Foundation Investigation and Design Report

Truck Inspection Station Building
Highway 400 Widening from North of King Road to
South of Lloydtown-Aurora Road, King City, Ontario
Assignment No. 2017-E-0016-015, G.W.P. 2835-02-00

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ASSIGNMENT NO. 2017-E-0016-015, G.W.P. 2385-02-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detail design of the widening of Highway 400 from north of King Road to south of 16th Sideroad, and from north of 16th sideroad to south of Lloydtown-Aurora Road (i.e. from King Road to Lloydtown-Aurora Road), as part of MTO Agreement No. 2017-E-0016, Assignment #15.

This report addresses the foundation investigation carried out for the proposed new truck inspection station building located within the relocated northbound truck inspection station (east of the northbound lanes of Highway 400 and east of the existing truck inspection station) at about Station 14+350, as shown on Drawing 1. The purpose of this investigation is to explore the subsurface conditions at the location of the proposed truck inspection station building by borehole drilling and geotechnical laboratory testing on selected samples and based on the results of the investigation, provide foundation engineering recommendations for the design and construction of the proposed building.

2.0 PROJECT / SITE DESCRIPTION

Highway 400 is to be widened from north of King Road to south of 16th Sideroad, some of which has been or is currently being constructed. As a result of the planned highway widening, the existing truck inspection station (TIS) will be abandoned / removed and a new truck inspection station will be reconstructed east of the existing location, including a new single-story building (i.e. scale house) and shed as shown on Drawing 1.

The existing TIS is constructed on an approximately 4 m high embankment, with the ground surface at about Elevation 312 m.

The proposed new building is located on the east embankment slope which is inclined at about 2 Horizontal to 1 Vertical (2H:1V) at the south end of the proposed building footprint to about 4H:1V at the north end of the proposed building footprint. The toe of the embankment slope is at about Elevation 308 m. An existing 150 mm diameter CSP culvert and 300 mm diameter CSP culvert outlet stormwater to the toe of the existing embankment within the proposed footprint of the new TIS building location as shown on Drawing 1.

The proposed shed is located east of the existing truck inspection station embankment. The existing ground surface at the proposed shed location is at about Elevation 313 m (about 1 m higher than the ground surface at the existing truck inspection station).

The property east of the truck inspection station consists of farmland and low-lying marsh / swamp area. The proposed building footprint is located over the existing embankment and low-lying marsh / swamp area, while the proposed shed footprint is located over the higher elevated farmland.

3.0 INVESTIGATION PROCEDURES

The foundation investigation for the new building was carried out on November 25 and 27, 2020 and on October 8 and 12, 2021, during which time six boreholes (designated as Boreholes TISB-1 to TISB-6) were advanced to depths between 0.9 m and 10.4 m below ground surface. The boreholes were advanced in the vicinity of the proposed building, as shown on Drawing 1. The borehole records are provided in Appendix A.

Boreholes TISB-1 and TISB-2 were advanced using a conventional D-120 drill rig with 203 mm outside diameter continuous flight hollow stem augers and Boreholes TISB-5 and TISB-6 were advanced using portable drilling equipment (tripod and washboring with casing), supplied and operated by Walker Drilling Inc. of Utopia, Ontario.

Soil samples were generally obtained at 0.75 m and 1.5 m intervals of depth with the conventional rig and continuously with the portable rig using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)[1]. The split-spoon samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 35 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension would not be sampled or represented in the grain size distributions.

Boreholes TISB-3 and TISB-4 were advanced in the wet swampy area east of the embankment toe using a hand auger with continuous sampling techniques by Golder personnel.

The groundwater conditions in the open boreholes were observed during the drilling operations and a standpipe piezometer was installed in Borehole TISB-1 to permit monitoring of the groundwater level at the borehole location. The standpipe piezometer consists of 50 mm diameter PVC pipe, with a slotted screen sealed at a selected depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen sand pack was backfilled to the ground surface with bentonite pellets and a stick-up monument casing was provided at the piezometer location. Piezometer installation details and water level readings are described on the borehole records presented in Appendix A. The remaining boreholes, in which a standpipe piezometer was not installed, were backfilled in general accordance with Ontario Regulation 903 (as amended).

The field work was observed on a full-time basis by a member of Golder's engineering staff, who located the boreholes, arranged for the clearance of underground utilities, directed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's geotechnical laboratory in Mississauga, Ontario where the samples underwent further visual examination and laboratory testing. The laboratory tests were carried out in general accordance to MTO LS and/or ASTM standards, as appropriate. Classification testing (water content, Atterberg limits, grain size distribution and organic content) was carried out on selected samples.

Select soil samples were submitted to a specialist analytical laboratory (Bureau Veritas Laboratories) under chain of custody procedures for testing of conductivity / resistivity, pH and chemical analysis of sulphate and chloride content, to assess the potential for the soil to cause deterioration to buried concrete and/or corrosion to steel.

The borehole locations and the ground surface elevations were surveyed by Golder using a Trimble Geo7X with a minimum horizontal and vertical accuracy of about 0.1 m. The borehole locations and elevations are referenced relative to MTM NAD 83 (Zone 10) northing and easting, and to geodetic datum (HT2_0 / CGVD 1928:1978), respectively. The borehole locations (including northing/easting and latitude/longitude), ground surface elevations, and drilled depths are summarized below.

[1] ASTM D1586 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

Borehole No.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude,°)	Easting (m) (Longitude,°)		
TISB-1	4,866,785.7 (43.941038)	299,144.9 (-79.570448)	311.8	10.4
TISB-2	4,866,801.0 (43.941176)	299,155.3 (-79.570318)	310.7	10.4
TISB-3	4,866,786.4 (43.941044)	299,159.4 (-79.570448)	308.6	0.9
TISB-4	4,866,792.0 (43.941094)	299,158.0 (-79.570285)	308.6	1.5
TISB-5	4,866,776.7 (43.940957)	299,164.1 (-79.570208)	308.6	9.8
TISB-6	4,866,789.7 (43.941074)	299,159.4 (-79.570268)	308.6	4.3

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The sections of Highway 400 included in this project traverses the three physiographic regions known as the South Slope, Oak Ridges Moraine and Simcoe Lowlands, according to *The Physiography of Southern Ontario (Chapman and Putman, 1984)*[2]. The South Slope is present at the southern portion of the project length, extending south from about 2 km north of King Road. The Oak Ridge Moraines is present through the centre portion of the project length, extending from about 2 km north of King Road to about 2 km south of Lloydtown-Aurora Road. The Simcoe Lowlands is present at the northern portion of the project length, extending north from about 2 km south of Lloydtown-Aurora Road.

The proposed building and shed are located within the Oak Ridge Moraine physiographic region. The Oak Ridges Moraine predominately consists of sand and gravel, although in the King Township area these soils are often overlain by till. It is understood that during grading for the initial construction of Highway 400 through this area, deep cuts exposed up to about 10 m of till overlying the sand and gravel deposits.

According to geologic mapping (*Surficial Geology of Southern Ontario, MRD128-REV, Ontario Geological Survey and Ministry of Northern Development, Mines and Forestry*)[3], the surficial geology at the proposed building and shed consist of glaciolacustrine-derived silty to clayey till.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the investigation (Boreholes TISB-1 to TISB-6) are presented on the borehole records in Appendix A. The *Abbreviations and Terms Used on Records of Boreholes and Test Pits* and *List of Symbols* sheets are provided in Appendix A to assist in the interpretation of the borehole records. The results of the geotechnical laboratory tests are presented in Appendix B and the results of the analytical laboratory tests are presented in Appendix C.

The results of the in situ field tests (i.e., SPT "N"-values) as presented on the borehole records and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries,

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[2] Chapman, L.J. and Putnam, D,F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P. 2715, Scale 1:600,000.

[3] Surficial Geology of Southern Ontario, MRD128-REV, Ontario Geological Survey and Ministry of Northern Development, Mines and Forestry

therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions at the proposed TIS building consist of cohesive fill overlying organic silt, which is underlain by clayey silt and clayey silt till. A description of the major soil layers encountered during the investigation is summarized below.

4.2.1 Pavement Structure

A 150 mm layer of asphalt was encountered at ground surface in Borehole TISB-1.

A 1.0 m thick layer of sand fill was encountered underlying the asphalt in Borehole TISB-1. The sand fill contains trace to some gravel, trace silt.

The SPT "N"-values measured within the non-cohesive fill are 10 blows and 13 blows per 0.3 m of penetration, indicating a compact state of compactness.

4.2.2 Topsoil

A 700 mm thick layer of topsoil was encountered at ground surface in Borehole TISB-2.

4.2.3 Clayey Silt Fill

A 2.5 m and 1.1 m thick layer of clayey silt fill was encountered underlying the pavement structure in Borehole TISB-1 and underlying the topsoil in Borehole TISB-2, respectively. The fill extends to depths of 3.7 m and 1.8 m below ground surface (i.e., to Elevations 308.1 m and 308.9 m), respectively. The fill composition ranges from some sand to sandy, trace gravel to gravelly, and contains trace organics including trace rootlets.

The SPT "N"-values measured within the clayey silt fill range from 7 blows to 20 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

Grain size distribution testing was carried on two samples of the clayey silt fill and the results are presented on Figure B-1 in Appendix B. Atterberg limit testing was carried out on two samples of the clayey silt fill and the results are presented on Figure B-2. The Atterberg limit testing measured liquid limits of 24% and 26%, plastic limits of 14% and 15%, and plasticity indices of 10% and 11%, indicating the fill is of low plasticity. The water content measured on two samples of the fill is about 9% and 12%.

4.2.4 Organic Silt

A 0.4 m to 1.9 m thick deposit of organic silt, some sand to sandy, was encountered underlying the fill in Boreholes TISB-1 and TISB-2 and at ground surface in Boreholes TISB-3, TISB-5, and TISB-6. Where fully penetrated, the deposit extends to depths ranging from 1.2 m to 5.6 m below ground surface (i.e., to Elevation 308.5 m to 306.2 m). Borehole TISB-3 was terminated at a depth of 0.9 m below ground surface (i.e., at Elevation 307.7 m) within the organic silt deposit.

The SPT "N"-values measured within the organic silt range from 2 blows to 27 blows per 0.3 m of penetration, suggesting the deposit is very loose to compact.

Grain size distribution testing was carried out on one sample of the organic silt and the results are presented on Figure B-3 in Appendix B. The natural water content measured on samples of the organic silt range from about 24% to 62%. Organic content testing was carried out on six samples of the organic silt and measured organic contents ranging from about 5% to 18%.

4.2.5 Clayey Silt

A deposit of clayey silt, trace sand to sandy, trace gravel was encountered underlying the organic silt deposit in Boreholes TISB-1, TISB-2, TISB-5, and TISB-6 and at ground surface in Borehole TISB-4. Where fully penetrated, the clayey silt deposit extends to depths ranging from 2.4 m to 7.1 m below ground surface (i.e., to Elevations 307.7 m to 304.7 m). Borehole TISB-4 was terminated at a depth of 1.5 m below ground surface (i.e., at Elevation 307.1 m) within the clayey silt deposit. The clayey silt deposit contains sand seams in Borehole TISB-1 and contains trace organics / trace rootlets in Boreholes TISB-4 to TISB-6.

The SPT "N"-values measured within the clayey silt deposit range from 8 blows to 21 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

Atterberg limit testing was carried out on two samples of the clayey silt deposit and the results are presented on Figure B-4 in Appendix B. The Atterberg limit testing measured liquid limits of about 24% and 26%, plastic limits of about 14%, and plasticity indices of about 10% and 12%, indicating the deposit is a clayey silt of low plasticity. The natural water content measured on samples of the clayey silt deposit range from about 16% to 36%. Organic content testing was carried out on three samples of the clayey silt deposit and measured organic contents ranging from about 1% to 4%.

4.2.6 Sandy Silt

A 1.6 m thick deposit of sandy silt, containing clayey silt seams, was encountered below the clayey silt deposit in Borehole TISB-1 at a depth of 7.1 m below ground surface (i.e., at Elevation 304.7).

The SPT "N"-value measured within the sandy silt layer was 10 blows per 0.3 m of penetration, indicating a loose to compact state of compactness.

Grain size distribution testing was carried out on one sample of the sandy silt layer and the results are presented on Figure B-7 in Appendix B. The natural water content measured on one sample of the sandy silt layer is about 17%.

4.2.7 Clayey Silt-Silt to Clayey Silt (Till)

A deposit of clayey silt-silt to clayey silt (till) containing variable amounts of sand (trace to sandy), trace gravel was encountered beneath the sandy silt deposit in Borehole TISB-1 and beneath the clayey silt deposit in Boreholes TSIB-2, TISB-5, and TISB-6. The boreholes were terminated within the till deposit at depths of 4.3 m to 10.4 m below ground surface (Elevation 304.3 m to 298.9 m). Previous experience in the region indicates that the glacial deposits in this area are known to contain cobbles and boulders that are not generally identified by conventional drilling, sampling and laboratory testing methods.

The SPT "N"-values measured within the till deposit range from 9 blows to 128 blows per 0.3 m of penetration, suggesting a stiff to hard consistency. The presence of "N"-values greater than "100 blows" suggest the presence of cobbles and potential boulders within the deposit.

Grain size distribution testing was carried out on five samples of the till deposit and the results are presented on Figure B-5 in Appendix B. Atterberg limit testing was carried out on six samples of the till deposit and the results are presented on Figure B-6 in Appendix B. The Atterberg limit testing measured liquid limits ranging from 18% to 24%, plastic limits ranging from 12% to 14%, and plasticity indices ranging from 6% to 10%, indicating the till ranges from a clayey silt-silt to a clayey silt of low plasticity. The natural water content measured on samples of the deposit range from about 14% to 18%.

4.2.8 Groundwater

Details of the groundwater levels measured in the open boreholes on completion of drilling are presented on the borehole records in Appendix A; however, these observations are based on the conditions at the time of drilling and are not necessarily representative of the stabilized groundwater level at the site.

A standpipe piezometer was installed in Borehole TISB-1 to measure the stabilized groundwater level at the site. The measured groundwater levels are summarized in the table below.

Borehole No.	Depth Below Ground Surface to Groundwater (m)	Groundwater Elevation (m)	Date of Observation
TISB-1	3.6	308.2	December 4, 2020
	3.0	308.8	February 10, 2021
	2.9	308.9	October 12, 2021

The groundwater level at the site will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation.

4.3 Analytical Testing Results

One soil sample was collected and submitted for analysis of parameters used to assess the potential corrosivity of the site soil to steel and concrete. A summary of the results of the analysis is presented below and the detailed test results and Certificate of Analysis is presented in Appendix C.

Borehole No. / Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Soluble Chlorides (µg/g)	Soluble Sulphates (µg/g)
TISB-1 / 3	7.72	310	3,230	1,800	<20

Note: 1. RDL indicates “Reportable Detection Limit”

5.0 CLOSURE

This Foundation Investigation Report was prepared by Anastasia Poliacik, P.Eng., a geotechnical engineer with Golder. Mr. Kevin Bentley, P.Eng., an MTO Foundations Designated Contact, conducted an independent technical and quality control review of the report.

Signature Page

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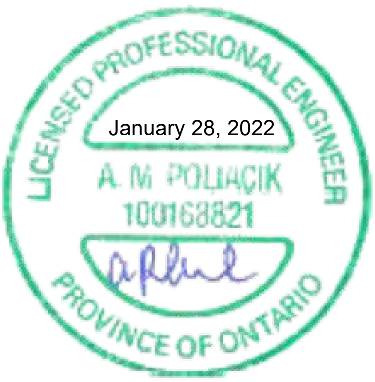

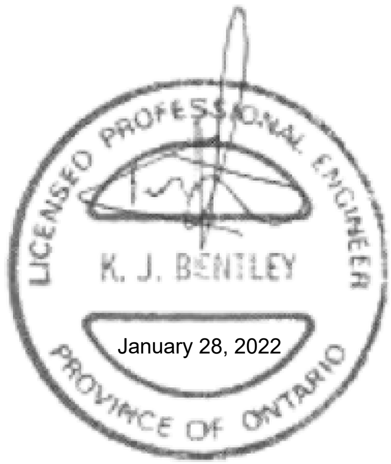

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PART B

FOUNDATION DESIGN REPORT
TRUCK INSPECTION STATION BUILDING
HIGHWAY 400 WIDENING FROM NORTH OF KING ROAD TO SOUTH OF LLOYDTOWN-AURORA ROAD, KING CITY, ONTARIO
ASSIGNMENT NO. 2017-E-0016-015, G.W.P. 2385-02-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides detail foundation recommendations for the proposed truck inspection station (TIS) building, in support of the detail design of the widening of Highway 400 from north of King Road to south of 16th Sideroad, and from north of 16th sideroad to south of Lloydtown-Aurora Rod (i.e. form King Road to Lloydtown-Aurora Road). The discussion and recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation in the vicinity of the new building footprint and are intended to provide the designer with sufficient information to carry out the design of the proposed building foundations and associated earthworks.

This Foundation Investigation and Design Report, including the discussion and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO), and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in the Foundation Investigation (Part A) of this report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling, and the like.

6.1 General

Based on the Contract Drawings (TIS structural and architectural drawings dated November 2021), the proposed single-story building located within the northbound truck inspection station will be approximately 27 m long and 13 m wide with a slab-on-grade finished floor at about Elevation 312.2 m. The proposed shed will be approximately 5 m long and 5 m wide with a slab-on-grade finished floor at about Elevation 311.7 m.

To accommodate the proposed new highway widening and new building, the existing embankment on which the existing truck inspection station is located will be widened approximately 20 m to the east. The location of the proposed building and shed are shown on Drawing 1.

There is no grade raise at the northwest corner of the proposed building, but up to a 4 m grade raise at the southeast corner of the proposed building, within the existing swamp area. Based on conversations with the designer, the proposed embankment widening will be inclined at 3 Horizontal: 1 Vertical (3H:1V) beyond the east footprint of the building. At the location of the shed, there will be a cut of about 1.5 m.

6.1.1 Subsurface Conditions at Proposed Shed

It is noted that the proposed shed is located about 50 m to 75 m northeast of Boreholes TISB-1 to TISB-6 and is east of the existing TIS embankment. The existing ground surface elevation at the proposed shed location is about 1 m higher than the existing TIS embankment, and about 1 m to 4 m above the ground surface elevation at Boreholes TISB-1 to TISB-6.

Considering Boreholes TISB-1 to TISB-6 were advanced through the existing embankment or within the low-lying marshy area, and the proposed shed is located beyond the existing embankment on the higher-elevated farmland, the subsurface conditions encountered in Boreholes TISB-1 to TISB-6 may not be representative of the subsurface conditions at the proposed shed location. Therefore, the subsurface conditions at the shed location have been inferred based on Golder's understanding of the regional geology and closest borehole (TISB-2) and must be confirmed at the time of construction.

6.2 Foundations

6.2.1 Foundation Options

Shallow foundations (spread and/or strip footings) and intermediate / deep foundations (helical piles, drilled shafts, driven steel H-Piles) were considered for support of the proposed building and shed. A summary of the foundation options is provided below and the feasibility, advantages, disadvantages, risks, and relative cost for the alternatives are provided in Table 1, following the text of this report.

- **Shallow foundations** consisting of spread and/or strip footings founded on engineered fill are considered feasible. The existing fill soils and organic soils must be completely removed from within and beyond the proposed structure footprint and replaced with engineered fill to mitigate the high risk of differential settlement across the building footprint. This option would require excavating about 2 m to 6 m below existing ground surface at the building location and is estimated to require excavating about 3 m below existing ground surface (1.5 m below final ground surface) at the shed location. Alternatively, ground improvement options (e.g. soil aggregate piers or stone columns) could be considered to reduce subexcavation and replacement volumes at the proposed building location; however, any environmental concerns related to methane generation from leaving the organic soils in place would need to be mitigated in the building design.

- **Intermediate / Deep foundations** consisting of helical piles, drilled shafts (caissons) or driven steel H-piles extending below the existing fill and organics and into the native soil deposits (i.e., below Elevation 306 m at the proposed building location) could be considered. However, although installation of intermediate/deep foundations would not require excavation of the organic soils, a structural slab would be required to prevent differential movement of the walls / columns relative to the floor slab where up to 4 m of new engineered fill is to be placed. Considering the risks associated with the limited scope of the investigation (i.e. no bedrock or consistent “100-blow soils were encountered across the building footprint), methane mitigation measures if organics are left in place, anticipated low design geotechnical resistance for intermediate/deep foundations and relatively small building and shed footprints compared to the cost of mobilizing such equipment, intermediate/deep foundations are not considered practical at this site.

Based on the above considerations and assuming the existing fill / organic soils will be sub-excavated and replacement with engineered fill, shallow foundations (spread or strip footings) are considered the most practical option from a foundations perspective for the proposed building and shed. Intermediate/deep foundations are also a viable foundation option; however, they are not considered economical for these lightly loaded structures and are not discussed further.

6.2.2 Frost Protection

All exterior footings or footings within unheated buildings should be provided with a minimum of 1.5 m of conventional soil cover for frost protection, in accordance with OPSD 3090.101 *(Foundation Frost Penetration Depths for Southern Ontario),* or equivalent thickness of insulation. As a guide, the MTO has adopted a 25 mm thickness of rigid polystyrene foam insulation as equivalent to a 0.3 m reduction in conventional soil cover.

6.2.3 Shallow Foundations

6.2.3.1 Founding Elevations

Based on the results of the subsurface investigation and the proposed grade raise of up to 4 m at the proposed building location, the proposed building can be founded on conventional spread and/or strip foundations bearing on the new Granular ‘A’ engineered fill, following removal of the topsoil, existing fill, organic soils or other loose / soft / deleterious soils within and beyond the foundation footprint (see Sections 6.6.1 and 6.6.3 for details).

Considering the regional geology, subsurface conditions encountered in Borehole TISB-2, and the proposed grade lowering of about 1.5 m at the proposed shed location, the proposed shed can be founded on conventional spread and/or strip foundations bearing on native stiff to very stiff clayey silt or clayey silt-silt till or on new Granular ‘A’ engineered fill, following removal of the topsoil, existing fill, organic soils or other loose / soft / deleterious soils within and beyond the foundation footprint (see Sections 6.6.1 and 6.6.3 for details).

The sub-excavation elevation, finished floor elevation, and corresponding highest foundation elevation and anticipated foundation soil are provided below.

Structure	Approximate Existing Ground Surface Elevation (m)	Anticipated Sub-excavation Elevation (m)	Approximate Average Finished Grade Elevation[1] (m)	Proposed Founding Elevation / Subgrade (m)	Anticipated Foundation Soils
Truck Inspection Station Building	311.8 to 308.6	306.0	312.2	310.7	3.2 m (north side) to 4.7 m (middle and south side) of new engineered fill over stiff clayey silt / stiff to hard clayey silt-silt to clayey silt (till)
Shed	313.0 to 313.3	Not Anticipated	311.7	310.2	Stiff to hard clayey silt-silt to clayey silt (till)[2]

Notes:
1) Assumed to be equal to finished floor elevation
2) The subsurface conditions at the shed founding elevation are inferred and must be confirmed at the time of construction.

6.2.3.2 Geotechnical Resistances

Shallow strip or spread footings founded on the properly prepared subgrade as discussed in the previous section can be designed using the factored ultimate and serviceability limit state geotechnical resistances presented below.

Structure Foundation	Footing Dimensions (m)	Factored Ultimate Limit State Geotechnical Resistance (kPa)	Factored Serviceability Limit State Geotechnical Resistance (for 25 mm of settlement) (kPa)
Truck Inspection Station Building Strip or Spread Footings	0.7 x 27	450	250
	2 x 2	350	150
Shed Strip Footings	0.7 x 5	65	50

The factored ultimate limit state geotechnical resistances provided above assume that the structural loading is applied perpendicular to the footings. It should be noted that the factored ultimate and serviceability limit state geotechnical resistances are dependent on the footing width and founding elevation and as such, the geotechnical resistances should be reviewed if the footing width or founding elevation differ from those specified above.

6.3 Slab-on-Grade

All topsoil, existing fill, organic soils, or other loose / soft / deleterious soils must be completely removed from within the footprint of the floor slabs. The exposed subgrade should be inspected by qualified geotechnical personnel, and remedial work (e.g., further sub-excavation and replacement) should be carried out on disturbed zones as directed prior to engineered fill placement.

Engineered fill shall consist of OPSS.PROV 1010 (*Aggregates*) Granular 'B' Type I or II, or Select Subgrade Material (SSM), placed in maximum 200 mm loose lifts and uniformly compacted to 100% of the material's Standard Proctor Maximum Dry Density (SPMDD) and in accordance with OPSS.PROV 501 *(Compacting).* The final lift of engineered fill directly beneath conventionally loaded slabs should consist of a minimum of 200 mm of OPSS.PROV 1010 Granular 'A' material, placed in maximum 200 mm loose lifts and uniformly compacted to 100% of the material's SPMDD and in accordance with OPSS.PROV 501 (*Compacting*).

The floor slabs should be structurally separated from the foundation walls and columns and sawcut control joints should be provided at regular intervals and along column lines to minimize shrinkage cracking and to allow for any differential settlement of the floor slabs. Where the slab-on-grade overlies perimeter strip foundations, a construction joint should be envisioned at the junction to accommodate potential differential load-induced behaviour between the two elements.

6.4 Seismic Considerations

Seismic hazard is defined for an earthquake with a 2% probability of exceedance in 50 years (i.e. a 2475-year return period) which encompasses a larger earthquake hazard than in prior editions to the 2012 Ontario Building Code (OBC). Design earthquakes are commonly defined by an earthquake magnitude, distance, and peak ground acceleration (PGA). The OBC uses the Uniform Hazard Spectra (UHS) to define the response of the structure to the design earthquake and considers the effects of the localized site conditions on the structural response. The OBC also uses a refined Site Classification system defined by the average soil/bedrock properties in the top 30 m of the subsurface profile beneath the structure(s). There are six Site Classes designated as A to F related to decreasing ground stiffness from A for hard rock to E for soft soil, and F for problematic soils (e.g., sites underlain by thick peat deposits and/or liquefiable soils). The Site Class is then used to obtain acceleration and velocity-based site coefficients, F_a and F_v, respectively, used to modify the reference UHS to account for the effects of site-specific soil conditions in design.

Depending on the structural design requirements, significant structural design and construction costs can apply. Significant cost savings may be realized by adopting a more accurate site classification method which can only be determined based on actual geophysical testing extending to a depth of at least 30 m below the structure.

6.4.1 Conservative Approach

A conservative site classification is based on physical borehole information obtained at depths of less than 30 m and based on general knowledge of the local geology and physiography. The SPT "N"-values measured in the soil deposits and the interpreted shear wave velocity of soils up to 30 m below founding level are used to define the seismic site classification.

Although the foundation investigation does not extend 30 m below the founding level, based on this methodology, it is considered that a Site Class D (15 < N_{60} > 50) would be applicable for the design of the structures in accordance with Table 4.1.8.4A of the 2012 OBC and in the absence of any geophysical testing.

6.4.2 Geophysical Method to Refine Seismic Site Class

To determine the actual site classification based on physical on-site measurements of shear wave velocity as required by the 2012 OBC, the Multichannel Analysis of Surface Waves (MASW) can be utilized. It is noted that a higher (improved) Site Class is not necessarily guaranteed.

6.5 Embankment Design

As outlined in Section 6.1, the existing truck inspection station is constructed on an approximately 4 m high embankment. The existing embankment will be widened approximately 20 m the east and the proposed building will be constructed on the widened embankment. The west limit of the building is located near the crest of the existing embankment side-slope where there is no grade raise and the east limit of the building is located at the toe of the existing embankment side-slope where there is about a 4 m grade raise. The widened embankment side-slope is to be sloped at 3H:1V, with the top of the embankment at about Elevation 312.2 m and the bottom of the embankment at about Elevation 308.2 m.

Settlement and stability analyses were carried out for the proposed new embankment configuration (assuming 3H:1V side slopes) to confirm the location of the new building is suitable from a foundations perspective. The selection of soil parameters for the analyses and results of the settlement and stability assessment are provided in the following sections.

6.5.1 Parameter Selection

The foundation engineering parameters for the soil types encountered in the boreholes at the proposed building location, used in the settlement and stability analyses, are presented in the table below. The parameters were estimated based on correlations with the SPT 'N'-values, published literature and engineering judgement from experience with similar soils in this region of Ontario. The groundwater level was taken to be at Elevation 309 m within the existing embankment (as measured in the piezometer near the west limit of the building) and at ground surface near the toe of the existing embankment (near the east limit of the building).

Idealized Stratigraphic Unit	γ (kN/m^3)	φ' (°)	S_u (kPa)	E' (MPa)
Firm to very stiff / compact existing fill	21	33	50	n/a[1]
Very loose to compact / soft to very stiff organic silt	17	26	25	n/a[1]
New engineered fill (combined Granular 'A', 'B' and backfill near structure)	21	34	-	n/a[1]
New earth fill (for embankment widening)	21	33	50	n/a[1]
Stiff to very stiff clayey silt	19	30	75	40
Compact sandy silt	20	33	-	15
Stiff to hard clayey silt-silt to clayey silt (till)	21	35	150	43

Where: γ = bulk unit weight
φ' = effective angle of internal friction
S_u = undrained shear strength
E' = effective modulus of elasticity (drained modulus of deformation)
n/a = not applicable (i.e., parameters not used in settlement or stability analyses).

6.5.2 Settlement

The settlement performance criteria for the design of embankment widenings outlined in Section 1.2 of MTO's "*Embankment Settlement Criteria for Design*", dated July 2, 2010 indicates total settlement of freeway widening should not exceed 50 mm over a 20-year period following completion of embankment construction. However, given that the proposed building will be constructed on the proposed embankment widening, a criterion of not more than 25 mm of total settlement has been adopted which is typical for foundations of similar building structures.

To estimate the magnitude of settlement due to the proposed widening and grade raise of up to about 4 m within the building footprint, settlement analyses were carried out using the commercially available program Settle3 (version 5.0), developed by Rocscience Inc. An idealized soil profile was estimated based on the boreholes advanced at the site and considering the existing fill and organic soils will be removed and replaced with engineered fill to about Elevation 306 m. The drained modulus of deformation foundation soil parameters shown in the previous section were used for the analysis. The new embankment loading was modelled as a distributed load up to 4 m high above existing ground surface and tapering to zero load at the crest of the existing embankment and at the toe of the new embankment, for a representative length (parallel to the highway) of about 250 m to account for boundary effects.

Based on the results of the analyses, placement of up to about 6 m of new embankment fill (4 m grade raise plus 2 m of subexcavation) will result in an estimated total settlement of less than 25 mm. The settlement is anticipated to occur during or shortly after construction (within one month of fill placement) provided all topsoil, organic soils, existing fill and any soft/loose soils, or other deleterious materials are completely removed within any settlement sensitive areas as outlined in Section 6.6.1.

6.5.3 Global Stability

A global stability analysis was carried for the proposed embankment widening at the proposed building location, assuming a widened embankment side slope at 3H:1V. An idealized soil profile was estimated based on the boreholes advanced at the site and considering the existing fill and organic soils will be removed and replaced with engineered fill to about Elevation 306 m. A total of four scenarios were analyzed as follows and soil parameters are shown on the corresponding figures:

- Scenario 1: Final embankment configuration assuming advanced dewatering below base of excavation is carried prior to excavation to allow subexcavated backslope to be sloped at 1H:1V, extending 2 m beyond the toe of the embankment. Analyses were carried out for both undrained (short-term) and drained (long-term) conditions as shown in Figures D-1 and D-2 respectively.
- Scenario 2: Final embankment configuration assuming dewatering is carried out during excavation and subexcavated backslope to be sloped at 3H:1V, extending 2 m beyond the toe of the embankment. Analyses were carried out for both undrained (short-term) and drained (long-term) conditions as shown in Figures D-3 and D-4 respectively.
- Scenario 3: Temporary excavation configuration through the existing embankment and underlying organic silt soil assuming advanced dewatering below the base of excavation is carried out prior to excavation to allow the temporary excavations to be sloped at 1H:1V. Analyses were carried out for both undrained (short-term) and drained (long-term) conditions as shown in Figures D-5 and D-6 respectively.

- Scenario 4: Temporary excavation configuration through the existing embankment and organic silt assuming dewatering is carried out during excavation to model the temporary excavations to be sloped at 1H:1V above the groundwater level and at 3H:1V below the groundwater level. Analyses were carried out for both undrained (short-term) and drained (long-term) conditions as shown in Figures D-7 and D-8 respectively.

Two-dimensional limit equilibrium slope stability analyses were performed using the commercially available program Slide2 (Version 9.017), developed by Rocscience Inc., employing the Morgenstern-Price method of analysis and analysing for both circular and non-circular slip surfaces. For all analyses, the Factors of Safety of numerous potential failure surfaces were computed to establish the minimum Factor of Safety. The Factor of Safety is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. For the purpose of the stability analyses, the Factor of Safety is equal to the inverse of the product of the consequence factor, Ψ, and the geotechnical resistance factor, ϕ_{gu}. (i.e., $FoS = 1/(\Psi \cdot \phi_{gu})$) as defined in the Canadian Highway Bridge Design Code (CHBDC, 2019).

The following minimum Factors of Safety have been targeted for the design of the embankment side slopes, as per Table 6.2 of the CHBDC, 2019:

- 1.3 for temporary (undrained) conditions; and
- 1.5 for long-term (drained) conditions

The results of the stability analyses are presented on Figures D-1 to D-8 in Appendix D. In summary, the stability analyses results indicate Factors of Safety for the final embankment configurations (Scenarios 1 and 2) are greater than the target values against deep-seated global failure at the building location, however the temporary excavation configuration results (Scenarios 3 and 4) indicate Factors of Safety near unity and less than the target Factor of Safety values for the drained analysis condition. Therefore, temporary excavations through the existing fill and subexcavation of the existing organic materials for the proposed building and TIS widening (between Station 14+315 and 14+370) should be carried out in such a way that the maximum width of open excavation should be limited to 5 m at any given time and should be continuously backfilled. Staged excavation and backfilling is required and an example NSSP is provided in Appendix E. Alternatively, temporary protection systems can be used as discussed in Section 6.6.4.

Further, where the embankment widening extends onto the existing low-lying marshy areas (i.e., at the proposed building location and south of the proposed building location), in order to achieve Factors of Safety which meet target values noted above for the permanent configuration, all organic soils must be removed from below the widened embankment (i.e., between the existing embankment toe and the widened embankment toe).

6.6 Construction Considerations

6.6.1 Site Preparation and Grading

All topsoil, organic soils, existing fill and any soft/loose soils, or other deleterious materials must be completely removed from within the zone of influence of the proposed foundations (taken as 1 m outside the proposed foundations, then outward and downward at 1 Horizontal to 1 Vertical), below the slab-on-grade (as per Section 6.3) and below any settlement sensitive structures / utilities within the proposed widened embankment. It is recommended that the subexcavation extend to the toe of the widened embankment slope (and then upward and outward at an inclination of 1 Horizontal to 1 Vertical (1H:1V)) east of the building footprint as illustrated in Figure D-1 and D-2. Based on the subsurface conditions encountered in Boreholes TISB-1 to TISB-6, organic soils extend up to about Elevation 306 m and therefore subexcavation to this depth (about 2 m to 6 m below existing ground surface) is anticipated to be required in the vicinity of the proposed building and within the low-lying marshy areas.

Where the embankment widening extends onto the existing low-lying marshy areas (i.e., at the proposed building location and south of the proposed building location), all organic soils must be removed from below the widened embankment (i.e., between the existing embankment toe and the widened embankment toe).

The exposed subgrade should be visually inspected by qualified geotechnical personnel and proof-rolled (where feasible), in general accordance with OPSS 902 (*Excavating and Backfilling - Structures*). Any softened/loosened or poorly performing areas of the subgrade soils should be sub-excavated and replaced with engineered fill as directed by qualified geotechnical personnel.

Site grading shall be carried out in general accordance with OPSS 206 (*Grading*). However, as noted in Section6.5.3, excavation of the existing fill embankment and subexcavation of existing organic materials (anticipated between Station 13+315 and 13+370) shall be undertaken in such a way that the maximum width of open excavation at any given time shall be 5 m. An example NSSP is provided in Appendix E for inclusion in the contract documents.

6.6.2 Temporary Excavations

It is anticipated that temporary excavations will extend through the existing fill, organic silt, and clayey silt. Temporary excavations should be observed and reviewed during construction to confirm that the soil and groundwater conditions are as anticipated. The excavations should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) for Construction Activities (Ontario Regulation 213). The existing fill, loose to compact organic silt and stiff clayey silt are classified as Type 3 soil above the groundwater level and Type 4 soils below the groundwater level. According to the OHSA, temporary excavations within Type 3 soils should be made with side slopes 1H:1V or flatter and temporary excavations within Type 4 soils should be made with side slopes 3H:1V or flatter. Depending on the time of year and variable nature of fill and organic soils, localized flattening of temporary excavations may be required in some areas during construction.

Excavated material must be stockpiled at a distance away from the excavation equal to or greater than the depth of the open cut excavation. Where sufficient space is not available to stockpile the excavated material at the site, off-site disposal of the excavated material intended for reuse would need to be arranged. Care must also be taken during excavation to ensure that adequate support is provided for any existing structures, roadways and underground services located adjacent to the excavations.

The temporary excavations for the footings and/or engineered fill to support the footings and slab-on-grade should be carried out in general accordance with OPSS.PROV 902 (*Excavating and Backfilling - Structures*).

6.6.3 Engineered Fill

Following stripping, temporary excavation, and approval of the subgrade, suitable engineered fill will need to be placed in accordance with OPSS.PROV 501 *(Compacting) and OPSS.PROV 206 (Grading)*.

Engineered fill consisting of OPSS.PROV 1010 Granular ‘A’ or Granular ‘B’ Type I or II and compacted to 100% Standard Proctor Maximum Dry Density (SPMDD) will need to be placed within the zone of influence of the footings and will need to extend at least 1 m beyond the edges of the footings (or settlement sensitive areas), then outward and downward at 1 horizontal to 1 vertical (1H:1V) to meet the approved subgrade.

Engineered fill below the slab-on-grade or other settlement sensitive areas / utilities should consist of OPSS.PROV 1010 Granular ‘A’ or Granular ‘B’ Type I or II and be compacted to 100% SPMDD.

Engineered fill in landscaped areas or in areas where settlement is not a major concern may consist of existing site soils which are generally at or near their optimum water content and do not contain topsoil or significant organics (typically less than 4% organics) or any other deleterious materials. The existing site soils for reuse as engineered fill must be approved by qualified geotechnical personnel prior to placement. Alternatively, imported materials meeting OPSS.PROV 1010 (*Aggregates*) Select Subgrade Material (SSM) may be used for engineered fill. Fill material should be approved by qualified geotechnical personnel at its source prior to importing the material to site.

All engineered fill should be placed in maximum 200 mm loose lifts and compacted to 100% SPMDD below the foundations, slab-on-grade, and in settlement sensitive areas and to at least 95% SPMDD in other areas. Placement of the engineered fill should be carried out under continuous inspection and in-situ density testing by qualified geotechnical personnel.

Engineered fill within the building foundation zone of influence and engineered fill below the proposed building slab-on-grade must be placed up to the underside of the slab-on-grade and left in place for a period of one month prior to construction of footings and slab-on-grade. An Operational Constraint should be included in the Contract documents; an example is included in Appendix E. The final surface of the engineered fill should be protected as necessary from construction traffic and should be sloped to provide positive drainage for surface water during the construction period. If the engineered fill will be left exposed (uncovered) during periods of freezing weather, consideration should be given to placing an additional soil cover above the interim grade to provide frost protection.

6.6.4 Temporary Protection Systems

Depending on staging of the construction and whether the existing TIS is to remain active, temporary excavations for removal of the existing fill and organics may interfere with TIS operations or other components of the proposed highway widening. As a result, temporary protection systems may be required.

The selection and design of the temporary protection system will be the responsibility of the Contractor. The temporary protection system should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*), as amended by SP 105S09. As a general guide, the lateral movement should meet Performance Level 2 near any active ramps or traffic, and the performance level may need to be enhanced if adjacent utilities / operations cannot tolerate this magnitude of deformation.

For conceptual purposes, sheet pile systems or soldier pile and lagging systems are considered feasible at this site. The presence of cobbles / boulders / gravelly soils within the till deposit could impede installation of the temporary protection systems, although pre-drilling and/or removal of localized obstructions to facilitate construction of the temporary protection systems is considered feasible. Given that only the west side of the excavation may require temporary shoring, a raker system could also be considered for lateral supports.

Temporary protection systems may be designed using the soil parameters given below. The system must be designed to accommodate the loads applied from earth pressures, water pressures and surcharge pressures from area, line or point loads, as well as the effects of sloping ground behind the system. The loading from construction equipment as well as any material stockpiles within a distance defined by a 1 horizontal to 1 vertical line drawn from the bottom of the excavation to the existing ground surface should be included as a surcharge in the design of the temporary protection system.

Stratigraphic Unit	Unit Weight of Material, γ (kN/m^3)	Angle of Internal Friction, φ (°)	Undrained Shear Strength, S_u (kPa)	Coefficients of Static Lateral Earth Pressure		
				Active, K_o	At Rest, K_a	Passive, K_p
New engineered fill	21	34	-	0.28	0.44	3.54
Firm to very stiff / compact existing fill	21	33	50	0.29	0.46	3.39
Very loose to compact / soft to very stiff organic silt	17	26	25	0.39	0.56	2.56
Stiff to very stiff clayey silt	19	30	75	0.33	0.50	3.00
Compact sandy silt	20	33	-	0.29	0.46	3.39
Stiff to hard clayey silt-silt to clayey silt (till)	21	35	150	0.27	0.43	3.69

Notes:
1) The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are expected, the coefficients shown need to be corrected accordingly.
2) The total passive resistance below the base of the excavation (i.e., within the shored excavation and / or adjacent to the temporary protection system) may be calculated based on the value of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of the CHBDC (2019) to account for the fact that a large strain would be required for mobilization of the full passive resistance.

It is recommended that the temporary protection system be fully removed upon completion of construction or each stage of construction (as required) to mitigate potential impediments to future rehabilitation/reconstruction work with the TIS. If the temporary protection system is left in place, it should be cut off at or below frost depth, not less than 1.5 m below the pavement surface.

6.6.5 Groundwater and Surface Water Control

Considering subexcavation of the existing fill and organic soils will extend to about Elevation 306 m and the groundwater level at the site was measured to be up to about Elevation 309 m, it is anticipated that excavations for the proposed building will extend about 3 m below the groundwater level. Therefore, dewatering will be required to allow for construction (i.e. excavations, placement of engineered fill and compaction) in dry conditions.

Although dewatering operations are considered temporary works and therefore the responsibility of the Contractor, due to the silty nature of the site soils and the adjacent marshy area, it is anticipated that advanced dewatering in the form of well points or eductor systems to lower the groundwater level to about 1 m below the base of subexcavation will be required prior to excavation / subexcavation operations. Dewatering operations should be carried out in accordance with OPSS.PROV 902 *(Excavation and Backfilling – Structures),* and OPSS.PROV 517 (*Dewatering*) as amended by FOUN0003 (*Dewatering Structure Excavation*), a copy of which is included in Appendix E. It is recommended that the groundwater level at the site be measured closer to the time of construction, in order for the contractor to assess the dewatering / surface water infiltration flow dewatering and/or diversion requirements during construction.

Water takings in excess of 50,000 L/day are regulated by the Ministry of the Environment, Conservation and Parks (MECP). Certain takings of groundwater and stormwater for construction dewatering purposes with a combined total less than 400,000 L/day qualify for self-registration on the MECP Environmental Activity and Sector Registry (EASR). Registry on the EASR replaces the need to obtain a PTTW for water taking and a Section 53 approval for discharge of water to the environment. A “Water Taking Plan” and a “Discharge Plan” are required by the MECP if water is taken in accordance with an EASR. In all cases, discharge under the EASR must be in accordance with a Discharge Plan (to be developed by a qualified professional). The Contractor will be responsible for obtaining any required discharge approvals and EASR registration. A Category 3 PTTW would be required for water takings in excess of 400,000 L/day.

Surface water should be directed away from the excavations at all times. Any existing drainage paths / ditches will need to be diverted around the proposed excavation footprint to reduce surface infiltration / seepage. At the location of the shed where a 1.5 m permanent cut is proposed, permanent diversion and passive drainage of surface water and groundwater around the shed should be incorporated into the stormwater drainage design.

6.6.6 Construction Materials Based on Analytical Testing

The results of analytical testing completed on one sample of the existing fill are summarized in Section 4.3 and presented in Appendix C. The potential for sulphate attack and corrosion are discussed in the following paragraphs. However, it should be noted that it is the responsibility of the designer to determine the appropriate construction materials, including the exposure class and ensuring that all aspects of CSA A23.1-24 Section 4.1.1 “*Durability Requirements”* are followed when designing concrete elements.

The potential for sulphate attack on concrete was determined by comparing analytical test results to CSA A23.1-14 Table 3 “*Additional Requirements for Concrete Subjected to Sulphate Attack”*. The water-soluble sulphate concentration measured in the existing fill is below 0.1%, which is below the exposure class of S-3 (Moderate) and is considered “Negligible” as per Table 7.2 of the MTO Gravity Pipe Guidelines (2014). Therefore, based on the test results from the sample, the effects of the sulphates may not need to be considered when the designer is selecting the exposure class for the structure. However, consideration should be given to the de-icing salts which may be used surrounding the building when selecting the exposure class.

The existing fill measured a pH value of 7.7 and a resistivity value of 310 ohm-cm. According to the MTO Gravity Pipe Guidelines, the pH is not considered detrimental to structure durability. The resistivity is less than 2,000 ohm-cm, which indicates that the soil corrosiveness is “Severe” (2,000 ohm-cm < R), as per Table 3.2 “*Soil Corrosiveness and Resistivity”* of the MTO Gravity Pipe Guidelines (2014).

6.6.7 Obstructions

The boreholes encountered glacial till soils which are expected to contain cobbles and boulders that could affect the installation of shallow foundations or temporary protection systems. An NSSP should be included in the Contract Documents to identify to the contractor the possible presence of cobbles and/or boulders within the glacial till soils at the proposed building and shed locations. An example NSSP is included in Appendix E.

6.6.8 Piezometer Decommissioning

As noted above, it is recommended that the groundwater level at the site be measured closer to the time of construction, in order for the Contractor to assess the dewatering / surface water infiltration flow diversion requirements during construction. The piezometer installed in Boreholes TISB-1 should be decommissioned during construction and a Non-Standard Special Provision (NSSP) should be added to the Contract Documents; an example NSSP for this purpose is attached in Appendix E.

7.0 CLOSURE

This Foundation Design Report was prepared by Anastasia Poliacik, P.Eng., a geotechnical engineer with Golder. Mr. Kevin Bentley, P.Eng., an MTO Foundations Designated Contact with Golder, conducted an independent technical and quality control review of the report.

Signature Page

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AMP/KJB/ljv

https://golderassociates.sharepoint.com/sites/21998g/deliverables/wo15 - hwy 400 widening lloydtown/6. tisb/5. final/1786658-wo15-r-rev0-2022'01'28-hwy 400 lloydtown-tisb.docx

REFERENCES

Canadian Standards Association (CSA). 2014. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA-S6-14*. CSA Special Publication.

Canadian Standards Association (CSA). 2019. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA-S6-19*. CSA Special Publication.

CSA Group. 2014. A23.1-14/A23.2-14 - Concrete materials and methods of concrete construction / Test methods and standard practices for concrete.

ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Ontario Provisional Standard Drawings:

OPSD 3090.101 Foundation, Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specifications:

OPSS.PROV 206 Construction Specification for Grading

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 902 Construction Specification for Excavating and Backfilling - Structures

OPSS.PROV 539 Construction Specification for Temporary Protection Systems

OPSS.PROV 1010 Material Specifications for Aggregates

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)

Ministry of Transportation, Ontario

Gravity Pipe Design Guideline. Drainage and Hydrology Design and Contract Standards Office, 2014.

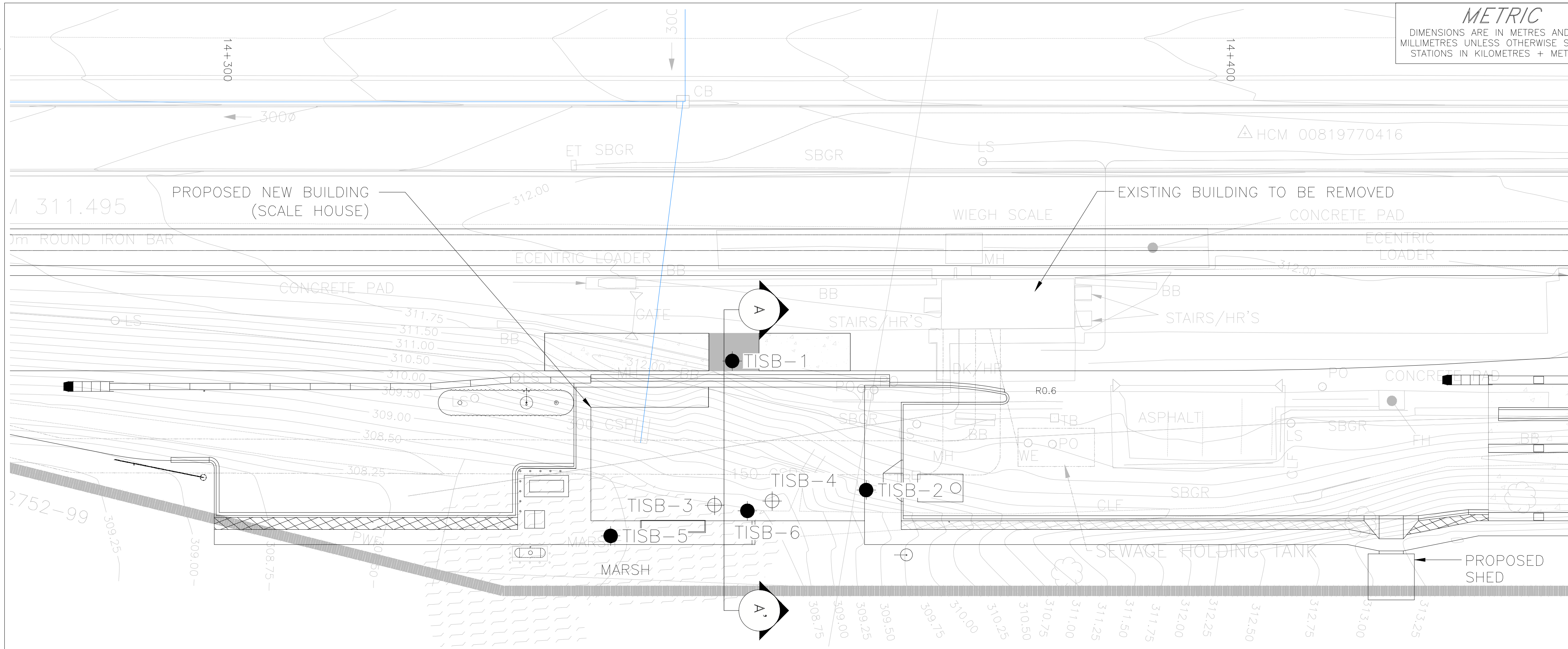
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2835-02-00

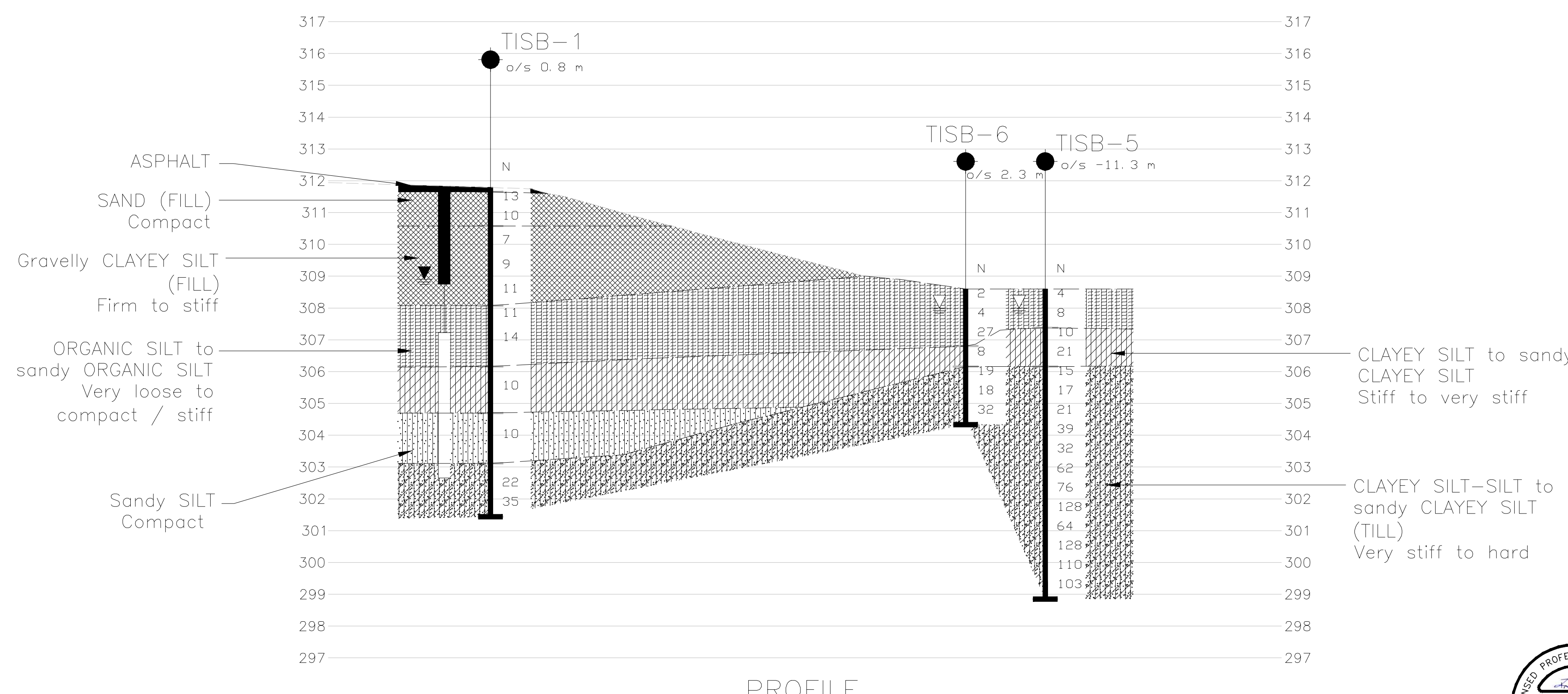
SHEET

TRUCK INSPECTION STATION BUILDING
STATION 14+200 TO 14+700
BOREHOLE LOCATIONS AND SOIL STRATA

GOLDER
MEMBER OF WSP



PLAN
SCALE
5 0 5 10 m



PROFILE
HORIZONTAL & VERTICAL SCALE
2 0 2 4 m

KEY PLAN
SCALE
1 0 1 2 km

LEGEND

- ● Borehole Location – Current Foundation Investigation
- ⊕ Hand Auger Location – Current Foundation Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▼ WL in piezometer, measured on October 12, 2021
- ▽ WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
TISB-1	311.8	4866785.7	299144.9
TISB-2	310.7	4866801.0	299155.3
TISB-3	308.6	4866786.4	299159.4
TISB-4	308.6	4866792.0	299158.0
TISB-5	308.6	4866776.7	299164.1
TISB-6	308.6	4866789.7	299159.4

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Scale house plan provided in digital format by MH, drawing file no x117116615design_NBTIS.dwg, received November 16, 2021.
Base plan provided in digital format by MH, drawing file no. X117116615Base (1).dwg, received June 15, 2021.
Topography plan provided in digital format by MH, drawing file no. X117116615Contours.dwg, received June 2, 2021.

LICENSED PROFESSIONAL ENGINEER K. J. BENTLEY Jan. 17, 2022 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER A. POLIACIK 100158821 Jan. 17, 2022 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 30M13-238

HWY. 400	PROJECT NO. 1786658 (W015)		DIST.
SUBM'D. AMP	CHKD. AMP	DATE: 01/17/2022	SITE:
DRAWN: DD	CHKD. AMP	APPD. KJB	DWG. 1

APPENDIX A

Borehole Records

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS
MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
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)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS[1,2]

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (*i.e.,* SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (*i.e.,* some sand)
≤ 10	trace (*i.e.,* trace fines)

1. Only applicable to components not described by Primary Group Name.
2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

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.). Values reported are as recorded in the field and are uncorrected.

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 friction (f_s) 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
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

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

COARSE-GRAINED SOILS

Compactness[1]

Term	SPT 'N' (blows/0.3m)[2]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

1. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.
2. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED 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.

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.

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
FoS	factor of safety

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

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

(a) Index Properties (continued)

w	water content
w_L or LL	liquid limit
w_P or PL	plastic limit
I_P or PI	plasticity index = $(w_l - w_p)$
NP	non-plastic
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)

(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
$C_{\alpha(e)}$	secondary compression index
C_α	rate of secondary compression
$C_{\alpha(\varepsilon)}$	modified 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
c'	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
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 or 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

RECORD OF BOREHOLE No TISB-1

SHEET 1 OF 1 **METRIC**

PROJECT 1786658 (W015)
G.W.P. 2835-02-00
LOCATION N 4866785.7; E 299144.9 MTM NAD 83 ZONE 10 (LAT. 43.941038; LONG. -79.570448)
ORIGINATED BY LM
DIST Central HWY 400
BOREHOLE TYPE Power Auger; 203 mm O.D. Hollow Stem Augers
COMPILED BY CC
DATUM CGVD28 / HT2_0 (Geodetic)
DATE November 26, 2020
CHECKED BY AMP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
311.8	GROUND SURFACE									
0.0	ASPHALT (150 mm)									
0.2	SAND (SP), trace to some gravel, trace silt (FILL) Compact Brown to grey Moist	1	SS	13	311					
		2A / 2B	SS	10						
310.6 / 1.2	Gravelly CLAYEY SILT (CL), some sand, trace organics (FILL) Firm to stiff Grey Moist	3	SS	7	310					
		4	SS	9	309		23	18	46	13
		5	SS	11						
308.1 / 3.7	Sandy ORGANIC SILT (OL) Compact Dark grey Moist - No sample recovery at 4.6 m depth (Sample 7)	6	SS	11	308	OC=8.0%	0	24	50	16
		7	SS	14	307					
306.2 / 5.6	CLAYEY SILT (CL), trace sand, containing sand seams Stiff Grey Moist	8	SS	10	306, 305					
304.7 / 7.1	Sandy SILT (ML), containing clayey silt seams Compact Brown Moist	9	SS	10	304		0	30	59	11
303.1 / 8.7	CLAYEY SILT (CL), some sand (TILL) Very stiff to hard Grey Moist	10	SS	22	303					
		11	SS	35	302					
301.4 / 10.4	END OF BOREHOLE									

NOTE:

1. Water measured in piezometer as follows:

Date	Depth (m)	Elev. (m)
04-Dec-20	3.6	308.2
10-Feb-21	3.0	308.8
12-Oct-21	2.9	308.9

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity   O ³% STRAIN AT FAILURE

RECORD OF BOREHOLE No TISB-2

SHEET 1 OF 1 **METRIC**

PROJECT 1786658 (W015)
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM CGVD28 / HT2_0 (Geodetic)

LOCATION N 4866801.0; E 299155.3 MTM NAD 83 ZONE 10 (LAT. 43.941176; LONG. -79.570318)
BOREHOLE TYPE Power Auger; 203 mm O.D. Hollow Stem Augers
DATE November 27, 2020

ORIGINATED BY LM
COMPILED BY CC
CHECKED BY AMP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
310.7	GROUND SURFACE
0.0	TOPSOIL
310.0 / 0.7	Sandy CLAYEY SILT (CL), trace gravel, trace organics, trace rootlets (FILL) Very stiff Brown Moist
308.9	ORGANIC SILT (OL), some sand Compact Black Moist
308.5 / 2.2	CLAYEY SILT (CL), trace sand Stiff Grey Moist
307.7 / 3.0	CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL), trace to some sand, trace gravel (TILL) Stiff to very stiff Grey Moist
300.3 / 10.4	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	9					
2	SS	20		6	29	48	17
3A	SS	11					
3B			OC=7.6%				
4	SS	12					
5	SS	13					
6	SS	9					
7	SS	12					
8	SS	13					
9	SS	18		1	9	68	22
10	SS	29					
11	SS	28					

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (310, 309, 308, 307, 306, 305, 304, 303, 302, 301); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No TISB-3

SHEET 1 OF 1

METRIC

PROJECT 1786658 (W015)
G.W.P. 2835-02-00
LOCATION N 4866786.4; E 299159.4 MTM NAD 83 ZONE 10 (LAT. 43.941044; LONG. -79.570448)
ORIGINATED BY LM
DIST Central HWY 400
BOREHOLE TYPE Hand Auger; 50 mm O.D. augers
COMPILED BY CC
DATUM CGVD28 / HT2_0 (Geodetic)
DATE November 25, 2020
CHECKED BY AMP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
308.6	GROUND SURFACE										
0.0	ORGANIC SILT (OL), some sand Dark brown to grey Wet		1	AS	-				62		OC=4.9%
			2	AS	-		308		O		
307.7			3	AS	-						OC=4.8%
0.9	END OF BOREHOLE DUE TO LIMIT OF HAND AUGER EQUIPMENT NOTE: 1. Water encountered at a depth of about 0.2 m (Elev. 208.4 m) during hand auger advancement.										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

GOLDER
MEMBER OF WSP

RECORD OF BOREHOLE No TISB-4

SHEET 1 OF 1 **METRIC**

PROJECT 1786658 (W015)
G.W.P. 2835-02-00
LOCATION N 4866792.0; E 299158.0 MTM NAD 83 ZONE 10 (LAT. 43.941094; LONG. -79.570285)
ORIGINATED BY LM
DIST Central HWY 400
BOREHOLE TYPE Hand Auger; 50 mm O.D. augers
COMPILED BY CC
DATUM CGVD28 / HT2_0 (Geodetic)
DATE November 27, 2020
CHECKED BY AMP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
308.6	GROUND SURFACE										
0.0	CLAYEY SILT (CL), some sand, trace organics Dark brown Wet		1	AS	-						
			2	AS	-		308		o	OC=3.8%	
			3	AS	-						
			4	AS	-				o	OC=4.0%	
307.1			5	AS	-						
1.5	END OF BOREHOLE DUE TO LIMIT OF HAND AUGER EQUIPMENT										

NOTES:

1. Water encountered at a depth of about 0.2 m (Elev. 208.4 m) during hand auger advancement.

2, Water measured at a depth of about 0.6 m (Elev. 208.0 m) in open borehole upon completion of hand augering.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30.

+3, ×3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No TISB-5

SHEET 1 OF 1

METRIC

PROJECT 1786658 (W015)

G.W.P. 2835-02-00 LOCATION N 4866776.7; E 299164.1 MTM NAD 83 ZONE 10 (LAT. 43.940957; LONG. -79.570208) ORIGINATED BY MJB

DIST Central HWY 400 BOREHOLE TYPE Tripod Washboring with 'N'-size casing COMPILED BY AMP

DATUM CGVD28 / HT2_0 (Geodetic) DATE October 8, 2021 CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
308.6	GROUND SURFACE											
0.0	ORGANIC SILT (OL), some sand Loose Black Moist	1	SS	4	▽	308						
		2	SS	8				OC = 4.6%				
307.4 1.2	CLAYEY SILT (CL), some sand, trace rootlets to 1.8 m depth Stiff to very stiff Grey Moist to wet	3	SS	10		307						
		4	SS	21								
306.2 2.4	CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL), some sand to sandy, trace gravel (TILL) Very stiff to hard Grey Moist	5	SS	15		306	plotted		3	23	56	18
		6	SS	17		305						
		7	SS	21								
		8	SS	39		304						
		9	SS	32								
		10	SS	62		303	plotted		1	11	64	24
		11	SS	76		302						
		12	SS	128								
		13	SS	64		301						
		14	SS	128								
		15	SS	110		300						
		16	SS	103		299						
298.9 9.8	END OF BOREHOLE NOTE: 1. Water encountered at a depth of about 0.6 m (Elev. 308.0 m) during drilling and prior to introducing water for washboring.											

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^3$, $\times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

GOLDER
MEMBER OF WSP

RECORD OF BOREHOLE No TISB-6

SHEET 1 OF 1

METRIC

PROJECT 1786658 (W015)
G.W.P. 2835-02-00
LOCATION N 4866789.7; E 299159.4 MTM NAD 83 ZONE 10 (LAT. 43.941074; LONG. -79.570268)
ORIGINATED BY MJB
DIST Central HWY 400
BOREHOLE TYPE Tripod Washboring with 'N'-size casing
COMPILED BY AMP
DATUM CGVD28 / HT2_0 (Geodetic)
DATE October 12, 2021
CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L (WATER CONTENT %)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
308.6	GROUND SURFACE											
0.0	ORGANIC SILT (OL), some sand Very loose to compact Black and brown Wet	1	SS	2	▽	308						
		2	SS	4				OC = 17.8%				
		3	SS	27		307						
306.8 1.8	Sandy CLAYEY SILT (CL), trace gravel, trace organics Stiff Grey Moist to wet	4	SS	8				OC = 1.4%				
306.2 2.4	Sandy CLAYEY SILT (CL), trace gravel (TILL) Very stiff to hard Grey Moist - Split spoon refusal at 3.0 m depth (See Note 1)	5	SS	19		306			2	21	55	22
		6	SS	18		305			1	20	51	28
		7	SS	32								
304.3 4.3	END OF BOREHOLE											

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED: 20 40 60 80 100
WATER CONTENT (%): 10 20 30
REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTES:

1. Split spoon refusal encountered at a depth of 3.0 m (Elevation 305.6 m). Borehole was moved 0.5 m west and Sample 6 and 7 were obtained from the moved borehole.

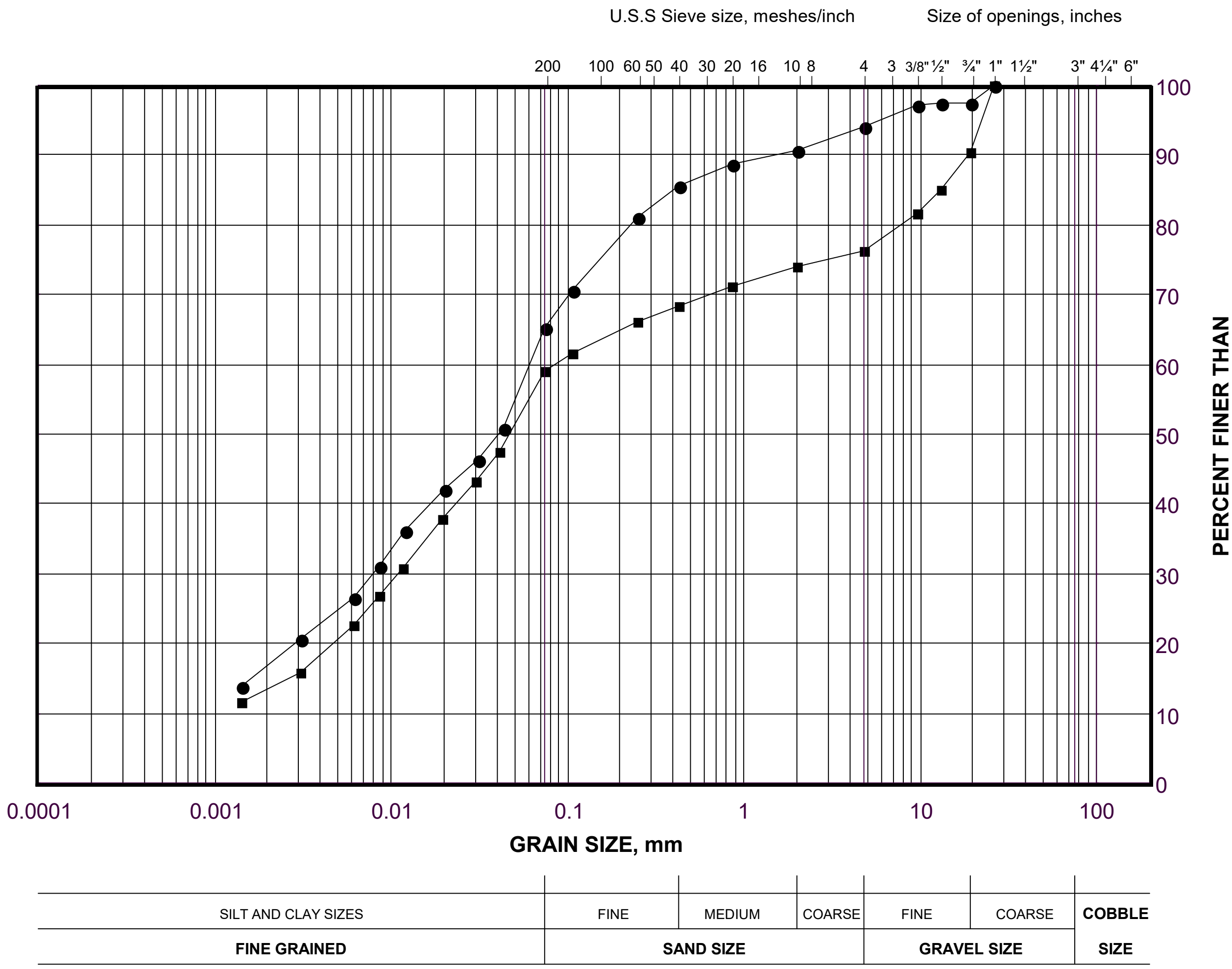
2. Water encountered at a depth of about 0.6 m (Elev. 308.0 m) during drilling and prior to introducing water for washboring.

$+^3, \times^3$: Numbers refer to Sensitivity   O $^{3\%}$ STRAIN AT FAILURE

APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION CLAYEY SILT (CL) (FILL)	FIGURE B-1



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION (m)
●	TISB-2	2	309.6
■	TISB-1	4	309.2

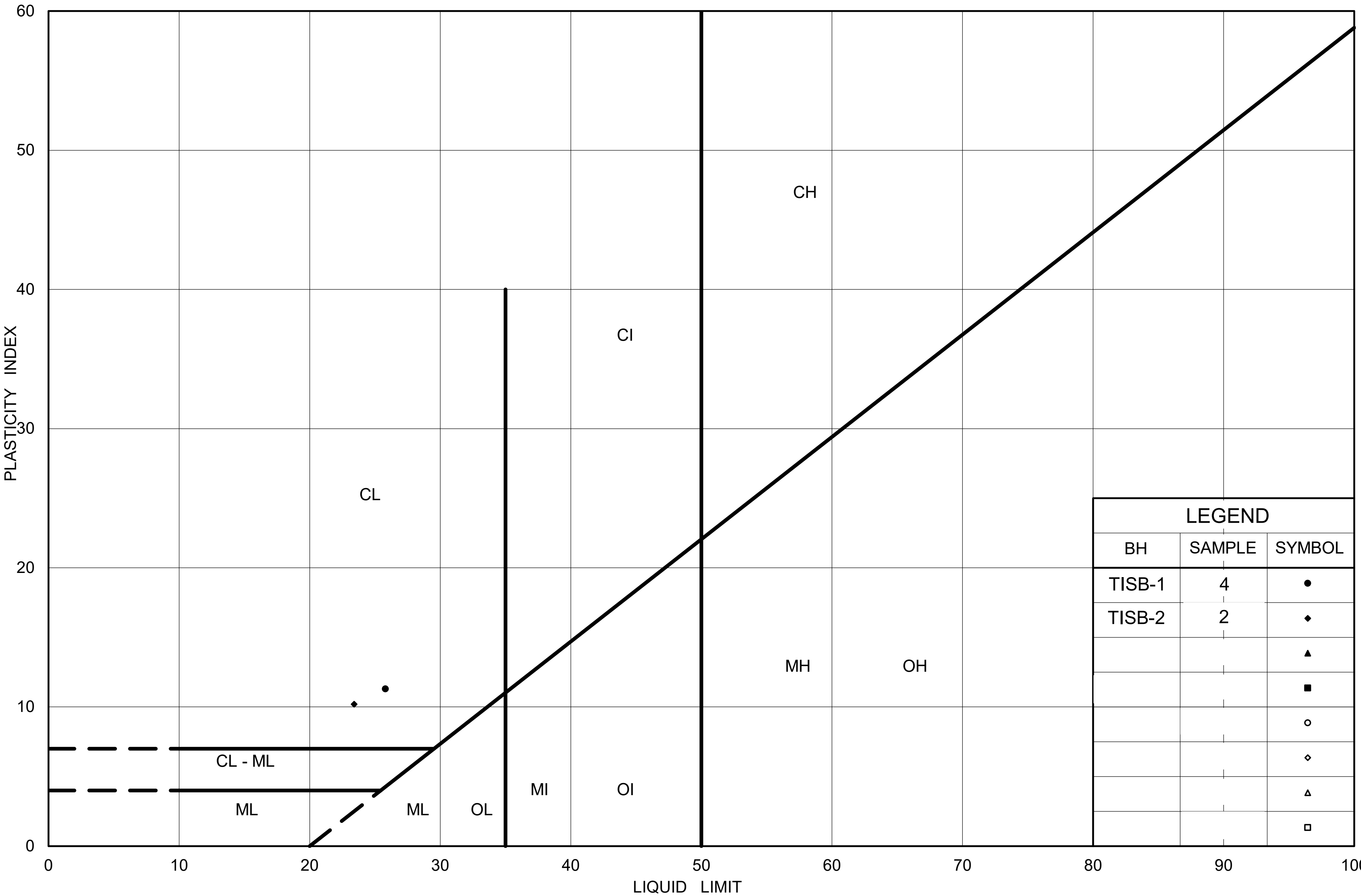
Project Number: 1786658-WO15-TISB

Checked By: AMP

Golder Associates

Date: 17-May-21

Oct 75, FF-S-21



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PLASTICITY CHART
CLAYEY SILT (CL) (FILL)

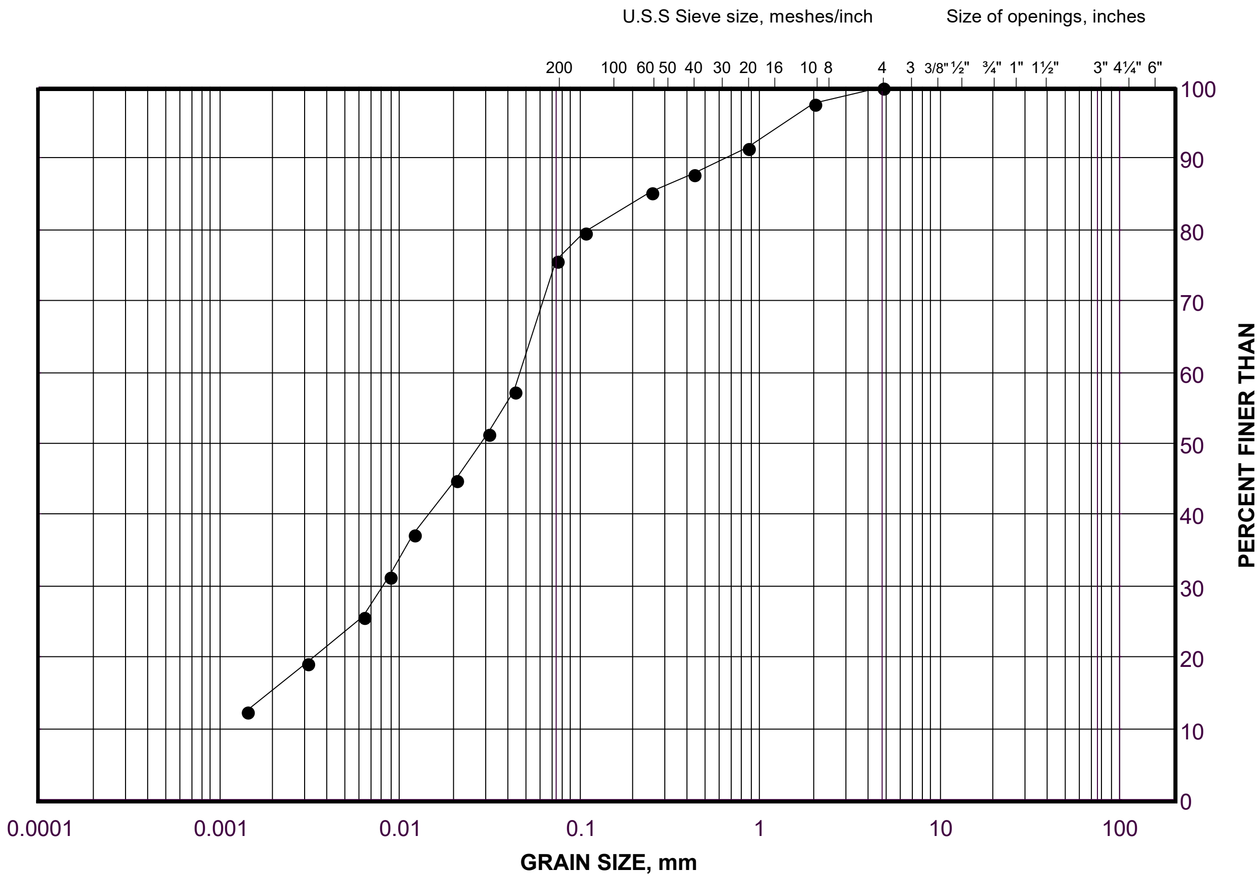
Figure No. B-2

Project No. 1786658 -WO15-TISB

Checked By: AMP

GRAIN SIZE DISTRIBUTION
Sandy ORGANIC SILT (OL)

FIGURE B-3



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION (m)
●	TISB-1	6	307.7

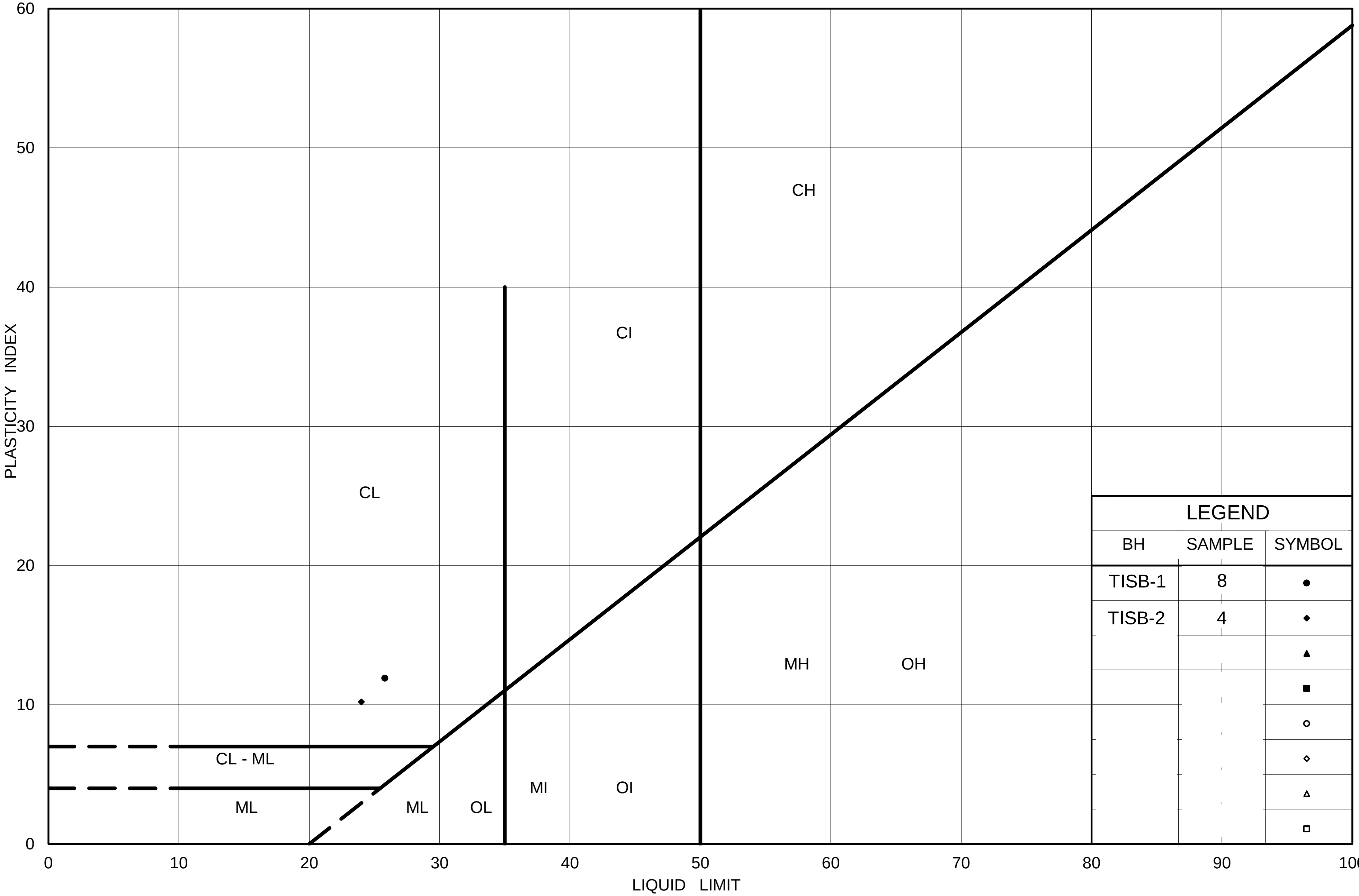
Project Number: 1786658-WO15-TISB

Checked By: AMP

Golder Associates

Date: 17-May-21

Oct 75, FF-S-21



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PLASTICITY CHART
CLAYEY SILT (CL)

Figure No. B-4

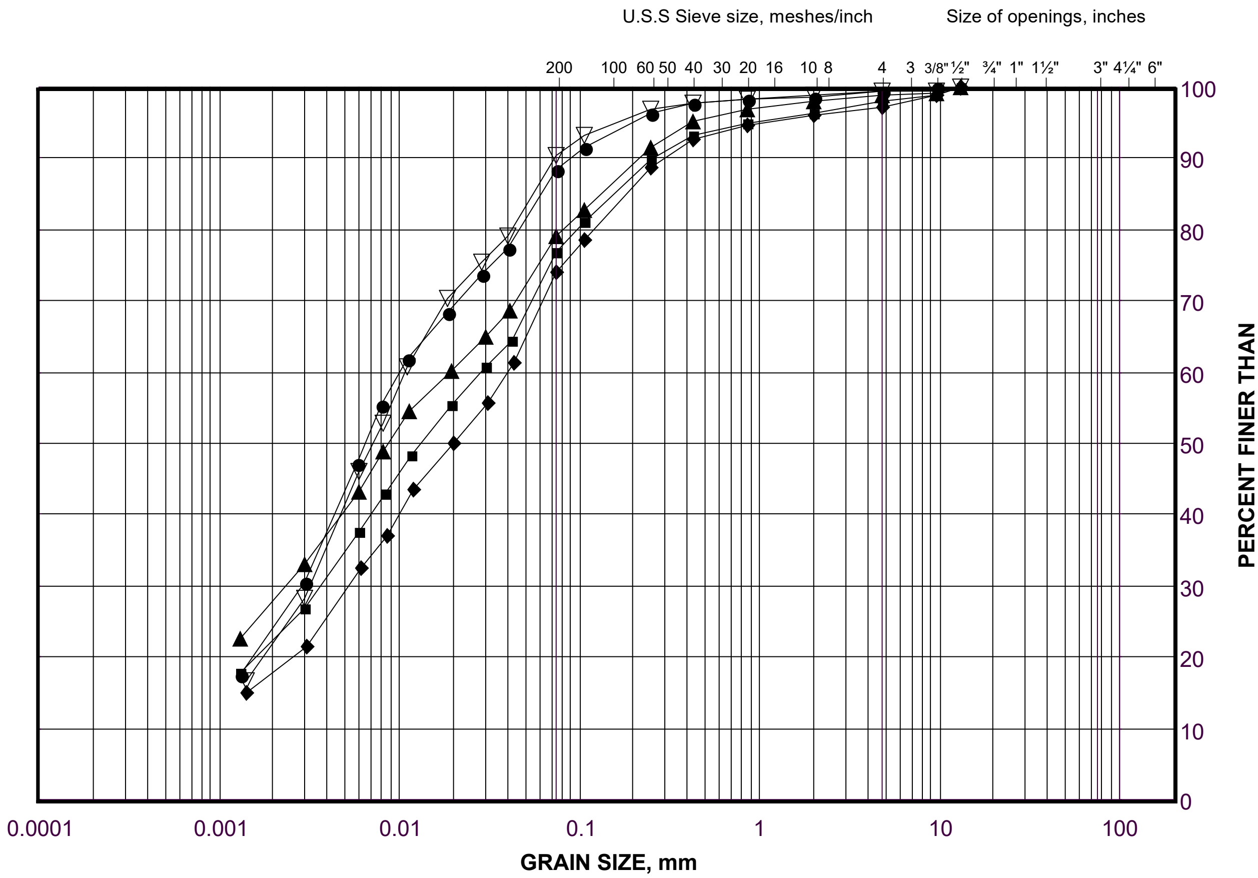
Project No. 1786658 WO015-TISB

Checked By: AMP

GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT- SILT (CL-ML) to CLAYEY SILT (CL) (TILL)

FIGURE B-5



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	TSIB-5	10	302.8
■	TSIB-6	5	305.9
◆	TSIB-5	5	305.9
▲	TSIB-6	6	305.2
▽	TISB-2	9	302.8

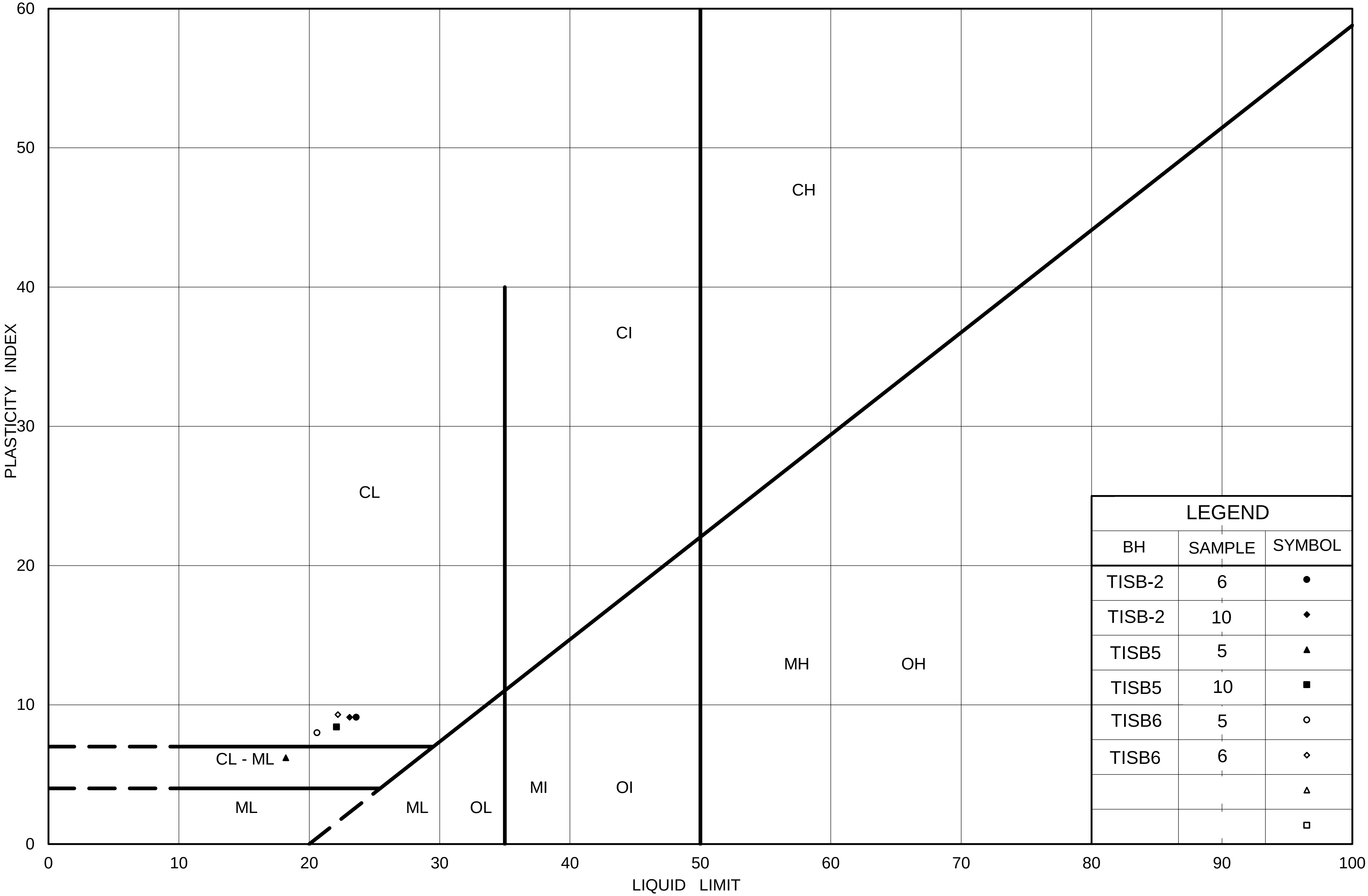
Project Number: 1786658-WO15-TISB

Checked By: AMP

Golder Associates

Date: 08-Nov-21

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Sandy CLAYEY SILT- SILT (CL-ML) to CLAYEY SILT (CL)
(TILL)

Figure No. B-6

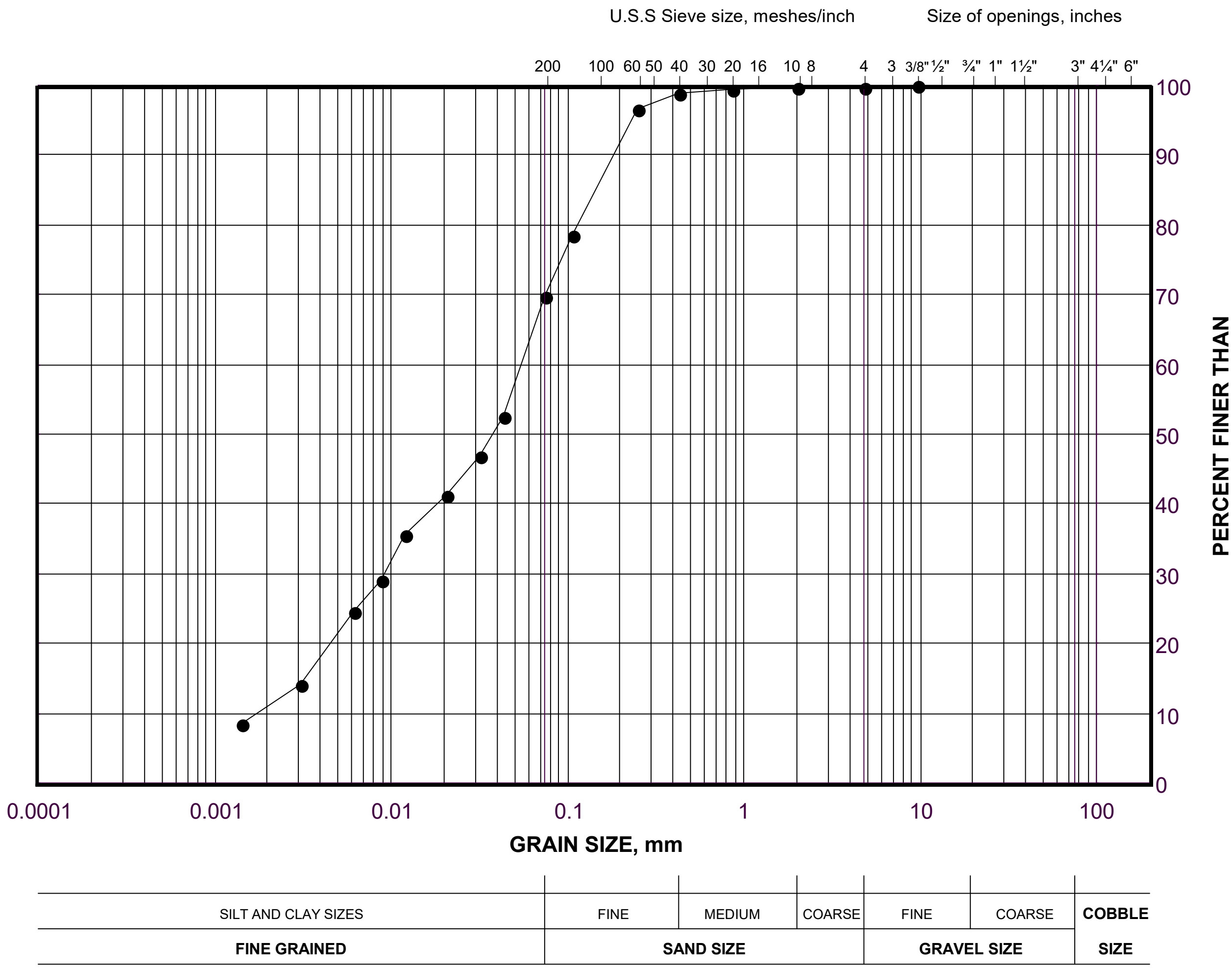
Project No. 1786658-WO15-TISB

Checked By: AMP

GRAIN SIZE DISTRIBUTION

Sandy SILT (ML)

FIGURE B-7



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	TISB-1	9	303.8

Project Number: 1786658-WO15-TISB

Checked By: AMP

Golder Associates

Date: 11-Nov-21

APPENDIX C

Analytical Laboratory Tests Results

Your Project #: 1786658 WO 15
Your C.O.C. #: 805726-01-01, 794544-05-01

Attention: Carter Comish

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2021/01/28
Report #: R6497775
Version: 5 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: C0X1766
Received: 2020/12/11, 18:34

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	1	2020/12/17	2020/12/18	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	1	2020/12/17	2020/12/17	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	1	2020/12/16	2020/12/16	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2020/12/14	2020/12/17	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2020/12/17	2020/12/18	CAM SOP-00464	EPA 375.4 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 1786658 WO 15
Your C.O.C. #: 805726-01-01, 794544-05-01

Attention: Carter Comish

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6925 Century Ave
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CANADA L5N 7K2

Report Date: 2021/01/28
Report #: R6497775
Version: 5 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: C0X1766
Received: 2020/12/11, 18:34

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: emese.gitej@bureauveritas.com
Phone# (905)817-5829
==
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

BV Labs Job #: C0X1766
Report Date: 2021/01/28

Golder Associates Ltd
Client Project #: 1786658 WO 15
Sampler Initials: CC

SOIL CORROSIVITY PACKAGE (SOIL)

BV Labs ID		OKC177		
Sampling Date		2020/11/26		
COC Number		805726-01-01		
	UNITS	**TISB-1 SA3**	**RDL**	**QC Batch**
Calculated Parameters				
Resistivity	ohm-cm	310		7108299
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	1800	60	7114805
Conductivity	umho/cm	3230	2	7114634
Available (CaCl2) pH	pH	7.72		7112629
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	7114979

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

BV Labs ID: OKC177
Sample ID: TISB-1 SA3
Matrix: Soil

Collected: 2020/11/26
Shipped:
Received: 2020/12/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7114805	2020/12/17	2020/12/18	Alina Dobreanu
Conductivity	AT	7114634	2020/12/17	2020/12/17	Tarunpreet Kaur
pH CaCl2 EXTRACT	AT	7112629	2020/12/16	2020/12/16	Neil Dassanayake
Resistivity of Soil		7108299	2020/12/17	2020/12/17	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7114979	2020/12/17	2020/12/18	Alina Dobreanu

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	5.7°C

Revised report (2021/01/28): Split report as per client request.

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7112629	Available (CaCl2) pH	2020/12/16			100	97 - 103			0.080	N/A
7114634	Conductivity	2020/12/17			102	90 - 110	<2	umho/cm	1.6	10
7114805	Soluble (20:1) Chloride (Cl-)	2020/12/18	118	70 - 130	103	70 - 130	<20	ug/g	NC	35
7114979	Soluble (20:1) Sulphate (SO4)	2020/12/18	115	70 - 130	106	70 - 130	<20	ug/g	NC	35

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Anastassia Hamanov, Scientific Specialist

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Bureau Veritas Laboratories
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.bvlabs.com

CHAIN OF CUSTODY RECORD

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:	Golder Associates	Quotation #:	B80683	BV Labs Job #:	Bottle Order #: 805726
Attention:	Accounts Payable	Attention:	~~Darcy Hansen~~ Carter Comish	P.O. #:			
Address:	6925 Century Ave Suite 100 Mississauga ON L5N 7K2	Address:	ccomish@golder.com	Project:	1786658 WO 15	COC #: C#805726-01-01	Project Manager: Ema Gitej
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	~~(905) 567-4444 Ext: 2064~~ Fax:	Project Name:			
Email:	CanadaAccountsPayableInvoices@golder.com	Email:	~~Darcy_Hansen@golder.com~~	Site #:			
				Sampled By:			

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☒ Medium/Fine ☐ Table 2 ☒ Ind/Comm ☐ Coarse ☒ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ☐ PWQO ☐ Reg 406 Table ☐ Other

Special Instructions: O. Reg 347 Schedule 4

Include Criteria on Certificate of Analysis (Y/N)? N

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Corrosivity pkg (Cl, SO4, pH, EC/Resistivity)	# of Bottles	Comments
1	RW-1 SA3		Dec 4 2020	AM	Soil		X		
2	TISB-1 SA3		Nov 26 2020				X		
3	CCTV-2 SA3B		Nov 27 2020				X		
4	CCTV-4 SA4		Nov 13 2020				X		
5	CCTV-5 SA3		Nov 10 2020				X		
6	26-6 SA4B		Nov 9 2020				X		
7	27-5 SA2		Nov 9 2020				X		
8	28-6 SA#6		Nov 17 2020				X		
9	29-5 SA12		Nov 5 2020				X		
10	33-5 SA8		Nov 12 2020				X		

Turnaround Time (TAT) Required: Please provide advance notice for rush projects

Regular (Standard) TAT: ☐
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: Time Required: ☐
Rush Confirmation Number: *(call lab for #)*

11-Dec-20 18:34
Ema Gitej
C0X1766
AF2 ENV-736

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Laboratory Use Only
Carter Comish	20/12/11	6pm	ALEXANDRA FODOR	2020/12/11	18:34			Temperature (°C) on Recei 4/7/6 ICE; Custody Seal Present Yes ✓ / No; Intact

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

Bureau Veritas Laboratories
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.bvlabs.com

CHAIN OF CUSTODY RECORD

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	1326 ~~#2292~~ Golder Associates Ltd	Company Name:		Quotation #:	B80683	BV Labs Job #:	Bottle Order #: 794544
Attention:	Accounts Payable	Attention:	~~Kimberley Rose~~ Carter Comish	P.O. #:			
Address:	~~100 Scotia Crt~~ 6925 Century Ave, #100	Address:	ccomish@golder.com	Project:	1895923.4000 1786658 WO15	COC #:	Project Manager:
	~~Whitby ON L1N 8Y6~~ Miss, ON, L5N 7K2			Project Name:		C#794544-05-01	Ema Gitej
Tel:	(905) 723-2727 Fax: (905) 723-2182	Tel:	~~(905) 723-5491 Ext. 6644~~ Fax: ~~(905) 723-2182~~	Site #:			
Email:	CanadaAccountsPayableInvoices@golder.com	Email:	~~Kimberley_Rose@golder.com~~	Sampled By:			

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011)
- [ ] Table 1 [ ] Res/Park [x] Medium/Fine
- [ ] Table 2 [x] Ind/Comm [ ] Coarse
- [x] Table 3 [ ] Agri/Other [ ] For RSC
- [ ] Table

Other Regulations
- [ ] CCME [ ] Sanitary Sewer Bylaw
- [ ] Reg 558 [ ] Storm Sewer Bylaw
- [ ] MISA Municipality
- [ ] PWQO [ ] Reg 406 Table
- [x] Other

Special Instructions
O. Reg 347 Schedule 4

Include Criteria on Certificate of Analysis (Y/N)? N

ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Field Filtered (please circle): Metals / Hg / Cr VI; ~~O.Reg 153 VOCs by HS & F1-F4 (Soil)~~; ~~O.Reg 153 PAHs~~; ~~O.Reg 153 Metals & Inorganics Pkg~~; Corrosivity Pkg short form

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: [ ]
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: Time Required: [ ]
Rush Confirmation Number: (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	# of Bottles	Comments
1	34-5 SA6		Nov 12 2020				
2	35-4 SA6		Nov 12 2020				
3	36-5 SA9		Nov 12 2020				
4							
5							
6							
7							
8							
9							
10							

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Laboratory Use Only
Carter Comish	20/11/12	6pm	ALEXANDRA FODOR	2020/12/11	18:34			Temperature (°C) on Recei 4/7/6 ice; Custody Seal Present / Intact: Yes

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

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** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

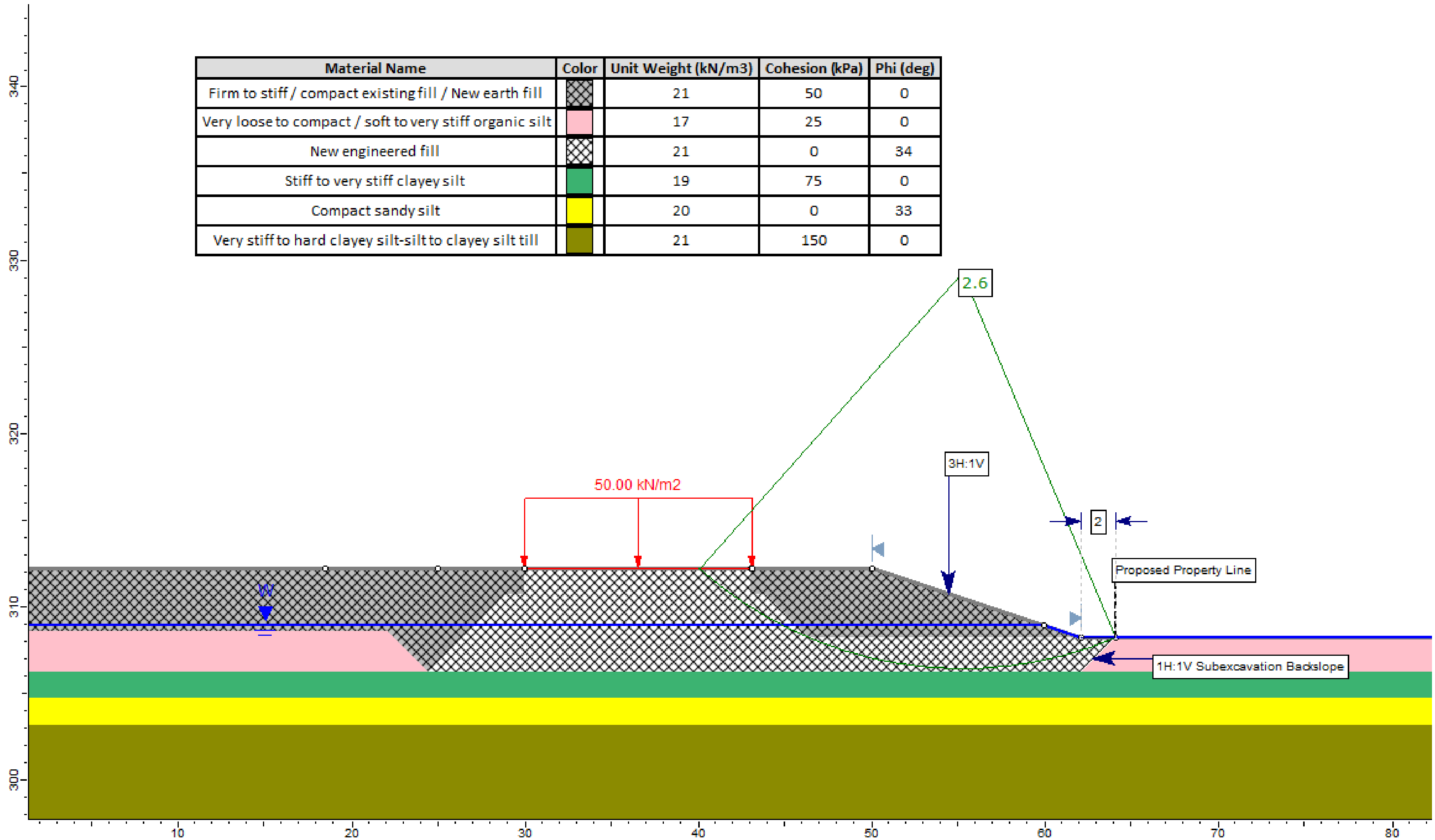
APPENDIX D

Results of Global Stability Analyses

Global Stability Analysis

Figure D-1

Scenario 1 (1H:1V Subexcavation Backslope)
Permanent Configuration - Short Term (Undrained) Analysis



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Firm to stiff / compact existing fill / New earth fill		21	50	0
Very loose to compact / soft to very stiff organic silt		17	25	0
New engineered fill		21	0	34
Stiff to very stiff clayey silt		19	75	0
Compact sandy silt		20	0	33
Very stiff to hard clayey silt-silt to clayey silt till		21	150	0

Date: January 2022
Project Number: 1786658-WO15-TISB

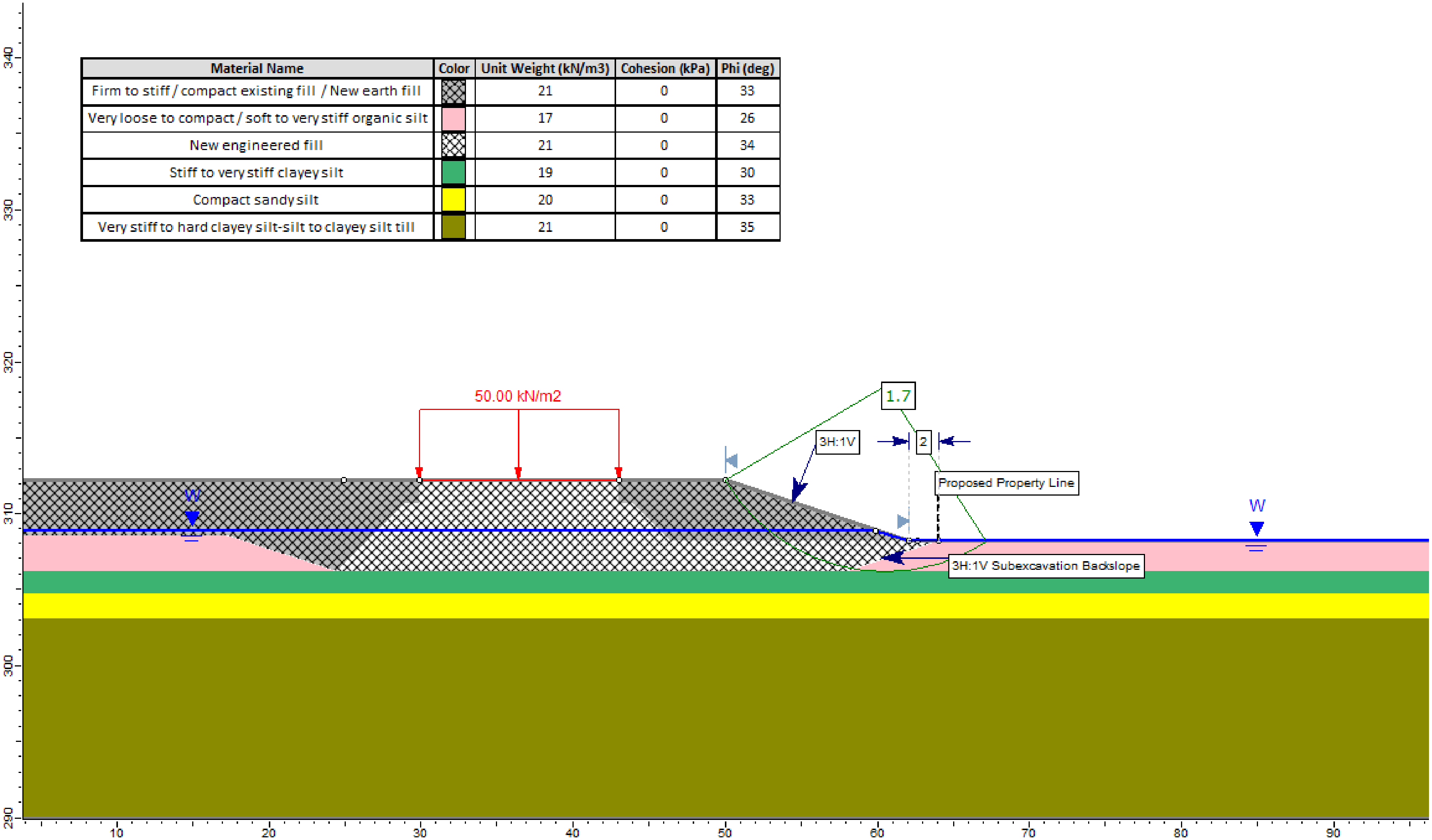
Analysis By: AMP
Reviewed By: KJB

GOLDER

Global Stability Analysis

Figure D-2

Scenario 1 (1H:1V Subexcavation Backslope)
Permanent Configuration - Long Term (Drained) Analysis



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Firm to stiff / compact existing fill / New earth fill		21	0	33
Very loose to compact / soft to very stiff organic silt		17	0	26
New engineered fill		21	0	34
Stiff to very stiff clayey silt		19	0	30
Compact sandy silt		20	0	33
Very stiff to hard clayey silt-silt to clayey silt till		21	0	35

Date: January 2022
Project Number: 1786658-WO15-TISB

Analysis By: AMP
Reviewed By: KJB

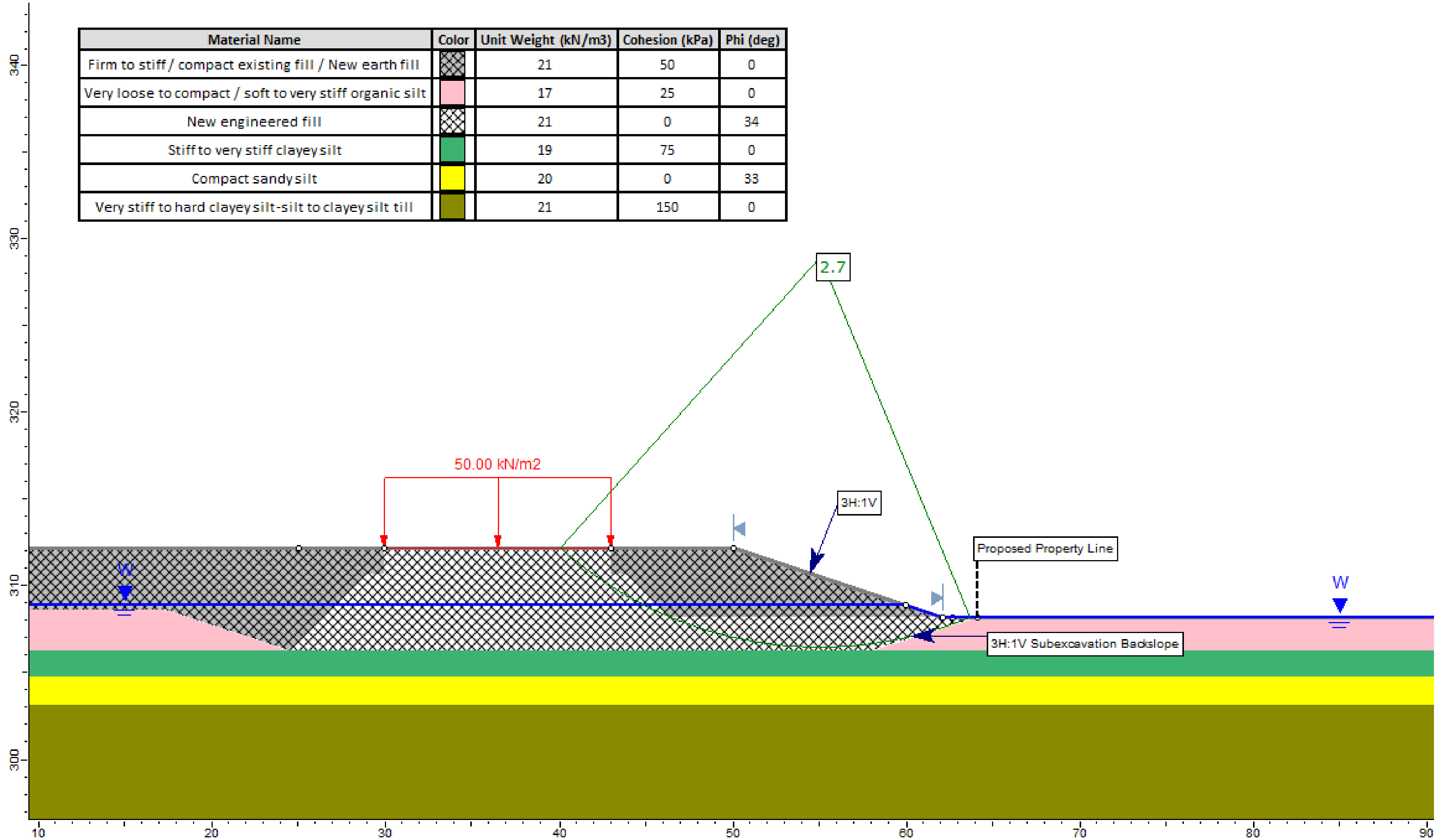
GOLDER

Global Stability Analysis

Figure D-3

Scenario 2 (3H:1V Subexcavation Backslope)
Permanent Configuration - Short Term (Undrained) Analysis

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Firm to stiff / compact existing fill / New earth fill		21	50	0
Very loose to compact / soft to very stiff organic silt		17	25	0
New engineered fill		21	0	34
Stiff to very stiff clayey silt		19	75	0
Compact sandy silt		20	0	33
Very stiff to hard clayey silt-silt to clayey silt till		21	150	0



Date: January 2022
Project Number: 1786658-WO15-TISB

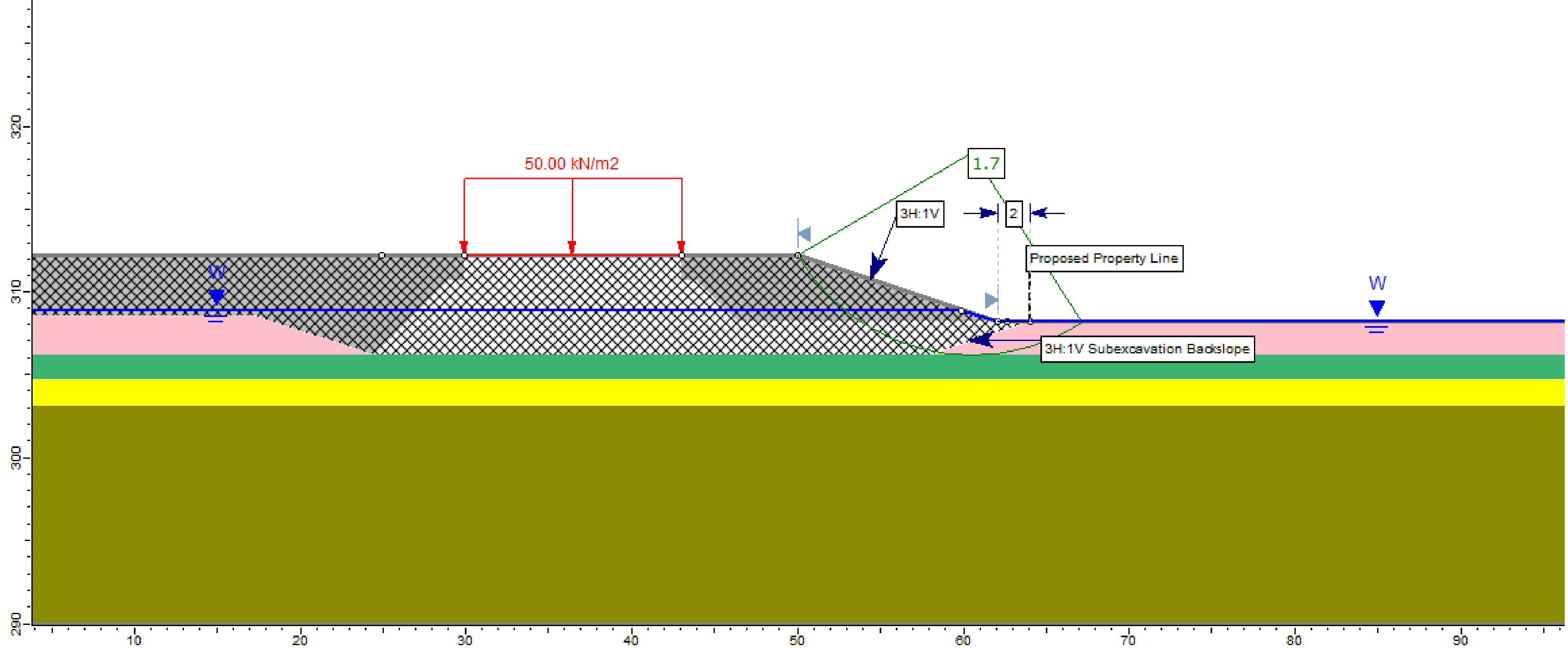
Analysis By: AMP
Reviewed By: KJB

Figure D-4

Global Stability Analysis

Scenario 2 (3H:1V Subexcavation Backslope)
Permanent Configuration - Long Term (Drained) Analysis

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Firm to stiff / compact existing fill / New earth fill		21	0	33
Very loose to compact / soft to very stiff organic silt		17	0	26
New engineered fill		21	0	34
Stiff to very stiff clayey silt		19	0	30
Compact sandy silt		20	0	33
Very stiff to hard clayey silt-silt to clayey silt till		21	0	35



Date: January 2022
Project Number: 1786658-WO15-TISB

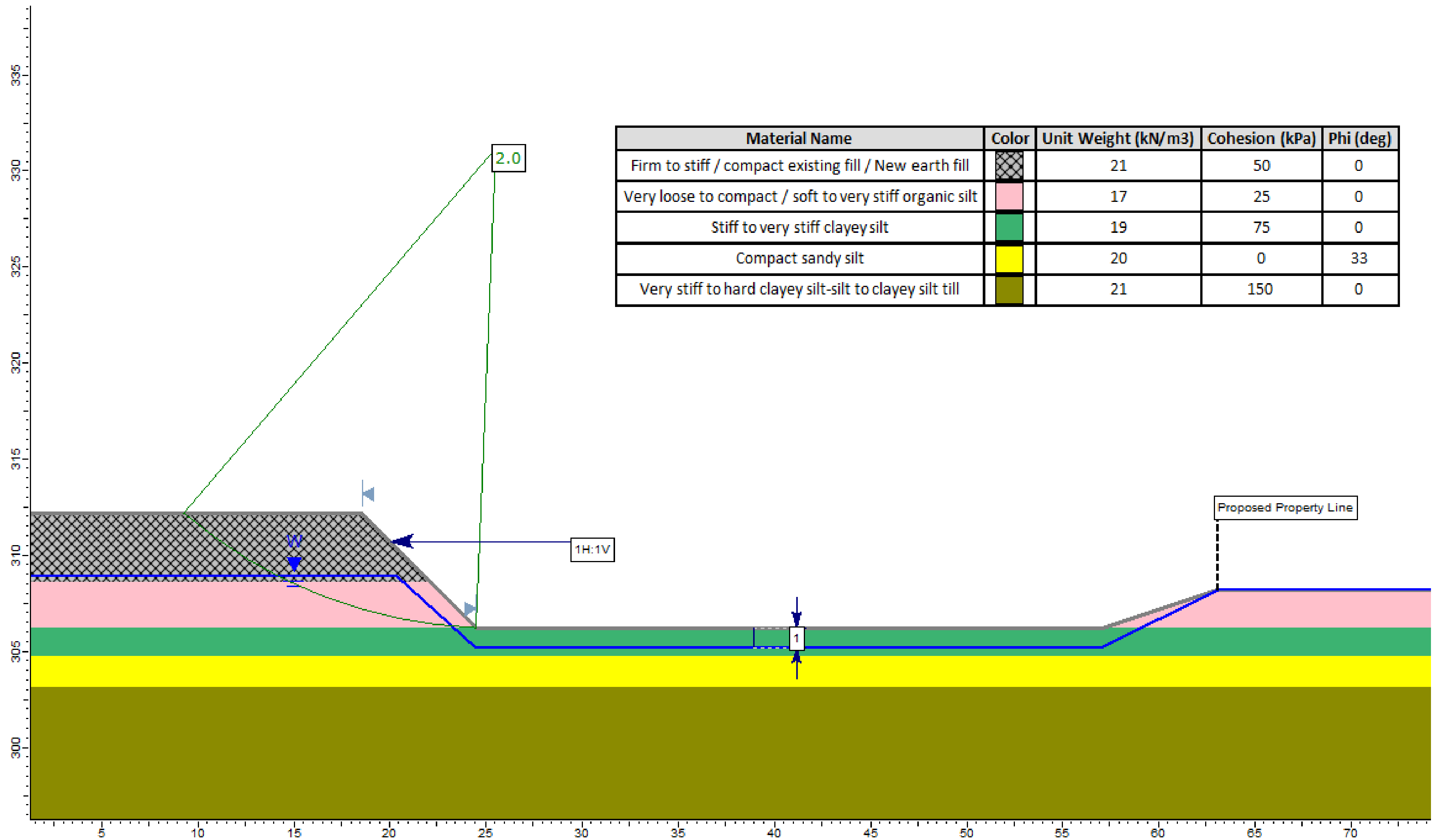
Analysis By: AMP
Reviewed By: KJB

GOLDER

Global Stability Analysis

Figure D-5

Scenario 3 (Embankment Subexcavation at 1H:1V)
Temporary Excavation – ShortTerm (Undrained) Analysis



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Firm to stiff / compact existing fill / New earth fill		21	50	0
Very loose to compact / soft to very stiff organic silt		17	25	0
Stiff to very stiff clayey silt		19	75	0
Compact sandy silt		20	0	33
Very stiff to hard clayey silt-silt to clayey silt till		21	150	0

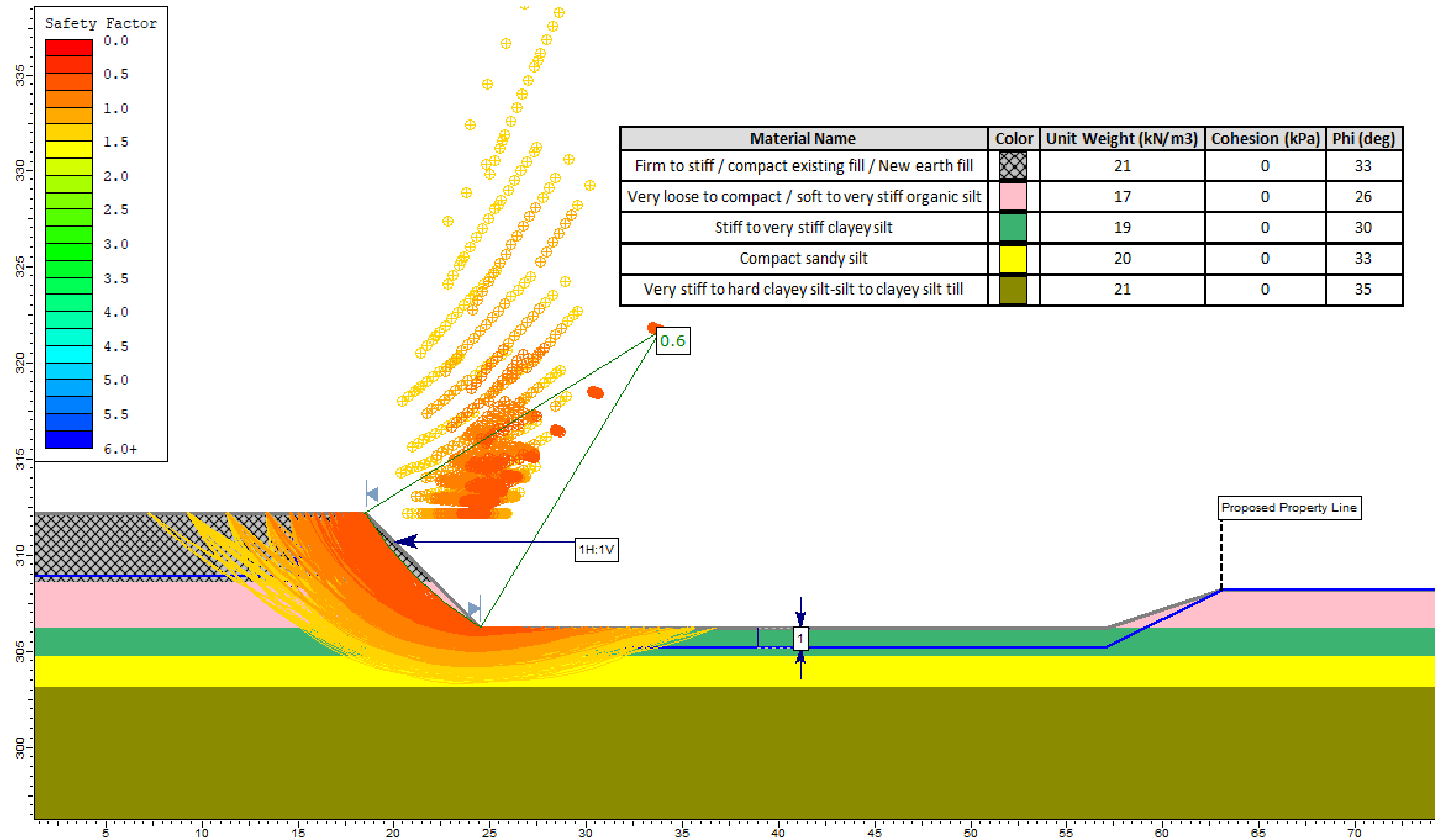
Date: January 2022
Project Number: 1786658-WO15-TISB

Analysis By: AMP
Reviewed By: KJB

Global Stability Analysis

Figure D-6

Scenario 3 (Embankment Subexcavation at 1H:1V)
Temporary Excavation – Long Term (Drained) Analysis



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Firm to stiff / compact existing fill / New earth fill		21	0	33
Very loose to compact / soft to very stiff organic silt		17	0	26
Stiff to very stiff clayey silt		19	0	30
Compact sandy silt		20	0	33
Very stiff to hard clayey silt-silt to clayey silt till		21	0	35

Date: January 2022
Project Number: 1786658-WO15-TISB

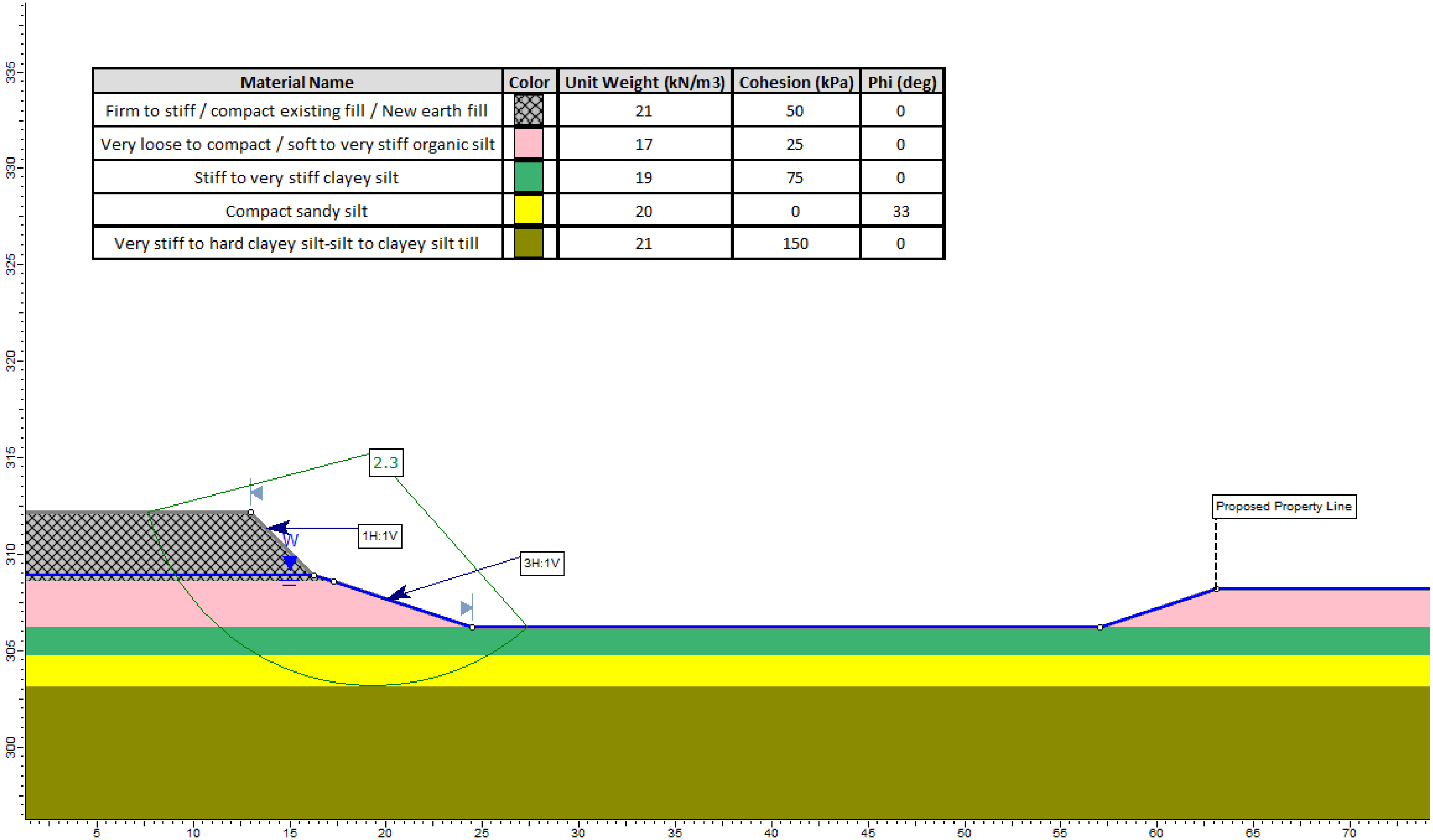
Analysis By: AMP
Reviewed By: KJB

Global Stability Analysis

Figure D-7

Scenario 4 (Embankment Subexcavation at 3H:1V)
Temporary Excavation – Short Term (Undrained) Analysis

Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Firm to stiff / compact existing fill / New earth fill		21	50	0
Very loose to compact / soft to very stiff organic silt		17	25	0
Stiff to very stiff clayey silt		19	75	0
Compact sandy silt		20	0	33
Very stiff to hard clayey silt-silt to clayey silt till		21	150	0



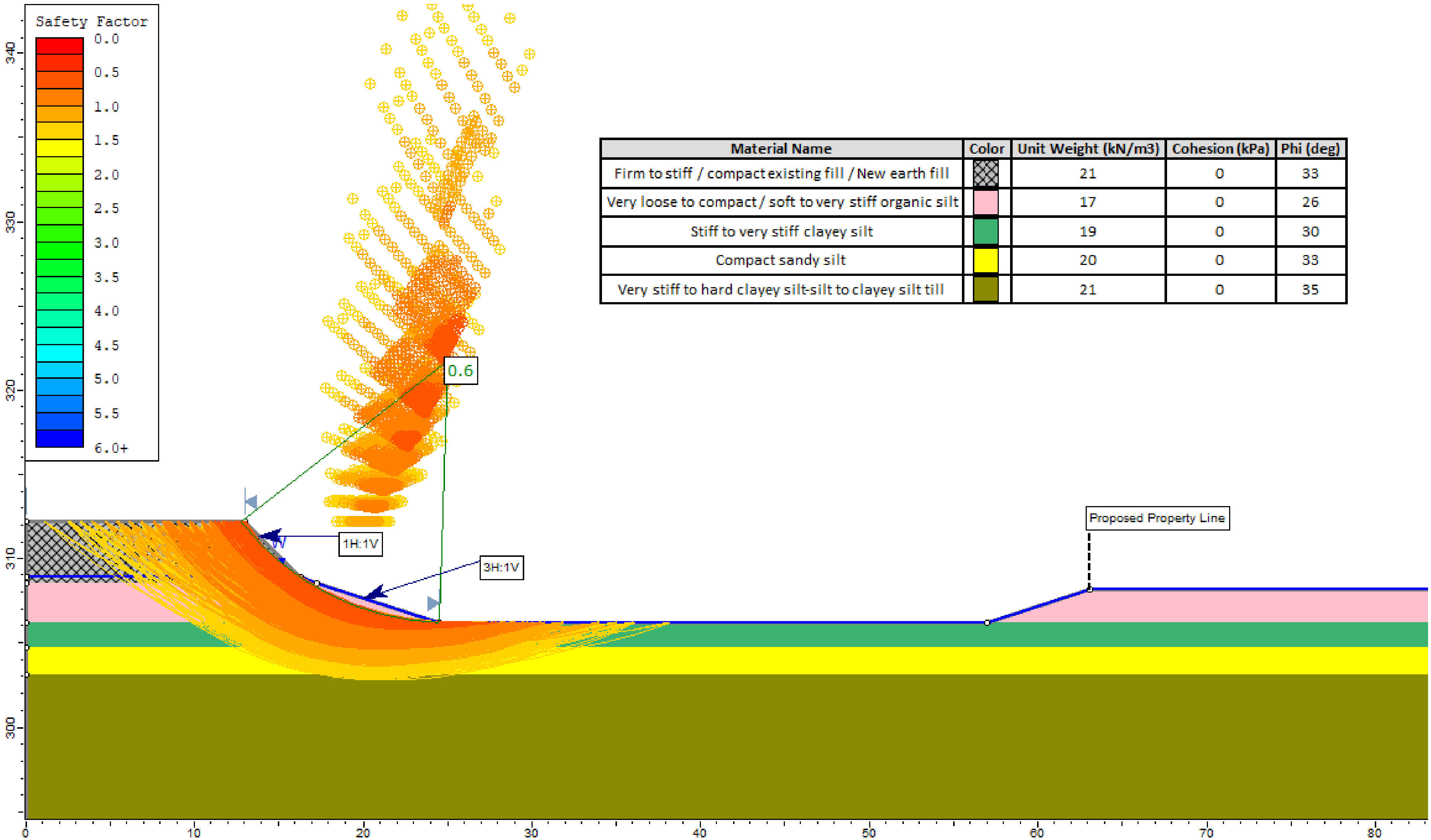
Date: January 2022
Project Number: 1786658-WO15-TISB

Analysis By: AMP
Reviewed By: KJB

Global Stability Analysis

Figure D-8

Scenario 4 (Embankment Subexcavation at 3H:1V)
Temporary Excavation – Long Term (Drained) Analysis



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Firm to stiff / compact existing fill / New earth fill		21	0	33
Very loose to compact / soft to very stiff organic silt		17	0	26
Stiff to very stiff clayey silt		19	0	30
Compact sandy silt		20	0	33
Very stiff to hard clayey silt-silt to clayey silt till		21	0	35

Date: January 2022
Project Number: 1786658-WO15-TISB

Analysis By: AMP
Reviewed By: KJB

APPENDIX E

Special Provisions and Non-Standard Special Provisions

EARTH EXCAVATION, GRADING – Item No.

Special Provision

Amendment to OPSS 206 dated November 2014

206.07 CONSTRUCTION

206.07.03 Excavation and Grading

206.07.03.03 Excavation for Widening

Clause 206.07.03.03 of OPSS 206 is amended by the addition of the following:

Staged temporary excavation of existing fill and native organic silt soil for the Northbound Truck Inspection Station Embankment Widening and proposed Truck Inspection Station building between Station 14+325 and 14+375, shall be carried out as follows:

a) Removal of the existing fill / native organic soils shall be carried out in short "strip" sections perpendicular to Highway 400. The base of the excavation shall not be wider than 5 m at any given time.

b) Strip excavation and backfilling (engineered fill placement) operations shall be carried out simultaneously in a manner that the excavation is not left open for more than one day.

c) Backfilling operations (engineered fill placement) shall continue to a minimum Elevation 309 m.

d) Surplus excavated material shall not be stockpiled in the immediate area of excavation to prevent unstable conditions.

Alternatively, temporary protection systems as per OPSS.PROV 539 may be used to stabilize the excavations prior to backfilling and placement of engineered fill.

<u>DEWATERING STRUCTURE EXCAVATIONS</u> - Item No.

Special Provision No. FOUN0003 March 8, 2018

Amendment to OPSS 902, November 2010

902.02 REFERENCES

Section 902.02 of OPSS 902 is amended by the addition of the following:

Ontario Provincial Standard Specifications, Construction

OPSS 517 Dewatering
OPSS 805 Temporary Erosion and Sediment Control Measures

902.03 DEFINITIONS

Section 903.03 of OPSS 902 is amended by the addition of the following:

Automatic Transfer Switch means as defined in OPSS 517.

Cofferdam means as defined in OPSS 539.

Cut-Off Wall means as defined in OPSS 517.

Design Storm Return Period means as defined in OPSS 517.

Dewatering System means as defined in OPSS 517.

Groundwater Control System means as defined in OPSS 517.

Plug means as defined in OPSS 517.

Sediment means as defined in OPSS 517.

Sediment Control Measure means as defined in OPSS 517.

Temporary Flow Passage System means as defined in OPSS 517.

Unwatering means as defined in OPSS 517.

Vegetated Discharge Area means as defined in OPSS 517.

Waterbody means as defined in OPSS 517.

Watercourse means as defined in OPSS 517.

902.04 DESIGN AND SUBMISSION REQUIREMENTS

902.04.01 Design Requirements

902.04.01.01 Dewatering

Clause 902.04.01.01 of OPSS 902 is deleted in its entirety and replaced with the following:

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work.

When the system includes temporary flow passage system, the system shall be designed, as a minimum, for a 2-year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

The dewatering system shall be according to the design requirements specified in OPSS 517.

902.04.02 Submission Requirements

Subsection 902.04.02 of OPSS 902 is deleted in its entirety and replaced with the following:

902.04.02.01 Working Drawings

Working Drawings for the dewatering system shall be according to OPSS 517.

902.04.02.02 Preconstruction Survey

When a groundwater control system by wells or a well point system will be used, a condition survey of property and structures that may be affected by the work shall be carried out. The condition survey shall include the location and condition of any adjacent properties, buildings, underground structures, water wells, utilities, and structures within a distance of 50 metres from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website https://www.ontario.ca/environment-and-energy/map-well-records or its successor site.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

902.04.02.03 Milestone Inspections

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

902.07 CONSTRUCTION

Subsection 902.07.04 of OPSS 902 is deleted in its entirety and replaced with the following:

902.07.04 Dewatering Structure Excavation

902.07.04.01 General

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation and deactivation of a temporary flow passage system, if applicable, shall be according to OPSS 517.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When a temporary flow passage system is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the system during the seasonal shutdown period.

Temporary erosion and sediment control measures, including controlling the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow passage systems shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

902.07.04.02 Discharge of Water

The discharge of water shall be according to OPSS 517.

902.07.04.03 Monitoring

Monitoring shall be according to OPSS 517.

902.07.04.04 System Amendments

Amendments to stop any displacement, damage, soil loss or erosion due to the operation of the dewatering system shall be according to OPSS 517.

902.07.04.05 Removal

Removal of dewatering system and temporary flow passage system components shall be according to OPSS 517.

<u>OBSTRUCTIONS</u>.

Non-Standard Special Provision

The Contactor is hereby notified that the soils at the proposed building and shed are glacially derived and as such should be expected to contain cobbles and boulders, which could affect the installation of foundations and temporary protection systems. Consideration of the presence of these obstructions must be made in selection of appropriate equipment and procedures for excavation, installation of the foundations, and temporary protection systems.

Basis of Payment
Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

<u>DECOMMISSIONING OF PIEZOMETERS</u> – Item No.

Special Provision

1.0 SCOPE

This special provision covers the requirements for the decommissioning of the piezometers located within the project limits.

A Standpipe piezometer was installed in Borehole TISB-1. The piezometer has been left in place to allow for monitoring of groundwater levels up to the time of construction. The piezometer location (relative to MTM NAD 83 Zone 10 and in latitude and longitude), piezometer diameter, borehole diameter, and piezometer depth are summarized below.

Standpipe Piezometer Identification	Approximate Location		PVC Pipe and Screen diameter / Borehole diameter	Depth (Below Ground Surface) to Tip of Screen
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
TISB-1	4,866,785.7 (43.941038)	299,144.9 (-79.570448)	50 mm / 203 mm	9.0 m

2.0 REFERENCES – Not Used

3.0 DEFINITIONS – Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS – Not Used

5.0 MATERIALS – Not Used

6.0 EQUIPMENT – Not Used

7.0 CONSTRUCTION

As part of the construction activities, the Contractor shall properly decommission the standpipe piezometers prior to the start of the construction works. The abandonment / decommissioning method for standpipe piezometers shall satisfy at least the minimum requirements of Ontario Regulation 903 Wells, as amended under the Ontario Water Resources Act.
In addition, the Contractor shall provide a written record of the decommissioning procedure to the Contract Administrator. The record shall include plugging material used, depth of plugging material and limit of the PVC standpipe/screen removal.

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT – Not Used

10.0 BASIS OF PAYMENT

Payment at the Contract price for this tender item shall be full compensation for all labour, Equipment and Materials to do the work.

OPERATIONAL CONSTRAINT – Preloading of Engineered Fill

Special Provision

Engineered fill within the building foundation zone of influence (measured as 1 m beyond the edges of the footings then outward and downward at 1 horizontal to 1 vertical) and engineered fill below the proposed building slab-on-grade must be placed up to the underside of the slab-on-grade and left in place for a period of one month prior to construction of footings and slab-on-grade.

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