March 27, 2017

GLACIER NATIONAL PARK AVALANCHE MITIGATION PHASES 1A, 1B AND 2

Geotechnical Investigation and Stability Assessment, East Gate Landslide Deflection Berm

Submitted to:
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REPORT

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Distribution:

1 e-copy: Parks Canada Agency
1 e-copy: McElhanney Consulting Services Ltd.
1 copy: Golder Associates Ltd.

Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Parks Canada Agency (PCA) to carry out a geotechnical investigation for the East Gate Landslide deflection berm upslope of the Trans-Canada Highway (TCH) (the Site). This work is being completed under Call-Up #014 to Standing Offer No. 5P420-15-5004/001.

This report provides the results of the geotechnical drilling investigation, stability analysis completed on the existing deflection berm and provides recommendations for various berm heights for increasing the capacity of the deflection berm. Where comments are made on the general site conditions and construction, they are provided to highlight aspects that could affect the design of the project.

Use of this report is subject to conditions outlined in the *Important Information and Limitations of this Report* section which follows the main text and forms an integral part of this document. Those requiring information on geotechnical aspects of the site beyond the scope of this report must make their own interpretation of the subsurface information, particularly as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

2.0 BACKGROUND

The East Gate Landslide (EGL) debris deflection berm is located about 4 km west of the east boundary of Glacier National Park, along the TCH (Figure 1). The EGL is located upslope and about 2 km east of the TCH. The EGL releases debris downslope towards the TCH. Debris flows typically occur during freshet and occasionally during the fall months (e.g., as occurred in 2015). Accumulated debris is removed by PCA. A portion of the accumulated debris upslope of the TCH has been left in place and reshaped to construct a debris deflection berm. Upslope of the deflection berm, catchment areas have been excavated through the slide debris north and south of the debris flow inlet. These are referred to as the north and south catchments. The deflection berm structure is about 1,100 m long and is oriented parallel to the TCH as shown on Figure 2.

Debris excavation and deflection berm reshaping activities at the EGLS in the fall of 2015 were partially completed due to debris flows that occurred during this construction. Preliminary cut slope angles for design were provided to PCA and McElhanney Consulting Services Ltd. (MCSL) by Tetra Tech EBA Inc. (TTEBA) in the report “East Gate Landslide Deflection Berm Stability Assessment” dated June 2016. The TTEBA report noted that the preliminary cut slope angles were contingent on verifying that the deflection berm is not underlain by organic soils. The TTEBA report recommended that a geotechnical investigation be completed to assess the potential presence of organic soil layers. It is understood that PCA and MCS require recommended berm cut and fill slope angles for design to plan and execute future debris removal and deflection berm shaping activities.

Golder completed a site reconnaissance of the EGL deflection berm on September 1, 2016 to provide comments and recommendations for further geotechnical investigation and preliminary design. A summary of the observations and collected during the site reconnaissance is provided in Golder’s technical memorandum titled: “East Gate Landslide Deflection Berm and Beaver Valley Ponding Phase 2, Geotechnical Site Reconnaissance and Assessment, Glacier National Park Avalanche Mitigation Phases 1A, 1B and 2”, Report No. 1654746_TM0006 Rev A, dated September 13, 2016.

3.0 GEOTECHNICAL INVESTIGATION

3.1 Field Drilling

Golder completed a geotechnical investigation between September 30 and October 5, 2016, which included putting down six boreholes (i.e. Boreholes EG-16-01 to EG-16-06). The location of the boreholes is shown on Figure 2. The Record of Borehole Sheets are provided in Appendix A. The purpose of the investigation was to determine if an organic soil layer is present below the deflection berm and to gather more refined information on the soil consistency and relative densities of the deflection berm material and underlying native material for input to Golder's slope stability assessment and our subsequent recommendations.

The borehole locations where located along the construction access road at the top of the deflection berm (Figure 2). The boreholes were drilled with a Diedrich D-120 Air Rotary drill rig with 140 mm casing using pneumatic percussive (ODEX) methods. The drilling equipment was owned and operated by Earth Drilling Company Ltd. under subcontract to Golder. The boreholes were drilled and samples were obtained to depths ranging from 18.75 mbgs (meters below ground surface at the borehole location) to 30.94 mbgs.

In-situ tests (i.e. Standard Penetration Tests (SPTs)) were completed at regular 1.5 m depth intervals to obtain samples and support soil consistency and relatively density estimates. Grab samples from the drilling cuttings were also obtained. More frequent sampling was completed near the inferred base of the deflection berm to assess the potential presence of a pre-existing organic soil layer and refine the estimated shear strength parameters of the soil underlying the berm.

Drilling operations were supervised by a member of Golder's geotechnical engineering staff, who visually observed and logged the soil and groundwater conditions encountered. Upon completion of drilling, the boreholes were backfilled with excess drill cuttings to ground surface and soil samples were transported to our geotechnical laboratory in Calgary, Alberta.

3.2 Laboratory Testing

Upon completion of the fieldwork, soil samples were returned to Golder's Calgary geotechnical laboratory for further examination, classification and testing on selected samples. The testing included determination of natural water content, grain-size distribution analysis, Atterberg Limits, organic content, Standard Proctor moisture-density relationship, and a set of large direct shear tests. The test results are provided in Appendix B with selected test results shown on the Record of Borehole Sheets.

All tests were carried out following ASTM procedures, as applicable.

4.0 ENCOUNTERED SUBSURFACE CONDITIONS

The soil and rock descriptions provided in this report are based on accepted standard methods of classification and identification routinely used in current geotechnical state of practice. Detailed descriptions of the subsurface conditions encountered in each of the boreholes are presented on the Record of Borehole Sheets shown in Appendix A. The stratigraphic boundaries shown on the Record of Borehole Sheets are inferred from non-continuous sampling, observations of drilling and the results of the Standard Penetration Tests (SPT). These boundaries represent transitions between soil types rather than exact planes of geological change.

The soils encountered during the drilling investigation generally comprise a mixture of low plastic silt, sand and gravel (with varying proportions of cobbles and boulders) within the deflection berm, underlain by an organic silt layer of varying organic content and thickness, underlain by native soil (i.e. predating the berm) that has similar composition to the deflection berm. The organic soils contained woody debris.

The deflection berm composition is relatively variable. The encountered and observed berm soils vary in composition from silty sand and gravel, to gravelly sandy silt, to silt with some gravel and some sand. The proportion of cobbles and boulders is also expected to be variable due the nature of deposition of the slide debris.

The relative density of the deflection berm was generally compact, with SPT N-values ranging from 6 blows/300 mm to 38 blows/300 mm. The underlying native soil was generally compact to very dense with SPT N-values ranging from 14 blows/300 mm to refusal at 50 blows/ 50 mm. Note that high SPT N-values may, in some instances, reflect gravel fragments that are lodged in the tip of the split spoon sampler.

The limited SPT N-values measured in the organic silt generally indicated a compact material, which ranged from 10 blows/300 mm to 24 blows/300 mm. The depth to the observed organic silt layer ranged in approximate elevation from 845.4 meters above sea level (masl) to 851.3 masl. Borehole Records for EG-16-04 and EG-16-06 indicated trace organic soils in some samples though a relatively distinct organic soil layer was not observed.

Groundwater seepage was not reported during the drilling investigation. No standpipes were attempted to measure groundwater level, as these standpipes would be expected to be destroyed during the next debris removal activities.

Bedrock was not encountered during the geotechnical investigation.

The encountered subsurface conditions are illustrated on six cross-sections that correspond to the borehole locations. The location of each cross-section, along with elevation contours, is shown on Figure 3. The cross-sections were developed using LiDAR data collected in March 2015 and updated with as-built survey information provided by MCS (survey dated July 9, 2016 in file EGLS_PondingI_Staging_As-Built August 2016.dwg). The cross-sections are labelled Section A at Borehole EG-16-01 (north end of the berm) to Section F at Borehole EG-16-06 (Figures 4 to 9, respectively).

5.0 SEISMICITY

Site specific information was reviewed to assess the seismic classification of the proposed site. Based on the available geotechnical information, the site seismic classification in terms of the National Building Code of Canada (NBCC 2010) requirements corresponds to Site Class D (NBCC and User Guide-Structural Commentaries Part 4). Site Class D is considered appropriate for design.

Table 1 shows the seismic parameters based on NBCC (2010) for the site, based on a 2% probability of exceedance in 50 years.

Table 1: Seismic Parameters Based on 2010 NBCC for Reference Site (Site Class D)

Probability of Exceedance (50 years)	PGA
2%	0.107 g

g = acceleration due to gravity

For slope stability analysis considering seismic conditions, a minimum pseudo-static Factor of Safety (FS) of 1.1 is recommended for a 475 year return period (i.e. 2% probability of exceedance in 50 years). A horizontal seismic coefficient of 0.67 was applied to the Peak Ground Acceleration (PGA), resulting in a pseudo-static horizontal acceleration of 0.07 g.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 Geotechnical Parameters

Geotechnical conditions are expected to vary laterally and with depth between borehole locations due to method of the slide debris deposition. Golder reviewed available information to assess the geotechnical conditions and parameters that we consider suitable for carrying out analyses and developing engineering comments and recommendations for the proposed development. The review incorporated available results of the geotechnical investigation, laboratory testing and Golder's experience with similar soils and geological conditions.

Large direct shear tests were completed an aggregate soil specimen comprising grab samples that were obtained during the site reconnaissance and selected SPT samples. These soil samples were combined into a single aggregate sample for the direct shear tests. The aggregate sample is considered representative of the encountered berm soil based on available information and in consideration of the disturbance and fracturing of coarse-grained soils that occurs during ODEX drilling and sampling. Test results for the aggregate sample (Appendix B) indicate this sample comprised silty, sandy gravel with a Standard Proctor Maximum Dry Density of 2010 kg/m^3 and Optimum Water Content of about 11%. Particles larger than 15 mm were removed from the aggregate sample prior to commencing the direct shear tests maintain compliance with ASTM requirements for maximum particle size for the shear box dimensions. The sheared samples comprised gravelly silty sand.

Normal stresses of 75 kPa, 200 kPa and 400 kPa were applied during the direct shear tests. The test results indicate a peak effective friction angle of 33° and residual effective friction angle of 30° (Appendix B). The measured peak and residual friction angles would be expected to be somewhat higher if particles larger than 15 mm diameter were allowed to remain in the test specimens. Peak and residual effective friction angles of 35° and 32°, respectively, are inferred for the berm material and relatively recent (fresh) slide debris.

The direct shear tests would not be expected to indicate an apparent cohesion for the tested soil, as sampling and test specimen preparation alter the soil structure (compared to its in situ structure). Based on site reconnaissance observations of eroded vertical faces up to 1.5 m high at a limited number of locations, a peak apparent cohesion of 5 kPa is inferred for the deflection berm material and native soil that pre-dates the berm. The apparent cohesion is attributed to relatively weak cementation of soil particles following drainage. Fresh slide debris was inferred to have no cohesion.

The soil parameters that were used for the slope stability analyses are summarized in Table 2.

Table 2: Soil Parameters used in Stability Analyses

Parameter	Fresh Debris	Deflection Berm and Native Soil
Bulk Unit weight, γ (kN/m^3)	20	20
Effective Friction Angle, ø' (degrees)	32	35
Cohesion intercept, c' (kPa)	0	5

Based on available information, Golder considers that the organic silt layer (where encountered) is generally similar, from a slope stability and shear strength perspective, to the deflection berm material. The organic soil (where encountered) comprised low plasticity organic silt that appeared to be discontinuous and mixed with mineral soil slide material, woody debris and roots. Hence, the geotechnical parameters for deflection berm and native material (Table 2) were also applied to the organic silt layer. It is noted that weaker parameters for the organic soil would have been recommended if high plasticity organic soil, for example, had been encountered.

Fresh debris (Table 2) refers to landslide debris that is relatively recent (that season, for example), is relatively wet and is retained upslope of the deflection berm.

Since there is no specific groundwater table elevation information at the site, Golder has inferred a groundwater table regime for the stability analyses. The inferred groundwater regimes are considered reasonable based on available information.

6.2 Design criteria

The design criteria for the deflection berm cut and fill slope angles are the acceptable (target) minimum Factor of Safety (FS) values. The FS is defined as the ratio of forces that tend to resist slope movement to the forces that tend to drive, or cause, slope movement. Golder has not been provided with design criteria for this assignment. Interim design criteria are presented below, for discussion purposes.

In civil engineering practice, target minimum FS values of between 1.3 and 1.5 are typically used for slopes under static loading conditions. A target value not less than 1.5 is generally used for slopes that support or are immediately adjacent to permanent infrastructure (such as the Trans-Canada Highway).

A target value not less than 1.3 may be used for slopes supporting temporary infrastructure, or permanent slopes that are sufficiently removed from public infrastructure that slope movement (should it occur) would not affect the public infrastructure.

Three potential failure modes were considered for design cut and fill slope angles during the stability assessment, as follows:

- Case 1. Slope movement of debris fill toward the TCH.
- Case 2. Slope movement of the upslope deflection berm face towards the interior of the north and south catchments.
- Case 3. Slope movement of the cut slope through native soil exposed on the east face of the catchments towards the catchment interior.

Cases 1 to 3 are illustrated on Figure 10.

The following design criteria have been used to develop the recommendations provided in this report:

- Case 1. Target minimum calculated FS not less than 1.5 or 1.3 (selected by PCA) and 1.1 for static and seismic loading conditions, respectively, in consideration of the proximity of the deflection berm to the TCH.
- Cases 2 and 3. Target minimum calculated FS not less than 1.2 and 1.0 for static and seismic loading conditions, respectively.

The target minimum FS of 1.2 for Cases 2 and 3 under static conditions is contingent on the methods used to excavate the catchment areas. A target minimum FS of 1.2 requires that any personnel within the catchment areas will be inside large construction equipment (i.e. excavators). The stability of the excavation side slopes generally increases with time after excavation (in this case) as the remaining debris and the deflection berm gradually drain (the groundwater table is highest immediately following a debris event). Provided that personnel within the excavation are restricted to being inside construction equipment and all foot traffic is minimized and avoided, a target minimum FS of 1.2 under static conditions is considered reasonable. Using a target minimum FS of 1.2 requires that excavation be monitored on a full time basis by a qualified geotechnical engineer, or their representative, who would observe the cut slopes for visual evidence of potential slope instability.

The design criteria should be discussed and confirmed as the design progresses. It is noted that selecting the design criteria is ultimately the responsibility of the Owner.

6.3 Slope Stability Assessment

The stability assessment considered the existing geometry of the deflection berm with subsequent assessment to estimate recommended cut and fill slope angles.

Slope stability assessments were completed using the software Slide™ (Version 7.022) by Rocscience Inc. Several thousand potential (i.e. trial) circular and non-circular failure surfaces were considered for each scenario that was assessed. These two-dimensional stability analyses were completed using the Morgenstern-Price General Limit Equilibrium Method.

6.3.1 Stability Analysis of Existing Slopes

The stability of the existing deflection berm was analyzed at each of the six borehole locations (Figures 4 to 9). Selected analysis results are shown in Appendix C. Note that the north catchment area was full of slide debris at the time of the survey and this was considered in the analysis.

The results in Table 3 indicate that the calculated minimum FS under static conditions is less than 1.5 for Sections A, B, D, E and F and is less than 1.3 for Section D.

Table 3: Existing Slope Stability Analysis Summary - Case 1

Section	Factor of Safety	
	Static	Seismic
A	1.33	1.14
B	1.45	1.28
C	1.51	1.31
D	1.27	1.14
E	1.42	1.24
F	1.40	1.22

6.3.2 Design Fill Slope Angles (Case 1)

Golder has completed stability analysis of the deflection berm downslope face (i.e. Case 1) for various design fill slope angles and slope heights up to 21 m.

Deflection berm height is defined as the vertical distance between the (downslope) berm crest and the downslope toe of the debris berm. An access road 5 m wide was included in all of the slope models. Construction traffic loads are transient and temporary. Construction traffic loads were not explicitly considered in the analyses, which Golder considers a reasonable approach for the Site.

The stability of the deflection berm was assessed when the catchment areas are empty and when the catchment areas are full of saturated fresh debris. The latter scenario tended to produce the lower calculated FS values.

The recommended maximum fill slope angles and corresponding heights to meet the static and seismic stability design criteria for Case 1 are provided in Table 4.

These fill slope angles require that placed debris used as fill is compacted to not less than 98% Standard Proctor Maximum Dry Density and within +/- 2% of its Optimum Water Content at the time of placement. Wet or poorly compacted fill, if used, would have a lower FS than the design criteria. These results apply to uniform slope angles. Locally steeper portions of the slope would have a lower FS than the design criteria and should be avoided.

Table 4: Recommended Slope Heights for Various Fill Slope Angles (Case 1)

Slope	Case 1, FS ≥ 1.5 (Static)	Case 1, FS ≥ 1.3 (Static)
1H: 1V	≤ 4 m	≤ 5 m
1.25H: 1V	≤ 5 m	≤ 8 m
1.5H: 1V	≤ 9 m	≤ 15 m
1.75H: 1V	≤ 15 m	≤ 18 m
2H: 1V	≤ 18 m	≤ 21 m

6.3.3 Design Cut Slope Angles (Cases 2 and 3)

Golder has completed stability analysis of the interior faces of the catchment areas (i.e. Cases 2 and 3) for design cut slope heights of up to about 20 m. Based on the geometry of the berm and the proximity of the TCH, it appears unlikely that cut slopes exposing more than 20 m heights of interior deflection berm slopes would be feasible from a geometric perspective (at higher cut slope heights on the interior berm face, the downslope berm would likely encroach into the TCH ditch). Cut slopes through the native soil upslope of the deflection berm that exceed a height of 10 m are not recommended, in consideration of the relatively limited geotechnical information upslope of the berm.

For Case 2, the cut slope height is defined as the vertical distance between the base of the excavation and the crest of the deflection berm. If any excavation spoils are temporarily stockpiled within 3 m of the deflection berm crest above the excavation, the cut slope height is defined as the vertical distance between the base of the excavation and the crest of the excavation spoils. The recommended cut slope angles for Case 2 are also applicable to earthen check dam side slopes within the catchments, noting that slope heights are measured from the lowest adjacent points in the catchment for Case 2 and Case 3.

For Case 3, the cut slope height is defined as the vertical distance between the base of the excavation and the crest of the cut through native soil. The natural (existing) slope angle of native ground upslope of the catchment basin was estimated to be 16° (measured from horizontal).

The recommended maximum cut slope angles and corresponding heights to meet the static and seismic stability design criteria for Case 2 and Case 3 are provided in Table 5. Excavation must cease if groundwater seepage is observed from cut slopes through the native ground or the deflection berm material. Cut slopes through fresh debris would likely need to be shallower than the cut slope angles inTable 5. These results apply to uniform slope angles. Locally steeper portions of the slope would have a lower FS than the design criteria and should be avoided.

Table 5: Recommended Slope Heights for Various Cut Slope Angles (Case 2 and Case 3)

Slope	Case 2	Case 3
1H: 1V	≤ 7 m	≤ 6 m
1.25H: 1V	≤ 12 m	≤ 8 m
1.5H: 1V	≤ 20 m	≤ 10 m

The recommended cut slope angles require that the excavations expose berm material (Case 2) that is several months older than the debris. Cut slope angles through relatively recent debris, which is wet and has not yet drained, will likely need to be to be shallower that the values recommended herein. Monitoring by qualified geotechnical personnel during debris excavation will be needed.

The recommended cut slope angles for Cases 2 and 3 consider groundwater tables that do not daylight in the excavation side slopes. Debris excavation should not proceed deeper if groundwater seepage is observed from the excavation side slopes.

During and following excavation, drainage along the base of the catchment basins shall be directed to the center of the catchment base. Directing drainage toward the toe of the side slopes may contribute to toe erosion and instability of these side slopes.

During shaping of the deflection berm and excavation of the catchments, the inside slope of the berm may be safely constructed provided that the potential risks associated with instability of these slopes are appropriately identified and mitigated during construction. These mitigations include but are not limited to: prohibiting foot traffic within these excavations; continuous monitoring for signs of slope instability by qualified geotechnical personnel during excavation using a framework of pre-established warning systems and egress routes; diligent survey control of constructed cut slope angles and heights; adjusting (flattening) cut slopes where instability is observed; and, excavating in an upstream direction (i.e. of gradually increasing cut slope height) to promote drainage and gain a better understanding of how the excavated slopes will perform based on the characteristics of the excavated debris at that time.

The performance of the cut slope and fill slopes will be affected by factors such as the age, water content and composition of the slide debris. These characteristics will vary laterally, vertically and with time following debris deposition. Monitoring by qualified geotechnical personnel is, therefore, recommended during excavation of the debris catchments.

A safety berm should be constructed along the crest of the deflection berm facing the highway at approximately 1 m tall with side slopes of 1.5H: 1V to deter material rolling down the slope from heavy equipment operating along the top of the berm.

6.4 On-Going Monitoring

In addition to monitoring during construction and excavation, on-going monitoring of the debris deflection berm should be undertaken by qualified geotechnical personnel during periods of snow melt, heavy rainfall and debris deposition (slide) events. The monitoring should include a visual assessment of the deflection berm slopes to check for signs of seepage or increased seepage, cracks, surficial failures and movement. The recommended cut and fill slope angles may need to be revised based on the monitoring results.

7.0 CLOSURE

We trust that this report provides the information that you require at this time. Please do not hesitate to contact the undersigned if there are any questions.

Yours truly,

GOLDER ASSOCIATES LTD.

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27 March 2017

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IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

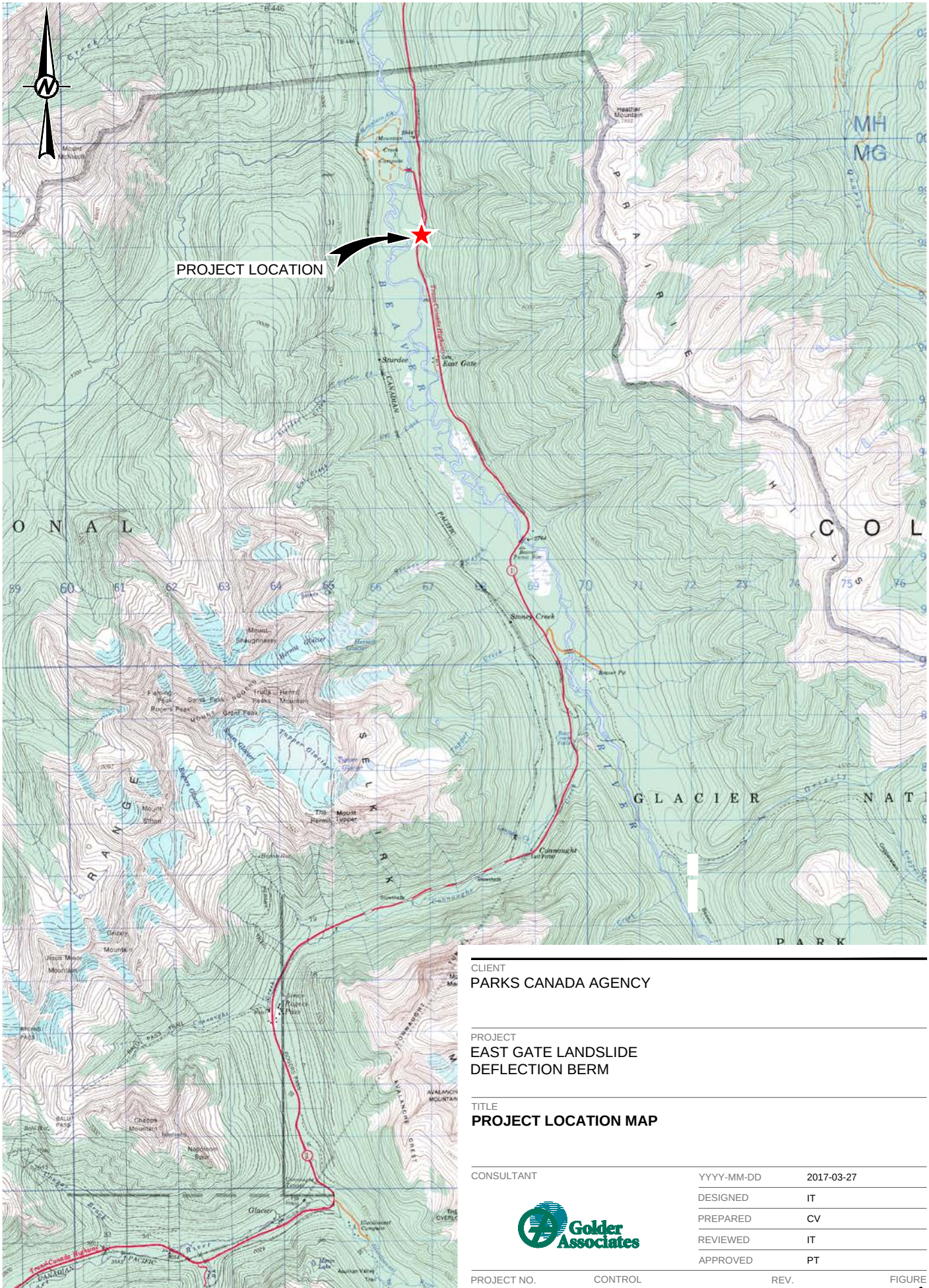
Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

FIGURES



CLIENT
PARKS CANADA AGENCY

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
PROJECT LOCATION MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-27
DESIGNED	IT
PREPARED	CV
REVIEWED	IT
APPROVED	PT

PROJECT NO.	CONTROL	REV.	FIGURE
1654746		0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

0 25 mm

LEGEND

BOREHOLE LOCATION

REFERENCE

1. IMAGE OBTAINED FROM GOOGLE EARTH PRO, USED UNDER LICENSE. IMAGERY DATE: MAY 26, 2012. GOOGLE EARTH IMAGE IS NOT TO SCALE.
2. COORDINATES AND ELEVATIONS REFERENCE NAD83 / UTM ZONE 11N.

0 50 100
1:2,500 METRES

CLIENT
PARKS CANADA AGENCY

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
Golder Associates

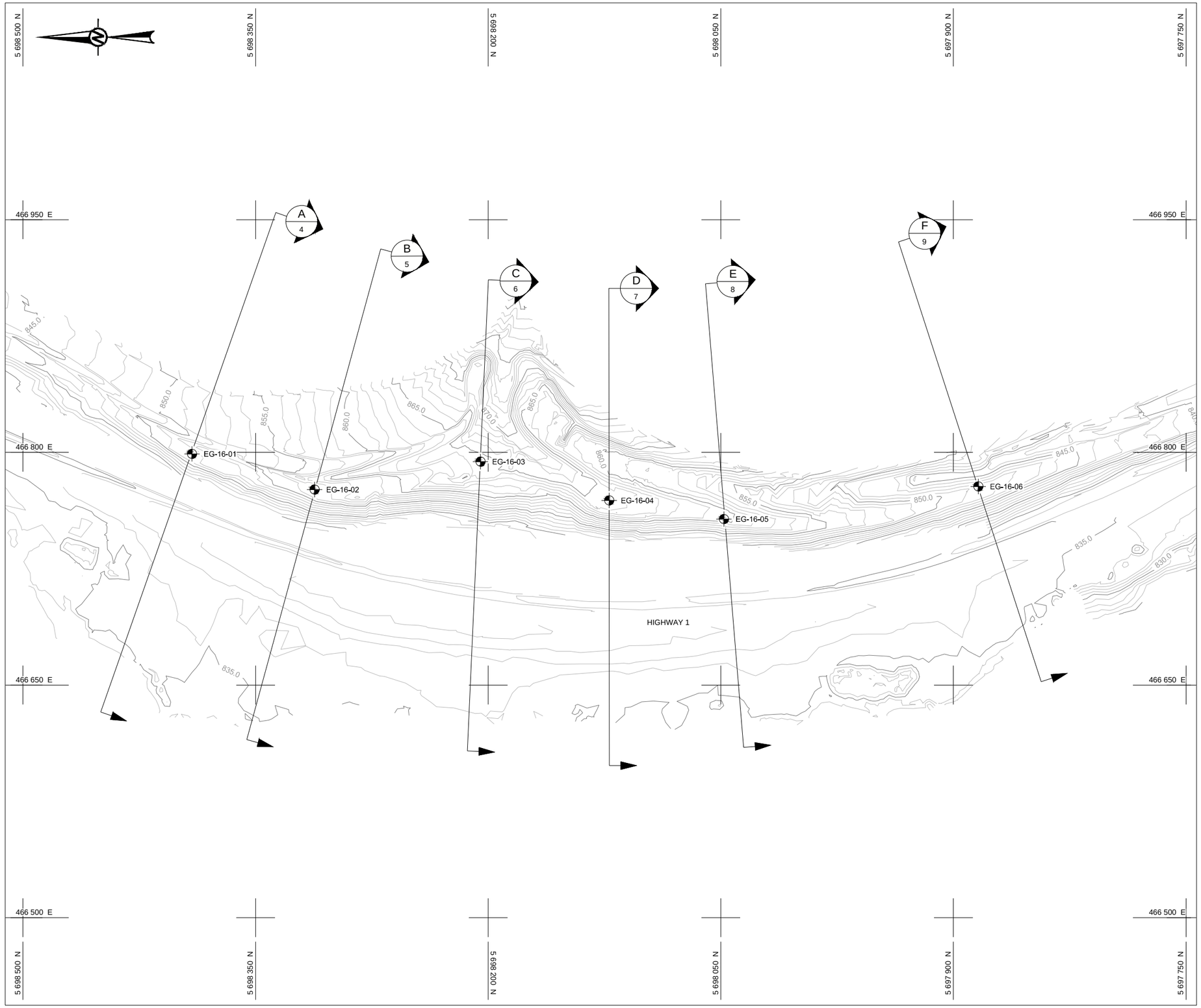
YYYY-MM-DD	2017-03-27
PREPARED	CV
DESIGN	IT
REVIEW	IT
APPROVED	PT

PROJECT No. 1654746 | CONTROL | Rev. 0 | FIGURE 2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm 0

Path: \\golder.gds\calgary\EDCAD\2016\1654746\PRODUCTION\FIGURES\ | File Name: 1654746FIG003.dwg



LEGEND

- BOREHOLE LOCATION
- GROUND ELEVATION CONTOURS (1m INTERVAL)

REFERENCE

1. TOPOGRAPHIC DATA PROVIDED BY MCELHANNEY CONSULTING SERVICES LTD., FILENAME; 'EGLS_PondingI_Staging_ As-Built August 2016.dwg'.
2. BERM AS-BUILT COMPLETED JULY 9, 2016. STAGING AREA AS-BUILT COMPLETED AUGUST 16, 2016. PONDING AREA AS-BUILT COMPLETED AUGUST 27, 2016.
3. ELEVATIONS AND COORDINATES REFERENCE UTM / NAD 83 ZONE 11N.

0 50 100
1:2,500 METRES

CLIENT
PARKS CANADA AGENCY

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
CONTOUR, BOREHOLE AND SECTION LOCATION PLAN

CONSULTANT
Golder Associates

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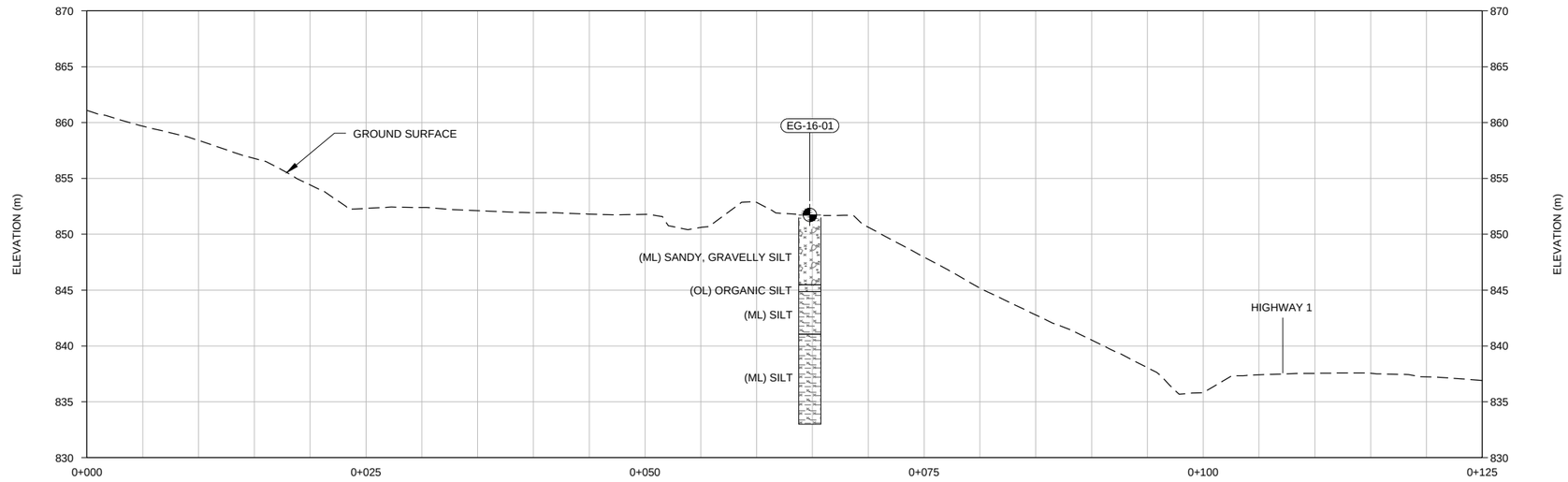
PREPARED	CV
DESIGN	IT
REVIEW	IT
APPROVED	PT

PROJECT No. 1654746 | CONTROL | Rev. 0 | FIGURE 3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

Path: \\golder.gds\calgary\EDCAD\2016\654746\PRODUCTION\FIGURES\ | File Name: 1654746FIG002.dwg



SCALE 1:500 A 3 SECTION A

0 10 20
1:500 METRES

NOTES / REFERENCES

1. GROUND SURFACE SHOWN IS A COMBINATION OF 2015 AND 2016 EXISTING GROUND SURFACES.
2. TOPOGRAPHIC DATA PROVIDED BY MCELHANNEY CONSULTING SERVICES LTD., FILENAME; '481_OG LiDAR.xml" (2015) and EGLS_PondingI_Staging_ As-Built August 2016.dwg' (2016).
3. BERM AS-BUILT COMPLETED JULY 9, 2016. STAGING AREA AS-BUILT COMPLETED AUGUST 16, 2016. PONDING AREA AS-BUILT COMPLETED AUGUST 27, 2016.
4. ELEVATIONS AND COORDINATES REFERENCE UTM / NAD 83 ZONE 11N.

CLIENT
PARKS CANADA AGENCY

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
SECTION A

CONSULTANT
Golder Associates

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REVIEW	IT
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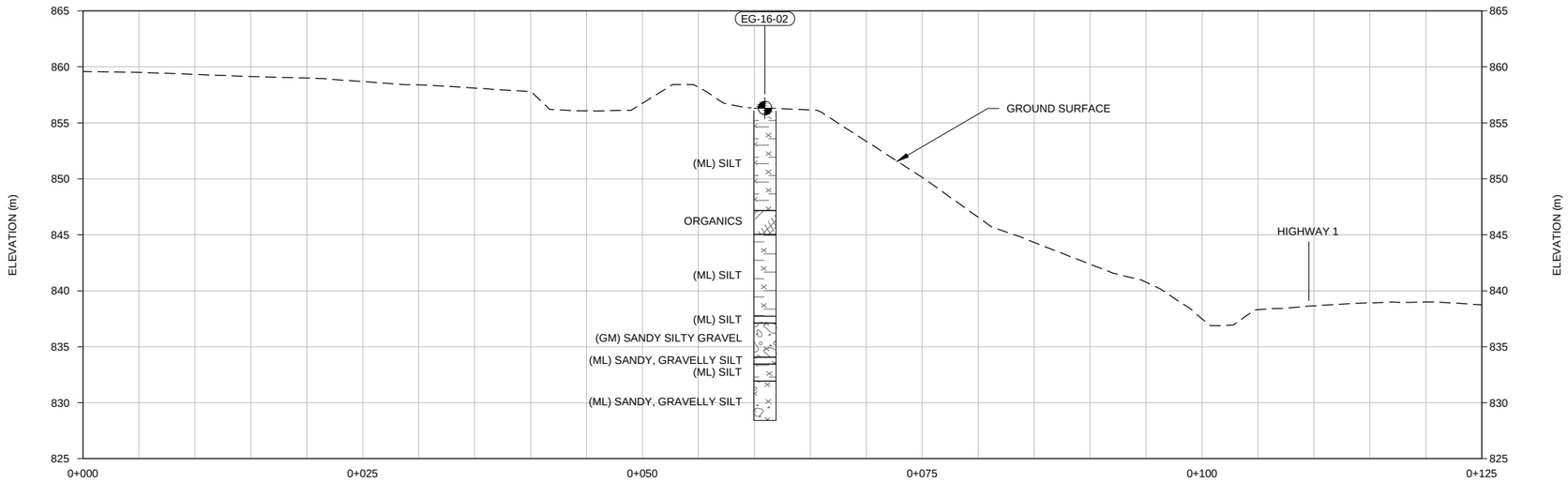
PROJECT No.	CONTROL	Rev.	FIGURE
1654746		0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

0

Path: \\golder.gds\calgary\EDCAD\2016\65-4746\PRODUCTION\FIGURES\ | File Name: 1654746FIG002.dwg



SCALE 1:500 B 3 SECTION B

0 10 20
1:500 METRES

NOTES / REFERENCES

1. GROUND SURFACE SHOWN IS A COMBINATION OF 2015 AND 2016 EXISTING GROUND SURFACES.
2. TOPOGRAPHIC DATA PROVIDED BY MCELHANNEY CONSULTING SERVICES LTD., FILENAME; '481_OG LiDAR.xml" (2015) and EGLS_PondingI_Staging_ As-Built August 2016.dwg' (2016).
3. BERM AS-BUILT COMPLETED JULY 9, 2016. STAGING AREA AS-BUILT COMPLETED AUGUST 16, 2016. PONDING AREA AS-BUILT COMPLETED AUGUST 27, 2016.
4. ELEVATIONS AND COORDINATES REFERENCE UTM / NAD 83 ZONE 11N.

CLIENT
PARKS CANADA AGENCY

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
SECTION B

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-03-27
PREPARED	CV
DESIGN	IT
REVIEW	IT
APPROVED	PT

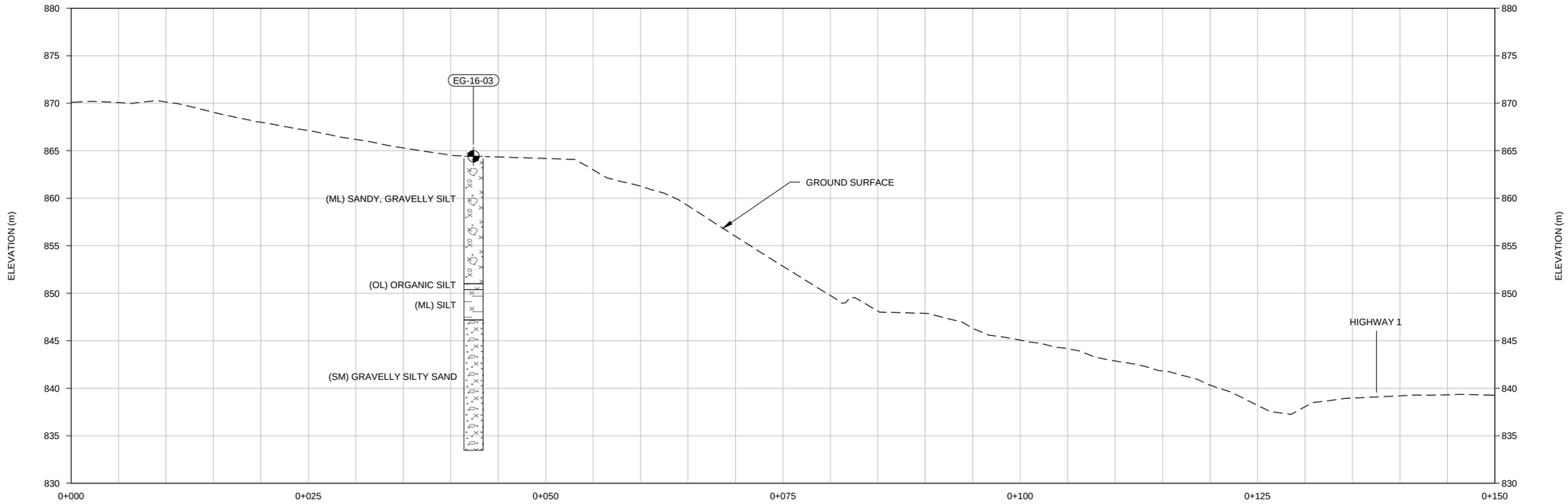
PROJECT No. 1654746 | CONTROL | Rev. 0 | FIGURE 5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

0

Path: \\golder.gds\calgary\EDCAD\2016\1654746\PRODUCTION\FIGURES\ | File Name: 1654746FIG002.dwg



SCALE 1:500 C 3 SECTION C

0 10 20
1:500 METRES

NOTES / REFERENCES

1. GROUND SURFACE SHOWN IS A COMBINATION OF 2015 AND 2016 EXISTING GROUND SURFACES.
2. TOPOGRAPHIC DATA PROVIDED BY MCELHANNEY CONSULTING SERVICES LTD., FILENAME; '481_OG LiDAR.xml" (2015) and EGLS_PondingI_Staging_ As-Built August 2016.dwg' (2016).
3. BERM AS-BUILT COMPLETED JULY 9, 2016. STAGING AREA AS-BUILT COMPLETED AUGUST 16, 2016. PONDING AREA AS-BUILT COMPLETED AUGUST 27, 2016.
4. ELEVATIONS AND COORDINATES REFERENCE UTM / NAD 83 ZONE 11N.

CLIENT
PARKS CANADA AGENCY

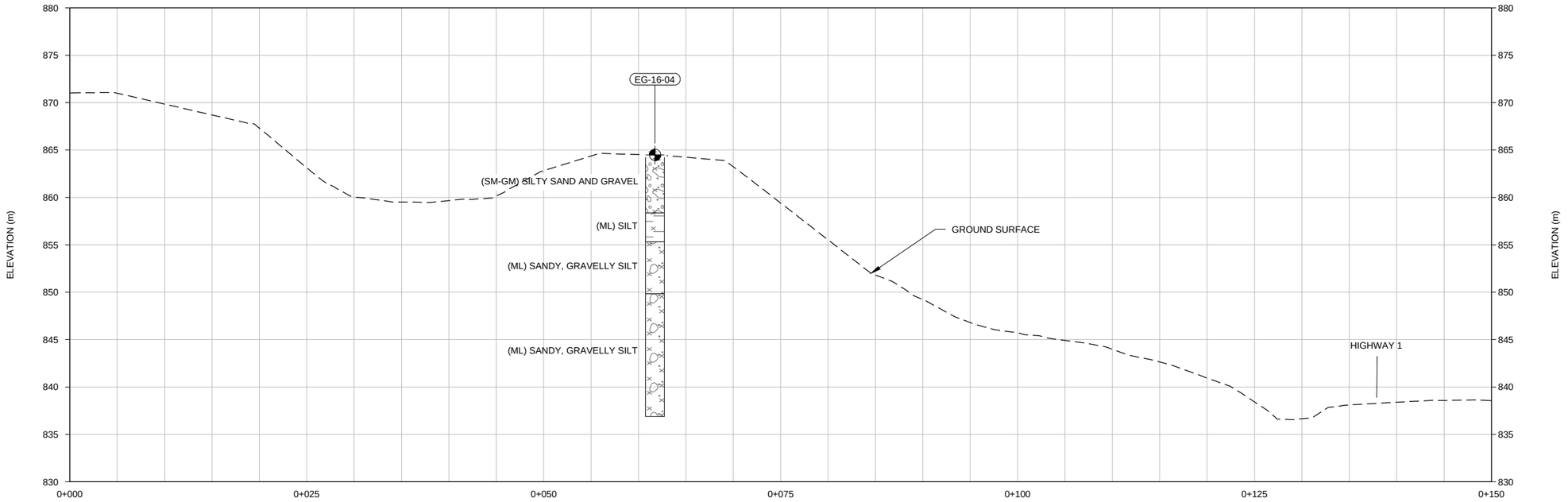
PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
SECTION C

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-27
PREPARED	CV
DESIGN	IT
REVIEW	IT
APPROVED	PT

PROJECT No. 1654746 | CONTROL | Rev. 0 | FIGURE 6



SCALE 1:500 D 3 SECTION D

0 10 20
1:500 METRES

NOTES / REFERENCES

1. GROUND SURFACE SHOWN IS A COMBINATION OF 2015 AND 2016 EXISTING GROUND SURFACES.
2. TOPOGRAPHIC DATA PROVIDED BY MCELHANNEY CONSULTING SERVICES LTD., FILENAME; '481_OG LiDAR.xml" (2015) and EGLS_Ponding!_Staging_ As-Built August 2016.dwg' (2016).
3. BERM AS-BUILT COMPLETED JULY 9, 2016. STAGING AREA AS-BUILT COMPLETED AUGUST 16, 2016. PONDING AREA AS-BUILT COMPLETED AUGUST 27, 2016.
4. ELEVATIONS AND COORDINATES REFERENCE UTM / NAD 83 ZONE 11N.

CLIENT
PARKS CANADA AGENCY

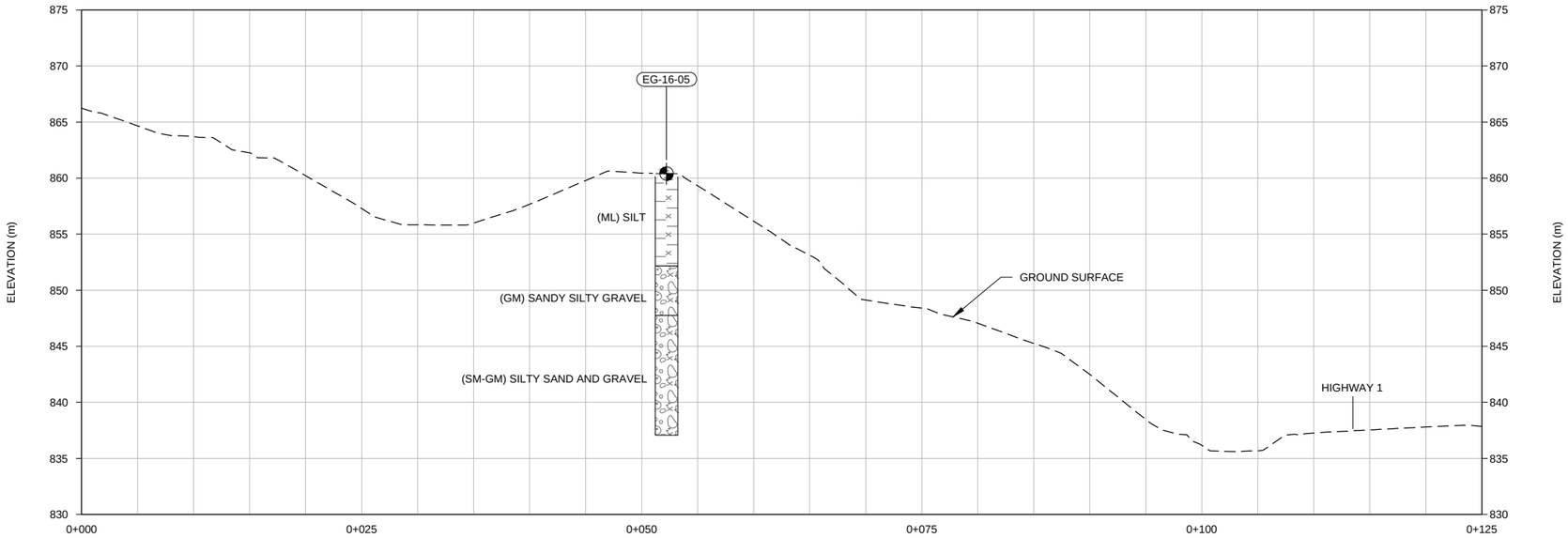
PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
SECTION D

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-27
PREPARED	CV
DESIGN	IT
REVIEW	IT
APPROVED	PT

PROJECT No. 1654746 | CONTROL | Rev. 0 | FIGURE 7



SCALE 1:500 E 3 SECTION E

NOTES / REFERENCES

1. GROUND SURFACE SHOWN IS A COMBINATION OF 2015 AND 2016 EXISTING GROUND SURFACES.
2. TOPOGRAPHIC DATA PROVIDED BY MCELHANNEY CONSULTING SERVICES LTD., FILENAME; '481_OG LiDAR.xml" (2015) and EGLS_Ponding!_Staging_ As-Built August 2016.dwg' (2016).
3. BERM AS-BUILT COMPLETED JULY 9, 2016. STAGING AREA AS-BUILT COMPLETED AUGUST 16, 2016. PONDING AREA AS-BUILT COMPLETED AUGUST 27, 2016.
4. ELEVATIONS AND COORDINATES REFERENCE UTM / NAD 83 ZONE 11N.

0 10 20
1:500 METRES

CLIENT
PARKS CANADA AGENCY

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
SECTION E

CONSULTANT
Golder Associates

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DESIGN	IT
REVIEW	IT
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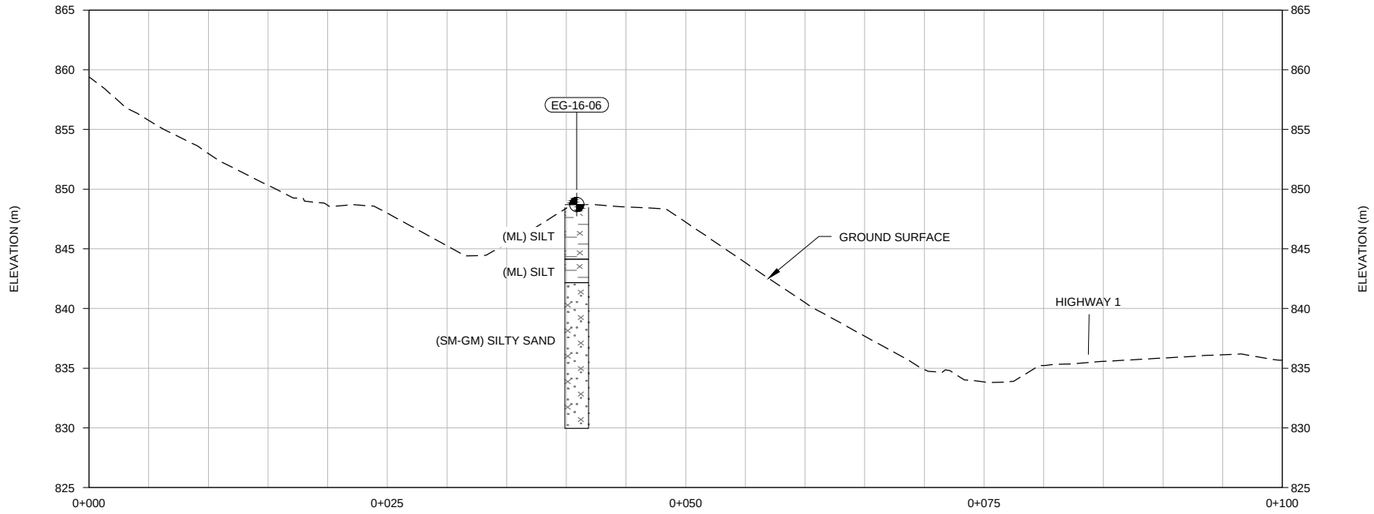
PROJECT No. 1654746 | CONTROL | Rev. 0 | FIGURE 8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
0 25 mm

Path: \\golder.gds\val\gary\EDCAD\2016\1654746\PRODUCTION\FIGURES\ | File Name: 1654746FIG002.dwg



SCALE 1:1000 — F 3 — SECTION F

0 10 20
1:500 METRES

NOTES / REFERENCES

1. GROUND SURFACE SHOWN IS A COMBINATION OF 2015 AND 2016 EXISTING GROUND SURFACES.
2. TOPOGRAPHIC DATA PROVIDED BY MCELHANNEY CONSULTING SERVICES LTD., FILENAME; '481_OG LiDAR.xml" (2015) and EGLS_PondingI_Staging_ As-Built August 2016.dwg' (2016).
3. BERM AS-BUILT COMPLETED JULY 9, 2016. STAGING AREA AS-BUILT COMPLETED AUGUST 16, 2016. PONDING AREA AS-BUILT COMPLETED AUGUST 27, 2016.
4. ELEVATIONS AND COORDINATES REFERENCE UTM / NAD 83 ZONE 11N.

CLIENT
PARKS CANADA AGENCY

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
SECTION F

CONSULTANT
Golder Associates

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PREPARED	CV
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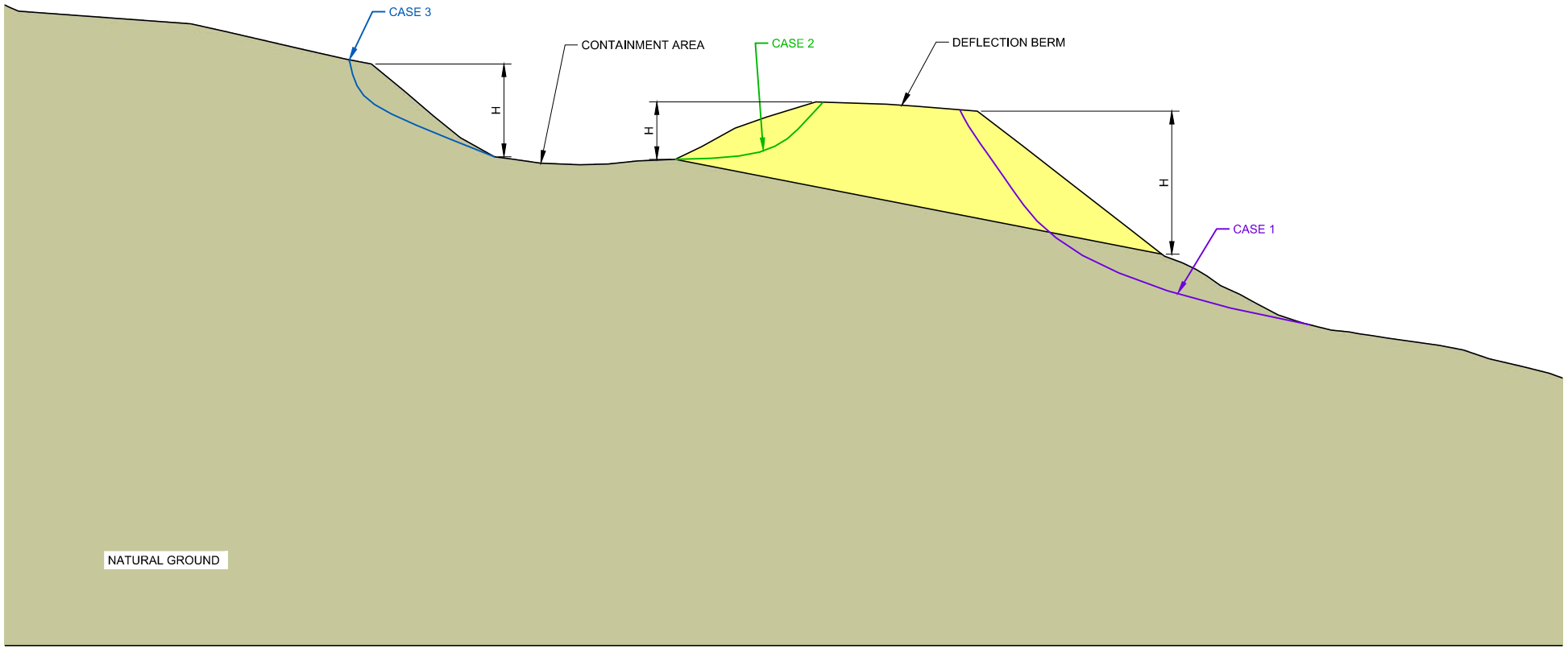
REVIEW	IT
APPROVED	PT

PROJECT No.	CONTROL	Rev.	FIGURE
1654746		0	9

Last Edited By: cvincent Date: 2017-03-20 Time:5:40:14 PM | Printed By: CVincent Date: 2017-03-27 Time:2:07:39 PM
Path: \\golder.gds\calgary\EDCAD\2016\1654746\PRODUCTION\FIGURES\ | File Name: 1654746FIG001.dwg



LEGEND

H - SLOPE HEIGHT

0 10 20
1:500 METRES

CLIENT
PARKS CANADA AGENCY

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM STABILITY ANALYSIS

TITLE
SLOPE STABILITY ANALYSIS CASES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-27
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PREPARED	TF
REVIEWED	IT
APPROVED	PT

PROJECT NO.	CONTROL	REV.	FIGURE
1654746		0	10

APPENDIX A

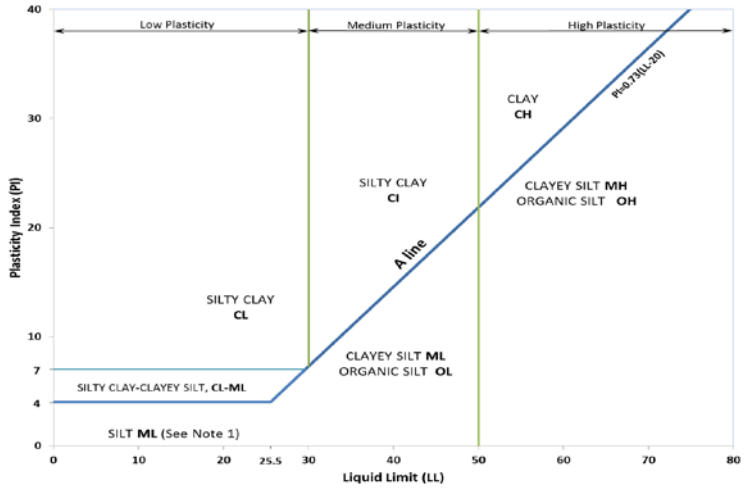
Record of Borehole Sheets

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% (see Note 2)	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, SAND and CLAY)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
GS	Grab Sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

DATA ENTRY:

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-01

SHEET 1 OF 2

LOCATION:

BORING DATE: 30 September 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface		851.73							
0		(ML) sandy, gravelly SILT; light brown; non-cohesive, loose to compact		0.00	1	AS					
1					2	DO	18		○		
2					3	AS					
3					4	DO	14		○		
4					5	AS					
5					6	DO	6		○		
6					7	AS					
				845.48							
		(OL) ORGANIC SILT, some sand, some gravel; brown to black; cohesive, compact		6.25	8	DO	10		W ⊖	OC	
				844.87							
7		(ML) SILT, some sand, some gravel; light greyish brown; non-cohesive, compact		6.86	9	DO	25		○		
		- light brown at 7.6m			10	DO	REF 50 for 50mm		○		
8					11	AS					
9					12	DO	16		○		
					13	AS					
10		*CONTINUED NEXT PAGE*									

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-01

SHEET 2 OF 2

LOCATION:

BORING DATE: 30 September 2016

DATUM: NAD83 UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		(ML) SILT, some sand, some gravel; light greyish brown; non-cohesive, compact *(continued)*			13	AS					
		- rock from 10.5m to 11.0m		841.06							
		(ML) SILT, some sand, some gravel; reddish brown, oxidization; non-cohesive, compact		10.67							
11					14	AS					
12					15	DO	25		○		
13					16	AS					
14					17	DO	15		○		
					18	AS					
15					19	DO	REF 50 for 50mm		○		
		- rock from 15.4m to 16.2m									
16					20	AS					
17					21	DO	32		○		
					22	AS					
18					23	DO	23		○		
				832.98							
19		END OF BOREHOLE = 18.75m Notes: 1. Upon completion of drilling, the borehole was backfilled with cuttings to the ground surface. End of .		18.75							
20											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DATA ENTRY:

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-02

SHEET 1 OF 3

LOCATION:

BORING DATE: 1 October 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		856.31							
		(ML) SILT, some sand, some gravel; light brown; non-cohesive, compact		0.00							
					24	AS					
1											
					25	DO	29		○		
2											
					26	AS					
3		- rock from 2.9m to 3.4m									
					27	AS					
4											
		- dark grey at 4.6m									
					28	DO	21		○		
5		- greyish brown at 5.2m									
					29	AS					
6											
					30	DO	10		○		
7					31	DO	14		○		
					32	DO	12		○		
8											
		- rock at 8.2m to 8.8m									
9					33	AS					
				847.17							
		ORGANICS, trees, some silt, some gravel		9.14	34	DO	REF 50 for 25mm				
					35	AS					
10		*CONTINUED NEXT PAGE*									

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-02

SHEET 2 OF 3

LOCATION:

BORING DATE: 1 October 2016

DATUM: NAD83 UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		ORGANICS, trees, some silt, some gravel *(continued)*			35	AS					
11					36	AS					
				845.04							
		(ML) SILT, some sand, some gravel; olive brown, oxidization; non-cohesive, dense to very dense		11.28	37	DO	31				
12					38	DO	48				
13					39	AS					
14					40	DO	REF 50 for 100mm				
					41	AS					
15											
16					42	AS					
17					43	DO	54				
					44	AS					
18											
				837.72	45	DO	37				
		(ML) SILT, trace organics, trace sand, trace gravel; light grey with reddish brown, oxidization; non-cohesive, compact to dense		18.59							
19				837.11							
		(GM) sandy SILTY GRAVEL, fine to coarse, sub-angular to angular gravel, fine to coarse sand; light greyish brown to reddish brown; non-cohesive, dense		19.20	46	DO	20				
20					47	DO	34				
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-02

SHEET 3 OF 3

LOCATION:

BORING DATE: 1 October 2016

DATUM: NAD83 UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		(GM) sandy SILTY GRAVEL, fine to coarse, sub-angular to angular gravel, fine to coarse sand; light greyish brown to reddish brown; non-cohesive, dense *(continued)*			47	DO	34			M	
21					48	AS					
22					49	DO	31				
				834.06							
		(ML) sandy, gravelly SILT; reddish brown; non-cohesive, compact		22.25	50	AS					
				833.45							
23		(ML) SILT, some sand, trace gravel; brown to dark brown, oxidization; non-cohesive, compact		22.86	51	DO	17				
24					52	AS					
				831.93							
		(ML) sandy, gravelly SILT; brown with reddish brown, oxidization; non-cohesive, compact to very dense		24.38	53	DO	29				
25					54	AS					
26					55	DO	REF 50 for 150mm				
27					56	AS					
					57	DO	76				
				828.42							
28		END OF BOREHOLE = 27.89m Notes: 1. Upon completion of drilling, the borehole was backfilled with cuttings to the ground surface. End of .		27.89							
29											
30											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DATA ENTRY:

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-03

SHEET 1 OF 4

LOCATION:

BORING DATE: 3 October 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface		864.41							
0		(ML) sandy, gravelly SILT; greyish brown; non-cohesive, compact		0.00							
					58	AS					
1											
					59	DO	17		○		
2											
		- trace organics (tree matter) at 2.3m			60	AS					
		- becomes dense to very dense at 9.1m									
3					61	DO	REF 50 for 100mm		○		
		- rock from 3.5m to 3.7m									
4					62	AS					
		- tree matter from 4.0m to 4.3m									
		- trace tree matter at 4.6m			63	DO	15		○		
5											
		- trace tree matter at 5.5m			64	AS					
6											
					65	DO	12		○		
7		- rock from 6.9m to 7.5m			66	AS					
					67	DO	14		○		
8		- trace tree matter at 8.2m									
					68	AS					
9											
					69	DO	38		○		
					70	AS					
10		*CONTINUED NEXT PAGE*									

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-03

LOCATION:

BORING DATE: 3 October 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○ W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		(ML) sandy, gravelly SILT; greyish brown; non-cohesive, compact *(continued)* - rock from 9.8m to 10.5m			70	AS					
					71	DO	REF 50 for 50mm		○		
11											
					72	AS					
12											
					73	DO	19		○		
13											
				851.00							
		(OL) ORGANIC SILT, some organics, trace sand; grey with reddish brown, oxidization; cohesive, compact		13.41	74	AS					
				850.39	75	DO	21		○		
14		(ML) SILT, some sand, some gravel, trace organics; reddish brown, oxidization; non-cohesive, compact to dense		14.02							
					76	AS					
15											
					77	DO	32		○		
16											
					78	AS					
17											
					79	DO	18		○		
				847.19							
		(SM) gravelly SILTY SAND, fine to coarse sand, fine to coarse sub-angular to angular gravel; reddish brown to greyish brown; non-cohesive, compact to dense		17.22							
18					80	AS					
					81	DO	29		○	M	
19											
					82	AS					
20					83	DO	37				
		CONTINUED NEXT PAGE									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-03

SHEET 3 OF 4

LOCATION:

BORING DATE: 3 October 2016

DATUM: NAD83 UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (20 40 60 80) nat V. + Q - ● rem V. ⊕ U - ○	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		(SM) gravelly SILTY SAND, fine to coarse sand, fine to coarse sub-angular to angular gravel; reddish brown to greyish brown; non-cohesive, compact to dense *(continued)*			83	DO	37		○		
21					84	AS					
22					85	DO	38		○		
23					86	AS					
24					87	DO	74		○		
25					88	AS					
26					89	DO	45		○		
27					90	AS					
28					91	DO	55		○		
29		- rock from 28.0m to 28.7m			92	AS					
30					93	DO	REF 50 for 75mm		○		
					94	AS					
					95	AS					
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DATA ENTRY:

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-03

SHEET 4 OF 4

LOCATION:

BORING DATE: 3 October 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○ W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
30		(SM) gravelly SILTY SAND, fine to coarse sand, fine to coarse sub-angular to angular gravel; reddish brown to greyish brown; non-cohesive, compact to dense *(continued)*			95	AS					
					96	DO			○		
				833.48							
31		END OF BOREHOLE = 30.94m Notes: 1. Upon completion of drilling, the borehole was backfilled with cuttings to the ground surface. End of .		30.94							
32											
33											
34											
35											
36											
37											
38											
39											
40											

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-04

SHEET 1 OF 3

LOCATION:

BORING DATE: 4 October 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface		864.47							
0		(SM/GM) SILTY SAND and fine to coarse sub-angular to angular GRAVEL, fine to coarse sand; greyish brown; non-cohesive, compact		0.00	97	AS					
1					98	DO	10		○		
2					99	AS					
3					100	DO	14		○		
4					101	AS					
5					102	DO	16		○	M	
					103	AS					
6				858.37							
		(ML) SILT, some sand, some gravel; dark olive brown; non-cohesive, compact		6.10	104	DO	14		○		
7		- trace organics at 7.0m			105	AS					
8					106	DO	10		○		
					107	AS					
9				855.32							
		(ML) sandy, gravelly SILT, with slight plasticity, fine to coarse sand, fine sub-angular to angular gravel, trace organics; dark greyish brown, oxidization; non-cohesive, compact		9.14	108	DO	14		○		
					109	AS					
10		*CONTINUED NEXT PAGE*									

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-04

SHEET 2 OF 3

LOCATION:

BORING DATE: 4 October 2016

DATUM: NAD83 UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○ W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		(ML) sandy, gravelly SILT, with slight plasticity, fine to coarse sand, fine sub-angular to angular gravel, trace organics; dark greyish brown, oxidization; non-cohesive, compact *(continued)*			109	AS					
11					110	DO	20		○		
					111	AS					
12					112	DO	29		○	M	
					113	AS					
13											
14					114	DO	12		○		
				849.84							
		(ML) sandy, gravelly SILT; reddish brown, oxidization; non-cohesive, dense		14.63	115	AS					
15											
					116	DO	33		○		
16					117	AS					
17					118	DO	36		○		
					119	AS					
18											
					120	DO	46		○		
19					121	AS					
20					122	DO	32				
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-04

SHEET 3 OF 3

LOCATION:

BORING DATE: 4 October 2016

DATUM: NAD83 UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20											
		(ML) sandy, gravelly SILT; reddish brown, oxidization; non-cohesive, dense *(continued)*			122	DO	32				
21					123	AS					
					124	DO	26				
22					125	AS					
23					126	DO	43				
					127	AS					
24					128	DO	REF 50 for 50mm				
25					129	AS					
26					130	DO	REF 50 for 100mm				
					131	AS					
27				836.88	132	DO	REF 50 for 75mm				
				27.58							
		END OF BOREHOLE = 27.58m Notes: 1. Upon completion of drilling, the borehole was backfilled with cuttings to the ground surface. End of .									
28											
29											
30											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DATA ENTRY:

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-05

SHEET 1 OF 3

LOCATION:

BORING DATE: 5 October 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface		860.39							
0		(ML) SILT, some sand, some gravel; olive brown; non-cohesive, loose to compact		0.00							
					133	AS					
1											
					134	DO	27				
2											
					135	AS					
3											
					136	DO	17				
4					137	AS					
					138	DO	8				
5											
					139	AS					
6											
					140	DO	13				
7					141	AS					
					142	DO	16				
8				852.17							
		(GM) sandy SILTY GRAVEL, fine to coarse sub-angular to angular gravel, fine to coarse sand, trace organics; dark greyish brown; non-cohesive, compact to dense		8.23	143	AS					
9											
					144	DO	24				
					145	AS					
10		*CONTINUED NEXT PAGE*									

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-05

SHEET 2 OF 3

LOCATION:

BORING DATE: 5 October 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		- interbedded organic soils from 9.1m to 10.7m (GM) sandy SILTY GRAVEL, fine to coarse sub-angular to angular gravel, fine to coarse sand, trace organics; dark greyish brown; non-cohesive, compact to dense *(continued)*			145	AS					
11					146	DO	38		○	M, OC	
12					148	DO	14		○		
				847.75							
13		(SM/GM) SILTY SAND and fine to coarse sub-angular to angular GRAVEL, fine to coarse sand; reddish brown, oxidization; non-cohesive, dense		12.65	149	AS					
14					150	DO	44		○	M	
					151	AS					
15											
					152	DO	44		○		
16					153	AS					
17					154	DO	31		○		
					155	AS					
18					156	DO	REF 50 for 25mm		○		
19					157	AS					
20					158	DO	27				
		CONTINUED NEXT PAGE									

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-05

SHEET 3 OF 3

LOCATION:

BORING DATE: 5 October 2016

DATUM: NAD83
UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		(SM/GM) SILTY SAND and fine to coarse sub-angular to angular GRAVEL, fine to coarse sand; reddish brown, oxidization; non-cohesive, dense *(continued)*			158	DO	27		○		
21					159	AS					
22					160	DO	65		○		
23					161	AS					
					162	DO	56		○		
				837.08							
		END OF BOREHOLE = 23.32m		23.32							
24		Notes: 1. Upon completion of drilling, the borehole was backfilled with cuttings to the ground surface. End of .									
25											
26											
27											
28											
29											
30											

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-06

SHEET 1 OF 2

LOCATION:

BORING DATE: 5 October 2016

DATUM: NAD83 UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○ W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface		848.71							
0		(ML) SILT, some sand, some gravel; light grey brown; non-cohesive, compact		0.00							
					163	AS					
1											
					164	DO	11		○		
2											
					165	AS					
3											
					166	DO	26		○		
4											
					167	AS					
				844.14							
		(ML) SILT, some sand, some gravel; greyish brown; non-cohesive, compact		4.57							
					168	DO	12		○		
5											
		- organics, dark greyish brown at 5.5m			169	AS					
6											
		- oxidization at 6.1m			170	DO	REF 50 for 50mm		○		
				842.16							
		(SM) gravelly SILTY SAND, fine to coarse sand, fine sub-angular to angular gravel; reddish brown, oxidization; non-cohesive, compact to very dense		6.55							
7					171	AS					
					172	DO	22		○	M	
8											
					173	AS					
9											
					174	DO	REF 50 for 50mm		○		
					175	AS					
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

PROJECT No.: 1654746 Eastgate Landslide

RECORD OF BOREHOLE: EG-16-06

SHEET 2 OF 2

LOCATION:

BORING DATE: 5 October 2016

DATUM: NAD83 UTM Zone 11

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		(SM) gravelly SILTY SAND, fine to coarse sand, fine sub-angular to angular gravel; reddish brown, oxidization; non-cohesive, compact to very dense *(continued)*			175	AS					
11					176	DO	18		○		
					177	AS					
12					178	DO	52		○		
13					179	AS					
14					180	DO	65		○		
					181	AS					
15					182	DO	51		○		
16					183	AS					
		- rock from 16.5m to 16.6m - 7cm wet silt layer at 16.8m			184	DO	50		○		
17					185	AS					
18					186	DO	31		○		
				829.97							
		END OF BOREHOLE = 18.75m		18.75							
19		Notes: 1. Upon completion of drilling, the borehole was backfilled with cuttings to the ground surface. End of .									
20											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JT

CHECKED: IGT

DATA ENTRY:

BOREHOLE - EXPANDED ADD. LAB TESTING 1654746 BOREHOLE LOGS.GPJ CALGARY.GDT 17/3/17

APPENDIX B

Laboratory Test Results

General Lab Testing Summary

Project No.: 1654746 | Phase: 3000.3204
Short Title: PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide | Sched: C091
Tested By: KH | Date: 12-Oct-16

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m)		Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
		from	to							
EG-16-01	2	1.5	2.0	C091-01	6.6					
	4	3.0	3.5	C091-02	11.5					
	6	4.6	5.0	C091-03	14.6					
	8	6.1	6.6	C091-04	43.0					
	9	6.9	7.3	C091-05	8.1					
	10	7.6	8.1	C091-06	8.9					
	12	9.1	9.6	C091-07	7.1					
	15	12.2	12.6	C091-08	5.3					
	17	13.7	14.2	C091-09	13.6					
	19	15.2	15.7	C091-10	11.5					
	21	16.8	17.2	C091-11	6.2					
	23	18.3	18.7	C091-12	9.2					

Reviewed By:_____

General Lab Testing Summary

Project No.: 1654746 | Phase: 3000.3204
Short Title: PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide | Sched: C091
Tested By: KH | Date: 12-Oct-16

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m)		Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
		from	to							
EG-16-02	25	1.5	2.0	C091-13	8.5					
	28	4.6	5.0	C091-14	7.9					
	30	6.1	6.6	C091-15	11.8					
	31	6.9	7.3	C091-16	11.8					
	32	7.6	8.1	C091-17	11.7					
	37	11.4	11.9	C091-18	12.4					
	38	12.2	12.6	C091-19	8.0					
	40	13.7	14.2	C091-20	13.1					
	43	16.8	17.2	C091-21	10.9					
	45	18.3	18.7	C091-22	5.7					
	46	19.1	19.5	C091-23	4.0					
	47	19.8	20.3	C091-24	7.1					
	49	21.3	21.8	C091-25	19.4					
	51	22.9	23.3	C091-26	37.1					
	53	24.4	24.8	C091-27	8.9					
	55	25.9	26.4	C091-28	8.3					
	57	27.4	27.9	C091-29	7.6					

Reviewed By:_____

General Lab Testing Summary

Project No.: 1654746 | Phase: 3000.3204
Short Title: PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide | Sched: C091
Tested By: KH | Date: 12-Oct-16

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
EG-16-03	59	1.5	2.0	C091-30	5.8					
	61	3.0	3.5	C091-31	4.7					
	63	4.6	5.0	C091-32	4.1					
	65	6.1	6.6	C091-33	7.6					
	67	7.6	8.1	C091-34	6.9					
	69	9.1	9.6	C091-35	3.5					
	71	10.7	11.1	C091-36	2.7					
	73	12.2	12.6	C091-37	6.9					
	75	13.7	14.2	C091-38	30.2					
	77	15.2	15.7	C091-39	11.5					
	79	16.8	17.2	C091-40	13.0					
	81	18.3	18.7	C091-41	4.9					
	83	19.8	20.3	C091-42	6.3					
	85	21.3	21.8	C091-43	7.5					
	87	22.9	23.3	C091-44	5.8					
	89	24.4	24.8	C091-45	7.7					
	91	25.9	26.4	C091-46	6.9					
	93	27.4	27.9	C091-47	7.9					
	96	30.5	30.9	C091-48	7.0					

Reviewed By:_____

General Lab Testing Summary

Project No.: 1654746 | Phase: 3000.3204
Short Title: PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide | Sched: C091
Tested By: KH | Date: 12-Oct-16

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m)		Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
		from	to							
EG-16-04	98	1.5	2.0	C091-49	7.7					
	100	3.0	3.5	C091-50	13.5					
	102	4.6	5.0	C091-51	7.8					
	104	6.1	6.6	C091-52	8.9					
	106	7.6	8.1	C091-53	13.4					
	108	9.1	9.6	C091-54	10.0					
	110	10.7	11.1	C091-55	12.1					
	112	12.2	12.6	C091-56	27.0					
	114	13.7	14.2	C091-57	6.9					
	116	15.2	15.7	C091-58	8.9					
	118	16.8	17.2	C091-59	8.4					
	120	18.3	18.7	C091-60	16.1					
	122	19.8	20.3	C091-61	9.3					
	124	21.3	21.8	C091-62	4.7					
	126	22.9	23.3	C091-63	7.4					
	128	24.4	24.8	C091-64	5.6					
	130	25.9	26.4	C091-65	6.1					

Reviewed By:_____

General Lab Testing Summary

Project No.: 1654746 | Phase: 3000.3204
Short Title: PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide | Sched: C091
Tested By: KH | Date: 12-Oct-16

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m)		Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
		from	to							
	134	1.5	2.0	C091-66	8.7					
	136	3.0	3.5	C091-67	11.3					
	138	4.6	5.0	C091-68	10.9					
	140	6.1	6.6	C091-69	9.4					
	142	7.6	8.1	C091-70	11.3					
	144	9.1	9.6	C091-71	34.3					
	146	10.7	11.1	C091-72	6.8					
EG-16-05	148	12.2	12.6	C091-73	12.8					
	150	13.7	14.2	C091-74	3.3					
	152	15.2	15.7	C091-75	7.7					
	154	16.8	17.2	C091-76	4.8					
	156	18.3	18.7	C091-77	4.9					
	158	19.8	20.3	C091-78	6.4					
	160	21.3	21.8	C091-79	5.9					
	162	22.9	23.3	C091-80	6.7					

Reviewed By:_____

General Lab Testing Summary

Project No.: 1654746 | Phase: 3000.3204
Short Title: PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide | Sched: C091
Tested By: KH | Date: 12-Oct-16

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m)		Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
		from	to							
EG-16-06	164	1.5	2.0	C091-81	8.5					
	166	3.0	3.5	C091-82	6.9					
	168	4.6	5.0	C091-83	14.0					
	170	6.1	6.6	C091-84	9.7					
	172	7.6	8.1	C091-85	8.3					
	174	9.1	9.6	C091-86	11.4					
	176	10.7	11.1	C091-87	11.6					
	178	12.2	12.6	C091-88	6.4					
	180	13.7	14.2	C091-89	4.4					
	182	15.2	15.7	C091-90	5.1					
	184	16.8	17.2	C091-91	7.4					
	186	18.3	18.7	C091-92	6.9					

Reviewed By:_____

General Lab Testing Summary

Project No.: 1654746 | Phase: 3000
Short Title: PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide | Sched: C100
Tested By: KH | Date: 01-Nov-16

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
EG-16-01	8	6.10	6.55	C100-01	43.0	45	32	13		
EG-16-02	47	19.80	20.30	C100-02	7.1	29	23	6		
EG-16-03	81	18.30	18.70	C100-03	4.9					
EG-16-04	102	4.60	5.00	C100-04	7.8					
	112	12.20	12.60	C100-05	27.0					
EG-16-05	146	10.70	11.10	C100-06	6.8					
	150	13.70	14.20	C100-07	3.3					
EG-16-06	172	7.60	8.10	C100-08	8.3					
SA2	SA2	-	-	C100-09	7.3				2010	10.8

Note: All oversize gravel > 16 mm was removed from C100-09 prior to testing the SPMDD.

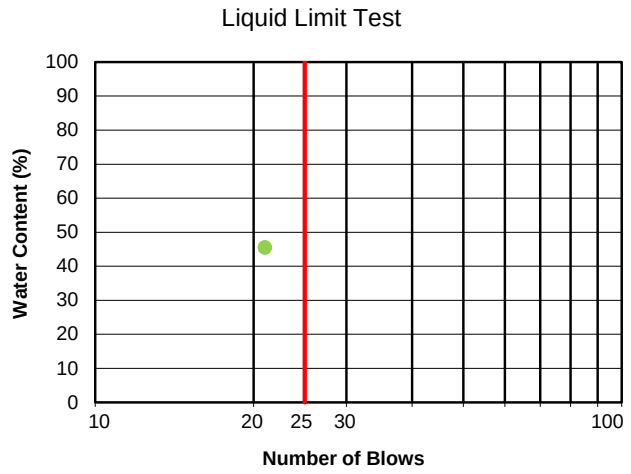
Reviewed By:

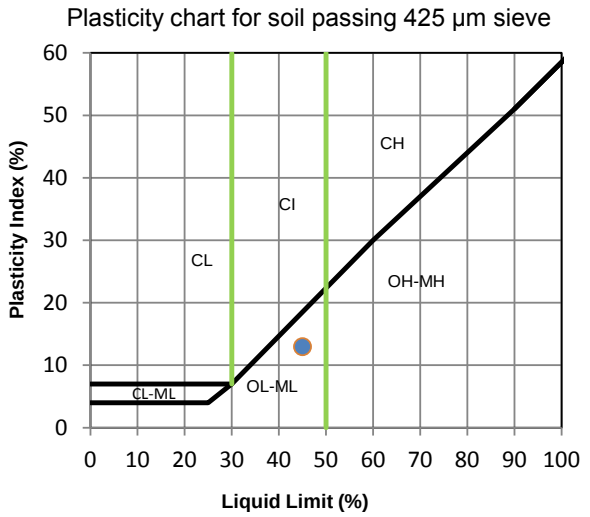
Atterberg Limits (ASTM D 4318)

Project No.:	1654746	Phase:	3000
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide	Lab No.:	C100-01
Tested By:	DS	Date:	26-Oct-16

Borehole: EG-16-01 Sample No.: 8 Depth: 6.1-6.6 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	21	21	As Received Water Content (%)		43.0%
Blow Correction Factor	0.98	0.98	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	27.46	27.07	Mass of wet sample + tare (g)	19.19	19.71
Mass of dry sample + tare (g)	25.11	24.66	Mass of dry sample + tare (g)	17.09	17.63
Mass of tare (g)	19.96	19.36	Mass of tare (g)	10.40	11.20
Weight of Water (g)	2.35	2.41	Weight of Water (g)	2.10	2.08
Weight of dry soil (g)	5.15	5.3	Weight of dry soil (g)	6.69	6.43
Water Content (%)	45.6	45.5	Water Content (%)	31.39	32.35
Liquid Limit	45.0	45.0	Average Water Content (%)		31.87





Liquid Limit =	45	%
Plastic Limit =	32	%
Plasticity Index =	13	

Comments:

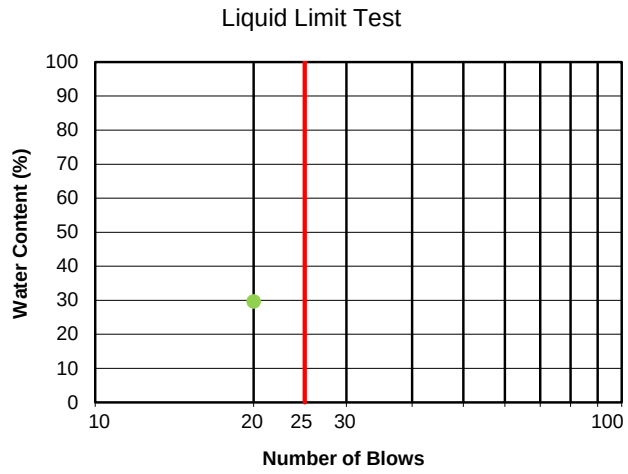
Reviewed:

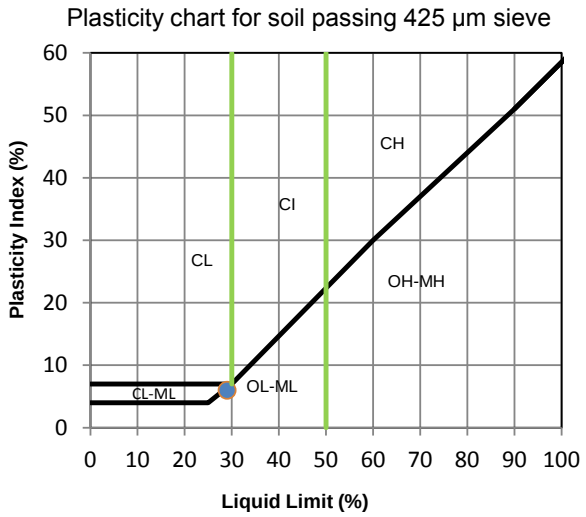
Atterberg Limits (ASTM D 4318)

Project No.:	1654746	Phase:	3000
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide	Lab No.:	C100-02
Tested By:	DS	Date:	26-Oct-16

Borehole: EG-16-02 Sample No.: 47 Depth: 20 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	20	20	As Received Water Content (%)		7.1%
Blow Correction Factor	0.97	0.97	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	23.99	30.29	Mass of wet sample + tare (g)	17.92	17.76
Mass of dry sample + tare (g)	22.71	29.35	Mass of dry sample + tare (g)	16.63	16.42
Mass of tare (g)	18.39	26.19	Mass of tare (g)	10.82	10.61
Weight of Water (g)	1.28	0.94	Weight of Water (g)	1.29	1.34
Weight of dry soil (g)	4.32	3.16	Weight of dry soil (g)	5.81	5.81
Water Content (%)	29.6	29.7	Water Content (%)	22.20	23.06
Liquid Limit	29.0	29.0	Average Water Content (%)		22.63





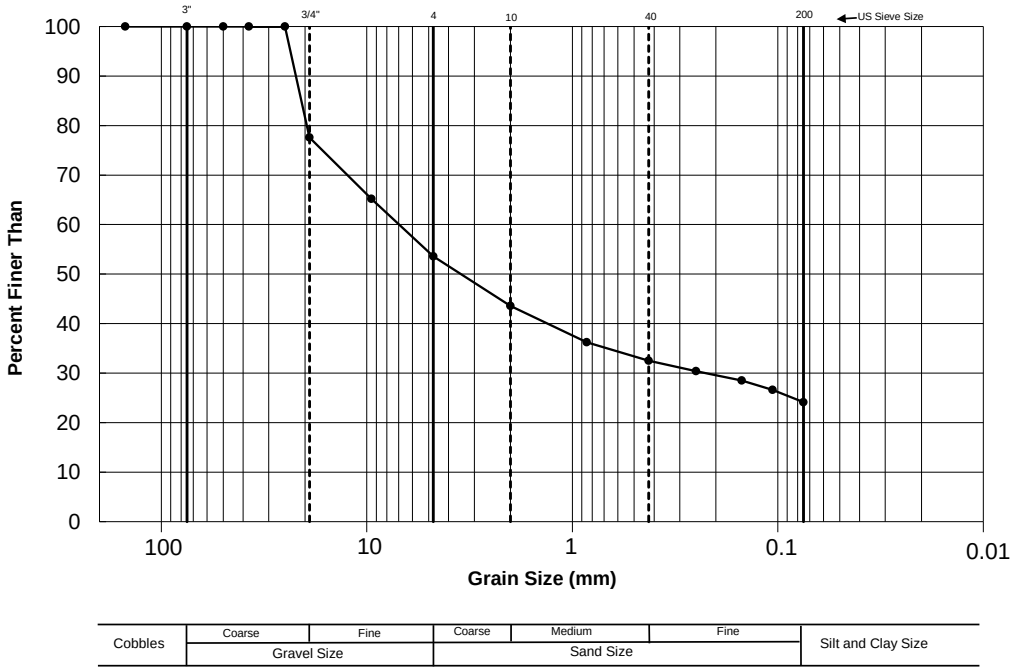
Liquid Limit =	29	%
Plastic Limit =	23	%
Plasticity Index =	6	

Comments:

Reviewed:

Particle Size Distribution of Soils using Sieve Analysis
(ASTM D6913-04)

Project No.:	1654746		Phase:	3000		Date:	26-Oct-16
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide						
Sub Sampled By:	DS		Washed By:	DS		Sieved By:	DS
Field Tag No.:	-		Source:		-	BH No.:	EG-16-02
Lab No.:	C100-02		Northing:	-	m	Sample No.:	47
Sampled By:	JT		Easting:	-	m	Depth From:	20.0 m
Sample Date:	1-Oct-16		Elevation:	-	m	Depth To:	20.0 m
Test Method:		A	Drying Method:	Air Dry			
Composite Sieve:		Yes	if Yes, Split on:	4.75	mm		
Material Excluded from Sieve:		No	Describe:				
Prior Testing on Sample:		No	Describe:				



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25.0	100
19.0	78
9.5	65
4.75	54
2.00	44
0.85	36
0.425	32
0.250	30
0.150	29
0.106	27
0.075	24

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
8.8	0	46	29	24	7.4	0.2	N/A	N/A	N/A

Sample Description: (GM) sandy SILTY GRAVEL, fine to coarse sub-angular to angular gravel, fine to coarse sand; brown; non-cohesive, moist

USCS Classification: GM

Remarks:

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

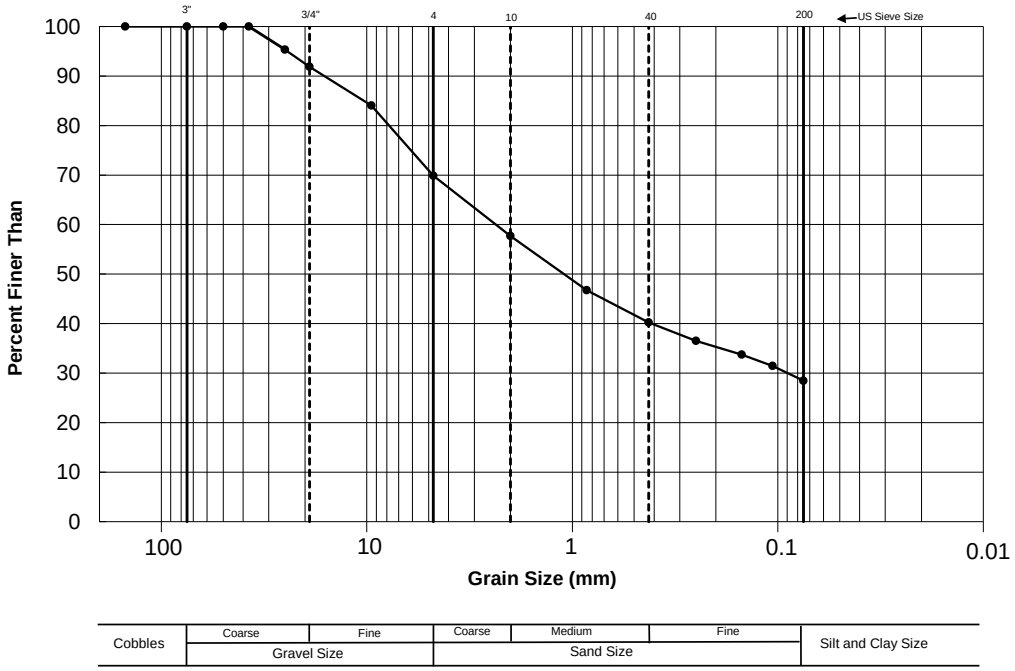
Reviewed by:

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1654746	Phase:	3000	Date:	26-Oct-16
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide				
Sub Sampled By:	DS	Washed By:	DS	Sieved By:	DS
Field Tag No.:	-	Source:	-	BH No.:	EG-16-03
Lab No.:	C100-03	Northing:	- m	Sample No.:	81
Sampled By:	JT	Easting:	- m	Depth From:	18.0 m
Sample Date:	2-Oct-16	Elevation:	- m	Depth To:	19.0 m

Test Method:	A	Drying Method:	Air Dry	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Excluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25.0	95
19.0	92
9.5	84
4.75	70
2.00	58
0.85	47
0.425	40
0.250	37
0.150	34
0.106	31
0.075	28

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
4.9	0	30	41	28	2.5	0.1	N/A	N/A	N/A

Sample Description: (SM) gravelly SILTY SAND, fine to coarse sand, fine to coarse sub-angular to angular gravel; brown; non-cohesive, moist

USCS Classification: SM

Remarks:

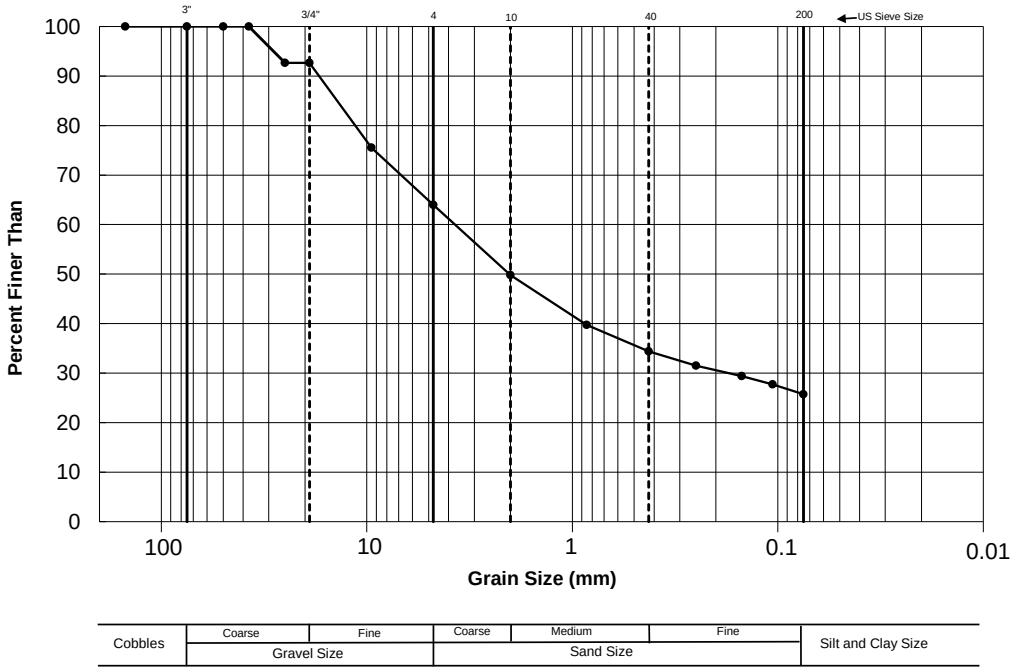
Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by:

Particle Size Distribution of Soils using Sieve Analysis
(ASTM D6913-04)

Project No.:	1654746	Phase:	3000		Date:	26-Oct-16
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide					
Sub Sampled By:	DS	Washed By:	DS		Sieved By:	DS
Field Tag No.:	-	Source:		-	BH No.:	EG-16-04
Lab No.:	C100-04	Northing:	-	m	Sample No.:	102
Sampled By:	JT	Easting:	-	m	Depth From:	4.6 m
Sample Date:	3-Oct-16	Elevation:	-	m	Depth To:	5.0 m

Test Method:	A	Drying Method:	Air Dry	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Excluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25.0	93
19.0	93
9.5	76
4.75	64
2.00	50
0.85	40
0.425	34
0.250	32
0.150	29
0.106	28
0.075	26

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
9.3	0	36	38	26	4.0	0.2	N/A	N/A	N/A

Sample Description: (SM) SILTY SAND and fine to coarse sub-angular to angular GRAVEL, fine to coarse sand; brown; non-cohesive, moist

USCS Classification: SM

Remarks:

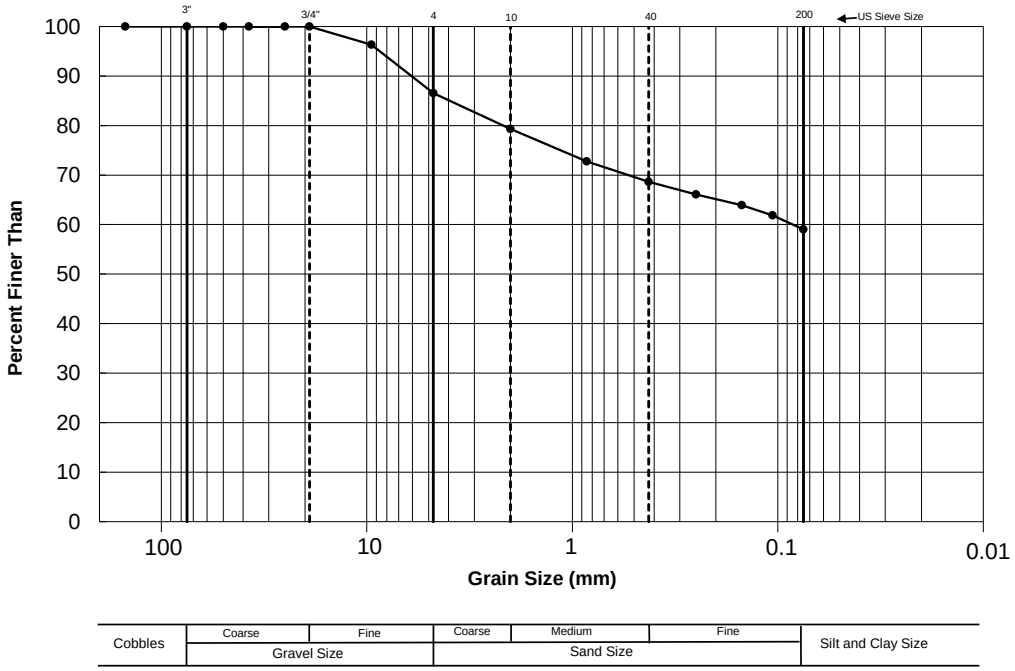
Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by:

Particle Size Distribution of Soils using Sieve Analysis
(ASTM D6913-04)

Project No.:	1654746	Phase:	3000	Date:	26-Oct-16
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide				
Sub Sampled By:	DS	Washed By:	DS	Sieved By:	DS
Field Tag No.:	-	Source:	-	BH No.:	EG-16-04
Lab No.:	C100-05	Northing:	- m	Sample No.:	112
Sampled By:	JT	Easting:	- m	Depth From:	12.0 m
Sample Date:	3-Oct-16	Elevation:	- m	Depth To:	13.0 m

Test Method:	A	Drying Method:	Air Dry	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Excluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25.0	100
19.0	100
9.5	96
4.75	87
2.00	79
0.85	73
0.425	69
0.250	66
0.150	64
0.106	62
0.075	59

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
24.7	0	13	28	59	0.1	N/A	N/A	N/A	N/A

Sample Description: (ML) sandy gravelly SILT with slight plasticity, fine to coarse sand, fine sub-angular to angular gravel, trace organics; brown; cohesive, w < PL

USCS Classification: Silt or Clay - See Limits Test

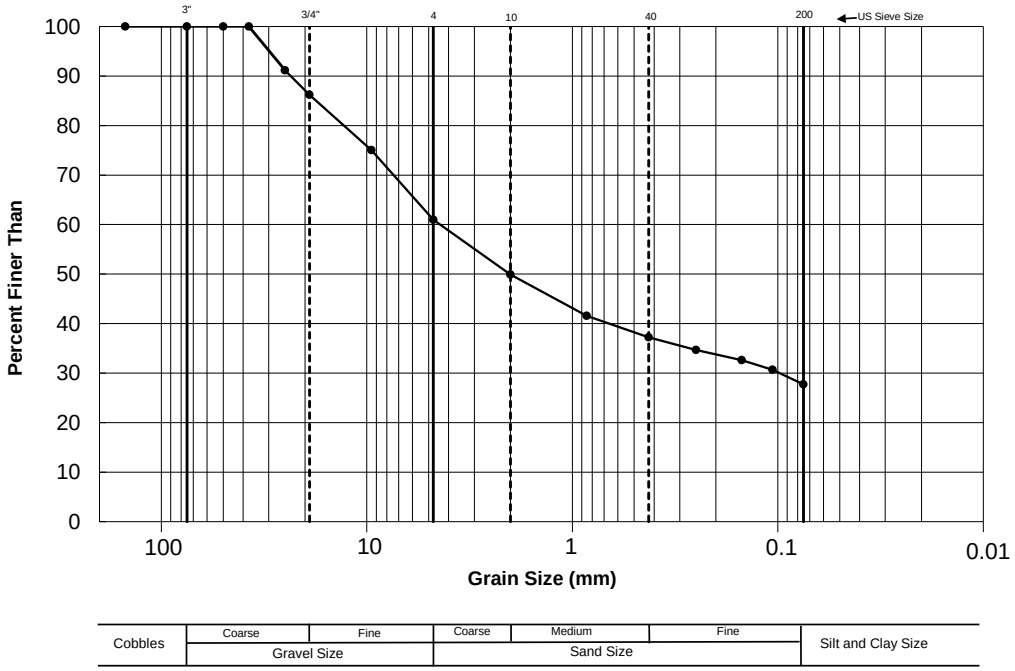
Remarks: No limits were scheduled for this sample.

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by:

Particle Size Distribution of Soils using Sieve Analysis
(ASTM D6913-04)

Project No.:	1654746		Phase:	3000		Date:	26-Oct-16
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide						
Sub Sampled By:	DS		Washed By:	DS		Sieved By:	DS
Field Tag No.:	-		Source:		-	BH No.:	EG-16-05
Lab No.:	C100-06		Northing:	-	m	Sample No.:	146
Sampled By:	JT		Easting:	-	m	Depth From:	11.0 m
Sample Date:	4-Oct-16		Elevation:	-	m	Depth To:	11.0 m
Test Method:		A	Drying Method:	Air Dry			
Composite Sieve:		Yes	if Yes, Split on:	4.75	mm		
Material Excluded from Sieve:		No	Describe:				
Prior Testing on Sample:		No	Describe:				



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25.0	91
19.0	86
9.5	75
4.75	61
2.00	50
0.85	42
0.425	37
0.250	35
0.150	33
0.106	31
0.075	28

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
5.9	0	39	33	28	4.5	0.1	N/A	N/A	N/A

Sample Description: (GM) sandy SILTY GRAVEL, fine to coarse sub-angular to angular gravel, fine to coarse sand; brown; non-cohesive, moist

USCS Classification: GM

Remarks:

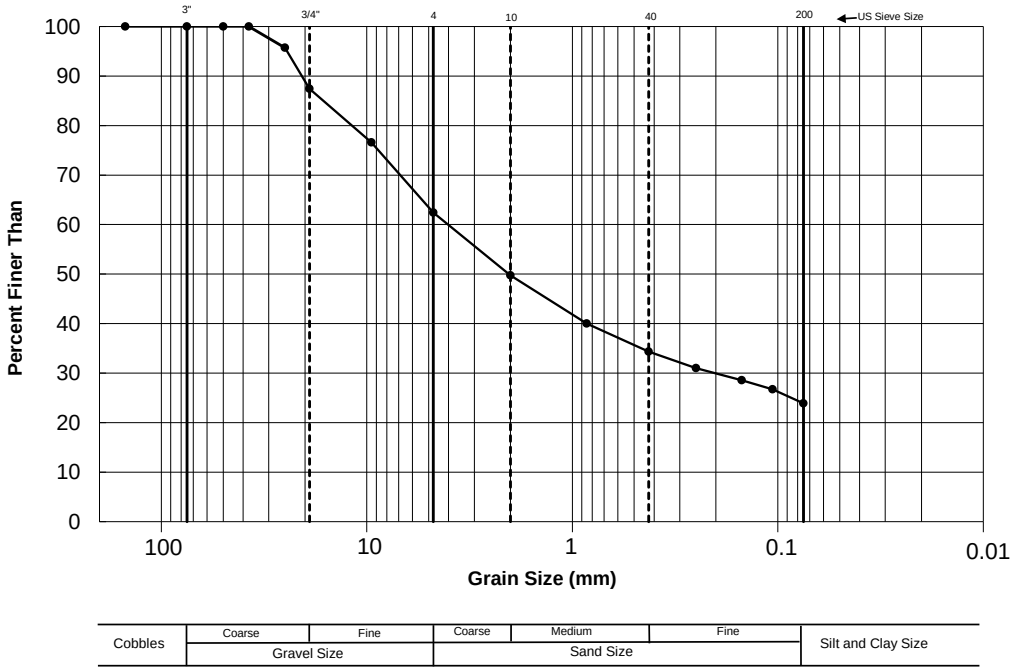
Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by:

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1654746		Phase:	3000		Date:	26-Oct-16
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide						
Sub Sampled By:	DS		Washed By:	DS		Sieved By:	DS
Field Tag No.:	-		Source:		-	BH No.:	EG-16-05
Lab No.:	C100-07		Northing:	-	m	Sample No.:	150
Sampled By:	JT		Easting:	-	m	Depth From:	14.0 m
Sample Date:	4-Oct-16		Elevation:	-	m	Depth To:	14.0 m
Test Method:		A	Drying Method:	Air Dry			
Composite Sieve:		Yes	if Yes, Split on:	4.75	mm		
Material Excluded from Sieve:		No	Describe:				
Prior Testing on Sample:		No	Describe:				



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25.0	96
19.0	87
9.5	77
4.75	62
2.00	50
0.85	40
0.425	34
0.250	31
0.150	29
0.106	27
0.075	24

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
3.4	0	38	38	24	4.2	0.2	N/A	N/A	N/A

Sample Description: (SM) SILTY SAND and fine to coarse sub-angular to angular GRAVEL, fine to coarse sand; brown; non-cohesive, moist

USCS Classification: SM

Remarks:

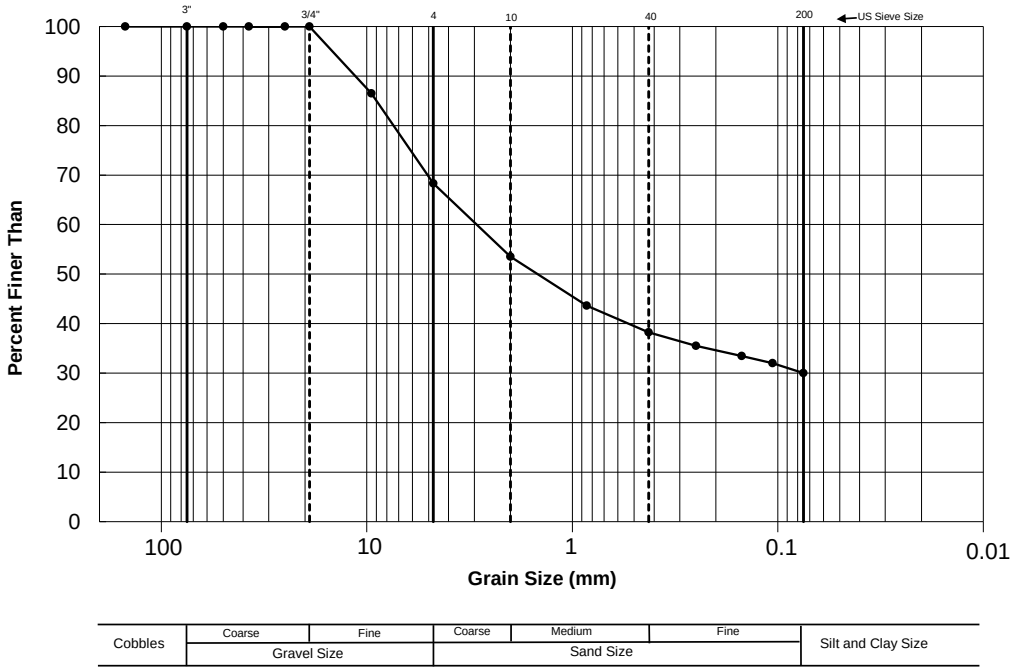
Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by:

Particle Size Distribution of Soils using Sieve Analysis
(ASTM D6913-04)

Project No.:	1654746		Phase:	3000		Date:	26-Oct-16
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide						
Sub Sampled By:	DS		Washed By:	DS		Sieved By:	DS
Field Tag No.:	-		Source:		-	BH No.:	EG-16-06
Lab No.:	C100-08		Northing:	-	m	Sample No.:	172
Sampled By:	JT		Easting:	-	m	Depth From:	7.6 m
Sample Date:	5-Oct-16		Elevation:	-	m	Depth To:	8.1 m

Test Method:	A	Drying Method:	Air Dry	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Excluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25.0	100
19.0	100
9.5	86
4.75	68
2.00	53
0.85	44
0.425	38
0.250	35
0.150	33
0.106	32
0.075	30

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
9.6	0	32	38	30	3.2	N/A	N/A	N/A	N/A

Sample Description: (SM) gravelly SILTY SAND, fine to coarse sand, fine sub-angular to angular gravel; brown; non-cohesive, moist

USCS Classification: SM

Remarks:

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by:

GOLDER ASSOCIATES - Calgary Lab
Bay 7, 820 28th St. NE
Calgary, AB, T2A 6K1
ASTM D3080/ D3080M-11

Direct Shear Test of Soils Under Consolidated Drained Conditions
(ASTM D3080/D3080M-11)

Sample Identification

Project No.:	1654746 Phase: 3000	Test Condition:	Moist - Optimum w
Client:	Parks Canada Agency	Sample:	Combined SPT Samples
Project Title:	PCA/GlacierNP-Cu14/Avalanche Mitigation - Eastgate Landslide	Lab No.:	C100-09

INITIAL - Sample Dimensions

Test No.	1	2	3
Shear Box Geometry	Rectangular	Rectangular	Rectangular
Length, mm	250	250	250
Width, mm	150	150	150
Height, mm	96	96	100
Area, cm^2	375	375	375
Volume, cm^3	3600	3600	3754

Weight Volume Relationships

Test No.	1	2	3
Sample Type	Reconstituted	Reconstituted	Reconstituted
Initial Wet Wt, kg	7.86	7.86	8.23
Initial Dry Wt, kg	7.09	7.09	7.39
Initial w, %	10.81	10.81	11.24
Final w, %	10.11	10.11	9.81
Initial γ_{dry}, kg/m^3	1970	1970	1970
Specific Gravity (assumed)	2.65	2.65	2.65
Initial Void Ratio, e	0.35	0.35	0.35

Equipment Description - LDS_30S

Axial LDT	Serial #	512414
Normal Load Cell	Serial #	618236
Shear Load Cell	Serial #	1084597
Vertical LDT	Serial #	BBD110465

Combined SPT Sample List

- Combined Proctor sample (SA2_1-4 Combined)
- EG-16-01, Sample 2 (5 ft to 6.5 ft)
- EG-16-02, Sample 28 (15 ft and 16.5 ft)_Sample 30 (20 ft and 21.5 ft) _Sample 31 (22.5 ft to 24 ft)_Sample 32 (25 ft to 26.5 ft)
- EG-16-05, Sample 134 (5 ft to 6.5 ft) and Sample 136 (10 ft to 11.5 ft)
- EG-16-06, Sample 166 (10 ft to 11.5 ft)

Remarks

- Area correction applied to normal and shear stress calculations
- Each of the test specimens were placed and compated in 3 layers
- Each of the three layers were compacted to 98% SPMDD at a targeted optimum water content of ~ 10.8%
- Three test specimens were built and sheared at 75, 200, and 400 kPa normal stresses
- The 200 kPa and 400 kPa material had to be reused due to insufficient sample amount
- All the residual shear points were done on the last post-400 kPa shear specimen (I.e. normal stress was backed off to 50 kPa and tested, then 200 kPa, etc.)
- There was one complete carrier-return pass completed prior to each of the residual shear points

Sample Description: (SM) gravelly SILTY SAND, fine sub-angular to angular gravel, fine to coarse sand; brown; low plastic fines, w<PL

Tested By: MB/KP Date Completed: 14-Nov-16

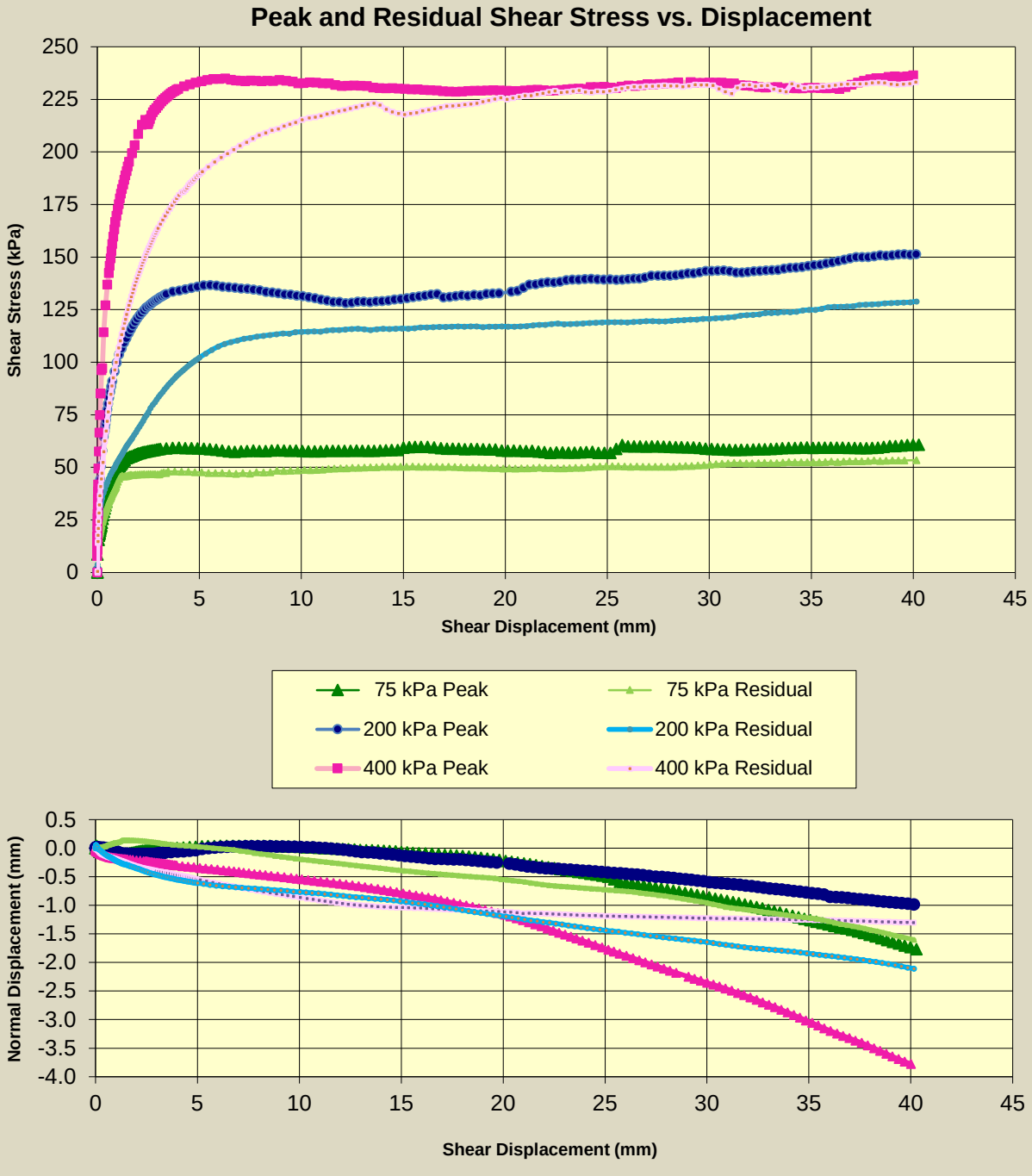
Reviewed By: MB Signature:

GOLDER ASSOCIATES - Calgary Lab
Bay 7, 820 28th St. NE
Calgary, AB, T2A 6K1
ASTM D3080/ D3080M-11

Direct Shear Test of Soils Under Consolidated Drained Conditions
(ASTM D3080/D3080M-11)

Sample Identification

Project No.:	1654746	Phase:	3000	Test Condition:	Moist - Optimum w
Client:	Parks Canada Agency			Sample:	Combined SPT Samples
Project Title:	PCA/GlacierNP-Cu14/Avalanche Mitigation - Eastgate Landslide			Lab No.:	C100-09

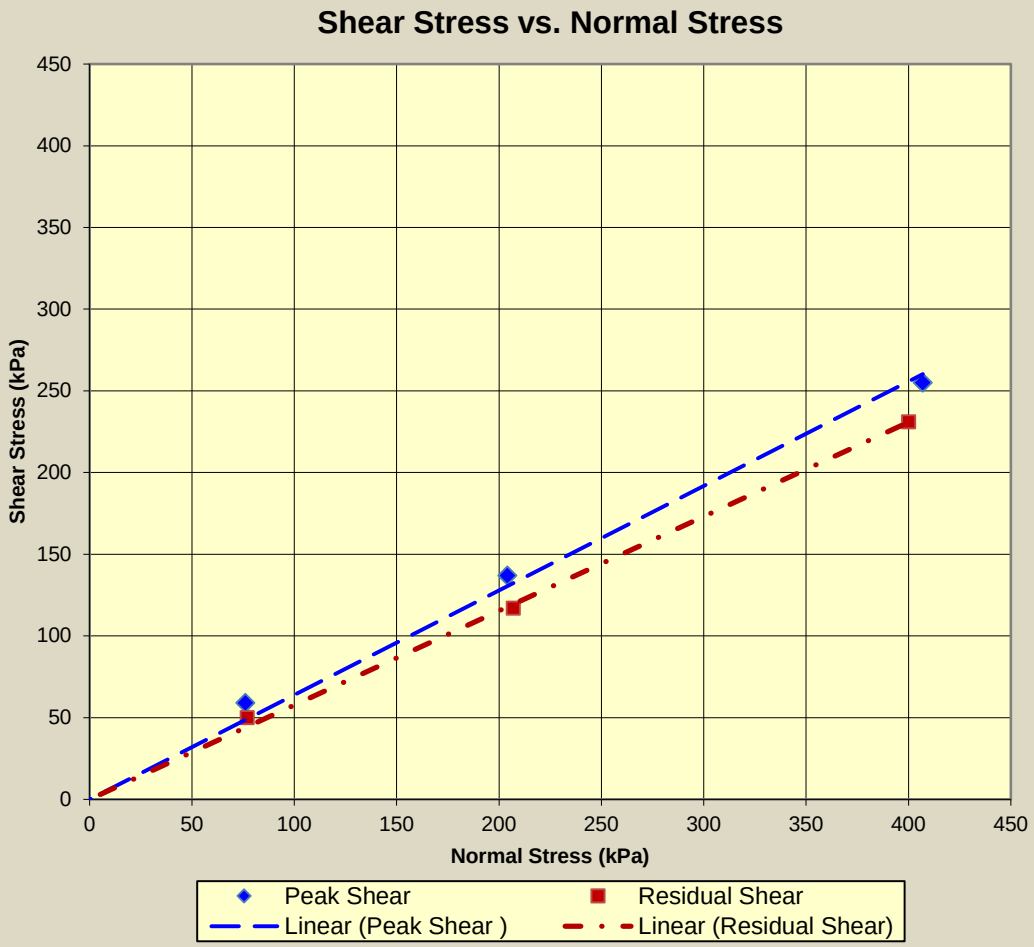


GOLDER ASSOCIATES - Calgary Lab
Bay 7, 820 28th St. NE
Calgary, AB, T2A 6K1
ASTM D3080/ D3080M-11

Direct Shear Test of Soils Under Consolidated Drained Conditions
(ASTM D3080/D3080M-11)

Sample Identification

Project No.:	1654746	Phase:	3000	Test Condition:	Moist - Optimum w
Client:	Parks Canada Agency			Sample:	Combined SPT Samples
Project Title:	PCA/GlacierNP-Cu14/Avalanche Mitigation - Eastgate Landslide			Lab No.:	C100-09



	Peak			Residual		
Test No.	1	2	3	1	2	3
Normal Stress, kPa	76	204	407	77	207	400
Shear Stress, kPa	59	137	255	50	117	231

	Peak	Residual
Friction Angle, Degrees	**33**	**30**
Cohesion, kPa	**0**	**0**

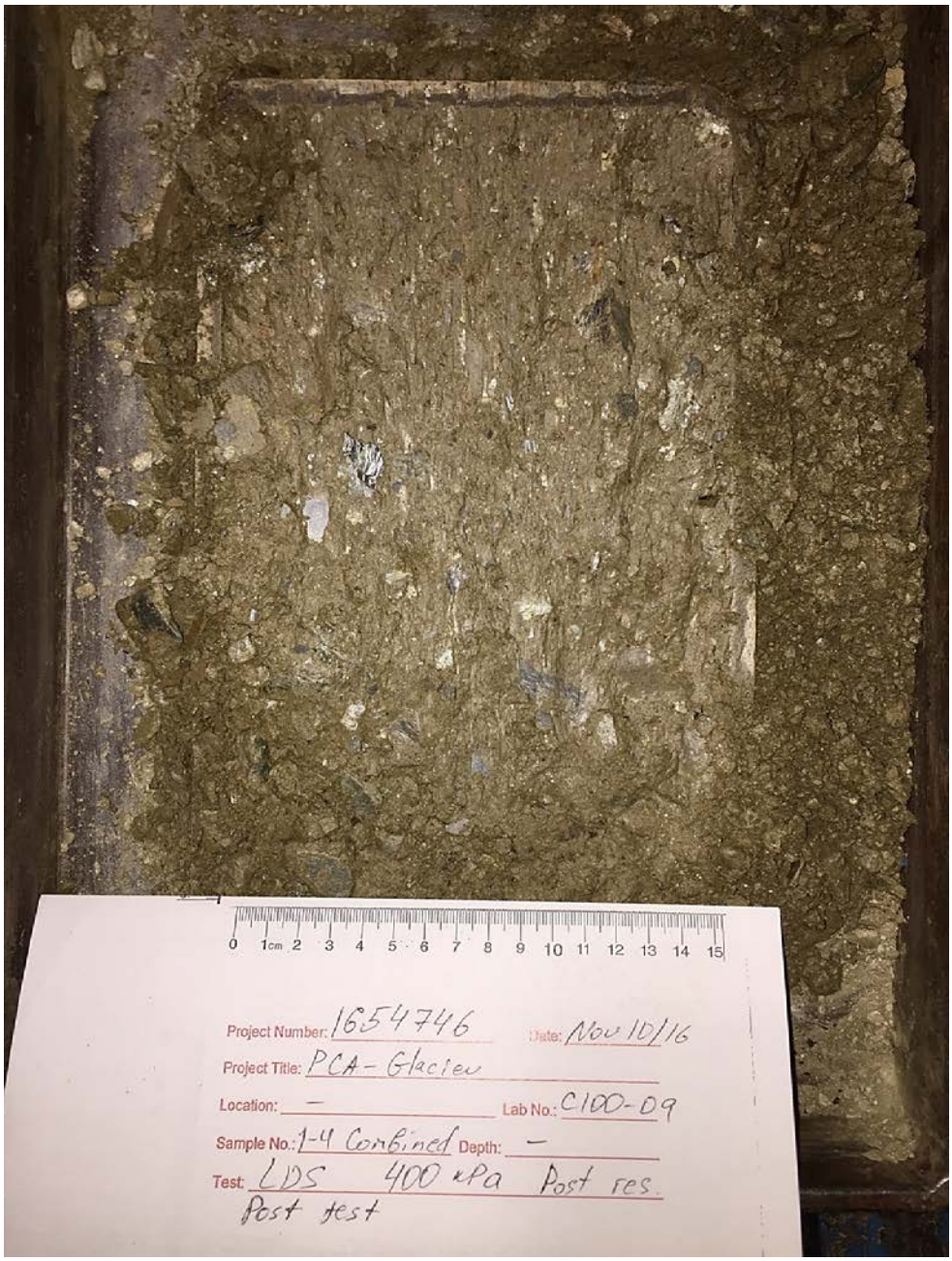
Large Direct Shear Testing - Test Photos

Project No.:	1654746	Phase:	3000
Short Title:	PCA/GlacierNP-Cu14/Avalanche Mitigation - Eastgate Landslide		
Tested by:	MB/KP	Date:	17-Sep-15

Lab No.: C100-09 Test Condition: Moist - Optimum w Sample: Combined SPT Samples

Sample Description: (SM) gravelly SILTY SAND, fine sub-angular to angular gravel, fine to coarse sand; brown; low plastic fines, w<PL

Post-Test Photo - 400 kPa Residual Point

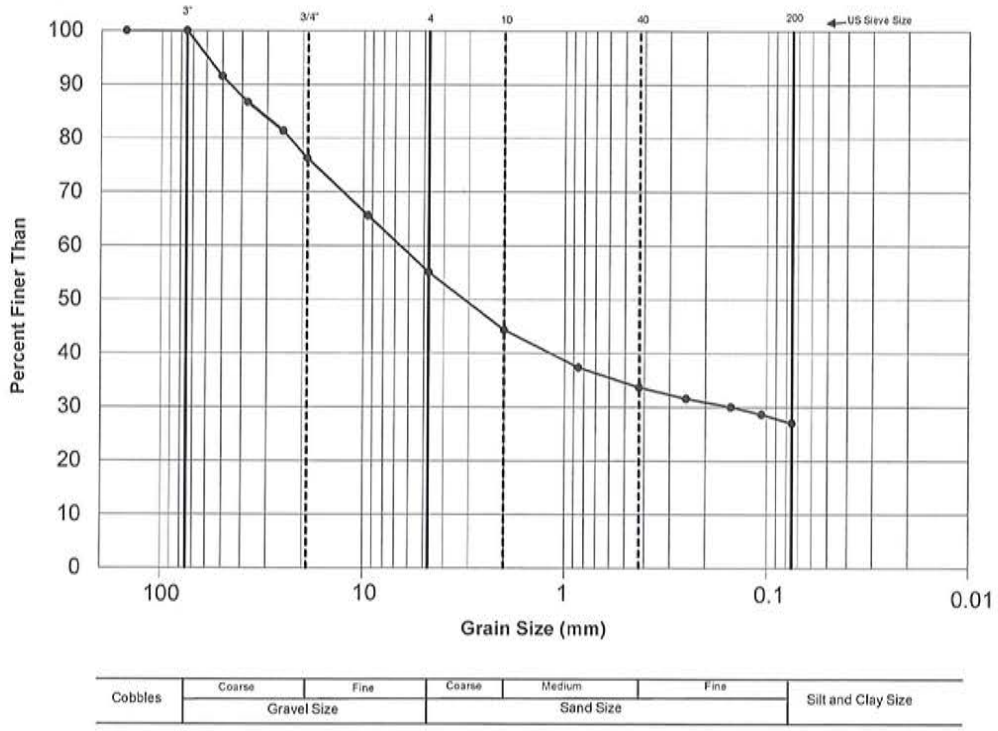


Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1654746	Phase:	3000	Date:	26-Oct-16
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide				
Sub Sampled By:	KH	Washed By:	KH	Sieved By:	KH
Field Tag No.:	-	Source:	-	BH No.:	SA2
Lab No.:	C100-09	Northing:	- m	Sample No.:	1-4 Combined
Sampled By:	JT	Easting:	- m	Depth From:	- m
Sample Date:	21-Sep-16	Elevation:	- m	Depth To:	- m

Test Method:	A	Drying Method:	Air Dry	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Excluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	92
37.5	87
25.0	81
19.0	76
9.5	66
4.75	55
2.00	44
0.85	37
0.425	34
0.250	32
0.150	30
0.106	29
0.075	27

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
7.3	0	45	28	27	7.0	0.2	N/A	N/A	N/A

Sample Description: (GM) sandy SILTY GRAVEL, fine coarse sub-angular to angular gravel, fine to coarse sand; brown; low plastic fines, w < PL

USCS Classification: GM

Remarks:

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by:

Laboratory Compaction Characteristics of Soil using Standard Effort

(ASTM D698)

Project No.:	1654746	Phase:	3000
Short Title:	PCA/GlacierNP-CU14/Avalanche Mitigation - Eastgate Landslide	Lab No.:	C100-09
Tested By:	MB	Test Date:	30-Oct-16

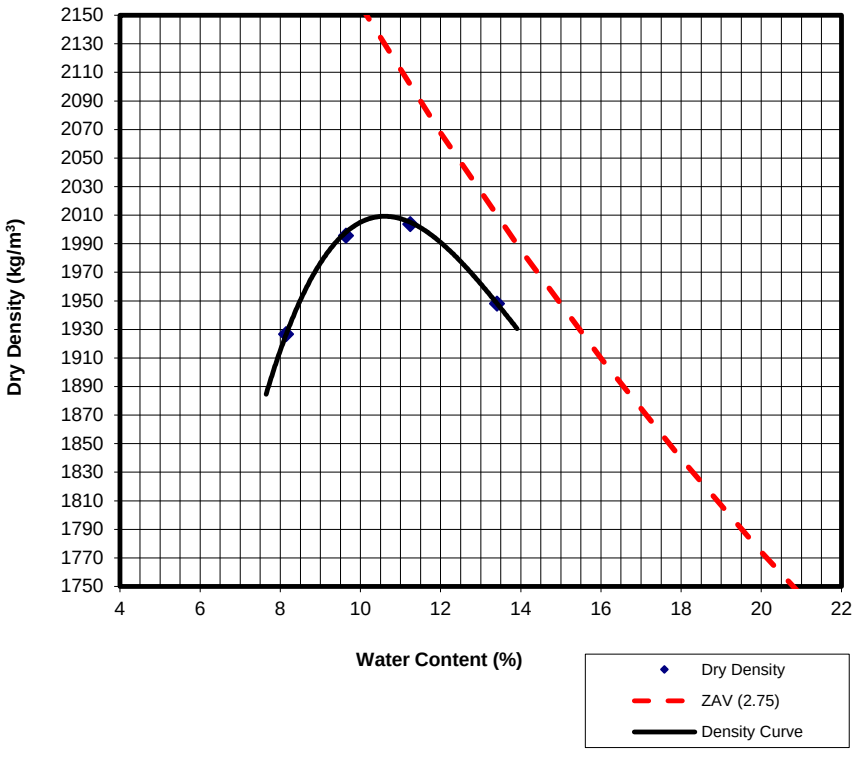
Borehole:	SA2	Date Sampled:	21-Sep-16
Sample No.:	1-4 Combined	Sample Source:	-
Sampled By:	JT	Sample Description:	Please see remarks

MOISTURE DENSITY RELATIONSHIP

Trial No.	1	2	3	4	5	6
Mold No.						
Wt of sample wet + mold (g)	10087.90	10308.20	10394.50	10352.90		
Wt. Of mold (g)	5695.80	5695.80	5695.80	5695.80		
Wt. Of sample wet (g)	4392.10	4612.40	4698.70	4657.10		
Volume of Mold (cm^3)	2107.97	2107.97	2107.97	2107.97		
Wet Density (kg/m^3)	2083.57	2188.08	2229.02	2209.28		
Dry Density (kg/m^3)	1927	1996	2004	1948		

WATER CONTENT

Tare No.						
Wt of sample wet + tare (g)	307.74	401.43	412.64	436.94		
Wt of sample dry + tare (g)	295.45	379.90	392.05	412.57		
Wt. Water	12.29	21.53	20.59	24.37		
Tare mass (g)	144.60	156.47	208.92	230.79		
Wt. Dry soil (g)	150.85	223.43	183.13	181.78		
Water content (%)	8.15	9.64	11.24	13.41		



Maximum Dry Density

Max. Dry Density **2010** kg/m^3

Optimum w **10.8** %

Method **C**

Note: scalped > 16 mm gravel

Rock Correction (if required)

% Oversize _____ %

Max. Dry Density _____ kg/m^3 @ _____

Assumed Specific Gravity = 2.75

Remarks:

(SM) gravelly SILTY SAND, fine sub-angular to angular gravel, fine to coarse sand; brown; low plastic fines, w<PL

As Received Water Content: 7.3%

Reviewed: _____

Golder Associates Ltd.
8 - 820 28th Street N.E
Calgary, AB
T2A 6K1

Golder Associates Ltd.
ATTN: DEREK HUDSON
8, 820-28th Street NE
Calgary AB T2A 6K1

Date Received: 27-OCT-16
Report Date: 02-NOV-16 13:43 (MT)
Version: FINAL

Client Phone: 403-248-6386

Certificate of Analysis

Lab Work Order #: L1849804

Project P.O. #: NOT SUBMITTED
Job Reference: 1654746
C of C Numbers: 10-254762
Legal Site Desc:

Jessica Spira, Env. Tech. DIPL
Senior Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1849804-1 EG-16-01 SA #8 (6.1-6.6M)							
Sampled By: CLIENT							
Matrix:							
Organic Matter by LOI at 375 deg C.							
Organic Matter	7.1		1.0	%	31-OCT-16	01-NOV-16	R3584872
Loss on Ignition @ 375 C	8.7		1.0	%	31-OCT-16	01-NOV-16	R3584872
L1849804-2 EG-16-05 SA #146 (11.0M)							
Sampled By: CLIENT							
Matrix:							
Organic Matter by LOI at 375 deg C.							
Organic Matter	<1.0		1.0	%	31-OCT-16	01-NOV-16	R3584872
Loss on Ignition @ 375 C	<1.0		1.0	%	31-OCT-16	01-NOV-16	R3584872

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
OM-LOI-SK	Soil	Organic Matter by LOI at 375 deg C.	CSSS (1978) p. 160

The dry-ash method involves the removal of organic matter by combustion at 375 degrees C for a minimum of 16 hours. Samples are dried prior to combustion.

Reference: McKeague, J.A. Soil Sampling and Methods of Analysis. Can. Soc. Soil Sci.(1978) method 4.23

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA

Chain of Custody Numbers:

10-254762

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: Golder Associates Ltd.
8, 820-28th Street NE
Calgary AB T2A 6K1
Contact: DEREK HUDSON

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
OM-LOI-SK	**Soil**							
Batch R3584872								
WG2422915-3 IRM		**SAL2001**						
Organic Matter			102.4		%		80-120	01-NOV-16
Loss on Ignition @ 375 C			102.2		%		80-120	01-NOV-16
WG2422915-2 MB								
Organic Matter			<1.0		%		1	01-NOV-16
Loss on Ignition @ 375 C			<1.0		%		1	01-NOV-16

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

10-254762

ALS Environmental

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Canada Toll Free: 1 t
www.alsglobal

L1849804-COFC

Page 1 of 1

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
Company:	Golder Associates Ltd.	Standard: ✓	Other (specify):	✓ Regular (Standard Turnaround Times - Business Days)
Contact:	Derek Hudson	Select: PDF ✓	Excel Digital Fax	Priority (2-4 Business Days) - 50% surcharge - Contact ALS to confirm TAT
Address:	8-820, 28th St. NE Calgary, AB	Email 1:	dhudson@golder.com	Emergency (1-2 Business Days) - 100% Surcharge - Contact ALS to confirm TAT
		Email 2:	melda_sivrac@golder.com	Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	Fax:			

Invoice To	Same as Report ? (circle) Yes or No (if No, provide details)	Client / Project Information	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1654746
Company:		PO / AFE:	
Contact:		LSD:	Eastgate Landslide
Address:			
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact:	Sampler:

Analysis Request

(Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Organic Content	Number of Containers
	EG-16-01 SA #8 (6.1-6.6 m)				1	
	EG-16-05 SA #146 (11.0 m)				1	

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

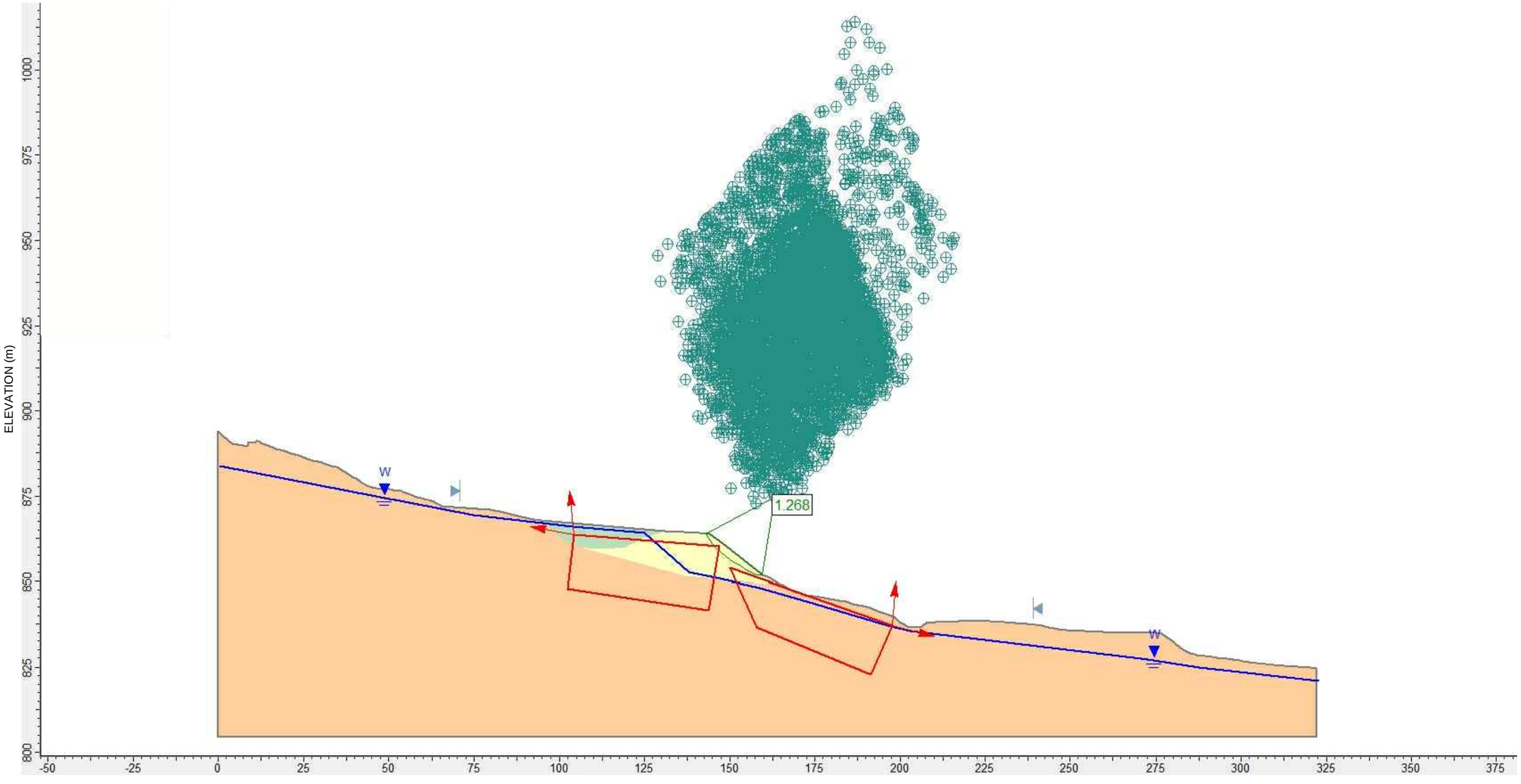
Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SI
D. Sobredo	26 Oct 16	15:35		10/27	11:55	19 °C				

APPENDIX C

Example Stability Analyses Results



LEGEND

- FRESH DEBRIS MATERIAL
- DEFLECTION BERM MATERIAL
- NATIVE MATERIAL

CLIENT
PARKS CANADA AGENCY

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-27
DESIGNED	IT
PREPARED	CV
REVIEWED	IT
APPROVED	PT

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

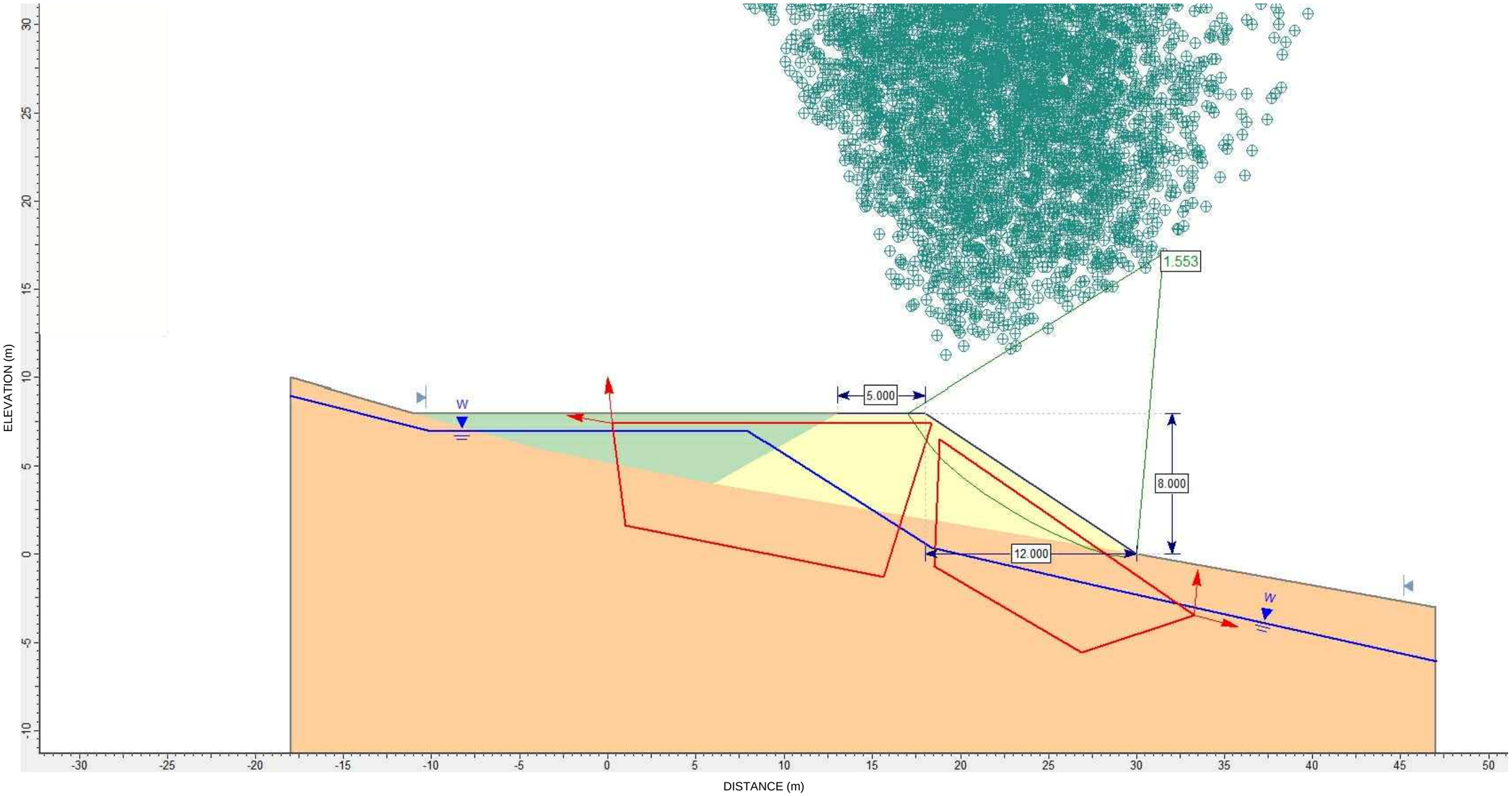
TITLE
STABILITY ANALYSIS RESULTS - EXISTING SLOPE FOR SECTION D, STATIC ANALYSIS

PROJECT NO.	CONTROL	REV.	FIGURE
1654746		0	C1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

0



LEGEND

- FRESH DEBRIS MATERIAL
- DEFLECTION BERM MATERIAL
- NATIVE MATERIAL

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PARKS CANADA AGENCY

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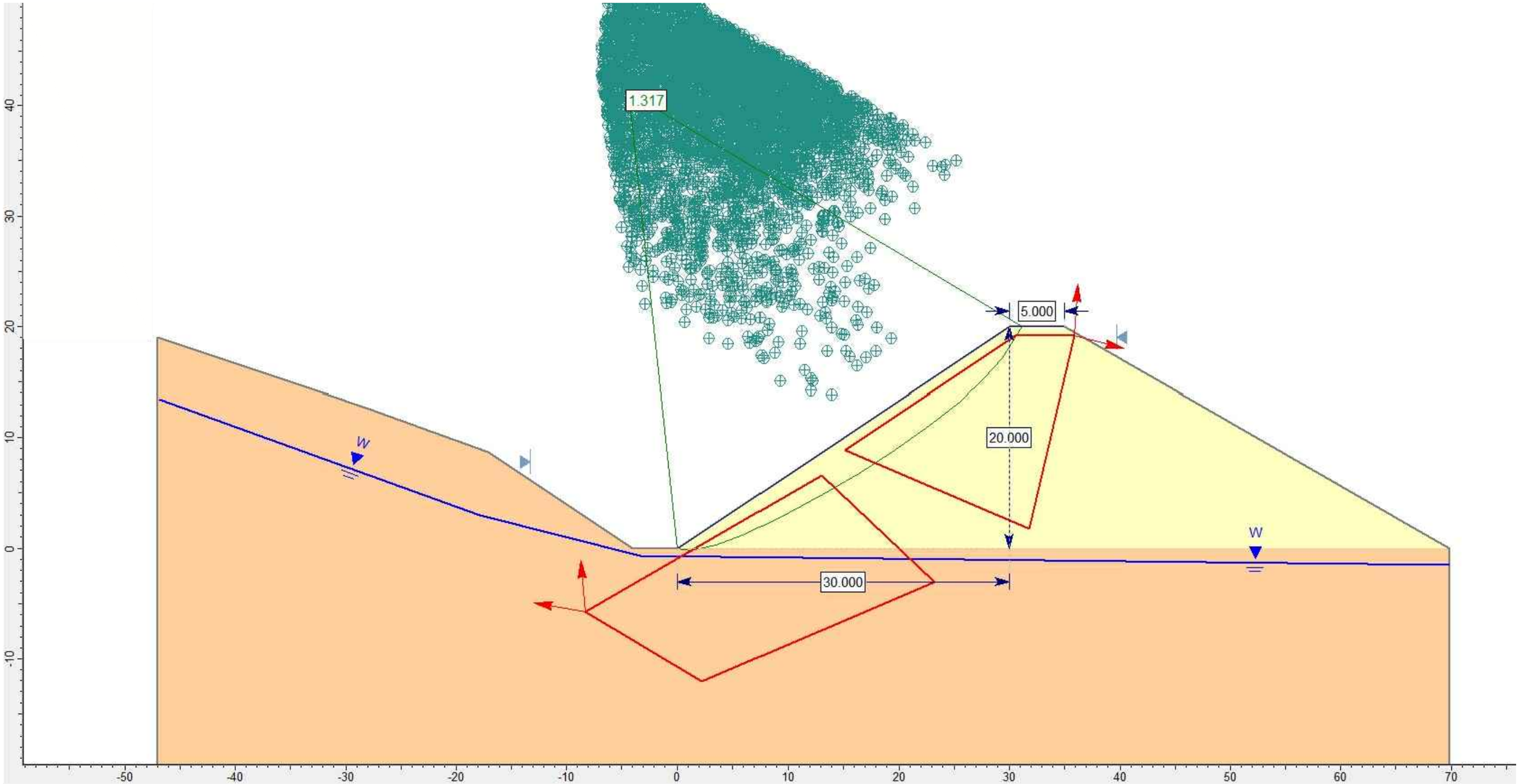
PREPARED	CV
REVIEWED	IT
APPROVED	PT

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
STABILITY ANALYSIS RESULTS - DESIGN SLOPE CASE 1 - STATIC ANALYSIS, 1.5H:1V WITH 8 m SLOPE HEIGHT

PROJECT NO.	CONTROL	REV.	FIGURE
1654746		0	C2



LEGEND

- FRESH DEBRIS MATERIAL
- DEFLECTION BERM MATERIAL
- NATIVE MATERIAL

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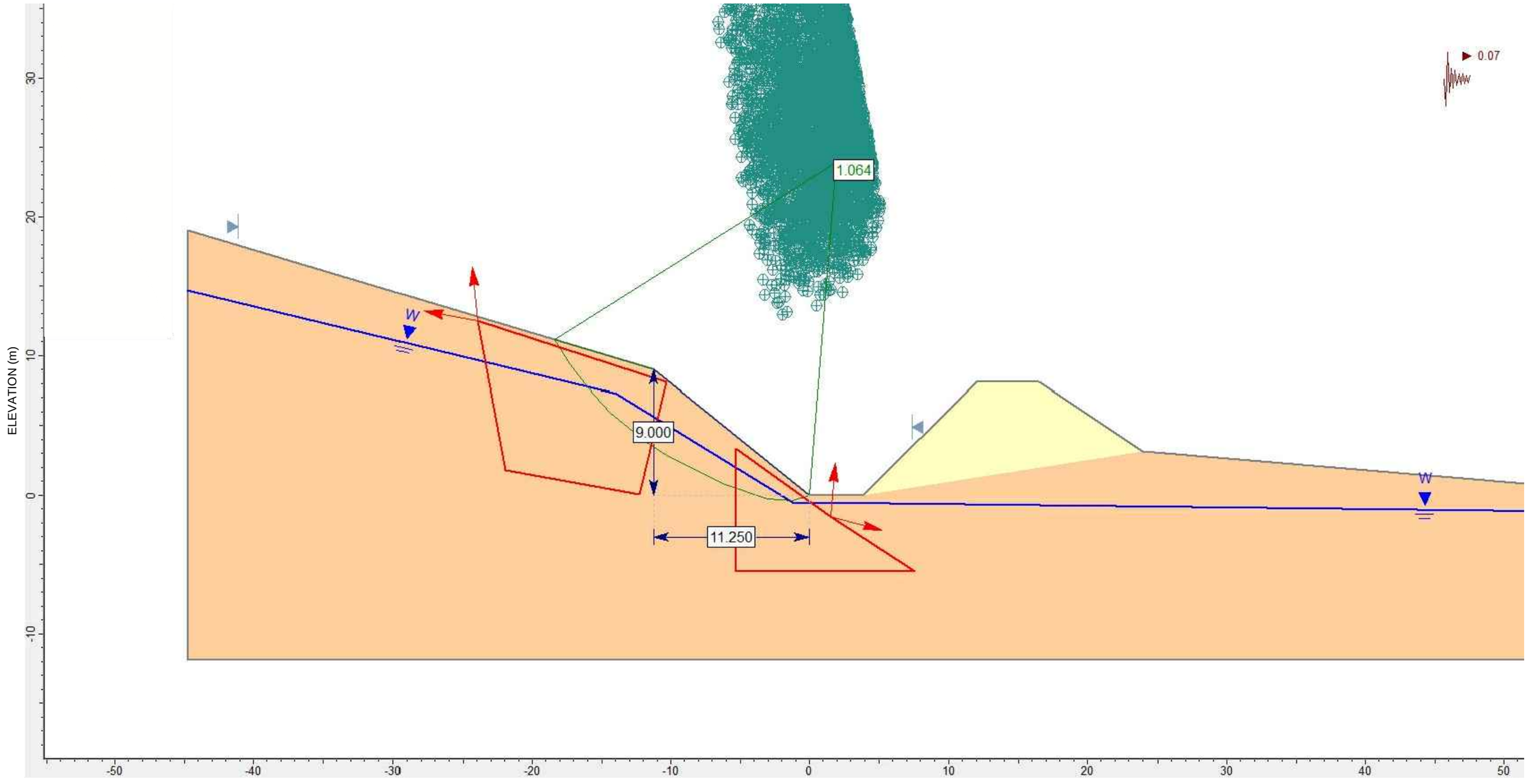
PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
STABILITY ANALYSIS RESULTS - DESIGN SLOPE CASE 2 - STATIC ANALYSIS, 1.5H:1V WITH 20 m SLOPE HEIGHT

PROJECT NO.	CONTROL	REV.	FIGURE
1654746		0	C3



LEGEND

- FRESH DEBRIS MATERIAL
- DEFLECTION BERM MATERIAL
- NATIVE MATERIAL

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DESIGNED	IT
PREPARED	CV
REVIEWED	IT
APPROVED	PT

PROJECT
EAST GATE LANDSLIDE
DEFLECTION BERM

TITLE
STABILITY ANALYSIS RESULTS - DESIGN SLOPE CASE 3 - SEISMIC ANALYSIS, 1.25H:1V WITH 9 m SLOPE HEIGHT

PROJECT NO.	CONTROL	REV.	FIGURE
1654746		0	C4

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

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