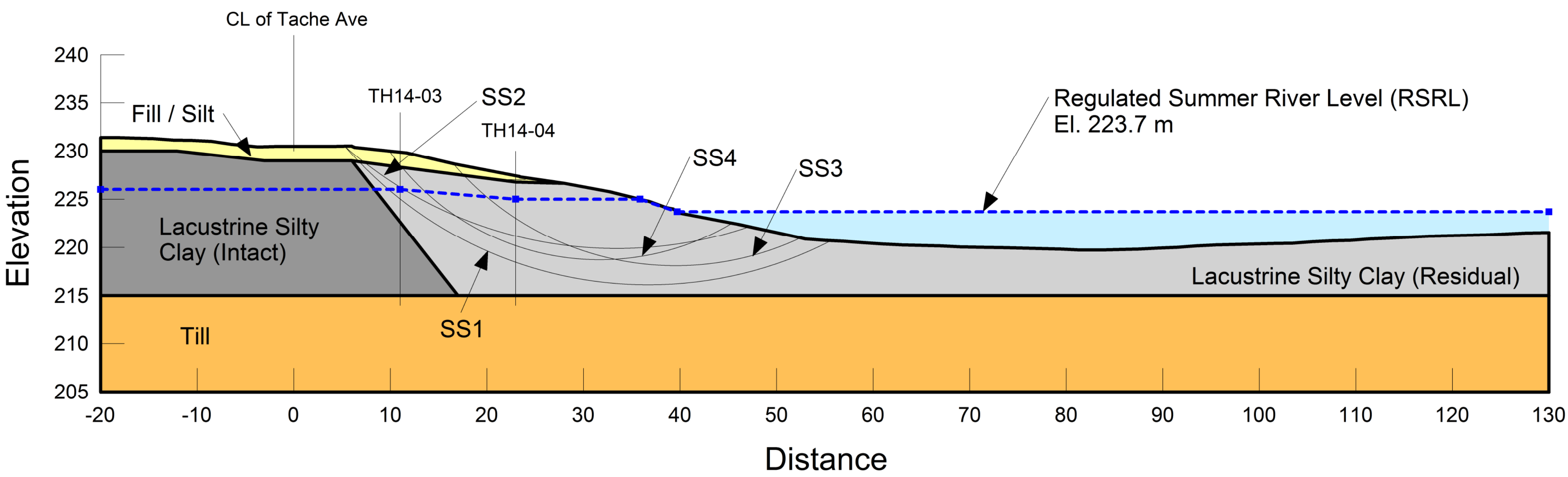
Slip Surfaces:
SS1 - Global Slip
SS2 - Upper Bank Slip
SS3 - Lower Bank Slip
SS4 - Midbank Slip

Name: Lacustrine Clay (Residual)
Unit Weight: 17.5 kN/m³
Cohesion': 3.5 kPa
Phi': 12 °

Name: Lacustrine Clay (Intact)
Unit Weight: 17.5 kN/m³
Cohesion': 5 kPa
Phi': 15 °

Name: Fill / Silt
Unit Weight: 18 kN/m³
Cohesion': 4 kPa
Phi': 20 °

Name: Till
Unit Weight: 20 kN/m³
Cohesion': 20 kPa
Phi': 40 °



AREA 2 - SECTION A

Riprap Blanket at 4.5H:1V from (37.6 m offset, El. 225 m)
3 m Effective Width Rockfill Column at 44 m Offset from Tache Ave CL
2 m Effective Width Rockfill Column at 28 m Offset from Tache Ave CL
Sheetpile 4 m Offset from Tache Ave Curb
Normal Steady State Conditions

Slip Surfaces:
SS1 - Global Slip
SS2 - Upper Bank Slip
SS3 - Lower Bank Slip
SS4 - Midbank Slip

Name: Lacustrine Silty Clay (Residual)
Model: Mohr-Coulomb
Unit Weight: 17.5 kN/m³
Cohesion': 3.5 kPa
Phi': 12 °

Name: Lacustrine Silty Clay (Intact)
Model: Mohr-Coulomb
Unit Weight: 17.5 kN/m³
Cohesion': 5 kPa
Phi': 15 °

Name: Clayey Silt / Fill
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 4 kPa
Phi': 20 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 20 kPa
Phi': 40 °

Name: Riprap
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 40 °

Name: Rockfill Column
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 50 °

Name: Granular Fill
Model: Mohr-Coulomb
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 35 °

Name: Sheetpile
Model: Bedrock (Impenetrable)