Morrison Hershfield Ltd.

Creek Bend Road Bridge Replacement (RFP No. 293-2022), Winnipeg, MB

Geotechnical Investigation Report

Prepared for:
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Project Number: 0035 110 00

Date: February 17, 2023

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February 17, 2023 Our File No. 0035 110 00

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RE: Creek Bend Road Bridge Replacement (RFP No. 293-2022), Winnipeg, MB – Geotechnical Investigation Report

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TREK Geotechnical Inc. is pleased to submit our final report for the geotechnical investigation for the above noted project.

Please contact the undersigned should you have any questions.

Sincerely,

TREK Geotechnical Inc.
Per:

Michael Van Helden, PhD., P. Eng.
Senior Geotechnical Engineer

Encl.

Revision History

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1.0 Introduction

This report summarizes the results of the geotechnical investigation completed by TREK Geotechnical Inc. (TREK) for the proposed bridge replacement on Creek Bend Road over the Seine River located in Winnipeg, Manitoba. The terms of reference for the investigation are included in our proposal addressed to Beth Phillips, P.Eng. from Morrison Hershfield Ltd. (MHL), dated July 7, 2022. The scope of work includes a sub-surface investigation, laboratory testing, and provision of preliminary and detailed design recommendations for foundations, slope stability assessment and stabilization measures. The current report forms our primary deliverable for the geotechnical assessment and preliminary design component of the project.

2.0 Background

2.1 Project Description

The existing crossing structure on Creek Bend Road over the Seine River is a three-span timber bridge supported on timber piles, with a gravel wearing surface. In 1979, erosion repairs were undertaken which included placing riprap (0.6 m thick) below the river level and grouted riprap (0.3 m thick) above the river level.

Preferred replacement structure options are a three span bridge or a cast-in-place concrete box culvert.

3.0 Field Program

3.1 Site Conditions

A visual inspection of site was conducted by TREK personnel prior to project award on June 29, 2022 to assess the general condition of the surrounding area, condition of the existing bridge, abutments, and riverbanks in order to identify signs of slope instability or erosion.

The existing riprap at the head slopes is in generally good condition, with a maximum particle size of approximately 0.3 m, although there is some evidence of potential scour of the south head slope likely as a result of remnant timber pile foundations obstructing channel flow. In 1983, wing-walls were repaired using new timber piles, which do not currently show signs of significant scour, movement, or distress.

Figure 01- Existing Bridge Looking Upstream (West)

Figure 2 Existing Bridge Looking from Above

3.2 Site Survey

A site survey was completed by MHL to gather topographic and cross-sectional data for hydrotechnical and geotechnical assessments. The survey data was used to determine the existing river geometry surrounding the bridge.

3.3 Sub-surface Investigation

A sub-surface investigation was completed on October 25 and 26, 2022 under the supervision of TREK personnel to determine the soil stratigraphy and groundwater conditions at the site.

Two test holes (TH22-01 and 06) were drilled and sampled to 21.1 and 24.6 m below ground surface near the existing bridge abutments. Four test holes (TH22-02 to 05) were drilled and sampled to 3.0 m below ground surface along Creek Bend Road. Two vibrating wire piezometers (VW) were installed within the clay in TH22-01. Test holes were backfilled with either grout, auger cuttings and/or bentonite chips to surface.

Test holes were drilled by Paddock Drilling Ltd. using an Acker MP-8 truck mounted geotechnical rig equipped with 125 mm solid stem diameter augers and HQ coring. Sub-surface soils encountered during drilling were visually classified based on the Unified Soil Classification System (USCS). Disturbed (auger cutting and split spoon) samples were retrieved at regular intervals and relatively undisturbed (Shelby tube) samples were also collected at select depths in cohesive soils. Bedrock core samples (HQ) were also retrieved in TH22-01. Standard Penetration Tests were performed at depths where split spoon samples were obtained.

All samples retrieved during drilling were transported to TREK's testing laboratory in Winnipeg, Manitoba. Laboratory testing consisted of moisture content determination on all samples as well as unconfined compression tests and bulk unit weight measurements on the Shelby tube samples. Unconfined compressive strength testing was also performed on a select bedrock core sample.

The test hole elevations were surveyed relative to a temporary benchmark (northeast corner of the existing bridge deck) using a rod and level. The test hole locations (shown on Figure 01) were determined using a handheld GPS unit.

The attached test hole logs include a description of the soil units encountered and other pertinent information such as groundwater, seepage and sloughing conditions, and a summary of the laboratory testing results. Detailed laboratory testing results are included in Appendix A.

3.4 Soil Stratigraphy

A brief description of the soil units encountered during drilling is provided below. All interpretation of soil stratigraphy for the purposes of design should refer to the detailed information provided on the attached test hole logs.

The site soil stratigraphy generally consists of fill (sand and gravel and/or clay fill) or topsoil overlying silty clay, silt till and dolomitic limestone bedrock, except in TH22-05 where a 150 mm thick layer of concrete overlaying fill was encountered. Silt within the silty clay was also encountered in TH22-01, 02, 03 and 05.

Sand and gravel fill is 30 to 120 mm thick, overlays clay fill or silty clay and was encountered in all test holes except TH22-01. The sand and gravel fill contains trace silt, is light brown, moist, compact, well graded, sub angular limestone.

Clay fill was encountered below the sand and gravel fill to 0.8 and 1.8 m below ground surface in TH22-04 and 06, respectively. The clay fill is silty, contains trace sand, trace gravel, is grey, moist, very stiff and is of intermediate plasticity.

Silt was encountered from 0.4 to 1.8 m below ground surface in TH22-01, 02, 03 and 05. The silt contains trace clay, trace sand, is light brown, moist, compact and is of low plasticity.

Silty clay was observed below the fill soils or topsoil to 18.6 and 18.9 m below ground surface in TH22-01 and TH22-06, respectively, and to the maximum explored depths (3.0 m below ground surface) in TH22-02 to 05. The silty clay contains trace sand, is brown becoming grey with depth, is moist, stiff to very stiff becoming soft below approximately 15.0 m depth, and is of intermediate to high plasticity.

Silt till was encountered below the silty clay to 23.0 m below ground surface in TH22-06 and to the maximum explored depth (21.9 m below ground surface) in TH22-01. The silt till contains trace clay, trace to some sand, trace to some gravel, is light brown, moist, compact and is of no to low plasticity. A large boulder and a cobble were encountered below 19.8 m depth during coring in TH22-06.

Dolomitic limestone bedrock was encountered from 23.0 m below ground surface to the maximum explored depth (24.6 m below ground surface) in TH22-06. The dolomitic limestone is from the Red River formation, Selkirk Member, is cream to white, mottled, hard, R3, vuggy throughout, massive (with no distinct bedding or foliation). The unconfined compressive strength of one core sample at 23.4 m depth was 37.6 MPa.

3.5 Power Auger Refusal

Power auger refusal occurred in TH22-01 at 21.9 m below ground surface within the silt (till), but was not encountered in TH22-06 where drilling switched to HQ coring below a depth of 19.8 m.

3.6 Groundwater Conditions

Groundwater seepage and sloughing were observed within the silt below 19.8 m depth in TH22-01. Seepage was observed within the silty clay below 3.0 m depth in TH22-06. Groundwater seepage and sloughing were not observed below 19.8 m depth in TH22-06 due to the drilling method.

TH22-01 was open to 20.1 m below ground surface immediately after drilling and the water level was not measured immediately after drilling. TH22-02 to 05 were open and dry to 3.0 m below ground surface immediately after drilling.

Two vibrating wire piezometers VW22-01 (S/N 2206446) and VW22-02 (S/N 2206445) were installed within the silty clay in TH22-01 at 3.0 and 6.1 m below ground surface, respectively. One monitoring event was performed on December 16, 2022, but both piezometers were not yet equilibrated.

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

4.0 Foundation Recommendations

Based on the sub-surface conditions encountered during the investigation, driven steel H piles and a mat foundation are feasible foundation alternatives for the new structure. Limit States Design and construction recommendations in accordance with Canadian Highway Bridge Design Code (CHBDC, CAN/CSA-S6S1-14, 2014) are provided in the following sections.

4.1 Limit States Design (CHBDC, CAN/CSA-S6S1-14, 2014).

Limit states design requires consideration of distinct loading scenarios comparing the structural loads to the foundation bearing capacity using resistance and load factors that are based on probabilistic reliability criteria. Two general design scenarios are evaluated corresponding to the serviceability and ultimate capacity requirements.

The **Ultimate Limit State (ULS)** is concerned with ensuring that the maximum structural loads do not exceed the nominal (ultimate) capacity of the foundation units. The ULS foundation bearing capacity is obtained by multiplying the nominal (ultimate) bearing capacity by a resistance factor (reduction factor), which is then compared to the factored (increased) structural loads. The ULS bearing capacity must be greater or equal to the maximum factored load. Table 01 summarizes the resistance factors that can be used for the design of foundations as per the CHBDC depending upon the method of analysis and verification testing completed during construction. The CHBDC also requires that the degree of understanding of soil conditions (which can be classified as either low, typical or high) be assessed in the selection of the resistance factors. We consider the current level of understanding at the site to be high. CHBDC also requires that the resistance factor be modified by a consequence factor which ranges from 0.9 for high consequence structures to 1.15 for low consequence structures. The structures for this project are interpreted to be of typical consequence based on the CHBDC guidelines and as such the consequence factor is 1.0.

The **Service Limit State (SLS)** is concerned with limiting deformation or settlement of the foundation under service loading conditions such that the integrity of the structure will not be impacted. The SLS should generally be analysed by calculating the settlement resulting from applied service loads and comparing this to the settlement tolerance of the structure. However, the settlement tolerance of the structure is typically not defined at the preliminary design stage. As such, SLS bearing capacities (or unit resistances) provided are developed on the basis of limiting settlement to approximately 25 mm or less. A more detailed settlement analysis should be conducted to refine the estimated settlement and/or adjust the SLS vertical bearing resistance if a more stringent settlement tolerance is required.

Table 01 ULS Resistance Factors for Foundations (CHBDC, 2014)

Description	Resistance Factor for Typical Degree of Understanding of Soil Conditions	Resistance Factor for High Degree of Understanding of Soil Conditions
Shallow foundations with a typical degree of understanding of soil conditions and using empirical analysis	0.50	0.60
Deep foundations in compression based on static analysis	0.40	0.45
Deep foundations in compression based on dynamic testing	0.50	0.55
Deep foundations in tension based on static analysis	0.30	0.40

4.2 Foundation Alternatives

4.2.1 Driven Steel H-Piles

Steel H-piles driven to refusal on bedrock are considered suitable to support the anticipated loads. This pile type will derive a majority of its resistance in end bearing with a relatively small contribution from shaft adhesion. The piles should be equipped with a driving shoe to protect against damage during driving from cobbles and boulders within the silt till.

This pile type will derive a majority of its resistance in end bearing with a significant contribution from shaft adhesion. Piles driven to refusal on bedrock are commonly designed for the ULS based on the structural strength of the pile section, however due to the relatively low rock strength and rock quality, reduced capacities are appropriate for this site based on regional dynamic pile load testing data. Piles driven to practical refusal based on the hammer energy and criteria described below are expected to develop a nominal pile capacity of 3,000 kN, resulting in a factored ULS pile capacity of 1,650 kN (based on a resistance factor of $\phi = 0.55$) and an SLS pile capacity of 1,000 kN.

A wave-equation analysis (WEAP) is recommended during detailed design to determine a termination criteria and driving energy such that the desired capacity can be reached without damage being done to the piles, and to aid in confirming the anticipated depth of refusal.

The pile head settlement under unfactored service loads can be calculated based on 5 mm or less of pile tip displacement plus elastic shortening of the pile.

Steel piles driven to refusal will derive their uplift resistance in skin friction within overburden deposits. For the purposes of uplift resistance calculations, a factored unit ULS uplift capacity of 9 kPa should be used for soils above bedrock, based on a resistance factor of 0.3.

The following design and construction recommendations apply to driven steel piles:

Design Recommendations

1. The weight of the embedded portion of the pile should be neglected in design.
2. Pile spacing should be a minimum of 3 pile diameters measured centre to centre. No reduction in pile capacity is required for the group effects provided the piles are driven to refusal on bedrock.

3. The piles must be structurally designed to withstand the design loads, handling stresses, and driving stresses.
4. All piles should be fitted with hard-bite driving tips (driving shoe) to protect the pile tip during installation and to prevent sliding of pile tips during driving on sloping bedrock. The driving tip must be designed to withstand driving stresses and long-term design load cases.

Installation Recommendations

1. A pile driving system (i.e. pile-driving hammer) capable of delivering at least 230 J per square-centimetre of pile cross-sectional area should be specified for driving steel piles. Delivered energy is the energy transferred to the pile head and is typically less than the potential energy of the ram prior to impact (calculated as the stroke of the hammer times the weight of the ram). For example, the minimum delivered energy for HP310x110 steel H-piles should therefore be 33 kJ. The pile-driving hammer should have the capability of adjusting the fuel setting or stroke to deliver higher energy to the pile during driving if the energy is not sufficient to drive the pile to the required tip elevation. The driving system should also have the capability of adjusting the fuel setting or stroke to deliver lower energy to prevent pile damage upon sudden pile refusal. Appropriately sized, locally available hammers for HP310x110 sections include the Pileco D19-42 or ICE i19v2 open-ended diesel hammers, or Junttan HHK5 hydraulic hammer.
2. The efficiency of the driving system (ratio of delivered to potential energy) depends on the type and condition of hammer used, as well as the properties of the soil and pile. The driving system efficiency is typically about 50 to 60% for single-acting diesel hammers and about 85 to 90% for hydraulic drop hammers, although it is not uncommon for values to fall outside this range. TREK can assist in developing specifications for piling hammers once the pile section to be used is known. The actual stroke (for hydraulic hammers) or blow rate (for open-ended diesel hammers) should be monitored during driving at refusal to confirm that the required potential energy is developed.
3. Piles should be driven to refusal on bedrock. Pile installation should be completed carefully near refusal to avoid overdriving of the piles, which could lead to pile damage or misalignment. Refusal is generally considered to be reached when three consecutive sets of 25 mm (or less) of pile penetration result from 10 to 15 blows of the hammer per set, provided that a driving system capable of producing the required delivered energy to the pile per blow is used.
4. Driving stresses in the pile should not exceed 90% of the yield stress of the pile material.
5. The Contractor should be required to submit a proposed driving system for approval a minimum of 7 days prior to the start of pile driving. The pile driving system should be capable of installing the piles to the required tip elevation within specified allowable driving stresses.
6. Driveability analysis (i.e. wave-equation analysis) should be performed prior to construction once the Contractor’s proposed driving system is known.
7. All piles driven within 5 pile diameters of one another should be monitored for pile heave and where heave is observed, all piles should be checked and piles exhibiting heave should be re-driven to one set of the specified refusal criteria.
8. Pile verticality (plumbness) should be measured on all piles after practical refusal has been achieved to check if verticality is within the limits of the structural design.

It is common local practice to specify a maximum acceptable percentage that the pile can be out of vertical plumbness (e.g. 2% out of plumb) or out of the specified batter.

9. Inspection of all driven piles must be performed by TREK personnel to confirm that the refusal criteria have been met and to record that pile installation has been completed according to the design.
10. Any piles damaged, out of plumb an excessive amount or reaching premature refusal may need to be replaced. The structural designer will have to assess non-conforming piles to determine if they are acceptable. PDA testing with CAPWAP analysis is recommended for any piles that are suspected to not meet the design capacity or to be damaged if a structural solution is not possible.

4.2.2 Mat Foundations

A mat foundation founded on stiff clay at an elevation of approximately 226 m is a suitable foundation alternative for box culverts or a concrete precast arch culvert. Softened channel deposits and dewatering may present construction challenges. Provided that the mat is founded on undisturbed stiff clay, foundations can be sized based on SLS bearing resistance of 85 kPa and a ULS bearing resistance of 150 kPa (based on a resistance factor of $\phi = 0.60$).

The weight of any riprap within the proposed culvert should be included in calculation of the net bearing pressure. Shallow foundations will be subject to movements following construction resulting from moisture conditions in bearing soils stabilizing to natural levels.

The following design and construction recommendations apply to shallow mat foundations:

1. Organics, silts, and any other deleterious material should be stripped such that the subgrade consists of native, undisturbed, stiff clay.
2. Excavation should be completed with a smooth bladed excavator bucket in a manner which minimizes disturbance to the exposed subgrade. Care should be taken not to over-excavate and to minimize the subgrade disturbance at all times.
3. The bearing surface should be protected from disturbance, freezing, drying, inundation and disturbance at all times. If any of these conditions occur, the disturbed material should be removed in its entirety such that only undisturbed stiff silty clay is present.
4. The final bearing surface should be inspected and documented by TREK prior to concrete placement to verify the adequacy of the bearing surface and proper installation of the raft.
5. Where soft or weak materials at the prepared subgrade surface are identified by the geotechnical personnel, these areas should be repaired as directed by TREK. This may require additional excavation and placement/compaction of suitable backfill material.
6. If some levelling of the bearing surface is required, sand or granular fill (e.g. 20 mm down crushed granular fill, such as Granular A Base Course in accordance with City of Winnipeg standard specifications CW 3110) can be used to level or raise the bearing surface. The sand or granular fill should be placed in lifts no greater than 150 mm and compacted to 100% of the Standard Proctor Maximum Dry Density (SPMDD). At this level of compaction, the granular fill should be expected to settle by approximately 0.5% of the fill thickness. Alternatively, a concrete mud-slab with a minimum compressive strength of 2 MPa may be used and may perhaps be more advantageous due to potential groundwater seepage and dewatering issues

7. The raft should be designed by a qualified structural engineer to resist all applied loads from the proposed structures.

Resistance to Overturning, Uplift and Sliding

If the structure is subjected to lateral and/or eccentric loads, the foundations must be designed to resist overturning and uplift forces. Lateral and eccentric loading will result in the development of overturning and uplift forces and consequently a non-uniform applied pressure distribution under footings. In this regard, the maximum applied pressure should not exceed the ULS unit bearing resistance and the minimum applied pressure should not be less than 0 kPa. Sliding is not expected to be a concern for design; however, the interface sliding resistance of concrete footings on clay can be based on a factored ULS friction angle of 15 degrees.

4.3 Downdrag (Negative Skin Friction)

Pile down drag (negative skin friction) is not expected to be of concern given that roadway elevations are not expected to change significantly (i.e. less than 2 m). Should the proposed alternative require substantial fill to raise roadway approaches, TREK can provide negative skin friction values to be used in design.

4.4 Lateral Loads

The soil response (subgrade reaction) to lateral loads can be modeled in a simplified manner that assumes the soil around a pile can be simulated by a series of horizontal springs for the preliminary design of pile foundations. The soil behaviour can be estimated using an equivalent spring constant referred to as the lateral subgrade reaction modulus (k_s). Table 02 provides the recommended subgrade reaction modulus for the lateral load analysis. The majority of lateral resistance will typically be offered by the upper 5 to 10 m of soil, depending on the relative stiffness of the pile and soil units. If pre-boring is required to aid in alignment of the piles or to reduce driving effects on adjacent structures, pre-bore holes should have a diameter at least 50 mm smaller than the pile to ensure compliance with the surrounding soil. If pre-bore holes are larger than the pile, the void space between the pile and the soil should be in-filled with sand. If in-filling is not completed, the depth of the pre-bore should be neglected from lateral pile resistance calculations.

Table 02. Recommended Values for Lateral Sub-grade Reaction Modulus (Ks)

Soil	Approximate Elevation (m)	K_s (kN/m^3)
Clay (Fill)/Silty Clay	Above 229.0	5360 / d
Silty Clay	224.5 to 229.0	3350 / d
Silty Clay	218.5 to 224.5	2345 / d
Silty Clay	212.0 to 218.5	1675 / d
Silt Till	209.5 to 212.0	4400 z / d

Notes: d = pile diameter, z = depth below ground surface

As part of detailed design, a more rigorous lateral pile analysis that incorporates the material and section properties of the pile, applied loads, final lateral deflection criteria and a more realistic elastic-plastic model of the soil response to loading should be carried out by TREK to confirm the lateral load capacity of the piles.

4.5 Foundation Concrete

All foundation concrete should be designed by a qualified structural engineer for the anticipated axial (compression and uplift), lateral, and bending loads from the structure. Based on local experience gathered through previous work in Winnipeg, the degree of exposure for concrete subjected to sulphate attack is classified as severe according to Table 3, CSA A23.1-09 (Concrete Materials and Methods of Concrete Construction). Accordingly, all concrete in contact with the native soil should be made with high sulphate-resistant cement (HS or HSb). Furthermore, the concrete should have a minimum specified 56-day compressive strength of 32 MPa and have a maximum water to cement ratio of 0.45 in accordance with Table 2, CSA A23.1-09 for concrete with severe sulphate exposure (S2). Concrete that may be exposed to freezing and thawing should be adequately air entrained to improve freeze-thaw durability in accordance with Table 4, CSA A23.1-09.

4.6 Foundation Inspection Requirements

In accordance with Engineers and Geoscientists of Manitoba, a Professional Engineer or delegated staff responsible to them must perform site reviews for the work presented in the documents they've sealed.

For conformance with the EGM requirements, TREK should be retained on a full-time basis to observe and document the installation of all pile foundations, shoring or engineered fills supporting the structure, and on an as-required basis for other components such as subgrade inspections and compaction testing. TREK is familiar with the geotechnical conditions present and the underlying design assumptions of our foundation recommendations. TREK is therefore solely qualified to evaluate identify deviations from design assumptions during installation and to evaluate any design modifications deemed to be necessary should altered subsurface conditions be encountered.

4.7 Settlement

It is anticipated that embankment fill (up to a maximum of 1.5 m) will be required to raise grades to accommodate the proposed structures and that consolidation settlement will be minimal. However, more significant settlement (perhaps differential) may occur if additional fill is needed to widen the existing embankment. Once final grades are established, settlement analysis can be carried out if necessary, however we do not anticipate that settlement mitigation (e.g. vertical drains, light weight fill) will be required.

5.0 Slope Stability Analysis

Slope stability analyses were conducted to provide preliminary recommendations for embankment head slope geometries. Stability analysis results are presented below based on crossing concepts developed by MHL's hydraulic engineers as part of the hydrotechnical assessment for the project.

The stability analyses were conducted using a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2016 software package (Geo-Slope International Inc.). The slope stability model used the Morgenstern-Price method of slices to calculate factors of safety. Critical slip surfaces were identified using a grid and radius slip surface method. The soil stratigraphy was based on the information provided in this report from the test holes drilled by TREK. Table 03 summarizes the properties used for the soil units in the slope stability analyses, which are considered reasonable based on the available information. The groundwater conditions were modelled using a static piezometric groundwater line.

Water levels in the channel were modelled at Elev. 228.70 m under normal (typical) and extreme groundwater conditions for the preliminary design alternatives. MHL provided additional information regarding the water levels at the Seine River when selecting the preferred design alternative and as such, the water levels in the channel were modelled at Elev. 228.50 and 228.0 m under normal (typical) and extreme groundwater conditions, respectively. Channel bank groundwater levels were assumed to be at Elev. 229.30 m for normal conditions, and at Elev. 230.15 m for extreme conditions. A factor of safety criteria of 1.50 was targeted under normal conditions, while a factor of safety of 1.30 was targeted under extreme conditions.

Table 03. Soil Properties used in Slope Stability Analysis

Soil Description	**Unit Weight** (kN/m^3)	**Cohesion** (kPa)	**Friction Angle** (degrees)
Granular (Fill)	20	0	30
Clay (Fill)	17.5	2	20
Clay	17	5	17
Rip Rap	19	0	35
Abutments	0.1	100	45
Cellular Concrete	4.5	50	45
EPS Foam	0.4	0	45

5.1 Stability Analysis Results

5.1.1 Preliminary Design Alternatives

Calculated factors of safety for a three span bridge (12 m spans) head slopes with a 0.75 or 1.5 m raise in roadway elevation are summarized in Table 04, with stability analysis results shown in the figures included in Appendix B (as referenced in the table).

Table 04. Slope Stability Analysis Results for Preliminary Design Alternatives

Stability Case	Modelling Case	Bank	Groundwater Elevation (m)¹	Channel Water Elevation (m)²	Critical FS	Figure Number (Appendix B)
Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)	Normal Case	North	229.30	228.70	1.46	B1
		South			1.53	B2
	Extreme Case	North	230.15		1.40	B3
		South			1.47	B4
Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5 m Bench)	Normal Case	North	229.30		1.49	B5
		South			1.52	B6
	Extreme Case	North	230.15		1.42	B7
		South			1.46	B8

Notes:

1) Extreme groundwater level based on 50% flood elevation on the Seine River with backwater effect from Red River at flood protection level (27 ft JASPD), as provided by MHL.
2) Water level at channel base is the low water level that was observed in the 1st week of November 2022.

Head slopes for the proposed three span bridge concept satisfy the target factors of safety with a slope angle of 4H:1V or flatter for up to 0.75 m of roadway raising. If roadway raising up to 1.5 m is required, a 1.5 m wide bench downslope of the abutment is required. . If steeper slopes are required to accommodate more economical span arrangements or culvert wing-wall designs, slope stabilization works (*e.g.*, shear key, lightweight fill, etc.) can be designed.

5.1.2 Preffered Design Alternative

5.1.2.1 Buoyancy

Buoyancy calculations with a groundwater level at Elev 230.15 m were performed for the cellular concrete and EPS foam slope stabilization alternatives and a factor of safety > 2.0 was obtained, therefore buoyancy is not of concern.

5.1.2.2 Slope Stability Results

Calculated factors of safety for a three span bridge (8 m spans) head slopes with a raise in roadway elevation (up to 1.0 m) and, cellular concrete or EPS foam stabilization measures are summarized in Table 04, with stability analysis results shown in the figures included in Appendix B (as referenced in the table).

Table 05. Slope Stability Analysis Results for the Preferred Design Alternative

Stability Case	Modelling Case	Bank	Groundwater Elevation (m)[1]	Channel Water Elevation (m)[2]	Critical FS	Figure Number (Appendix B)
Three Span Bridge (8 m spans) with a roadway raise and Rip Rap (4H and 4.9H:1V Slopes)	Normal Case	North	229.30	228.5	1.24	B9
		South			1.43	B10
	Extreme Case	North	230.15	228.0	1.27	B11
		South			1.36	B12
Three Span Bridge (8 m spans) with a roadway raise, Rip Rap (4H and 4.9H:1V Slopes) and Cellular Concrete at the abutments	Normal Case	North	229.30	228.5	1.52	B13
		South			1.54	B14
	Extreme Case	North	230.15	228.0	1.38	B15
		South			1.41	B16
Three Span Bridge (8 m spans) with a roadway raise, Rip Rap (4H and 4.9H:1V Slopes) and EPS Foam at the abutments	Normal Case	North	229.30	228.5	1.50	B17
		South			1.52	B18
	Extreme Case	North	230.15	228.0	1.37	B19
		South			1.40	B20

Notes:

1) Extreme groundwater level based on 1% flood elevation on the Seine River with backwater effect from Red River at flood protection level (27 ft JASPD) . Normal groundwater level based on 50% flood elevation on the Seine River without backwater effect from Red River at flood protection level (6.5 ft JASPD). Flood elevation levels were provided by MHL.
2) A winter water level of 228.5 m and a low water level of 228.0 m for the Seine River were provided by MHL and were used for the normal and extreme conditions, respectively.

Head slopes for the preferred three span bridge (8 m spans) do not satisfy the target factors of safety with a rip rap and slope angle of 4H and 4.9:1V and up to 1.0 m of roadway raising. As such, slope statilization measures using cellular concrete or EPS foam at the abutments are required to satisfy the target factors of safety.

6.0 Excavations, Shoring, and Backfill

All excavations must be carried out in compliance with the appropriate regulation(s) under the Manitoba Workplace Safety and Health Act. Excavations should be kept free of water at all times. If seepage is encountered in an excavation, it should be directed to a sump area and pumped out of the excavation. Surface water should be diverted away from the excavation. Excavations deeper than 3 m require review and design by a qualified geotechnical engineer. The excavation should be backfilled as soon as possible following construction. Stockpiles of excavated material should not be permitted near the edge of an open excavation. In the event that significant seepage is observed during excavation, the slopes of the excavation may need to be flattened. Gravel buttresses could be used to prevent wet sands from flowing into excavations, in conjunction with sump pits used to dewater the excavation. Maintaining the stability of the excavation slopes for the duration of construction should be the responsibility of the contractor.

Cantilevered (un-braced or braced) walls will be required for deep excavations where temporary shoring is necessary. Walls will need to be designed to protect against piping or base heave instabilities in the silt till. Table 06 provides the recommended earth pressure coefficients and bulk unit weights of each soil layer for calculation of lateral earth pressures on cantilevered walls. Surcharge loads and hydrostatic water pressure based on a water level coincident with the channel level or ground surface behind the wall (whichever is greater) should be incorporated into the design of cantilevered walls, as well as an adequate factor of safety against instability.

Table 06. Lateral Earth Pressure Coefficients

Design Parameter	Earth Pressure Coefficients and Bulk Unit Weights	
	Clay/Clay Fill (Existing)	Granular Fill (New)
Active (K_a)	0.5	0.3
At-rest (K_o)	0.7	0.5
Passive (K_p)	1.8	3.0
Bulk Unit Weight, γ (kN/m^3)	18	20

A certain amount of ground movement behind the shoring will occur and is largely unavoidable. The amount of movement that will occur cannot be accurately predicted, mainly because the movement is as much a function of installation procedures and workmanship as it is a function of theoretical considerations. It is anticipated that the design of temporary shoring will be the responsibility of the Contractor. The shoring design and shop drawings should be submitted by the Contractor for review and comment by TREK prior to construction. Performance of the excavation system should be monitored from the onset of installation to removal of the shoring system.

Over-compaction of the backfill soils adjacent to the abutment may result in earth pressures that are considerably higher than those predicted in design. Compaction of the granular fills within about 1.5 m of the vertical walls (abutments or vertical walls) should be conducted with a light hand operated vibrating plate compactor and the number of compaction passes should be limited to achieve a maximum of 92% of Standard Proctor Maximum Dry Density (SPMDD). Backfilling procedures should be reviewed during construction to verify that they are consistent with the design assumptions.

7.0 Dewatering and Cofferdams

Cofferdams may be required to divert stream flow and/or maintain a dry construction area to facilitate the construction of the box culverts. A cofferdam is defined as a temporary earth structure or structure made using engineered components (e.g., sheet piles, soldier piles/lagging, etc.), designed to isolate the work and enable construction under dry conditions. The water level in the river at the time of construction is a key risk factor, and therefore winter construction is recommended to minimize this risk and reduce the robustness of cofferdams. The contractor should be responsible for diverting flow using a method acceptable to the engineer and in accordance with existing guidelines for in-stream work and should be responsible for its installation and removal.

The presence of alluvium in the channel is possible, and may require seepage cut-off measures (e.g., sheet piles, low permeability clay trench) to tie into the underlying clay. Consideration should be given to seepage cut-offs on all four sides of the work area, since seepage may occur from alluvium or other permeable layers beneath the existing embankments, although none such layers were identified in the test holes.

8.0 Closure

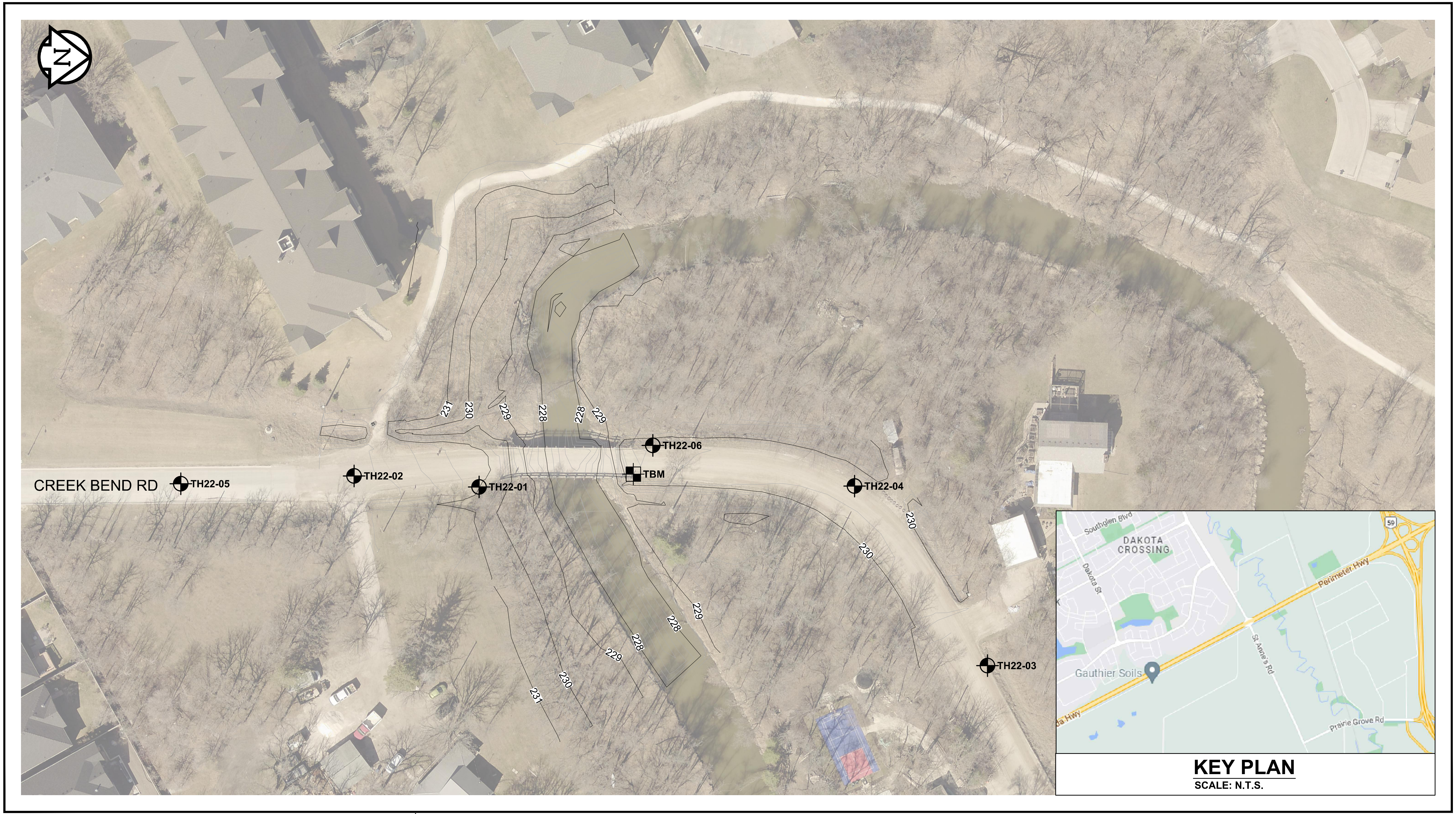
The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation and laboratory testing). Soil conditions are natural deposits that can be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

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

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

Figures

0035 110 00
Morrison Hershfield
Creek Bend Bridge Replacement



0 10 20 30 m

SCALE = 1 : 750 (279 mm x 432 mm)

LEGEND:

- ⊕ TEST HOLE (TREK, 2022)
- ▚ TEMPORARY BENCHMARK
- —— EXISTING MAJOR CONTOUR (1 m INTERVAL)
- —— EXISTING MINOR CONTOUR (0.25 m INTERVAL)

NOTES:

1. AERIAL IMAGERY FROM CITY OF WINNIPEG (2021).
2. TEST HOLE LOCATIONS WERE ESTABLISHED USING A HANDHELD GPS UNIT.
3. TEST HOLE ELEVATIONS WERE SURVEYED RELATIVE TO A TBM (ASSIGNED ELEVATION OF 100.0 m LOCAL) LOCATED ON THE NORTHEAST CORNER OF THE EXISTING BRIDGE DECK.

Figure 01
Test Hole Location Plan

Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 01 2022-12-09 Creek Bend Bridge Replacement 0_B 0035-110-00.dwg, 2022-12-09 9:17:41 AM

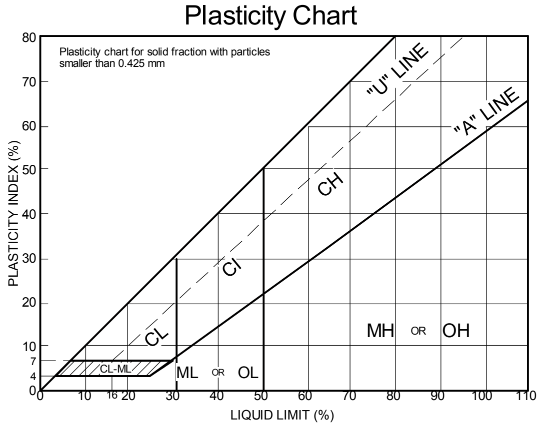
Test Hole Logs

TREK GEOTECHNICAL

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

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

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

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

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

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

Other Symbol Types

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

TREK GEOTECHNICAL

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

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

VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling
▼ Water Level at End of Drilling
▼ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

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

* Used when the material is classified based on behaviour as a cohesive material

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

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

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

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

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

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

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

EXPLANATION OF ROCK CLASSIFICATION

(Canadian Foundation Engineering Manual, 4th Edition, 2006)

Grade*	Term	Uniaxial Comp. Strength (MPa)	Point Load Index (MPa)	Field Estimate of Strength	Examples
R6	Extremely strong	>250	>10	Specimen can only be chipped with a geological hammer	Fresh basalt, chert, diabase, gneiss, granite, quartzite
R5	Very strong	100-250	4-10	Specimen requires many blows of a geological hammer to fracture it	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, peridotite, rhyolite, tuff
R4	Strong	50-100	2-4	Specimen requires more than one blow of a geological hammer to fracture it	Limestone, marble, sandstone, schist
R3	Medium Strong	25-50	1-2	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow from a geological hammer	Concrete, phyllite, schist, siltstone
R2	Weak	5-25	***	Can be peeled with a pocket knife with difficulty, shallow indentation made by a firm blow with the point of a geological hammer	Chalk, claystone, potash, marl, siltstone, shale, rocksalt
R1	Very weak	1-5	***	Crumbles under firm blows with point of a geological hammer, can be peeled with a pocket knife	Highly weathered or altered rock, shale
R0	Extremely weak	0.25-1	***	Indented by thumbnail	Stiff fault gouge

* Grade according to ISRM (1981).

** All rock types exhibit a broad range of uniaxial comprehensive strengths reflecting heterogeneity in composition and anisotropy in structure. Strong rocks are characterized by well-interlocked crystal fabric and few voids.

*** Rocks with a uniaxial compressive strength below 25 MPa are likely to yield highly ambiguous results under point load testing.

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-01

Client: Morrison Hershfield

Project Name: Creek Bend Road Bridge Replacement

Contractor: Paddock Drilling Ltd.

Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

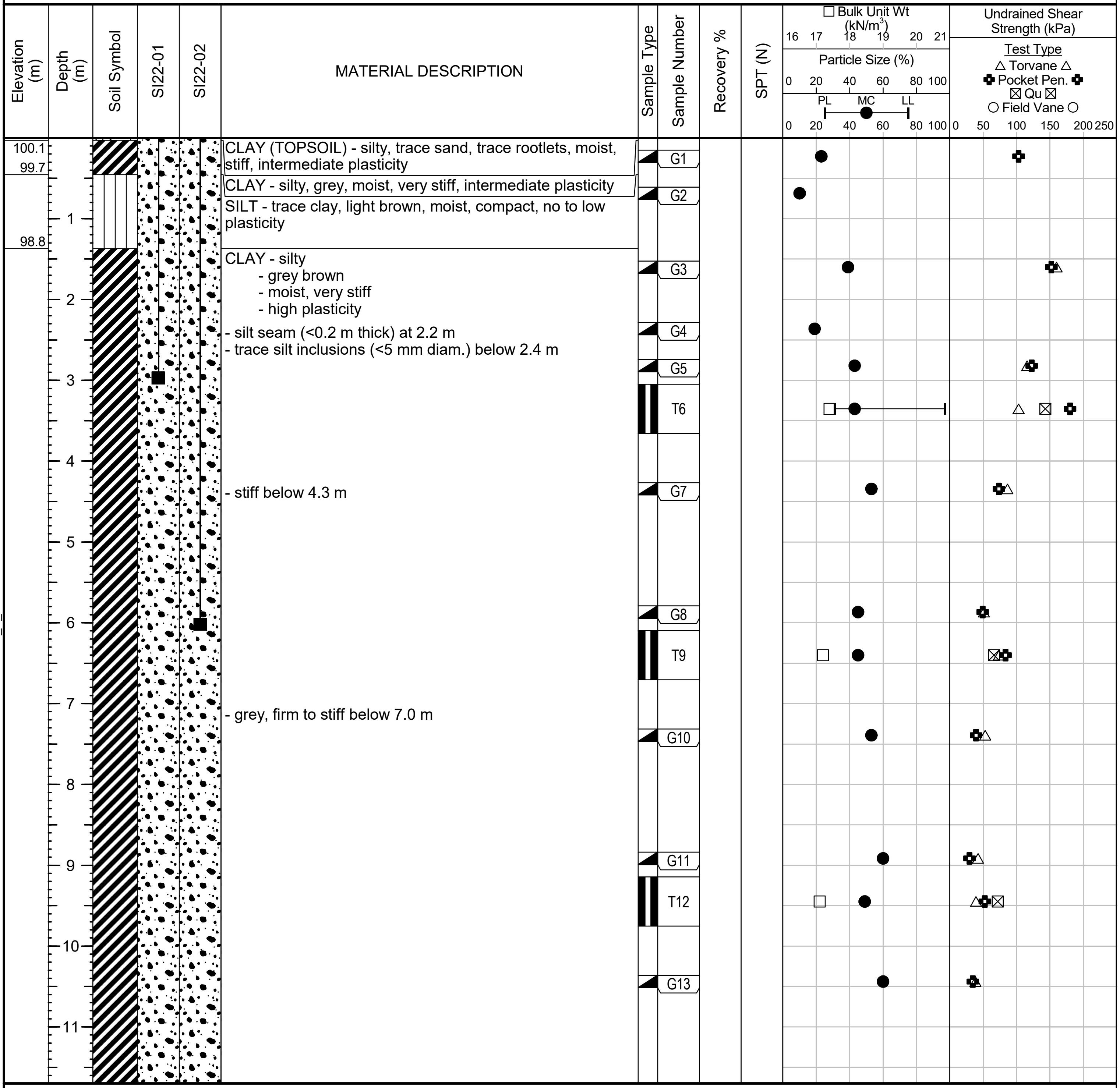
Project Number: 0035-110-00

Location: UTM N-5519615, E-638708

Ground Elevation: 100.16 m (local datum)

Date Drilled: October 25, 2022

Sample Type:	◪ Grab (G)	▮ Shelby Tube (T)	☒ Split Spoon (SS) / SPT	⧓ Split Barrel (SB) / LPT	▯ Core (C)
Particle Size Legend:	▦ Fines	▨ Clay	▥ Silt	⁘ Sand	Gravel	Cobbles	Boulders
Backfill Legend:	■ Bentonite	▩ Cement	▨ Drill Cuttings	Filter Pack Sand	Grout	Slough



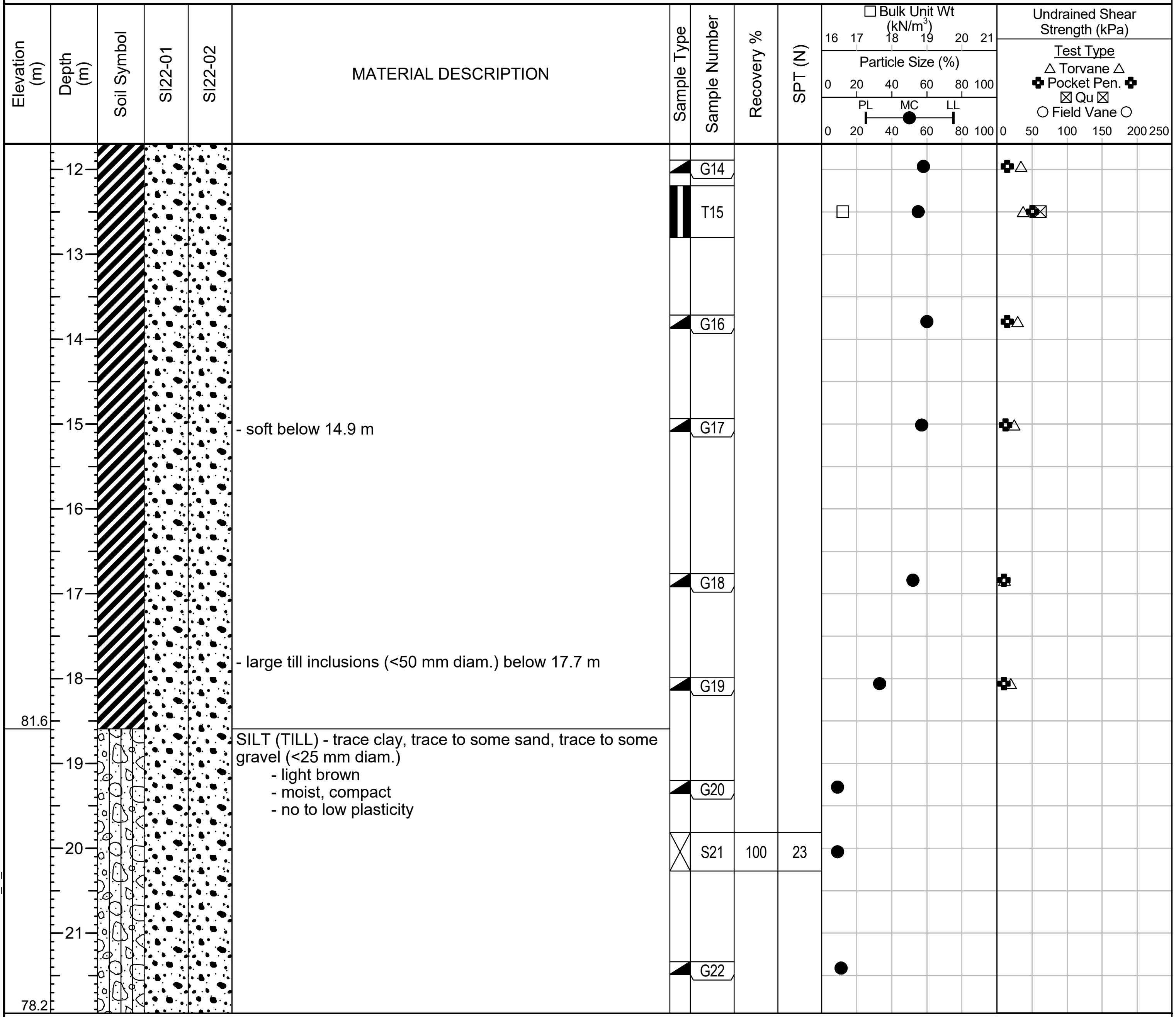
Elevation (m)	MATERIAL DESCRIPTION
100.1	CLAY (TOPSOIL) - silty, trace sand, trace rootlets, moist, stiff, intermediate plasticity
99.7	CLAY - silty, grey, moist, very stiff, intermediate plasticity SILT - trace clay, light brown, moist, compact, no to low plasticity
98.8	CLAY - silty - grey brown - moist, very stiff - high plasticity - silt seam (<0.2 m thick) at 2.2 m - trace silt inclusions (<5 mm diam.) below 2.4 m - stiff below 4.3 m - grey, firm to stiff below 7.0 m

Logged By: Kate Franklin **Reviewed By:** Michael Van Helden **Project Engineer:** Nuno Mendonca

Sub-Surface Log

Test Hole TH22-01

2 of 2



- soft below 14.9 m

- large till inclusions (<50 mm diam.) below 17.7 m

SILT (TILL) - trace clay, trace to some sand, trace to some gravel (<25 mm diam.)
- light brown
- moist, compact
- no to low plasticity

Sample Number	Recovery %	SPT (N)
G14		
T15		
G16		
G17		
G18		
G19		
G20		
S21	100	23
G22		

END OF TEST HOLE AT 21.9 M IN SILT TILL

Notes:
1. Power auger refusal at 21.9 m.
2. Sloughing observed below 19.8 m.
3. Seepage observed below 19.8 m.
4. Test hole open to 20.1 m immediately after drilling.
5. Unable to determine the water level immediately after drilling.
6. Vibrating wire piezometer VW22-01 (S/N 2206446) installed, tip at 3.0 m.
7. Vibrating wire piezometer VW22-02 (S/N 2206445) installed, tip at 6.1 m.
8. Test hole backfilled with a cement-grout mix to surface.

Logged By: Kate Franklin **Reviewed By:** Michael Van Helden **Project Engineer:** Nuno Mendonca

Test Hole TH22-02

1 of 1

Sub-Surface Log

Client: Morrison Hershfield

Project Name: Creek Bend Road Bridge Replacement

Contractor: Paddock Drilling Ltd.

Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

Project Number: 0035-110-00

Location: UTM N-5519589, E-638706

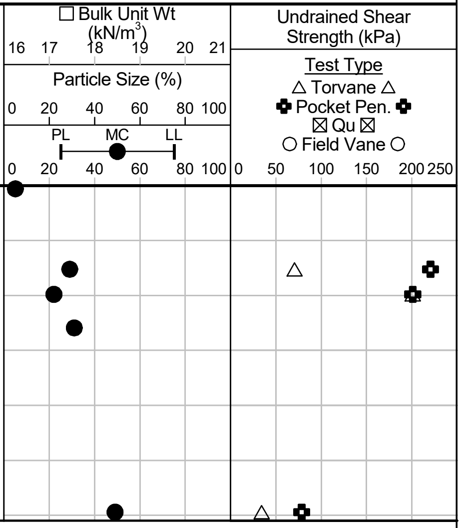
Ground Elevation: 100.92 m (local datum)

Date Drilled: October 25, 2022

Sample Type: ◪ Grab (G) ◧ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ⧓ Split Barrel (SB) / LPT ◧ Core (C)

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

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	Recovery %	SPT (N)
100.9		SAND AND GRAVEL (FILL) - trace silt, light brown, moist, compact, well graded, sub angular (25 mm down limestone)	◪	G23		
	1	CLAY - silty, trace sand - grey - moist, stiff to very stiff - medium plasticity	◪	G24		
99.7		SILT - trace clay, light brown, moist, compact, low plasticity	◪	G25		
99.4	2	CLAY - silty - mottled brown and grey - moist, firm to stiff - high plasticity	◪	G26		
97.9	3		◪	G27		



END OF TEST HOLE AT 3.0 m IN CLAY.

Notes:

1. Seepage and sloughing not observed.
2. Test hole open and dry to 3.0 m immediately after drilling.
3. Test hole backfilled with cuttings and bentonite to surface.

Logged By: Kate Franklin **Reviewed By:** Michael Van Helden **Project Engineer:** Nuno Mendonca

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-03

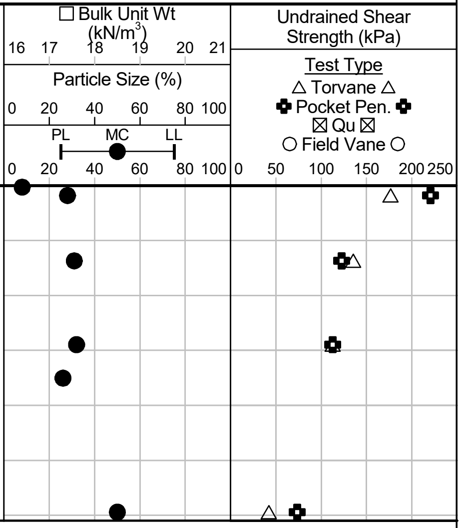
1 of 1

Client: Morrison Hershfield
Project Number: 0035-110-00
Project Name: Creek Bend Road Bridge Replacement
Location: UTM N-5519721, E-638744
Contractor: Paddock Drilling Ltd.
Ground Elevation: 100.30 m (local datum)
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Date Drilled: October 25, 2022

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

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

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	Recovery %	SPT (N)
100.2		⁘	SAND AND GRAVEL (FILL) - trace silt, light brown, moist, compact, well graded, sub angular (25 mm down limestone)	◢	G28 G29		
98.8	1	▨	CLAY - silty, trace sand - grey - moist, very stiff - intermediate plasticity	◢	G30		
98.2	2	▥	SILT - trace clay, trace sand, light brown, moist, compact, low plasticity	◢ ◢	G31 G32		
97.2	3	▨	CLAY - silty - mottled brown and grey - moist, stiff - high plasticity	◢	G33		



END OF TEST HOLE AT 3.0 m IN CLAY.
Notes:
1. Seepage and sloughing not observed.
2. Test hole open and dry to 3.0 m immediately after drilling.
3. Test hole backfilled with cuttings and bentonite to surface.

Logged By: Kate Franklin
Reviewed By: Michael Van Helden
Project Engineer: Nuno Mendonca

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-04

1 of 1

Client: Morrison Hershfield

Project Name: Creek Bend Road Bridge Replacement

Contractor: Paddock Drilling Ltd.

Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

Project Number: 0035-110-00

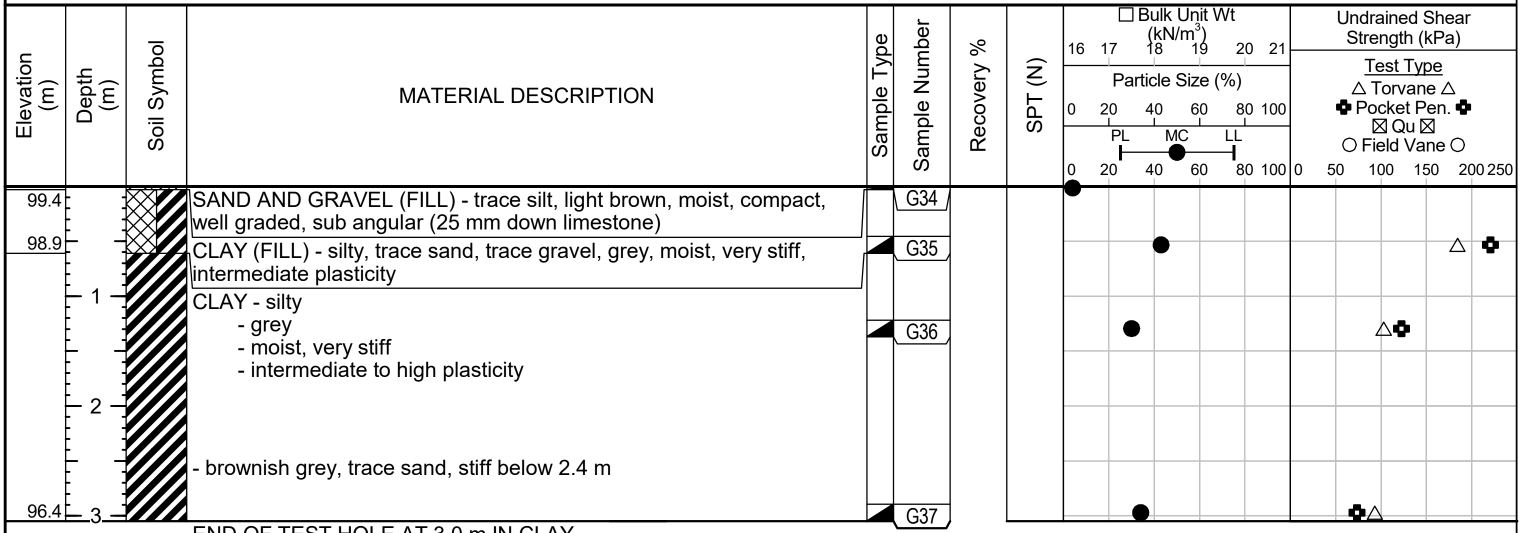
Location: UTM N-5519693, E-638707

Ground Elevation: 99.48 m (local datum)

Date Drilled: October 25, 2022

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

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand Gravel Cobbles Boulders



SAND AND GRAVEL (FILL) - trace silt, light brown, moist, compact, well graded, sub angular (25 mm down limestone)

CLAY (FILL) - silty, trace sand, trace gravel, grey, moist, very stiff, intermediate plasticity

CLAY - silty
- grey
- moist, very stiff
- intermediate to high plasticity

- brownish grey, trace sand, stiff below 2.4 m

END OF TEST HOLE AT 3.0 m IN CLAY.
Notes:
1. Seepage and sloughing not observed.
2. Test hole open and dry to 3.0 m immediately after drilling.
3. Test hole backfilled with cuttings and bentonite to surface.

Logged By: Kate Franklin **Reviewed By:** Michael Van Helden **Project Engineer:** Nuno Mendonca

Test Hole TH22-05

1 of 1

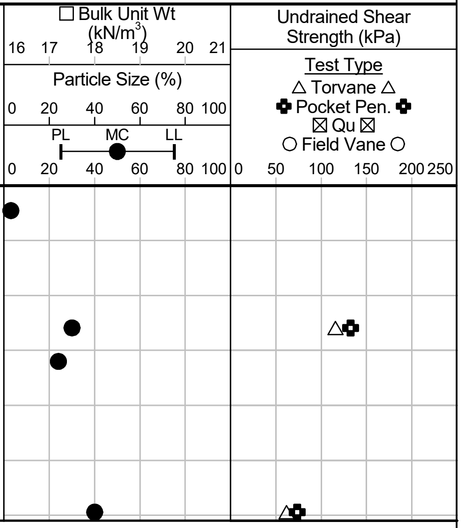
Sub-Surface Log

Client: Morrison Hershfield
Project Name: Creek Bend Road Bridge Replacement
Contractor: Paddock Drilling Ltd.
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Project Number: 0035-110-00
Location: UTM N-5519553, E-638708
Ground Elevation: 101.31 m (local datum)
Date Drilled: October 26, 2022

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

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

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	Recovery %	SPT (N)
101.2		▒	CONCRETE - 150 mm thick				
100.5		▩	SAND AND GRAVEL (FILL) - trace silt, light brown, moist, compact, well graded, sub angular (25 mm down limestone)	◢	G38		
99.8	1	▨	CLAY - silty, trace sand - grey - moist, very stiff - intermediate plasticity	◢	G39		
99.5		▥	SILT - trace clay, trace sand, light brown, moist, compact, low plasticity	◢	G40		
98.3	2 3	▨	CLAY - silty - brown - moist, stiff - high plasticity	◢	G41		



END OF TEST HOLE AT 3.0 m IN CLAY.
Notes:
1. Seepage and sloughing not observed.
2. Test hole open and dry to 3.0 m immediately after drilling.
3. Test hole backfilled with cuttings and bentonite to surface.

Logged By: Kate Franklin
Reviewed By: Michael Van Helden
Project Engineer: Nuno Mendonca

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-06

1 of 2

Client: Morrison Hershfield

Project Name: Creek Bend Road Bridge Replacement

Contractor: Paddock Drilling Ltd.

Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

Project Number: 0035-110-00

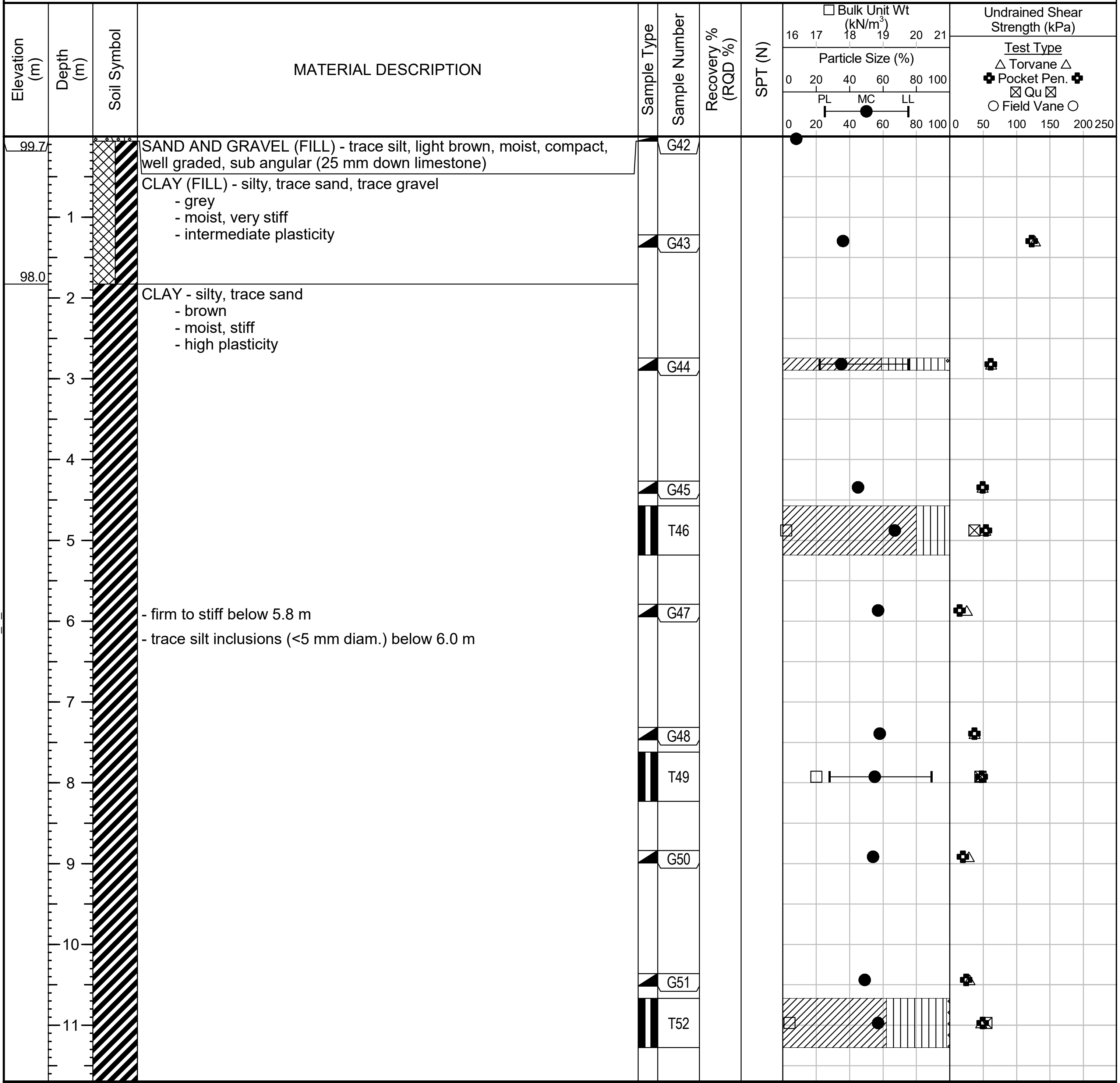
Location: UTM N-5519651, E-638699

Ground Elevation: 99.79 m (local datum)

Date Drilled: October 26, 2022

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

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



SAND AND GRAVEL (FILL) - trace silt, light brown, moist, compact, well graded, sub angular (25 mm down limestone)

CLAY (FILL) - silty, trace sand, trace gravel
- grey
- moist, very stiff
- intermediate plasticity

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

- firm to stiff below 5.8 m
- trace silt inclusions (<5 mm diam.) below 6.0 m

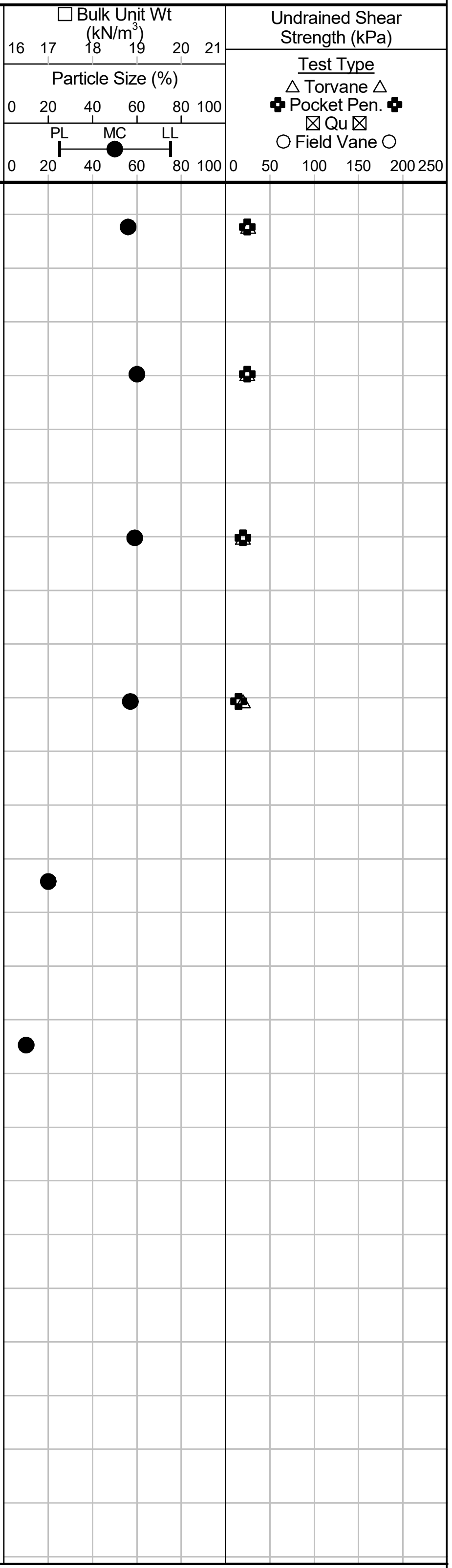
Logged By: Kate Franklin **Reviewed By:** Michael Van Helden **Project Engineer:** Nuno Mendonca

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-06

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Number	Recovery % (RQD %)	SPT (N)
		- soft to firm below 12.0 m	G53		
			G54		
			G55		
			G56		
		- trace sand, trace gravel, very soft, transition to till below 17.7 m	G57		
80.9	19	SILT (TILL) - trace clay, trace to some sand, trace to some gravel (<50 mm diam.) - light brown - moist, compact - no to low plasticity			
			G58		
		- boulder (700 mm diam.) at 19.8 m	RC59	52	
		- cobble (300 mm diam.) at 21.6 m	RC60	99	
			RC61	98	
76.7	23	DOLOMITIC LIMESTONE - Red River formation, Selkirk Member, cream to white colour, mottled, hard, R3, vuggy throughout, massive (no distinct bedding or foliation) - unconfined compressive strenght of 37.6 MPa at 23.4 m	RC62	75 (62)	
75.2					



END OF TEST HOLE AT 24.6 m IN DOLOMITIC LIMESTONE

Notes:

1. Sloughing not observed.
2. Seepage observed below 3.0 m.
3. Driling method switched from 125 mm SSA to HQ coring below 19.8 m.
4. Test hole backfilled with cuttings and bentonite to surface.

Logged By: Kate Franklin **Reviewed By:** Michael Van Helden **Project Engineer:** Nuno Mendonca

Appendix A

Laboratory Testing

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

MEMORANDUM

Date	November 30, 2022
To	Kate Franklin, TREK Geotechnical
From	Angela Fidler-Kliewer, TREK Geotechnical
Project No.	0035-110-00
Project	Creek Bend Road Bridge
Subject	Laboratory Testing Results – Lab Req. R22-638
Distribution	Michael Van Helden, TREK Geotechnical

Attached are the laboratory testing results for the above noted project. This report includes moisture content determinations, Atterberg Limits and unconfined compression tests with related testing on Shelby tube samples.

Regards,

Angela Fidler-Kliewer, C.Tech.

Attach.

Review Control:

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

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield

PROJECT NAME Creek Bend Road Bridge

PROJECT NO: 0035-110-00

FIELD TECHNICIAN: Kate Franklin

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILARY TESTS		TV, PP, Tube Visual moisture Content	Bulk Unit weight		Soil Description/Comments
TH22-01	G1	0.5 - 1.0		✓											Clay 0-1.5 ft
TH22-01	G2	2.0 - 2.5		✓											Silt 1.5-4.5 ft
TH22-01	G3	5.0 - 5.5		✓											Clay 4.5-7.5 ft
TH22-01	G4	7.5 - 8.0		✓											Silt 7.5-8 ft
TH22-01	G5	9.0 - 9.5		✓											Clay (lacustrian) 8-61 ft
TH22-01	T6	10.0 - 12.0				✓						✓			
TH22-01	G7	14.0 - 14.5		✓											
TH22-01	G8	19.0 - 19.5		✓											
TH22-01	T9	20.0 - 22.0										✓			
TH22-01	G10	24.0 - 24.5		✓											
TH22-01	G11	29.0 - 29.5		✓											
TH22-01	T12	30.0 - 32.0										✓			
TH22-01	G13	34.0 - 34.5		✓											
TH22-01	G14	39.0 - 39.5		✓											
TH22-01	T15	40.0 - 42.0				✓						✓			
TH22-01	G16	45.0 - 45.5		✓											
TH22-01	G17	49.0 - 49.5		✓											
TH22-01	G18	55.0 - 55.5		✓											
TH22-01	G19	59.0 - 59.5		✓											
TH22-01	G20	63.0 - 63.5		✓											Silt (till) 61-72
TH22-01	S21	65.0 - 66.5		✓											
TH22-01	G22	70.0 - 70.5		✓											
TH22-02	G23	0.0 - 0.2		✓											granular (road sand) 2in
TH22-02	G24	3.0 - 3.5		✓											Clay 2in-4ft
TH22-02	G25	4.0 - 4.5		✓											Silt 4.5-5ft
TH22-02	G26	5.5 - 6.0		✓											Clay 5-10ft
TH22-02	G27	9.5 - 10.0		✓											Clay
TH22-03	G28	0.0 - 0.1		✓											granular (road sand) 0.5in
TH22-03	G29	0.1 - 0.5		✓											Clay (topsoil) 0.5in-6in
TH22-03	G30	2.0 - 2.5		✓											Clay 05-4.5ft
TH22-03	G31	4.5 - 5.0		✓											Silt and clay 4.5-5ft
TH22-03	G32	5.5 - 6.0		✓											Silt 5-7 ft
TH22-03	G33	9.5 - 10.0		✓											Clay 7-10ft
TH22-04	G34	0.0 - 0.1		✓											Granular 1in labelled as G35
TH22-04	G35	1.5 - 2.0		✓											Clay (fill) 1in -2ft

REQUESTED BY: Kate Franklin

REPORT TO: Michael van Helden

REQUISITION DATE:

DATE REQUIRED:

COMMENTS:

REQUISITION NO. R22-638

PAGE 1 OF 2

TREK LABORATORY REQUISITION LOGS 2022-10-26 TH LOGS CREEK BEND ROAD BRIDGE DRAFT 0_A_KF 0035-110-00.GPJ TREK GEOTECHNICAL.GDT 11/7/22

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield

PROJECT NO: 0035-110-00

PROJECT NAME Creek Bend Road Bridge

FIELD TECHNICIAN: Kate Franklin

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/Comments
TH22-04	G36	4.0 - 4.5		✓											Clay (native) 2-10ft
TH22-04	G37	9.5 - 10.0		✓											
TH22-05	G38	0.5 - 1.0		✓											granular (road sand) 0.5-2.5ft
TH22-05	G39	4.0 - 4.5		✓											Clay 2.5-5ft
TH22-05	G40	5.0 - 5.5		✓											Silt 5-6ft
TH22-05	G41	9.5 - 10.0		✓											Clay 6-10ft
TH22-06	G42	0.0 - 0.2		✓											granular (road sand) 2in
TH22-06	G43	4.0 - 4.5		✓											Clay (fill) 2in -6ft
TH22-06	G44	9.0 - 9.5		✓											Clay (native, alluvial) 6-12ft
TH22-06	G45	14.0 - 14.5		✓											Clay (lacustrian) 12-62 ft
TH22-06	T46	15.0 - 17.0								✓					
TH22-06	G47	19.0 - 19.5		✓											
TH22-06	G48	24.0 - 24.5		✓											
TH22-06	T49	25.0 - 27.0				✓						✓			
TH22-06	G50	29.0 - 29.5		✓											
TH22-06	G51	34.0 - 34.5		✓											
TH22-06	T52	35.0 - 37.0								✓					
TH22-06	G53	39.5 - 40.0		✓											
TH22-06	G54	44.0 - 44.5		✓											
TH22-06	G55	49.0 - 49.5		✓											
TH22-06	G56	54.0 - 54.5		✓											
TH22-06	G57	59.5 - 60.0		✓											
TH22-06	G58	64.5 - 65.0		✓											Silt (till) 62-69ft
TH22-06	RC59	65.0 - 70.8													limestone bedrock
TH22-06	RC60	70.8 - 74.6													limestone bedrock
TH22-06	RC61	74.6 - 75.6													limestone bedrock
TH22-06	RC62	75.6 - 80.6													limestone bedrock

REQUESTED BY: Kate Franklin

REPORT TO:

REQUISITION DATE:

DATE REQUIRED:

COMMENTS:

REQUISITION NO.

PAGE 2 OF 2

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

Moisture Content Report
ASTM D2216-10

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Sample Date	26-Oct-22
Test Date	17-Nov-22
Technician	TR

Test Hole	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01
Depth (m)	0.2 - 0.3	0.6 - 0.8	1.5 - 1.7	2.3 - 2.4	2.7 - 2.9	4.3 - 4.4
Sample #	G01	G02	G03	G04	G05	G07
Tare ID	W19	E35	AB88	Z109	H11	AB19
Mass of tare	9.2	8.6	6.8	8.7	8.6	6.9
Mass wet + tare	203.2	209.3	253.8	149.2	238.1	250.8
Mass dry + tare	166.7	190.6	184.5	126.7	168.9	166.8
Mass water	36.5	18.7	69.3	22.5	69.2	84.0
Mass dry soil	157.5	182.0	177.7	118.0	160.3	159.9
Moisture %	23.2%	10.3%	39.0%	19.1%	43.2%	52.5%

Test Hole	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01
Depth (m)	5.8 - 5.9	7.3 - 7.5	8.8 - 9.0	10.4 - 10.5	11.9 - 12.0	13.7 - 13.9
Sample #	G08	G10	G11	G13	G14	G16
Tare ID	W97	AB18	E134	K14	W32	AB11
Mass of tare	8.7	6.8	8.5	8.5	8.6	7.0
Mass wet + tare	250.3	231.9	226.4	225.4	224.6	279.9
Mass dry + tare	166.4	161.7	151.4	144.3	145.5	177.5
Mass water	83.9	70.2	75.0	81.1	79.1	102.4
Mass dry soil	157.7	154.9	142.9	135.8	136.9	170.5
Moisture %	53.2%	45.3%	52.5%	59.7%	57.8%	60.1%

Test Hole	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01
Depth (m)	14.9 - 15.1	16.8 - 16.9	18.0 - 18.1	19.2 - 19.4	19.8 - 20.3	21.3 - 21.5
Sample #	G17	G18	G19	G20	S21	G22
Tare ID	AB01	N26	F128	W42	N09	AC09
Mass of tare	6.7	8.4	8.6	8.6	8.8	6.9
Mass wet + tare	230.6	215.1	235.1	248.4	201.8	248.6
Mass dry + tare	149.2	144.2	178.7	229.0	186.3	225.3
Mass water	81.4	70.9	56.4	19.4	15.5	23.3
Mass dry soil	142.5	135.8	170.1	220.4	177.5	218.4
Moisture %	57.1%	52.2%	33.2%	8.8%	8.7%	10.7%

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Moisture Content Report
ASTM D2216-10

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Sample Date	26-Oct-22
Test Date	17-Nov-22
Technician	TR

Test Hole	TH22-02	TH22-02	TH22-02	TH22-02	TH22-02	TH22-03
Depth (m)	0.0 - 0.1	0.9 - 1.1	1.2 - 1.4	1.7 - 1.8	2.9 - 3.0	0.0 - 0.0
Sample #	G23	G24	G25	G26	G27	G28
Tare ID	Z105	AA20	Z139	D24	D5	F57
Mass of tare	8.5	6.7	8.6	8.7	8.3	8.6
Mass wet + tare	238.2	267.3	250.8	216.7	217.0	210.2
Mass dry + tare	226.6	208.2	206.7	167.0	148.8	195.8
Mass water	11.6	59.1	44.1	49.7	68.2	14.4
Mass dry soil	218.1	201.5	198.1	158.3	140.5	187.2
Moisture %	5.3%	29.3%	22.3%	31.4%	48.5%	7.7%

Test Hole	TH22-03	TH22-03	TH22-03	TH22-03	TH22-03	TH22-04
Depth (m)	0.0 - 0.2	0.6 - 0.8	1.4 - 1.5	1.7 - 1.8	2.9 - 3.0	0.0 - 0.0
Sample #	G29	G30	G31	G32	G33	G34
Tare ID	K9	F130	E120	W59	Z10	Z134
Mass of tare	8.5	8.8	8.4	8.5	8.9	8.8
Mass wet + tare	240.4	245.8	229.1	270.2	217.1	224.0
Mass dry + tare	190.3	189.9	175.4	215.5	147.3	215.7
Mass water	50.1	55.9	53.7	54.7	69.8	8.3
Mass dry soil	181.8	181.1	167.0	207.0	138.4	206.9
Moisture %	27.6%	30.9%	32.2%	26.4%	50.4%	4.0%

Test Hole	TH22-04	TH22-04	TH22-04	TH22-05	TH22-05	TH22-05
Depth (m)	0.5 - 0.6	1.2 - 1.4	2.9 - 3.0	0.2 - 0.3	1.2 - 1.4	1.5 - 1.7
Sample #	G35	G36	G37	G38	G39	G40
Tare ID	W24	AB27	AA16	F44	N91	D49
Mass of tare	8.3	6.9	6.8	8.5	8.6	8.6
Mass wet + tare	231.2	242.3	205.8	238.3	234.1	240.7
Mass dry + tare	164.5	188.4	155.9	230.9	181.6	196.1
Mass water	66.7	53.9	49.9	7.4	52.5	44.6
Mass dry soil	156.2	181.5	149.1	222.4	173.0	187.5
Moisture %	42.7%	29.7%	33.5%	3.3%	30.3%	23.8%

Moisture Content Report
ASTM D2216-10

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Sample Date	26-Oct-22
Test Date	17-Nov-22
Technician	TR

Test Hole	TH22-05	TH22-06	TH22-06	TH22-06	TH22-06	TH22-06
Depth (m)	2.9 - 3.0	0.2 - 0.3	1.2 - 1.4	2.7 - 2.9	4.3 - 4.4	5.8 - 5.9
Sample #	G41	G42	G43	G44	G45	G47
Tare ID	D9	D39	E72	E56	N93	H50
Mass of tare	8.6	8.5	8.5	8.6	8.5	8.7
Mass wet + tare	211.6	184.3	225.8	247.0	223.6	222.2
Mass dry + tare	153.4	171.7	168.4	184.8	156.4	144.7
Mass water	58.2	12.6	57.4	62.2	67.2	77.5
Mass dry soil	144.8	163.2	159.9	176.2	147.9	136.0
Moisture %	40.2%	7.7%	35.9%	35.3%	45.4%	57.0%

Test Hole	TH22-06	TH22-06	TH22-06	TH22-06	TH22-06	TH22-06
Depth (m)	7.3 - 7.5	8.8 - 9.0	10.4 - 10.5	12.0 - 12.2	13.4 - 13.6	14.9 - 15.1
Sample #	G48	G50	G51	G53	G54	G55
Tare ID	AB12	F17	P06	P85	N32	F66
Mass of tare	7.1	8.6	8.6	8.6	8.5	8.6
Mass wet + tare	274.3	212.1	220.4	238.2	252.5	231.9
Mass dry + tare	176.5	140.7	150.8	156.0	161.1	149.2
Mass water	97.8	71.4	69.6	82.2	91.4	82.7
Mass dry soil	169.4	132.1	142.2	147.4	152.6	140.6
Moisture %	57.7%	54.0%	48.9%	55.8%	59.9%	58.8%

Test Hole	TH22-06	TH22-06	TH22-06			
Depth (m)	16.5 - 16.6	18.1 - 18.3	19.7 - 19.8			
Sample #	G56	G57	G58			
Tare ID	F50	N16	AB85			
Mass of tare	8.6	8.8	6.8			
Mass wet + tare	222.0	233.2	272.9			
Mass dry + tare	144.6	195.8	248.7			
Mass water	77.4	37.4	24.2			
Mass dry soil	136.0	187.0	241.9			
Moisture %	56.9%	20.0%	10.0%			

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Atterberg Limits
ASTM D4318-10e1

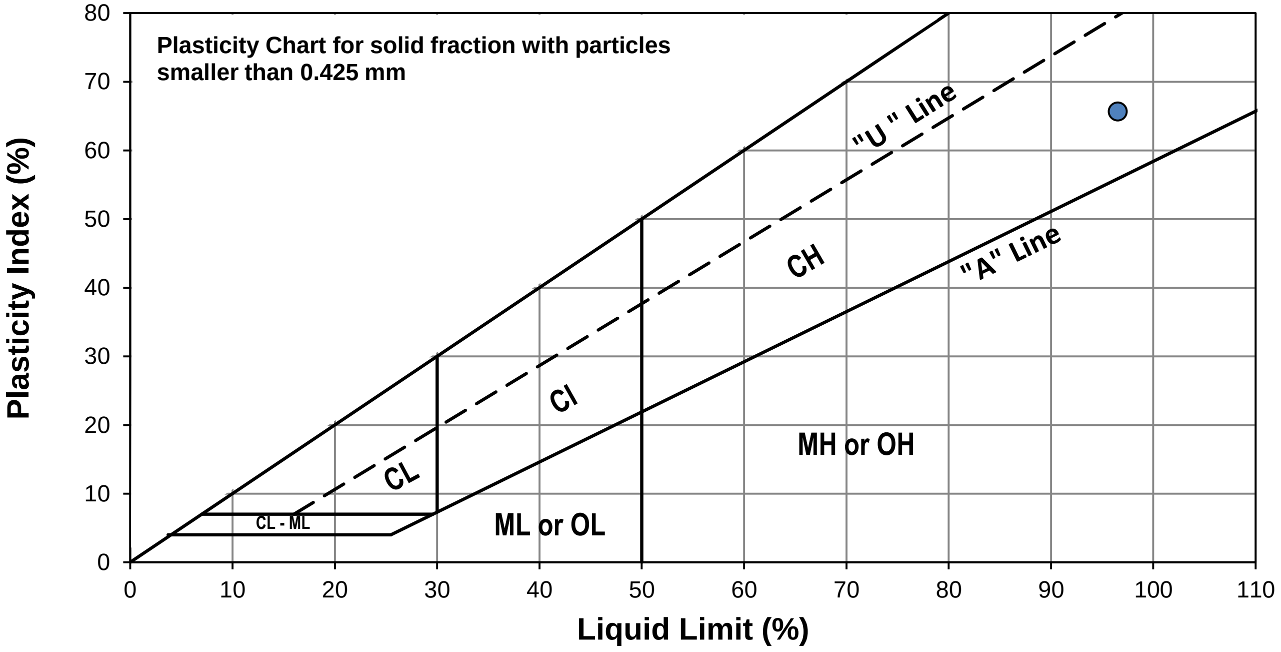
Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Test Hole TH22-01
Sample # T6
Depth (m) 3.0 - 3.7
Sample Date 25-Oct-22
Test Date 28-Nov-22
Technician MT

Liquid Limit	97
Plastic Limit	31
Plasticity Index	66

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	17	27	32		
Mass Tare (g)	14.064	14.002	14.100		
Mass Wet Soil + Tare (g)	25.205	22.637	23.362		
Mass Dry Soil + Tare (g)	19.587	18.412	18.902		
Mass Water (g)	5.618	4.225	4.460		
Mass Dry Soil (g)	5.523	4.410	4.802		
Moisture Content (%)	101.720	95.805	92.878		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.156	14.174			
Mass Wet Soil + Tare (g)	24.080	22.046			
Mass Dry Soil + Tare (g)	21.739	20.189			
Mass Water (g)	2.341	1.857			
Mass Dry Soil (g)	7.583	6.015			
Moisture Content (%)	30.872	30.873			

Note: Additional information recorded/measured for this test is available upon request.

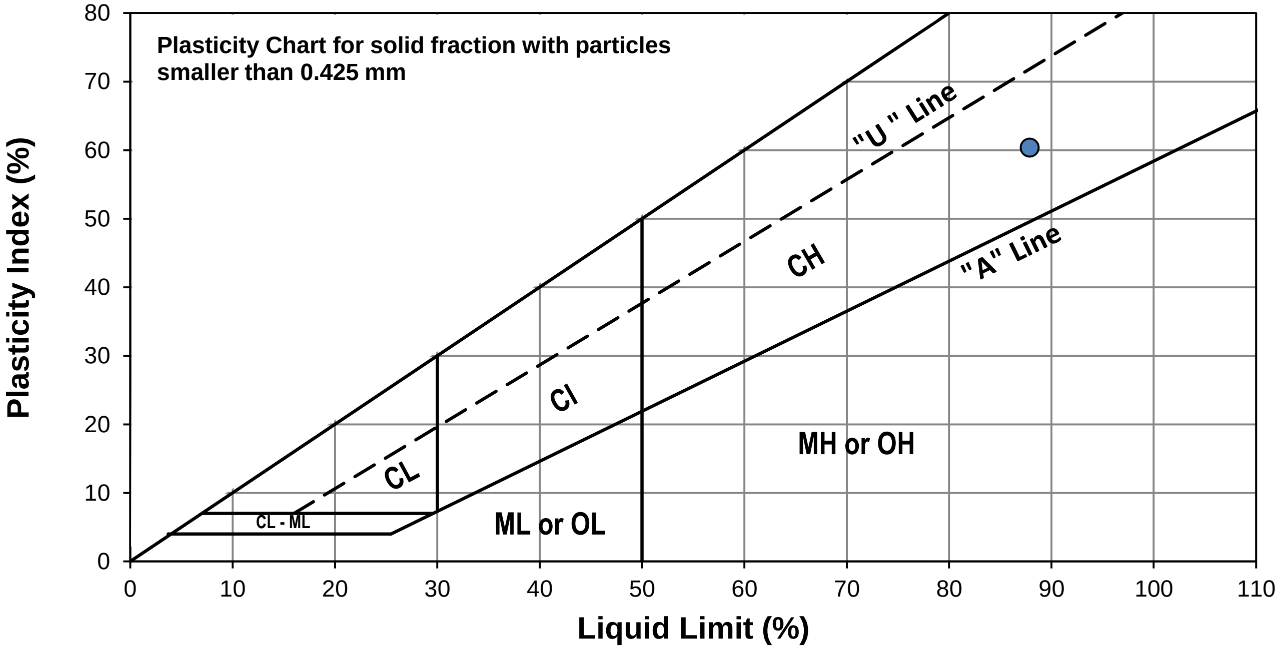
Atterberg Limits
ASTM D4318-10e1

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T15
Depth (m)	12.2 - 12.8
Sample Date	25-Oct-22
Test Date	28-Nov-22
Technician	MT

Liquid Limit	88
Plastic Limit	28
Plasticity Index	60

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	16	23	28		
Mass Tare (g)	13.820	13.992	13.948		
Mass Wet Soil + Tare (g)	25.928	23.603	26.438		
Mass Dry Soil + Tare (g)	20.190	19.096	20.616		
Mass Water (g)	5.738	4.507	5.822		
Mass Dry Soil (g)	6.370	5.104	6.668		
Moisture Content (%)	90.078	88.303	87.313		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.089	13.936			
Mass Wet Soil + Tare (g)	21.730	23.325			
Mass Dry Soil + Tare (g)	20.063	21.322			
Mass Water (g)	1.667	2.003			
Mass Dry Soil (g)	5.974	7.386			
Moisture Content (%)	27.904	27.119			

Note: Additional information recorded/measured for this test is available upon request.

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Atterberg Limits
ASTM D4318-10e1

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

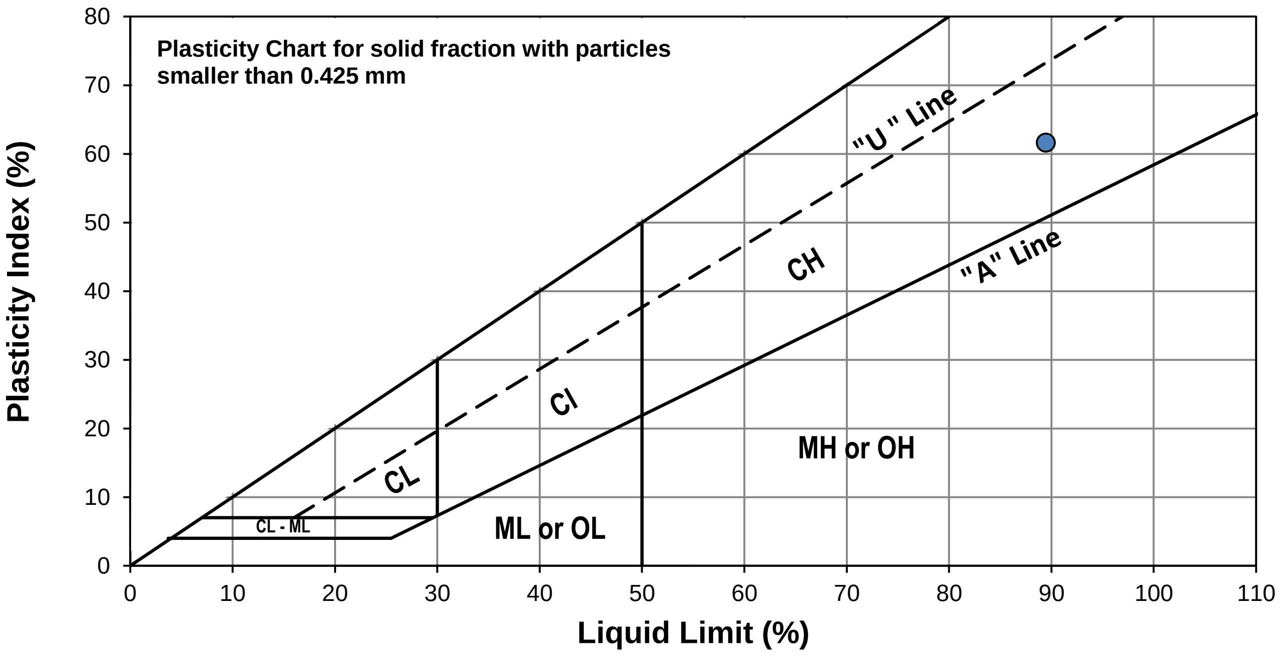
Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Test Hole TH22-06
Sample # T49
Depth (m) 7.6 - 8.2
Sample Date 26-Oct-22
Test Date 28-Nov-22
Technician MT

Liquid Limit	89
Plastic Limit	28
Plasticity Index	62

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	18	22	30		
Mass Tare (g)	14.051	14.070	14.203		
Mass Wet Soil + Tare (g)	24.609	23.835	24.238		
Mass Dry Soil + Tare (g)	19.516	19.189	19.556		
Mass Water (g)	5.093	4.646	4.682		
Mass Dry Soil (g)	5.465	5.119	5.353		
Moisture Content (%)	93.193	90.760	87.465		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.102	14.109			
Mass Wet Soil + Tare (g)	21.652	23.681			
Mass Dry Soil + Tare (g)	20.014	21.591			
Mass Water (g)	1.638	2.090			
Mass Dry Soil (g)	5.912	7.482			
Moisture Content (%)	27.706	27.934			

Note: Additional information recorded/measured for this test is available upon request.

Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T06
Depth (m)	3.0 - 3.7
Sample Date	25-Oct-22
Test Date	25-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 585

Bottom - 3.7 m 3.48 m 3.38 m 3.22 m **Top - 3.1 m**

Keep	Bulk	Moisture Content PP/TV Visual Atterberg	Toss
225 mm	100 mm	160 mm	100 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<10 mm diam.)	
trace gravel (<10 mm diam.)	
trace precipitates (sulphates, <10 mm diam.)	
trace organics	
Color	brownish grey
Moisture	moist
Consistency	very stiff
Plasticity	high plasticity
Structure	laminated, silt and clay (<6 mm thick)
Gradation	-

Torvane

Reading	0.42
Vane Size (s,m,l)	s
Undrained Shear Strength (kPa)	103.0

Pocket Penetrometer

Reading	**1**	3.50
	2	3.60
	3	3.90
	Average	3.67
Undrained Shear Strength (kPa)		179.8

Moisture Content

Tare ID	W14
Mass tare (g)	8.8
Mass wet + tare (g)	416
Mass dry + tare (g)	293.5
Moisture %	43.0%

Unit Weight

Bulk Weight (g)		699.2
Length (mm)	**1**	94.43
	2	94.39
	3	94.38
	4	93.41
Average Length (m)		0.094
Diam. (mm)	**1**	73.03
	2	73.01
	3	72.84
	4	73.45
Average Diameter (m)		0.073
Volume (m^3)		3.95E-04
Bulk Unit Weight (kN/m^3)		17.4
Bulk Unit Weight (pcf)		110.5
Dry Unit Weight (kN/m^3)		12.1
Dry Unit Weight (pcf)		77.3

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T09
Depth (m)	6.1 - 6.7
Sample Date	25-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 665 (overpush)

Bottom - 6.7 m	6.60 m	6.44 m	6.23 m	6.09 m **Top - 6 m**
Toss	Bulk	Moisture Content PP/TV Visual	Keep	Toss
105 mm	160 mm	190 mm	160 mm	50 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<10 mm diam.)	
trace organics	
trace oxidation	
Color	mottled brown and grey
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.75
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	73.6

Pocket Penetrometer

Reading	**1**	1.70
	2	1.60
	3	1.80
	Average	1.70
Undrained Shear Strength (kPa)		83.4

Moisture Content

Tare ID	N59
Mass tare (g)	8.4
Mass wet + tare (g)	404.4
Mass dry + tare (g)	281.2
Moisture %	45.2%

Unit Weight

Bulk Weight (g)		1080.2
Length (mm)	**1**	150.64
	2	150.87
	3	150.69
	4	150.43
Average Length (m)		0.151
Diam. (mm)	**1**	72.09
	2	71.94
	3	72.75
	4	71.82
Average Diameter (m)		0.072
Volume (m^3)		6.16E-04
Bulk Unit Weight (kN/m^3)		17.2
Bulk Unit Weight (pcf)		109.5
Dry Unit Weight (kN/m^3)		11.8
Dry Unit Weight (pcf)		75.4

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T12
Depth (m)	9.1 - 9.8
Sample Date	25-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 640 (overpush)

Bottom - 9.8 m	9.70 m	9.58 m	9.42 m	9.25 m **Top - 9.1 m**
Toss	Moisture Content PP/TV Visual	Bulk	Keep	Toss
100 mm	120 mm	160 mm	170 mm	90 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<45 mm diam.)	
trace gravel (<5 mm diam.)	
Color	brownish grey
Moisture	moist
Consistency	firm to stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.40
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	39.2

Pocket Penetrometer

Reading	**1**	1.10
	2	1.00
	3	1.10
	Average	1.07
Undrained Shear Strength (kPa)		52.3

Moisture Content

Tare ID	AC39
Mass tare (g)	6.8
Mass wet + tare (g)	370.5
Mass dry + tare (g)	251.2
Moisture %	48.8%

Unit Weight

Bulk Weight (g)		1089.9
Length (mm)	**1**	150.69
	2	150.65
	3	150.63
	4	150.70
Average Length (m)		0.151
Diam. (mm)	**1**	73.17
	2	71.71
	3	72.72
	4	73.14
Average Diameter (m)		0.073
Volume (m^3)		6.25E-04
Bulk Unit Weight (kN/m^3)		17.1
Bulk Unit Weight (pcf)		108.8
Dry Unit Weight (kN/m^3)		11.5
Dry Unit Weight (pcf)		73.1

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T15
Depth (m)	12.2 - 12.8
Sample Date	25-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 605

Bottom - 12.8 m	12.63 m	12.47 m	12.31 m **Top - 12.2 m**
Moisture Content PP/TV Visual Atterberg	Bulk	Keep	Toss
170 mm	160 mm	160 mm	115 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<20 mm diam.)	
trace gravel (<10 mm diam.)	
Color	grey
Moisture	moist
Consistency	firm to stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.38
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	37.3

Pocket Penetrometer

Reading	**1**	1.00
	2	1.00
	3	1.10
	Average	1.03
Undrained Shear Strength (kPa)		50.7

Moisture Content

Tare ID	W26
Mass tare (g)	8.6
Mass wet + tare (g)	438.2
Mass dry + tare (g)	285.4
Moisture %	55.2%

Unit Weight

Bulk Weight (g)		1044.8
Length (mm)	**1**	151.97
	2	152.18
	3	152.02
	4	152.32
Average Length (m)		0.152
Diam. (mm)	**1**	71.64
	2	71.25
	3	72.08
	4	72.30
Average Diameter (m)		0.072
Volume (m^3)		6.16E-04
Bulk Unit Weight (kN/m^3)		16.6
Bulk Unit Weight (pcf)		105.8
Dry Unit Weight (kN/m^3)		10.7
Dry Unit Weight (pcf)		68.2

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-06
Sample #	T46
Depth (m)	4.6 - 5.2
Sample Date	26-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 635 (overpush)

5.12 m 4.91 m 4.75 m

Bottom - 5.2 m **Top - 4.5 m**

Toss	Keep	Qu Bulk	Moisture Content PP/TV Visual
85 mm	205 mm	160 mm	185 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<10 mm diam.)	
trace gravel (<15 mm diam.)	
trace organics	
trace oxidation	
Color	mottled brown and grey
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.43
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	42.2

Pocket Penetrometer

Reading	**1**	0.80
	2	0.90
	3	0.90
	Average	0.87
Undrained Shear Strength (kPa)		42.5

Moisture Content

Tare ID	Z138
Mass tare (g)	8.6
Mass wet + tare (g)	402
Mass dry + tare (g)	244.8
Moisture %	66.6%

Unit Weight

Bulk Weight (g)		1066.4
Length (mm)	**1**	151.51
	2	151.64
	3	151.34
	4	151.55
Average Length (m)		0.152
Diam. (mm)	**1**	73.31
	2	74.30
	3	74.02
	4	74.30
Average Diameter (m)		0.074
Volume (m^3)		6.51E-04
Bulk Unit Weight (kN/m^3)		16.1
Bulk Unit Weight (pcf)		102.2
Dry Unit Weight (kN/m^3)		9.6
Dry Unit Weight (pcf)		61.4

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Unconfined Compressive Strength

ASTM D2166

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Test Hole	TH22-06
Sample #	T46
Depth (m)	4.6 - 5.2
Sample Date	26-Oct-22
Test Date	24-Nov-22
Technician	JC

Unconfined Strength

	kPa	**ksf**
Max q_u	73.4	1.5
Max S_u	36.7	0.8

Specimen Data

Description CLAY - silty, trace silt inclusions (<10 mm diam.), trace gravel (<15 mm diam.), trace organics, trace oxidation, mottled brown and grey , moist, firm, high plasticity

Length	151.5	(mm)	**Moisture %**	67%	
Diameter	74.0	(mm)	**Bulk Unit Wt.**	16.1	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	9.6	(kN/m^3)
Initial Area	0.00430	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

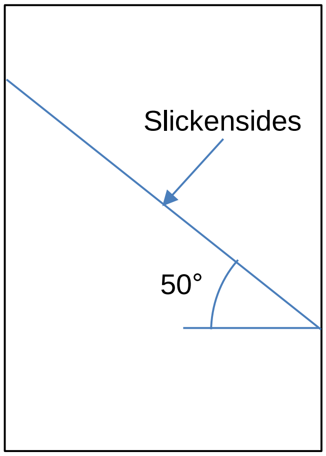
Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.43	42.2	0.88
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	0.80	39.2	0.82
	0.90	44.1	0.92
	0.90	44.1	0.92
Average	**0.87**	**42.5**	**0.89**

Failure Geometry

Sketch:



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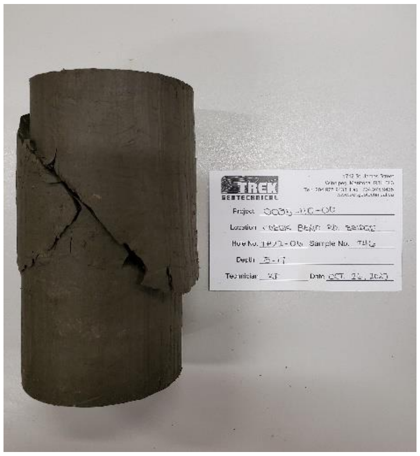
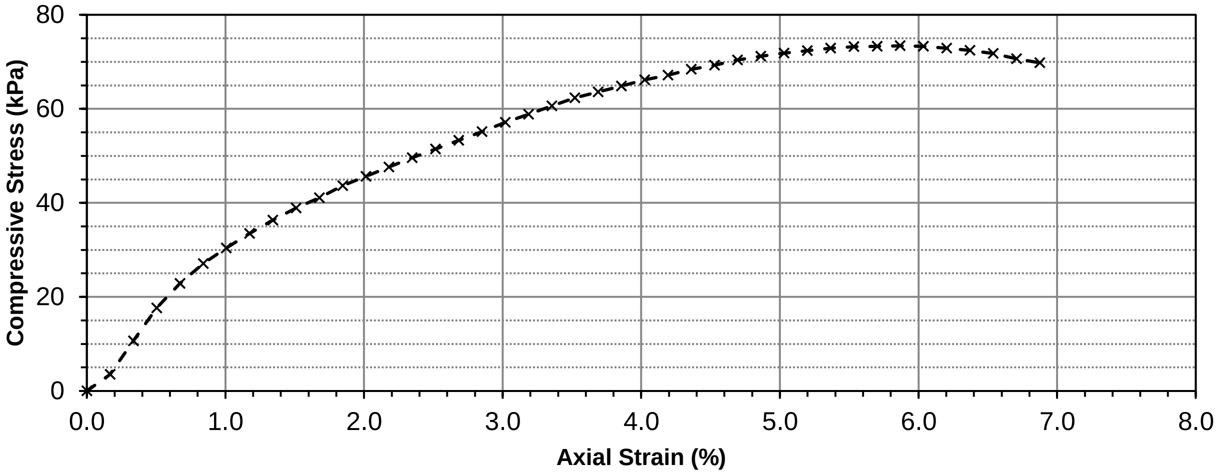


Unconfined Compressive Strength

ASTM D2166

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.37	0.0000	0.00	0.004299	0.0	0.00	0.00
10	0.67	0.2540	0.17	0.004306	15.1	3.51	1.76
20	1.28	0.5080	0.34	0.004313	45.9	10.63	5.32
30	1.88	0.7620	0.50	0.004321	76.1	17.62	8.81
40	2.33	1.0160	0.67	0.004328	98.8	22.83	11.41
50	2.70	1.2700	0.84	0.004335	117.4	27.09	13.54
60	2.99	1.5240	1.01	0.004342	132.1	30.41	15.21
70	3.26	1.7780	1.17	0.004350	145.7	33.49	16.74
80	3.51	2.0320	1.34	0.004357	158.3	36.32	18.16
90	3.74	2.2860	1.51	0.004365	169.9	38.92	19.46
100	3.93	2.5400	1.68	0.004372	179.4	41.04	20.52
110	4.16	2.7940	1.84	0.004380	191.0	43.62	21.81
120	4.34	3.0480	2.01	0.004387	200.1	45.61	22.81
130	4.52	3.3020	2.18	0.004395	209.2	47.60	23.80
140	4.70	3.5560	2.35	0.004402	218.2	49.58	24.79
150	4.87	3.8100	2.51	0.004410	226.8	51.44	25.72
160	5.04	4.0640	2.68	0.004417	235.4	53.29	26.64
170	5.21	4.3180	2.85	0.004425	244.0	55.13	27.57
180	5.39	4.5720	3.02	0.004433	253.0	57.08	28.54
190	5.55	4.8260	3.19	0.004440	261.1	58.80	29.40
200	5.72	5.0800	3.35	0.004448	269.7	60.62	30.31
210	5.88	5.3340	3.52	0.004456	277.7	62.33	31.16
220	6.00	5.5880	3.69	0.004463	283.8	63.58	31.79
230	6.12	5.8420	3.86	0.004471	289.8	64.82	32.41

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	**Load Ring Dial Reading**	**Deflection (mm)**	**Axial Strain (%)**	**Corrected Area (m^2)**	**Axial Load (N)**	**Compressive Stress, q_u (kPa)**	**Shear Stress, S_u (kPa)**
240	6.25	6.0960	4.02	0.004479	296.4	66.17	33.08
250	6.35	6.3500	4.19	0.004487	301.4	67.18	33.59
260	6.47	6.6040	4.36	0.004495	307.5	68.40	34.20
270	6.56	6.8580	4.53	0.004503	312.0	69.29	34.65
280	6.67	7.1120	4.69	0.004511	317.5	70.40	35.20
290	6.75	7.3660	4.86	0.004518	321.6	71.17	35.58
300	6.82	7.6200	5.03	0.004526	325.1	71.82	35.91
310	6.88	7.8740	5.20	0.004534	328.1	72.36	36.18
320	6.94	8.1280	5.36	0.004542	331.1	72.90	36.45
330	6.98	8.3820	5.53	0.004551	333.2	73.21	36.61
340	7.00	8.6360	5.70	0.004559	334.2	73.31	36.65
350	7.02	8.8900	5.87	0.004567	335.2	73.40	36.70
360	7.02	9.1440	6.04	0.004575	335.2	73.26	36.63
370	7.00	9.3980	6.20	0.004583	334.2	72.91	36.46
380	6.97	9.6520	6.37	0.004591	332.7	72.45	36.23
390	6.92	9.9060	6.54	0.004600	330.1	71.78	35.89
400	6.83	10.1600	6.71	0.004608	325.6	70.66	35.33
410	6.76	10.4140	6.87	0.004616	322.1	69.77	34.89

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-06
Sample #	T49
Depth (m)	7.6 - 8.2
Sample Date	26-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 660 (overpush)

8.05 m 7.90 m 7.74 m 7.57 m

Bottom - 8.2 m **Top - 7.6 m**

Toss	Moisture Content PP/TV Visual Atterberg	Bulk	Keep	Toss
155 mm	150 mm	155 mm	170 mm	30 mm

Visual Classification

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

Torvane

Reading	0.47
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	46.1

Pocket Penetrometer

Reading	**1**	1.00
	2	1.00
	3	0.90
	Average	0.97
Undrained Shear Strength (kPa)		47.4

Moisture Content

Tare ID	P04
Mass tare (g)	8.8
Mass wet + tare (g)	395.4
Mass dry + tare (g)	257.6
Moisture %	55.4%

Unit Weight

Bulk Weight (g)		1075.2
Length (mm)	**1**	148.90
	2	148.70
	3	149.09
	4	149.01
Average Length (m)		0.149
Diam. (mm)	**1**	72.53
	2	72.40
	3	72.41
	4	73.87
Average Diameter (m)		0.073
Volume (m^3)		6.20E-04
Bulk Unit Weight (kN/m^3)		17.0
Bulk Unit Weight (pcf)		108.3
Dry Unit Weight (kN/m^3)		10.9
Dry Unit Weight (pcf)		69.7

Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Test Hole	TH22-06
Sample #	T52
Depth (m)	10.7 - 11.3
Sample Date	26-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 630

Bottom - 11.3 m	11.22 m	11.06 m	10.85 m **Top - 10.6 m**
Toss	Qu Bulk	Moisture Content PP/TV Visual	Keep
80 mm	160 mm	215 mm	175 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<25 mm diam.)	
trace gravel (<10 mm diam.)	
Color	grey
Moisture	moist
Consistency	firm to stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.48
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	47.1

Pocket Penetrometer

Reading	**1**	1.10
	2	1.10
	3	1.00
	Average	1.07
Undrained Shear Strength (kPa)		52.3

Moisture Content

Tare ID	AB13
Mass tare (g)	6.8
Mass wet + tare (g)	344.2
Mass dry + tare (g)	222.2
Moisture %	56.6%

Unit Weight

Bulk Weight (g)		1043.6
Length (mm)	**1**	150.99
	2	151.27
	3	151.56
	4	151.40
Average Length (m)		0.151
Diam. (mm)	**1**	72.72
	2	72.45
	3	73.05
	4	73.01
Average Diameter (m)		0.073
Volume (m^3)		6.30E-04
Bulk Unit Weight (kN/m^3)		16.2
Bulk Unit Weight (pcf)		103.4
Dry Unit Weight (kN/m^3)		10.4
Dry Unit Weight (pcf)		66.0

Unconfined Compressive Strength

ASTM D2166

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Test Hole	TH22-06
Sample #	T52
Depth (m)	10.7 - 11.3
Sample Date	26-Oct-22
Test Date	24-Nov-22
Technician	JC

Unconfined Strength

	kPa	**ksf**
Max q_u	109.1	2.3
Max S_u	54.6	1.1

Specimen Data

Description CLAY - silty, trace silt inclusions (<25 mm diam.), trace gravel (<10 mm diam.), grey, moist, firm to stiff, high plasticity

Length	151.3	(mm)
Diameter	72.8	(mm)
L/D Ratio	2.1	
Initial Area	0.00416	(m^2)
Load Rate	1.00	(%/min)

Moisture %	57%	
Bulk Unit Wt.	16.2	(kN/m^3)
Dry Unit Wt.	10.4	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

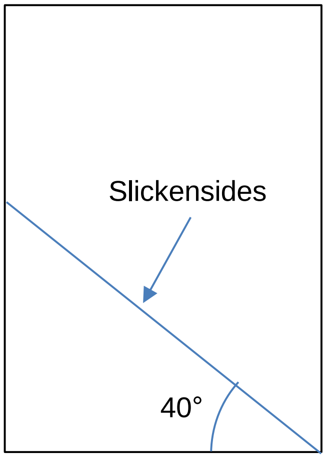
Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.48	47.1	0.98
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	1.10	54.0	1.13
	1.10	54.0	1.13
	1.00	49.1	1.02
Average	**1.07**	**52.3**	**1.09**

Failure Geometry

Sketch:



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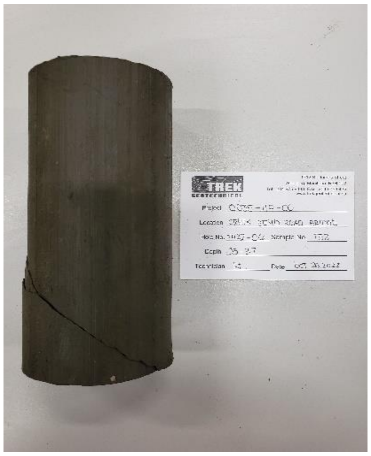
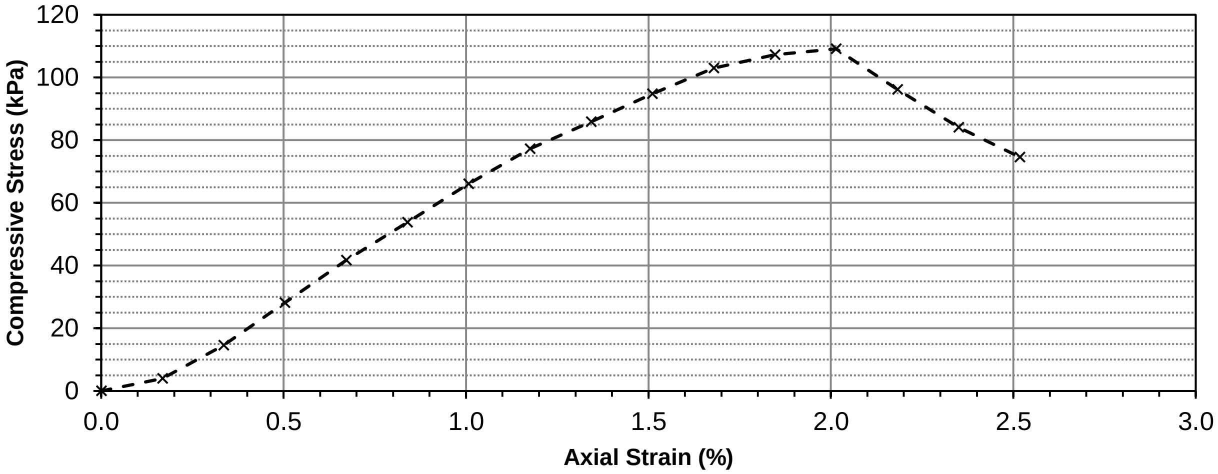


Unconfined Compressive Strength

ASTM D2166

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.35	0.0000	0.00	0.004163	0.0	0.00	0.00
10	0.68	0.2540	0.17	0.004170	16.6	3.99	1.99
20	1.56	0.5080	0.34	0.004177	61.0	14.60	7.30
30	2.69	0.7620	0.50	0.004184	117.9	28.19	14.09
40	3.82	1.0160	0.67	0.004191	174.9	41.73	20.86
50	4.83	1.2700	0.84	0.004199	225.8	53.78	26.89
60	5.86	1.5240	1.01	0.004206	277.7	66.03	33.02
70	6.81	1.7780	1.18	0.004213	325.6	77.29	38.64
80	7.54	2.0320	1.34	0.004220	362.4	85.88	42.94
90	8.30	2.2860	1.51	0.004227	400.7	94.79	47.40
100	9.00	2.5400	1.68	0.004234	436.0	102.96	51.48
110	9.38	2.7940	1.85	0.004242	455.1	107.30	53.65
120	9.55	3.0480	2.01	0.004249	463.7	109.13	54.57
130	8.47	3.3020	2.18	0.004256	409.3	96.16	48.08
140	7.46	3.5560	2.35	0.004264	358.4	84.05	42.03
150	6.67	3.8100	2.52	0.004271	318.5	74.59	37.29

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

MEMORANDUM

Date	December 8, 2022
To	Nuno Mendonca, TREK Geotechnical
From	Angela Fidler-Kliewer, TREK Geotechnical
Project No.	0035-110-00
Project	Creek Bend Road Bridge
Subject	Laboratory Testing Results – Lab Req. R22-660
Distribution	Michael Van Helden

Attached is the laboratory testing result for the above noted project. The testing included unconfined compression test on rock core.

Regards,

Angela Fidler-Kliewer, C.Tech.,

Attach.

Review Control:

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

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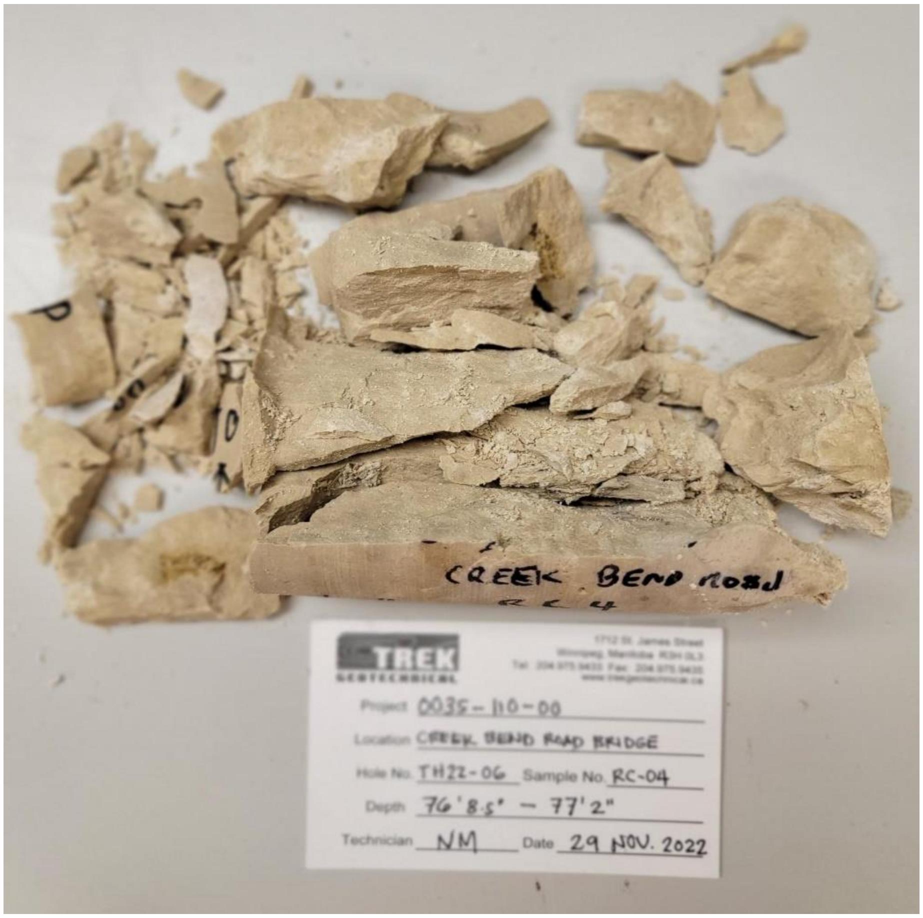
Rock Core Unconfined Compressive Strength Report

UNCONFINED COMPRESSIVE STRENGTH OF INTACT ROCK CORE SPECIMENS (ASTM D 7012)

Project No.	035-110-00	**Date Received**	29-Nov-22	**Test Date**	08-Dec-22
Project	Creek Bend Road Bridge	**Sampled by**	NM	**Report No.**	R22-660
Client	Morrison Hershfield	**Requested by**	NM	**Technician**	IA

Core No.	Core Length as Received (mm)	Core Diameter (mm)	Core Length (mm)	Core Weight (g)	Density (g/mm³)	Area (sq.mm)	Core Load (kN)	Core Strength (Mpa)	Notes
TH22-06 (C04)	168	62.75	130.5	970.2	2.404 X10^{-3}	3093	116.30	37.6	



Project 0035-110-00
Location CREEK BEND ROAD BRIDGE
Hole No. TH22-06 Sample No. RC-04
Depth 76'8.5" – 77'2"
Technician NM Date 29 NOV. 2022

Comments:

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

MEMORANDUM

Date	December 12, 2022
To	Nuno Mendonca, TREK Geotechnical
From	Angela Fidler-Kliewer, TREK Geotechnical
Project No.	0035-110-00
Project	Creek Bend Road Bridge
Subject	Laboratory Testing Results – Lab Req. R22-651B
Distribution	Michael Van Helden

Attached are the laboratory testing results for the above noted project. This report includes Atterberg Limits, grain size distribution (Hydrometer method) and unconfined compressive strength on Shelby tube samples.

Regards,

Angela Fidler-Kliewer, C.Tech.

Attach.

Review Control:

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

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield

PROJECT NAME Creek Bend Road Bridge

PROJECT NO: 0035-110-00

FIELD TECHNICIAN: Kate Franklin

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/Comments
TH22-01	G1	0.5 - 1.0													
TH22-01	G2	2.0 - 2.5													
TH22-01	G3	5.0 - 5.5													
TH22-01	G4	7.5 - 8.0													
TH22-01	G5	9.0 - 9.5													
TH22-01	T6	10.0 - 12.0								X					clay
TH22-01	G7	14.0 - 14.5													
TH22-01	G8	19.0 - 19.5													
TH22-01	T9	20.0 - 22.0								X					clay
TH22-01	G10	24.0 - 24.5													
TH22-01	G11	29.0 - 29.5													
TH22-01	T12	30.0 - 32.0								X					clay
TH22-01	G13	34.0 - 34.5													
TH22-01	G14	39.0 - 39.5													
TH22-01	T15	40.0 - 42.0								X					clay
TH22-01	G16	45.0 - 45.5													
TH22-01	G17	49.0 - 49.5													
TH22-01	G18	55.0 - 55.5													
TH22-01	G19	59.0 - 59.5													
TH22-01	G20	63.0 - 63.5													
TH22-01	S21	65.0 - 66.5													
TH22-01	G22	70.0 - 70.5													
TH22-02	G23	0.0 - 0.2													
TH22-02	G24	3.0 - 3.5													
TH22-02	G25	4.0 - 4.5													
TH22-02	G26	5.5 - 6.0													
TH22-02	G27	9.5 - 10.0													
TH22-03	G28	0.0 - 0.1													
TH22-03	G29	0.1 - 0.5													
TH22-03	G30	2.0 - 2.5													
TH22-03	G31	4.5 - 5.0													
TH22-03	G32	5.5 - 6.0													
TH22-03	G33	9.5 - 10.0													
TH22-04	G34	0.0 - 0.1													
TH22-04	G35	1.5 - 2.0													

REQUESTED BY: Kate Franklin /NM

REQUISITION DATE: 2022/12/06

COMMENTS:

REPORT TO: NM / MVH

DATE REQUIRED: ASAP

REQUISITION NO. R22-651B

PAGE 1 OF 2

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield
PROJECT NO: 0035-110-00
PROJECT NAME Creek Bend Road Bridge
FIELD TECHNICIAN: Kate Franklin

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS				Soil Description/Comments
TH22-04	G36	4.0 - 4.5												
TH22-04	G37	9.5 - 10.0												
TH22-05	G38	0.5 - 1.0												
TH22-05	G39	4.0 - 4.5												
TH22-05	G40	5.0 - 5.5												
TH22-05	G41	9.5 - 10.0												
TH22-06	G42	0.0 - 0.2												
TH22-06	G43	4.0 - 4.5												
TH22-06	G44	9.0 - 9.5				X	X							
TH22-06	G45	14.0 - 14.5												
TH22-06	T46	15.0 - 17.0					X			~~X~~				Did the Qu already
TH22-06	G47	19.0 - 19.5												
TH22-06	G48	24.0 - 24.5												
TH22-06	T49	25.0 - 27.0					X			X				e/zy
TH22-06	G50	29.0 - 29.5												
TH22-06	G51	34.0 - 34.5												
TH22-06	T52	35.0 - 37.0								~~X~~				Did the Qu already
TH22-06	G53	39.5 - 40.0												
TH22-06	G54	44.0 - 44.5												
TH22-06	G55	49.0 - 49.5												
TH22-06	G56	54.0 - 54.5												
TH22-06	G57	59.5 - 60.0												
TH22-06	G58	64.5 - 65.0												
TH22-06	RC59	65.0 - 70.8												
TH22-06	RC60	70.8 - 74.6												
TH22-06	RC61	74.6 - 75.6												
TH22-06	RC62	75.6 - 80.6												

REQUESTED BY: Kate Franklin /NH
REPORT TO: NH / MVH
REQUISITION DATE: 2022/12/06
DATE REQUIRED: ASAP
COMMENTS:

REQUISITION NO. R22-6513

TREK LABORATORY REQUISITION LOGS 2022-10-26 TH LOGS CREEK BEND ROAD BRIDGE DRAFT 0_A_KF 0035-110-00.GPJ TREK GEOTECHNICAL.GDT 11/7/22

Atterberg Limits
ASTM D4318-10e1

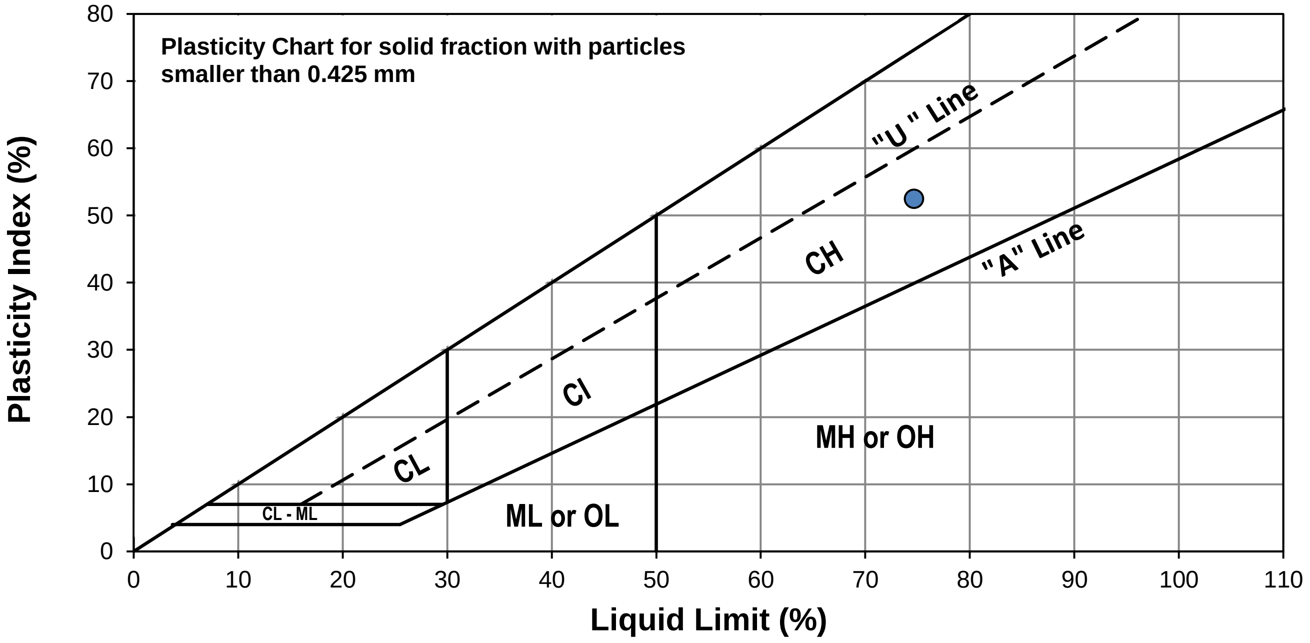
CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-06
Sample #	G44
Depth (m)	7.6 - 8.2
Sample Date	26-Oct-22
Test Date	08-Dec-22
Technician	DS

Liquid Limit	75
Plastic Limit	22
Plasticity Index	52

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	18	23	29		
Mass Tare (g)	14.051	14.062	14.068		
Mass Wet Soil + Tare (g)	21.541	23.138	24.376		
Mass Dry Soil + Tare (g)	18.265	19.240	20.014		
Mass Water (g)	3.276	3.898	4.362		
Mass Dry Soil (g)	4.214	5.178	5.946		
Moisture Content (%)	77.741	75.280	73.360		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.166	14.102			
Mass Wet Soil + Tare (g)	21.889	22.612			
Mass Dry Soil + Tare (g)	20.475	21.078			
Mass Water (g)	1.414	1.534			
Mass Dry Soil (g)	6.309	6.976			
Moisture Content (%)	22.412	21.990			

Note: Additional information recorded/measured for this test is available upon request.

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

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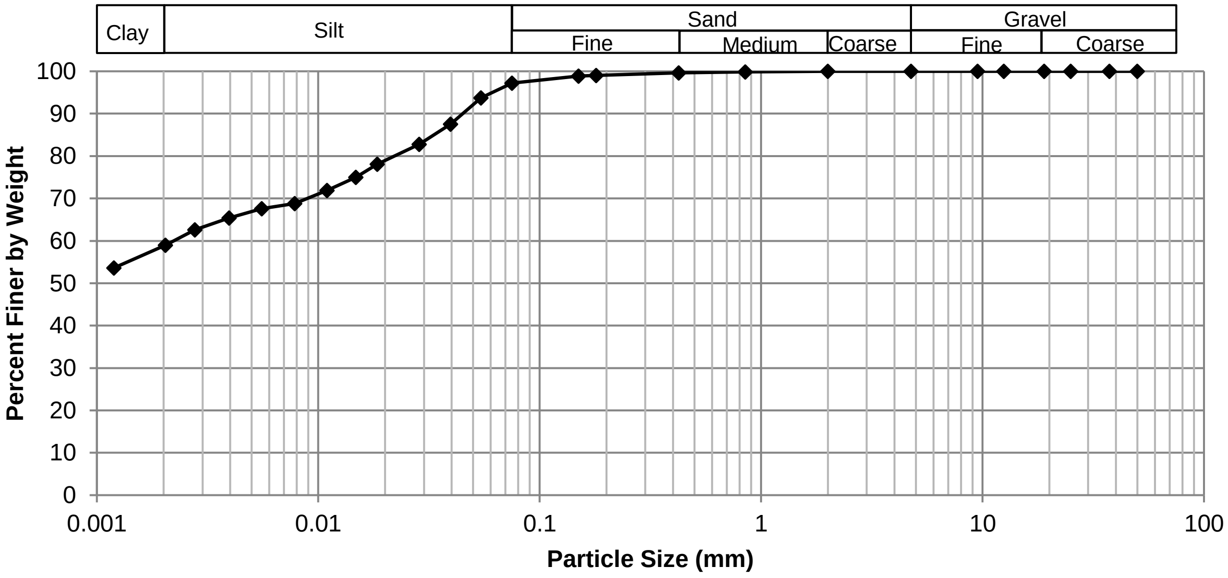
For specific tests as listed on www.ccil.com

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-06
Sample #	G44
Depth (m)	4.3 - 4.4
Sample Date	26-Oct-22
Test Date	9-Dec-22
Technician	DS

Gravel	0.0%
Sand	2.8%
Silt	38.5%
Clay	58.8%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	97.23
37.5	100.00	2.00	100.00	0.0543	93.76
25.0	100.00	0.850	99.87	0.0396	87.51
19.0	100.00	0.425	99.62	0.0286	82.82
12.5	100.00	0.180	99.06	0.0185	78.13
9.50	100.00	0.150	98.88	0.0148	75.00
4.75	100.00	0.075	97.23	0.0110	71.88
				0.0078	68.79
				0.0056	67.59
				0.0040	65.40
				0.0028	62.63
				0.0020	59.01
				0.0012	53.61

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

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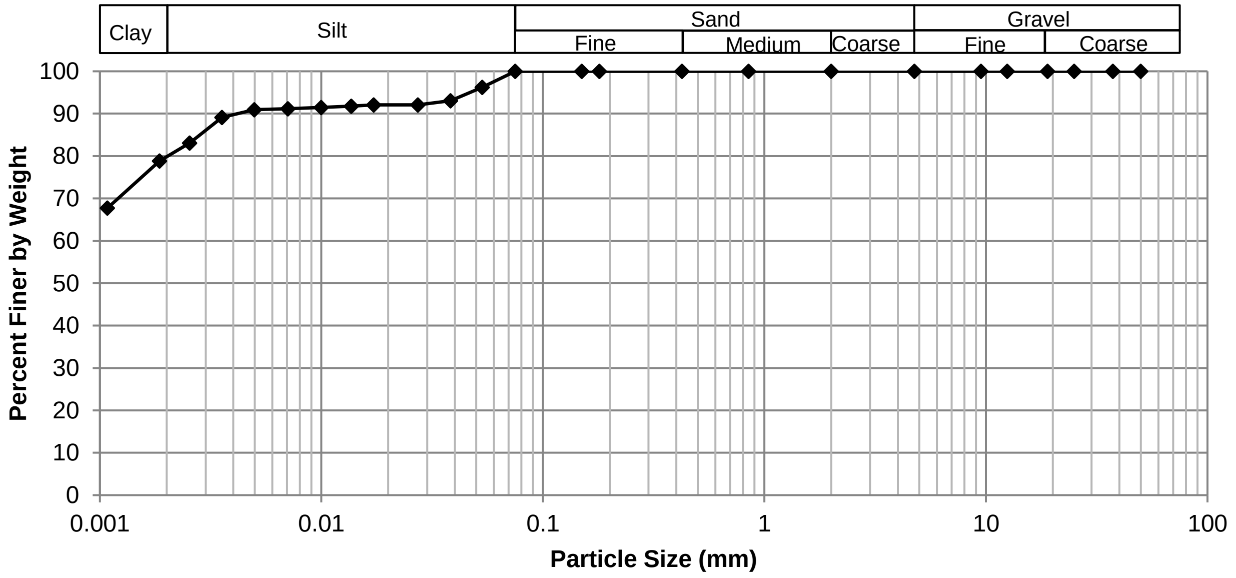
Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-06
Sample #	T46
Depth (m)	4.6 - 5.2
Sample Date	26-Oct-22
Test Date	9-Dec-22
Technician	DS

Gravel	0.0%
Sand	0.0%
Silt	20.3%
Clay	79.7%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	100.00
37.5	100.00	2.00	100.00	0.0533	96.21
25.0	100.00	0.850	100.00	0.0383	93.09
19.0	100.00	0.425	100.00	0.0272	92.11
12.5	100.00	0.180	100.00	0.0172	92.11
9.50	100.00	0.150	100.00	0.0136	91.79
4.75	100.00	0.075	100.00	0.0100	91.48
				0.0071	91.17
				0.0050	90.98
				0.0036	89.10
				0.0025	83.08
				0.0019	78.83
				0.0011	67.73

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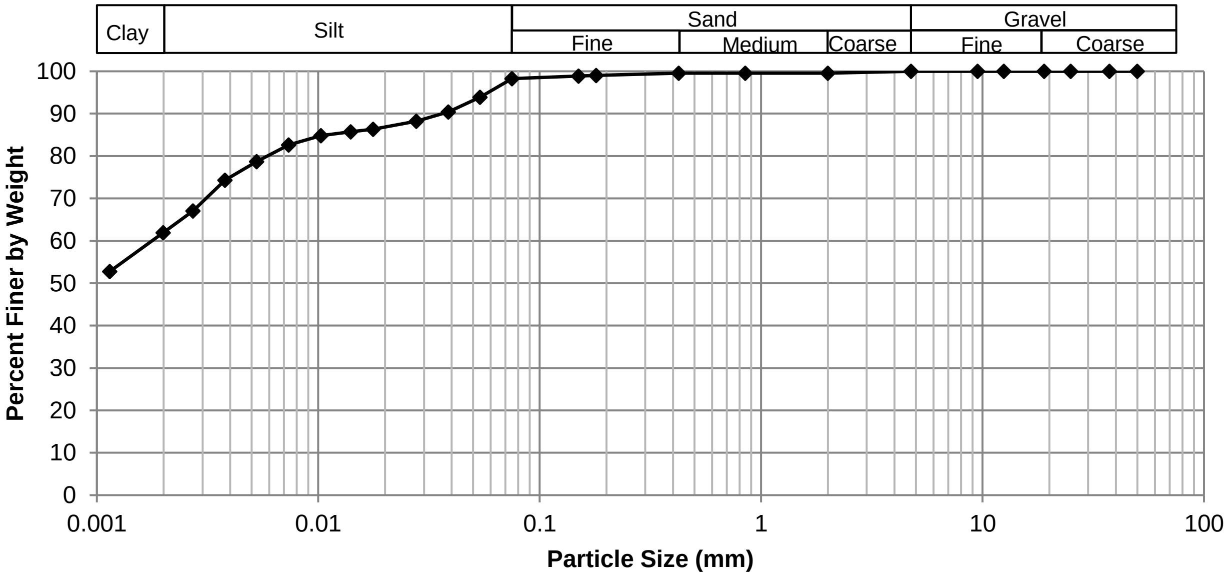
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Test Hole TH22-06
Sample # T49
Depth (m) 7.6 - 8.2
Sample Date 26-Oct-22
Test Date 9-Dec-22
Technician DS

Gravel	0.0%
Sand	1.7%
Silt	36.3%
Clay	62.0%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	98.29
37.5	100.00	2.00	99.59	0.0538	93.88
25.0	100.00	0.850	99.59	0.0387	90.45
19.0	100.00	0.425	99.59	0.0277	88.24
12.5	100.00	0.180	99.01	0.0177	86.37
9.50	100.00	0.150	98.88	0.0140	85.75
4.75	100.00	0.075	98.29	0.0103	84.81
				0.0073	82.63
				0.0053	78.69
				0.0038	74.33
				0.0027	67.10
				0.0020	61.90
				0.0011	52.78

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T06
Depth (m)	3.0 - 3.7
Sample Date	25-Oct-22
Test Date	25-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 585

Bottom - 3.7 m	3.48 m	3.38 m	3.22 m **Top - 3.1 m**
Keep UTC	Bulk	Moisture Content PP/TV Visual Atterberg	Toss
225 mm	100 mm	160 mm	100 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<10 mm diam.)	
trace gravel (<10 mm diam.)	
trace precipitates (sulphates, <10 mm diam.)	
trace organics	
Color	brownish grey
Moisture	moist
Consistency	very stiff
Plasticity	high plasticity
Structure	laminated, silt and clay (<6 mm thick)
Gradation	-

Torvane

Reading	0.42
Vane Size (s,m,l)	s
Undrained Shear Strength (kPa)	103.0

Pocket Penetrometer

Reading	**1**	3.50
	2	3.60
	3	3.90
	Average	3.67
Undrained Shear Strength (kPa)		179.8

Moisture Content

Tare ID	W14
Mass tare (g)	8.8
Mass wet + tare (g)	416
Mass dry + tare (g)	293.5
Moisture %	43.0%

Unit Weight

Bulk Weight (g)		699.2
Length (mm)	**1**	94.43
	2	94.39
	3	94.38
	4	93.41
Average Length (m)		0.094
Diam. (mm)	**1**	73.03
	2	73.01
	3	72.84
	4	73.45
Average Diameter (m)		0.073
Volume (m^3)		3.95E-04
Bulk Unit Weight (kN/m^3)		17.4
Bulk Unit Weight (pcf)		110.5
Dry Unit Weight (kN/m^3)		12.1
Dry Unit Weight (pcf)		77.3

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Unconfined Compressive Strength

ASTM D2166

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Test Hole	TH22-01
Sample #	T06
Depth (m)	3.0 - 3.7
Sample Date	25-Oct-22
Test Date	25-Nov-22
Technician	JC

Unconfined Strength

	kPa	ksf
Max q_u	286.8	6.0
Max S_u	143.4	3.0

Specimen Data

Description CLAY - silty, trace silt inclusions (<10 mm diam.), trace gravel (<10 mm diam.), trace precipitates (sulphates, <10 mm diam.), trace organics, brownish grey, moist, very stiff, high plasticity , laminated, silt and clay (<6 mm thick)

Length	94.2	(mm)	**Moisture %**	43%	
Diameter	73.1	(mm)	**Bulk Unit Wt.**	17.4	(kN/m^3)
L/D Ratio	1.3		**Dry Unit Wt.**	12.1	(kN/m^3)
Initial Area	0.00419	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.42	103.0	2.15

Vane Size

s

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	3.50	171.7	3.59
	3.60	176.6	3.69
	3.90	191.3	4.00
Average	**3.67**	**179.9**	**3.76**

Failure Geometry

Sketch:

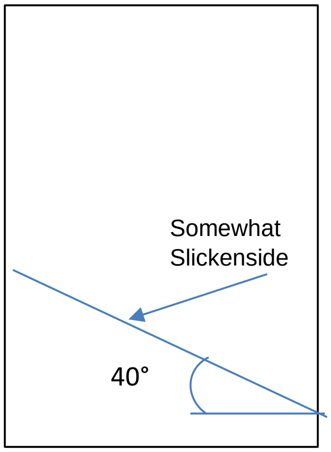


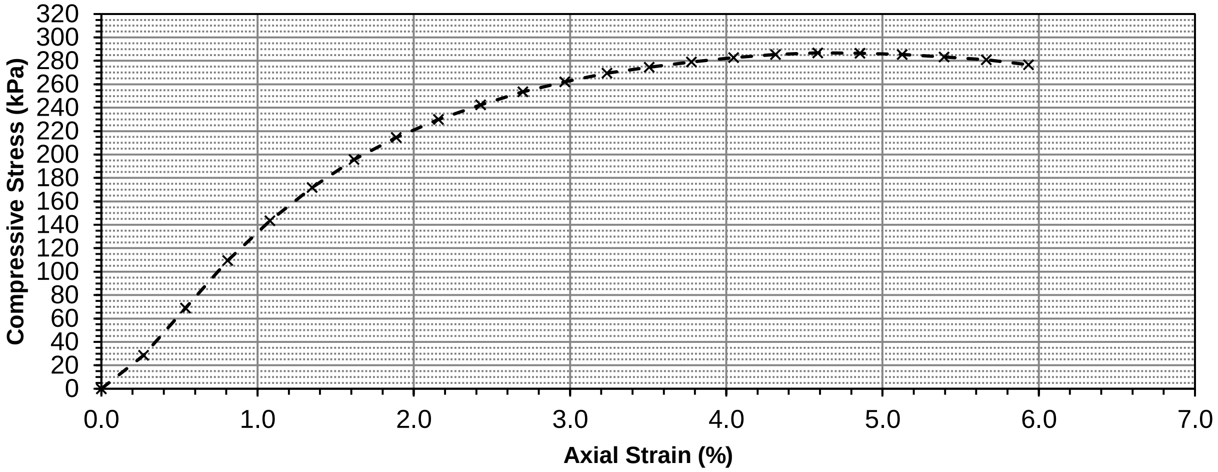
Photo:

Unconfined Compressive Strength

ASTM D2166

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.37	0.0000	0.00	0.004195	0.0	0.00	0.00
10	2.76	0.2540	0.27	0.004206	120.5	28.64	14.32
20	6.14	0.5080	0.54	0.004218	290.8	68.96	34.48
30	9.56	0.7620	0.81	0.004229	463.2	109.53	54.76
40	12.43	1.0160	1.08	0.004241	607.9	143.34	71.67
50	14.86	1.2700	1.35	0.004252	730.3	171.76	85.88
60	16.92	1.5240	1.62	0.004264	834.2	195.64	97.82
70	18.57	1.7780	1.89	0.004276	917.3	214.55	107.28
80	19.94	2.0320	2.16	0.004287	986.4	230.07	115.03
90	21.04	2.2860	2.43	0.004299	1041.8	242.33	121.16
100	22.07	2.5400	2.70	0.004311	1093.7	253.70	126.85
110	22.86	2.7940	2.97	0.004323	1133.6	262.21	131.10
120	23.54	3.0480	3.24	0.004335	1167.8	269.39	134.69
130	24.04	3.3020	3.51	0.004347	1193.0	274.43	137.22
140	24.51	3.5560	3.78	0.004360	1216.7	279.10	139.55
150	24.90	3.8100	4.05	0.004372	1236.4	282.81	141.41
160	25.20	4.0640	4.32	0.004384	1251.5	285.47	142.73
170	25.39	4.3180	4.59	0.004396	1261.1	286.84	143.42
180	25.44	4.5720	4.86	0.004409	1263.6	286.60	143.30
190	25.40	4.8260	5.13	0.004421	1261.6	285.33	142.67
200	25.30	5.0800	5.40	0.004434	1256.5	283.38	141.69
210	25.16	5.3340	5.67	0.004447	1249.5	280.99	140.49
220	24.84	5.5880	5.94	0.004460	1233.4	276.57	138.28

Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T09
Depth (m)	6.1 - 6.7
Sample Date	25-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 665 (overpush)

Bottom - 6.7 m	6.60 m	6.44 m	6.23 m	6.09 m **Top - 6 m**
Toss	Bulk UTC	Moisture Content PP/TV Visual	Keep	Toss
105 mm	160 mm	190 mm	160 mm	50 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<10 mm diam.)	
trace organics	
trace oxidation	
Color	mottled brown and grey
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.75
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	73.6

Pocket Penetrometer

Reading	**1**	1.70
	2	1.60
	3	1.80
	Average	1.70
Undrained Shear Strength (kPa)		83.4

Moisture Content

Tare ID	N59
Mass tare (g)	8.4
Mass wet + tare (g)	404.4
Mass dry + tare (g)	281.2
Moisture %	45.2%

Unit Weight

Bulk Weight (g)		1080.2
Length (mm)	**1**	150.64
	2	150.87
	3	150.69
	4	150.43
Average Length (m)		0.151
Diam. (mm)	**1**	72.09
	2	71.94
	3	72.75
	4	71.82
Average Diameter (m)		0.072
Volume (m^3)		6.16E-04
Bulk Unit Weight (kN/m^3)		17.2
Bulk Unit Weight (pcf)		109.5
Dry Unit Weight (kN/m^3)		11.8
Dry Unit Weight (pcf)		75.4

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Unconfined Compressive Strength

ASTM D2166

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Test Hole TH22-01
Sample # T09
Depth (m) 6.1 - 6.7
Sample Date 25-Oct-22
Test Date 24-Nov-22
Technician JC

Unconfined Strength

	kPa	ksf
Max q_u	132.2	2.8
Max S_u	66.1	1.4

Specimen Data

Description CLAY - silty, trace silt inclusions (<10 mm diam.), trace organics, trace oxidation, mottled brown and grey , moist, stiff, high plasticity

Length	150.7	(mm)	**Moisture %**	45%	
Diameter	72.2	(mm)	**Bulk Unit Wt.**	17.2	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	11.8	(kN/m^3)
Initial Area	0.00409	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

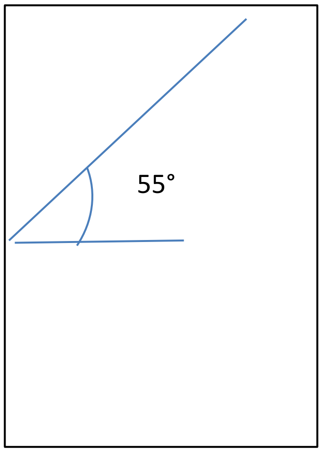
Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.75	73.6	1.54
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	1.70	83.4	1.74
	1.60	78.5	1.64
	1.80	88.3	1.84
Average	**1.70**	**83.4**	**1.74**

Failure Geometry

Sketch:



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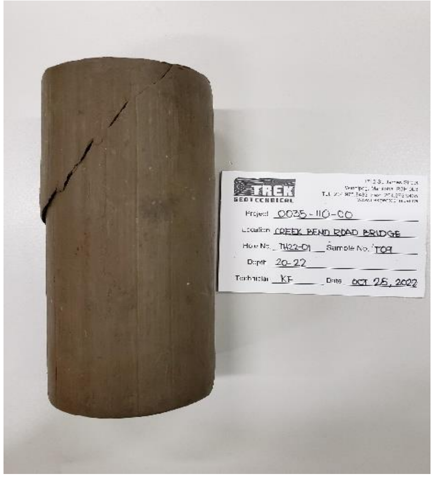
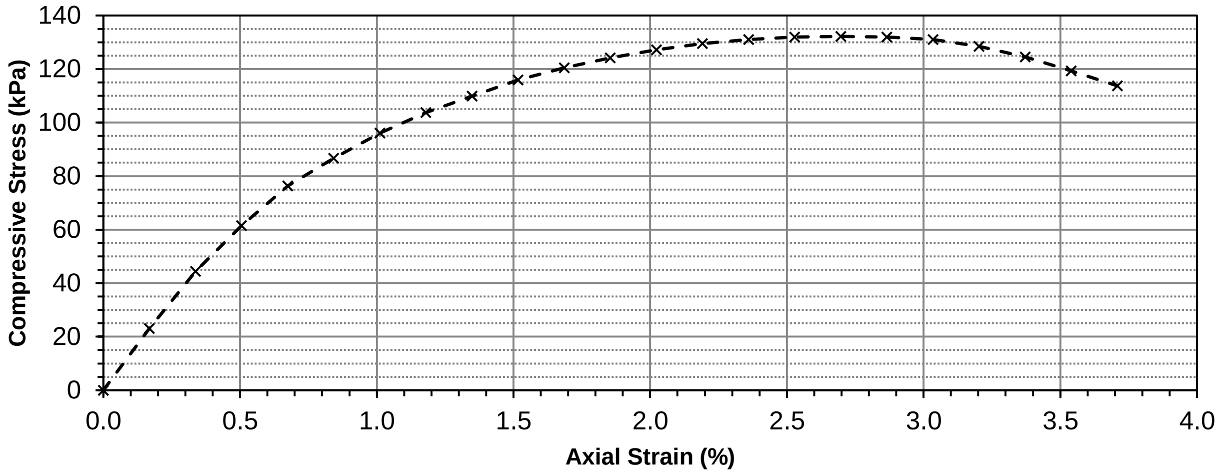


Unconfined Compressive Strength

ASTM D2166

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.43	0.0000	0.00	0.004088	0.0	0.00	0.00
10	2.30	0.2540	0.17	0.004095	94.3	23.01	11.51
20	4.05	0.5080	0.34	0.004102	182.5	44.48	22.24
30	5.44	0.7620	0.51	0.004109	252.5	61.45	30.73
40	6.67	1.0160	0.67	0.004116	314.5	76.41	38.20
50	7.52	1.2700	0.84	0.004123	357.4	86.67	43.33
60	8.30	1.5240	1.01	0.004130	396.7	96.04	48.02
70	8.95	1.7780	1.18	0.004137	429.4	103.80	51.90
80	9.47	2.0320	1.35	0.004144	455.6	109.94	54.97
90	9.98	2.2860	1.52	0.004151	481.3	115.95	57.97
100	10.37	2.5400	1.69	0.004159	501.0	120.47	60.24
110	10.69	2.7940	1.85	0.004166	517.1	124.14	62.07
120	10.96	3.0480	2.02	0.004173	530.7	127.19	63.59
130	11.17	3.3020	2.19	0.004180	541.3	129.50	64.75
140	11.32	3.5560	2.36	0.004187	548.9	131.08	65.54
150	11.41	3.8100	2.53	0.004195	553.4	131.94	65.97
160	11.45	4.0640	2.70	0.004202	555.4	132.19	66.10
170	11.45	4.3180	2.87	0.004209	555.4	131.96	65.98
180	11.39	4.5720	3.03	0.004216	552.4	131.01	65.51
190	11.20	4.8260	3.20	0.004224	542.8	128.52	64.26
200	10.88	5.0800	3.37	0.004231	526.7	124.48	62.24
210	10.46	5.3340	3.54	0.004239	505.5	119.27	59.64
220	10.01	5.5880	3.71	0.004246	482.9	113.72	56.86

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T12
Depth (m)	9.1 - 9.8
Sample Date	25-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 640 (overpush)

Bottom - 9.8 m	9.70 m	9.58 m	9.42 m	9.25 m **Top - 9.1 m**
Toss	Moisture Content PP/TV Visual	Bulk	Keep UTC	Toss
100 mm	120 mm	160 mm	170 mm	90 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<45 mm diam.)	
trace gravel (<5 mm diam.)	
Color	brownish grey
Moisture	moist
Consistency	firm to stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.40
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	39.2

Pocket Penetrometer

Reading	**1**	1.10
	2	1.00
	3	1.10
	Average	1.07
Undrained Shear Strength (kPa)		52.3

Moisture Content

Tare ID	AC39
Mass tare (g)	6.8
Mass wet + tare (g)	370.5
Mass dry + tare (g)	251.2
Moisture %	48.8%

Unit Weight

Bulk Weight (g)		1089.9
Length (mm)	**1**	150.69
	2	150.65
	3	150.63
	4	150.70
Average Length (m)		0.151
Diam. (mm)	**1**	73.17
	2	71.71
	3	72.72
	4	73.14
Average Diameter (m)		0.073
Volume (m^3)		6.25E-04
Bulk Unit Weight (kN/m^3)		17.1
Bulk Unit Weight (pcf)		108.8
Dry Unit Weight (kN/m^3)		11.5
Dry Unit Weight (pcf)		73.1

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Unconfined Compressive Strength

ASTM D2166

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Test Hole	TH22-01
Sample #	T12
Depth (m)	9.1 - 9.8
Sample Date	25-Oct-22
Test Date	24-Nov-22
Technician	JC

Unconfined Strength

	kPa	**ksf**
Max q_u	143.5	3.0
Max S_u	71.7	1.5

Specimen Data

Description CLAY - silty, trace silt inclusions (<45 mm diam.), trace gravel (<5 mm diam.), brownish grey, moist, firm to stiff, high plasticity

Length	150.7	(mm)
Diameter	72.7	(mm)
L/D Ratio	2.1	
Initial Area	0.00415	(m^2)
Load Rate	1.00	(%/min)

Moisture %	49%	
Bulk Unit Wt.	17.1	(kN/m^3)
Dry Unit Wt.	11.5	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

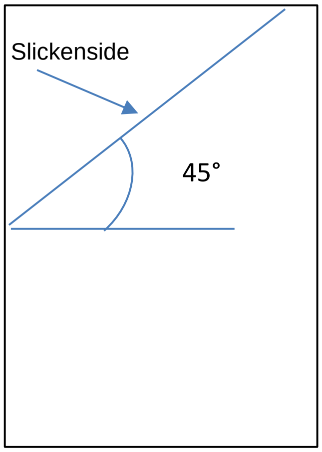
Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.40	39.2	0.82
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	1.10	54.0	1.13
	1.00	49.1	1.02
	1.10	54.0	1.13
Average	**1.07**	**52.3**	**1.09**

Failure Geometry

Sketch:



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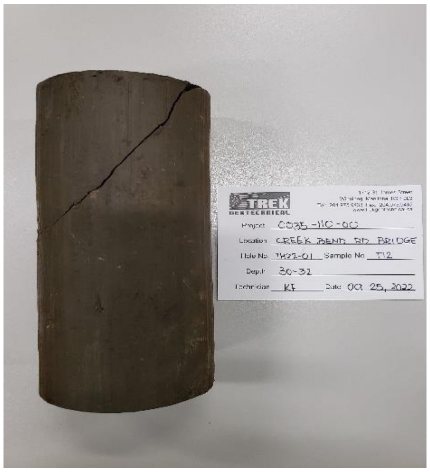
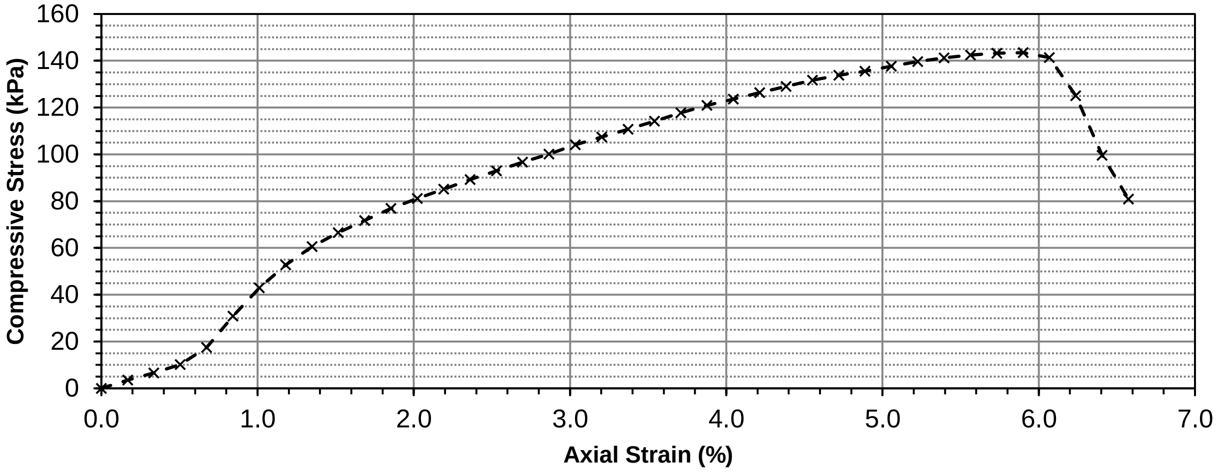


Project 0035-110-00
Location CREEK BEND RD BRIDGE
Hole No. TH22-01 Sample No. T12
Depth 30-32
Technician KF Date OCT 25, 2022

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.40	0.0000	0.00	0.004149	0.0	0.00	0.00
10	0.69	0.2540	0.17	0.004156	14.6	3.52	1.76
20	0.94	0.5080	0.34	0.004163	27.2	6.54	3.27
30	1.24	0.7620	0.51	0.004170	42.3	10.15	5.08
40	1.85	1.0160	0.67	0.004178	73.1	17.49	8.75
50	2.96	1.2700	0.84	0.004185	129.0	30.83	15.42
60	3.97	1.5240	1.01	0.004192	179.9	42.93	21.46
70	4.79	1.7780	1.18	0.004199	221.3	52.70	26.35
80	5.46	2.0320	1.35	0.004206	255.0	60.64	30.32
90	5.96	2.2860	1.52	0.004213	280.2	66.51	33.26
100	6.41	2.5400	1.69	0.004220	302.9	71.77	35.89
110	6.85	2.7940	1.85	0.004228	325.1	76.90	38.45
120	7.22	3.0480	2.02	0.004235	343.7	81.17	40.58
130	7.57	3.3020	2.19	0.004242	361.4	85.19	42.59
140	7.93	3.5560	2.36	0.004250	379.5	89.31	44.65
150	8.25	3.8100	2.53	0.004257	395.7	92.94	46.47
160	8.58	4.0640	2.70	0.004264	412.3	96.68	48.34
170	8.89	4.3180	2.87	0.004272	427.9	100.17	50.09
180	9.24	4.5720	3.03	0.004279	445.6	104.12	52.06
190	9.54	4.8260	3.20	0.004287	460.7	107.47	53.73
200	9.83	5.0800	3.37	0.004294	475.3	110.69	55.34
210	10.14	5.3340	3.54	0.004302	490.9	114.13	57.06
220	10.47	5.5880	3.71	0.004309	507.6	117.79	58.89
230	10.76	5.8420	3.88	0.004317	522.2	120.97	60.48

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	11.00	6.0960	4.05	0.004324	534.3	123.55	61.78
250	11.26	6.3500	4.21	0.004332	547.4	126.36	63.18
260	11.51	6.6040	4.38	0.004340	560.0	129.04	64.52
270	11.76	6.8580	4.55	0.004347	572.6	131.71	65.86
280	11.96	7.1120	4.72	0.004355	582.7	133.79	66.90
290	12.13	7.3660	4.89	0.004363	591.2	135.52	67.76
300	12.34	7.6200	5.06	0.004370	601.8	137.70	68.85
310	12.53	7.8740	5.23	0.004378	611.4	139.65	69.82
320	12.69	8.1280	5.39	0.004386	619.5	141.24	70.62
330	12.82	8.3820	5.56	0.004394	626.0	142.48	71.24
340	12.91	8.6360	5.73	0.004402	630.5	143.25	71.63
350	12.95	8.8900	5.90	0.004410	632.6	143.45	71.73
360	12.79	9.1440	6.07	0.004417	624.5	141.37	70.68
370	11.38	9.3980	6.24	0.004425	553.4	125.06	62.53
380	9.16	9.6520	6.41	0.004433	441.5	99.59	49.80
390	7.53	9.9060	6.57	0.004441	359.4	80.92	40.46

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-01
Sample #	T15
Depth (m)	12.2 - 12.8
Sample Date	25-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 605

Bottom - 12.8 m	12.63 m	12.47 m	12.31 m **Top - 12.2 m**
Moisture Content PP/TV Visual Atterberg	Bulk	Keep UCT	Toss
170 mm	160 mm	160 mm	115 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<20 mm diam.)	
trace gravel (<10 mm diam.)	
Color	grey
Moisture	moist
Consistency	firm to stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.38
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	37.3

Pocket Penetrometer

Reading	**1**	1.00
	2	1.00
	3	1.10
	Average	1.03
Undrained Shear Strength (kPa)		50.7

Moisture Content

Tare ID	W26
Mass tare (g)	8.6
Mass wet + tare (g)	438.2
Mass dry + tare (g)	285.4
Moisture %	55.2%

Unit Weight

Bulk Weight (g)		1044.8
Length (mm)	**1**	151.97
	2	152.18
	3	152.02
	4	152.32
Average Length (m)		0.152
Diam. (mm)	**1**	71.64
	2	71.25
	3	72.08
	4	72.30
Average Diameter (m)		0.072
Volume (m^3)		6.16E-04
Bulk Unit Weight (kN/m^3)		16.6
Bulk Unit Weight (pcf)		105.8
Dry Unit Weight (kN/m^3)		10.7
Dry Unit Weight (pcf)		68.2

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Unconfined Compressive Strength

ASTM D2166

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Test Hole	TH22-01
Sample #	T15
Depth (m)	12.2 - 12.8
Sample Date	25-Oct-22
Test Date	24-Nov-22
Technician	JC

Unconfined Strength

	kPa	**ksf**
Max q_u	123.5	2.6
Max S_u	61.8	1.3

Specimen Data

Description CLAY - silty, trace silt inclusions (<20 mm diam.), trace gravel (<10 mm diam.), grey, moist, firm to stiff, high plasticity

Length	152.1	(mm)
Diameter	71.8	(mm)
L/D Ratio	2.1	
Initial Area	0.00405	(m^2)
Load Rate	1.00	(%/min)

Moisture %	55%	
Bulk Unit Wt.	16.6	(kN/m^3)
Dry Unit Wt.	10.7	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.38	37.3	0.78
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	1.00	49.1	1.02
	1.00	49.1	1.02
	1.10	54.0	1.13
Average	**1.03**	**50.7**	**1.06**

Failure Geometry

Sketch:

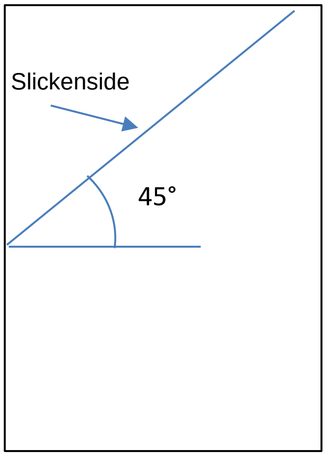
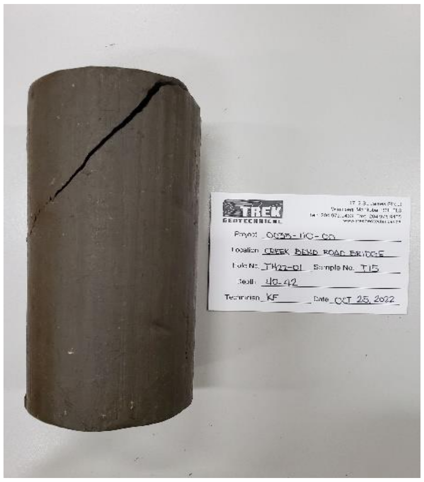


Photo:

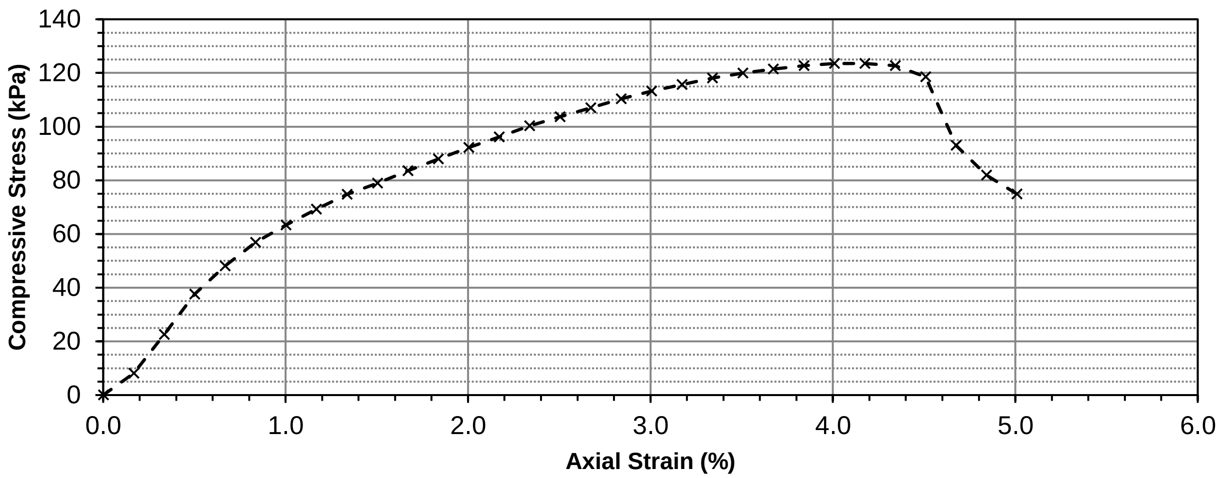


Unconfined Compressive Strength

ASTM D2166

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.36	0.0000	0.00	0.004051	0.0	0.00	0.00
10	1.01	0.2540	0.17	0.004058	32.8	8.07	4.04
20	2.18	0.5080	0.33	0.004064	91.7	22.57	11.28
30	3.39	0.7620	0.50	0.004071	152.7	37.51	18.76
40	4.25	1.0160	0.67	0.004078	196.1	48.08	24.04
50	4.97	1.2700	0.83	0.004085	232.4	56.88	28.44
60	5.50	1.5240	1.00	0.004092	259.1	63.31	31.66
70	5.99	1.7780	1.17	0.004099	283.8	69.23	34.62
80	6.45	2.0320	1.34	0.004106	307.0	74.76	37.38
90	6.80	2.2860	1.50	0.004113	324.6	78.93	39.46
100	7.19	2.5400	1.67	0.004120	344.3	83.56	41.78
110	7.56	2.7940	1.84	0.004127	362.9	87.94	43.97
120	7.92	3.0480	2.00	0.004134	381.0	92.18	46.09
130	8.26	3.3020	2.17	0.004141	398.2	96.16	48.08
140	8.61	3.5560	2.34	0.004148	415.8	100.25	50.13
150	8.90	3.8100	2.50	0.004155	430.4	103.60	51.80
160	9.20	4.0640	2.67	0.004162	445.6	107.05	53.53
170	9.49	4.3180	2.84	0.004169	460.2	110.38	55.19
180	9.74	4.5720	3.01	0.004176	472.8	113.20	56.60
190	9.96	4.8260	3.17	0.004184	483.9	115.66	57.83
200	10.18	5.0800	3.34	0.004191	495.0	118.10	59.05
210	10.35	5.3340	3.51	0.004198	503.5	119.94	59.97
220	10.49	5.5880	3.67	0.004205	510.6	121.41	60.71
230	10.62	5.8420	3.84	0.004213	517.1	122.76	61.38

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	10.70	6.0960	4.01	0.004220	521.2	123.50	61.75
250	10.72	6.3500	4.17	0.004227	522.2	123.52	61.76
260	10.67	6.6040	4.34	0.004235	519.7	122.71	61.36
270	10.34	6.8580	4.51	0.004242	503.0	118.58	59.29
280	8.20	7.1120	4.68	0.004250	395.2	92.99	46.49
290	7.28	7.3660	4.84	0.004257	348.8	81.93	40.97
300	6.70	7.6200	5.01	0.004265	319.6	74.93	37.47

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Shelby Tube Visual

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge
Test Hole	TH22-06
Sample #	T49
Depth (m)	7.6 - 8.2
Sample Date	26-Oct-22
Test Date	24-Nov-22
Technician	JC

Tube Extraction

Recovery (mm) 660 (overpush)

Bottom - 8.2 m | 8.05 m | 7.90 m | 7.74 m | 7.57 m | **Top - 7.6 m**

Toss	Moisture Content PP/TV Visual Atterberg	Bulk	Keep UTC	Toss
155 mm	150 mm	155 mm	170 mm	30 mm

Visual Classification

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

Torvane

Reading	0.47
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	46.1

Pocket Penetrometer

Reading	**1**	1.00
	2	1.00
	3	0.90
	Average	0.97
Undrained Shear Strength (kPa)		47.4

Moisture Content

Tare ID	P04
Mass tare (g)	8.8
Mass wet + tare (g)	395.4
Mass dry + tare (g)	257.6
Moisture %	55.4%

Unit Weight

Bulk Weight (g)		1075.2
Length (mm)	**1**	148.90
	2	148.70
	3	149.09
	4	149.01
Average Length (m)		0.149
Diam. (mm)	**1**	72.53
	2	72.40
	3	72.41
	4	73.87
Average Diameter (m)		0.073
Volume (m^3)		6.20E-04
Bulk Unit Weight (kN/m^3)		17.0
Bulk Unit Weight (pcf)		108.3
Dry Unit Weight (kN/m^3)		10.9
Dry Unit Weight (pcf)		69.7

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Test Hole	TH22-06
Sample #	T49
Depth (m)	7.6 - 8.2
Sample Date	26-Oct-22
Test Date	24-Nov-22
Technician	JC

Unconfined Strength

	kPa	ksf
Max q_u	91.5	1.9
Max S_u	45.8	1.0

Specimen Data

Description CLAY - silty, trace silt inclusions (<10 mm diam.), trace gravel (<10 mm diam.), trace oxidation, grey, moist, firm, high plasticity

Length	148.9	(mm)	**Moisture %**	55%	
Diameter	72.8	(mm)	**Bulk Unit Wt.**	17.0	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	10.9	(kN/m^3)
Initial Area	0.00416	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.47	46.1	0.96
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	1.00	49.1	1.02
	1.00	49.1	1.02
	0.90	44.1	0.92
Average	**0.97**	**47.4**	**0.99**

Failure Geometry

Sketch:

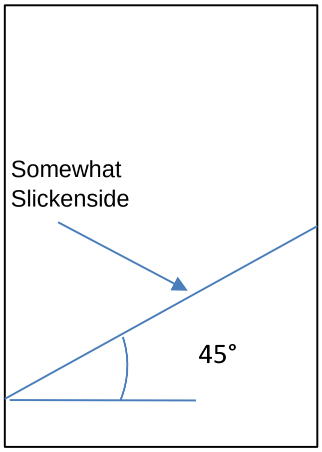


Photo:

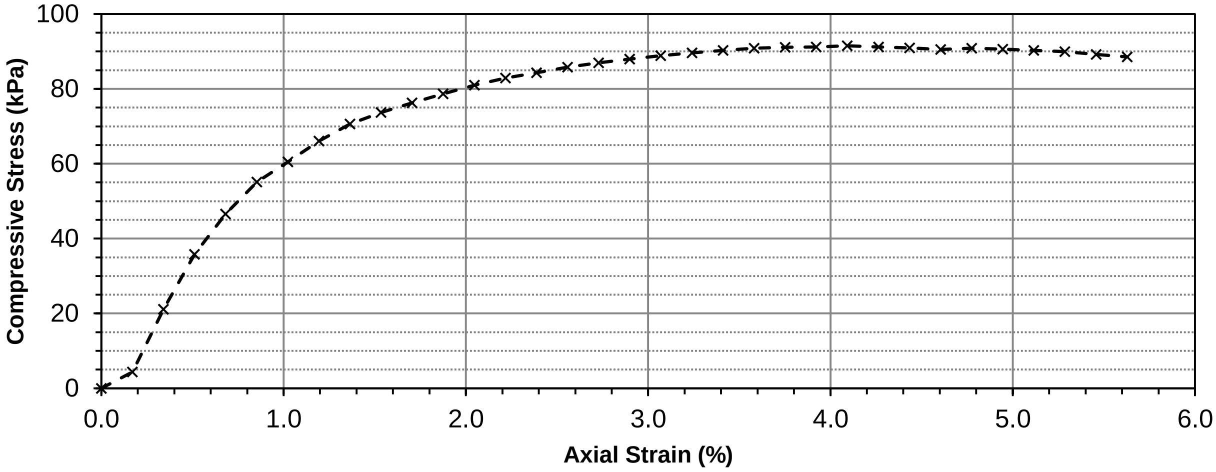
Project 0035-110-00
Location CREEK BEND BRIDGE
Hole No. TH22-06 Sample No. T49
Depth 25-27
Technician KF Date OCT 26, 2022

Unconfined Compressive Strength

ASTM D2166

Project No.	0035-110-00
Client	Morrison Hershfield
Project	Creek Bend Road Bridge

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.37	0.0000	0.00	0.004163	0.0	0.00	0.00
10	0.73	0.2540	0.17	0.004170	18.1	4.35	2.18
20	2.12	0.5080	0.34	0.004177	88.2	21.12	10.56
30	3.34	0.7620	0.51	0.004184	149.7	35.78	17.89
40	4.24	1.0160	0.68	0.004191	195.1	46.54	23.27
50	4.96	1.2700	0.85	0.004199	231.3	55.10	27.55
60	5.42	1.5240	1.02	0.004206	254.5	60.52	30.26
70	5.89	1.7780	1.19	0.004213	278.2	66.04	33.02
80	6.28	2.0320	1.36	0.004220	297.9	70.58	35.29
90	6.55	2.2860	1.54	0.004228	311.5	73.68	36.84
100	6.78	2.5400	1.71	0.004235	323.1	76.29	38.14
110	6.99	2.7940	1.88	0.004242	333.7	78.65	39.33
120	7.20	3.0480	2.05	0.004250	344.3	81.01	40.50
130	7.37	3.3020	2.22	0.004257	352.8	82.88	41.44
140	7.50	3.5560	2.39	0.004265	359.4	84.27	42.13
150	7.64	3.8100	2.56	0.004272	366.4	85.77	42.89
160	7.75	4.0640	2.73	0.004280	372.0	86.92	43.46
170	7.85	4.3180	2.90	0.004287	377.0	87.94	43.97
180	7.94	4.5720	3.07	0.004295	381.6	88.84	44.42
190	8.02	4.8260	3.24	0.004302	385.6	89.62	44.81
200	8.09	5.0800	3.41	0.004310	389.1	90.29	45.14
210	8.15	5.3340	3.58	0.004317	392.1	90.83	45.41
220	8.19	5.5880	3.75	0.004325	394.2	91.13	45.57
230	8.21	5.8420	3.92	0.004333	395.2	91.20	45.60

Project No. 0035-110-00
Client Morrison Hershfield
Project Creek Bend Road Bridge

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	8.25	6.0960	4.09	0.004340	397.2	91.51	45.75
250	8.24	6.3500	4.26	0.004348	396.7	91.23	45.61
260	8.23	6.6040	4.43	0.004356	396.2	90.95	45.47
270	8.21	6.8580	4.61	0.004364	395.2	90.56	45.28
280	8.25	7.1120	4.78	0.004372	397.2	90.85	45.43
290	8.24	7.3660	4.95	0.004379	396.7	90.58	45.29
300	8.23	7.6200	5.12	0.004387	396.2	90.30	45.15
310	8.21	7.8740	5.29	0.004395	395.2	89.91	44.95
320	8.16	8.1280	5.46	0.004403	392.6	89.17	44.59
330	8.12	8.3820	5.63	0.004411	390.6	88.56	44.28

Appendix B

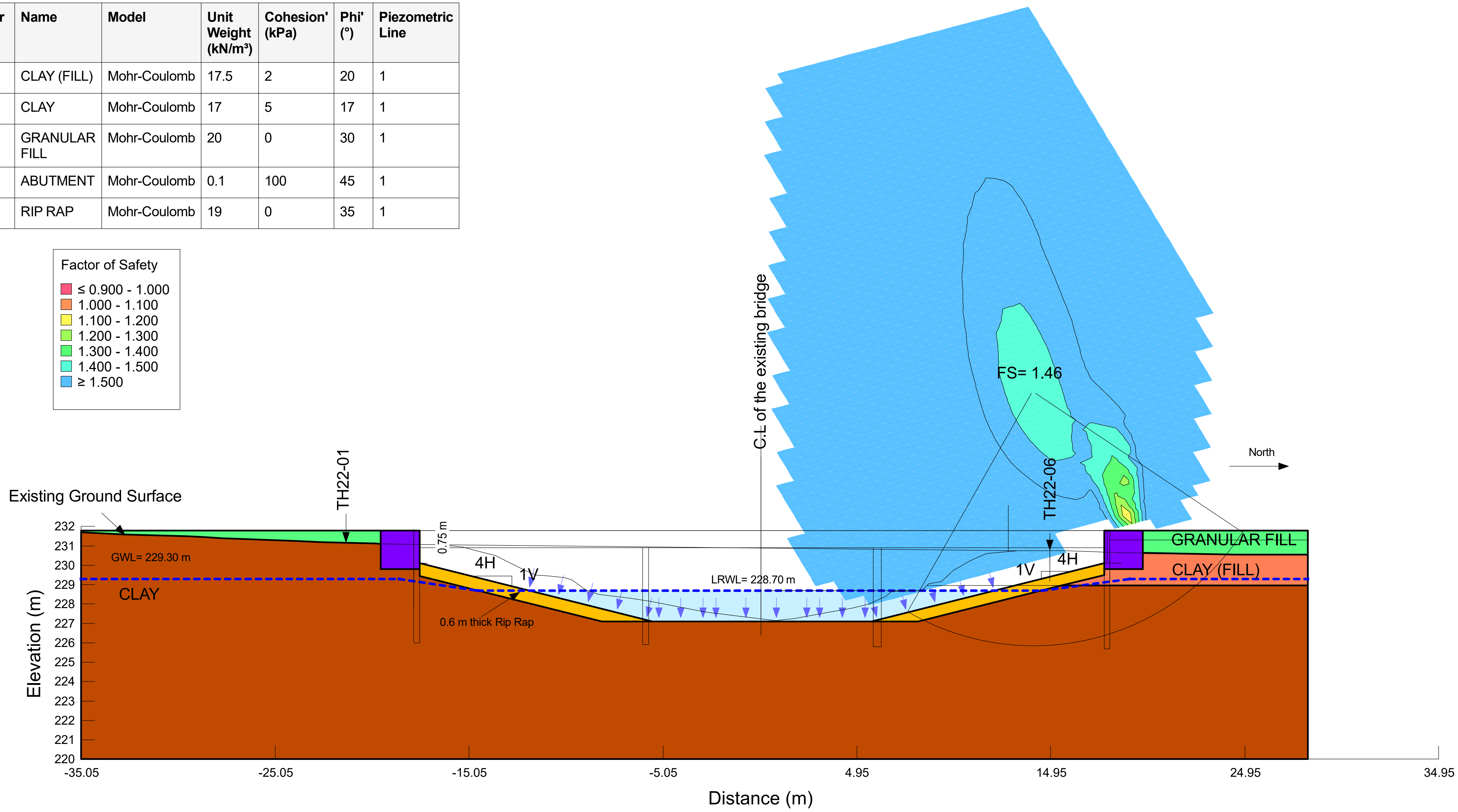
Slope Stability Outputs

Tabloid (279mm x 432mm)

SAVED: 2022-12-09 3:43:55 PM

SCALE: 1:221 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1



FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\M009 Creek Bend road (4H to1V) - Normal Conditions (reviewed MVH).gsz

Figure 1

Figure B1

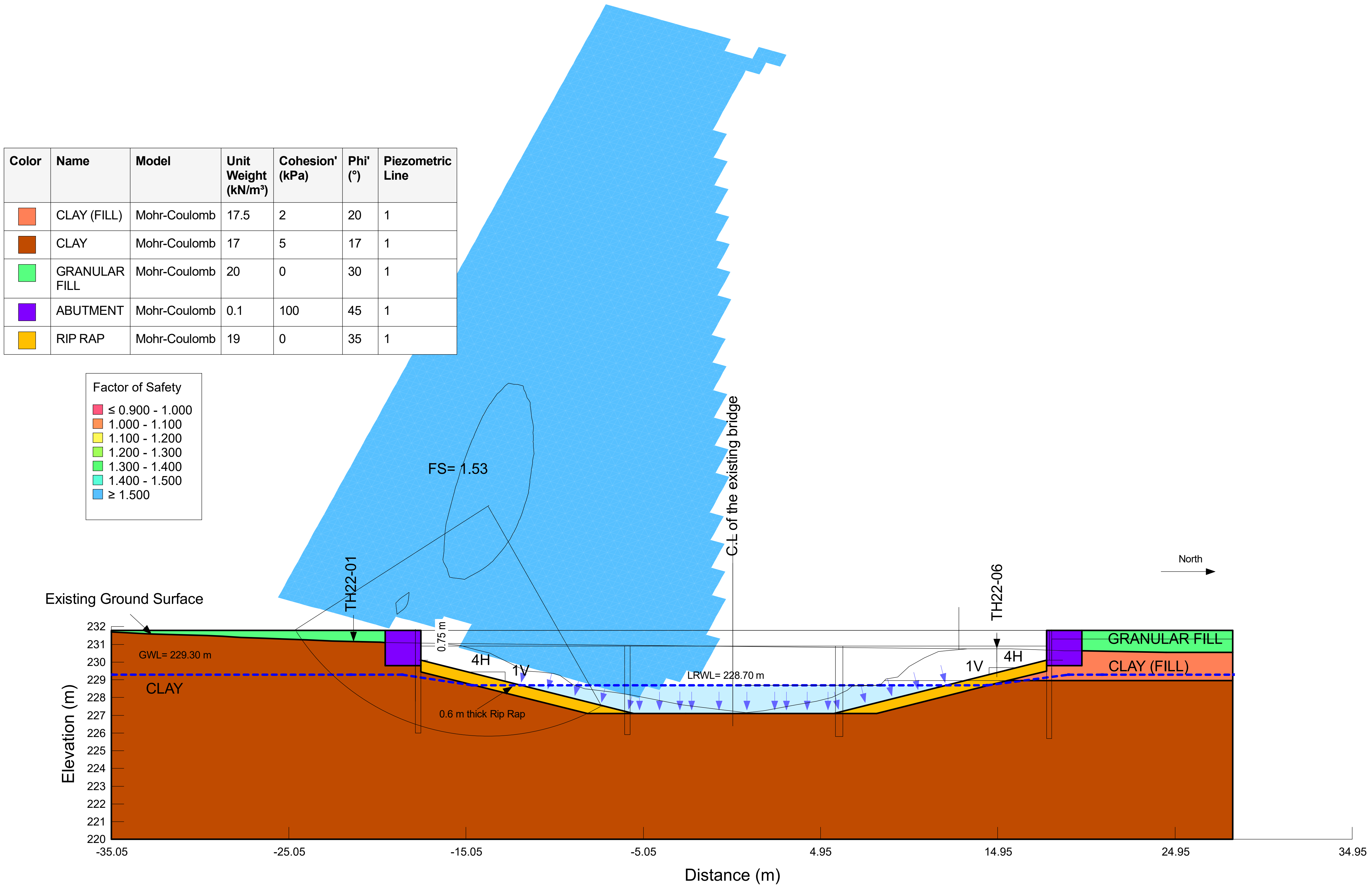
Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)
Normal Conditions

0035 110 00
Morrison Hershfield Ltd.
Creek Bend Road Bridge Replacement

Tabloid (279mm x 432mm)

SAVED: 2022-12-09 3:43:55 PM

SCALE: 1:221 (279mm x 432mm)



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

Factor of Safety

- 🟥 ≤ 0.900 - 1.000
- 🟧 1.000 - 1.100
- 🟨 1.100 - 1.200
- 🟩 1.200 - 1.300
- 🟩 1.300 - 1.400
- 🟦 1.400 - 1.500
- 🟦 ≥ 1.500

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\M009 Creek Bend road (4H to1V) - Normal Conditions (reviewed MVH).gsz

Figure B2

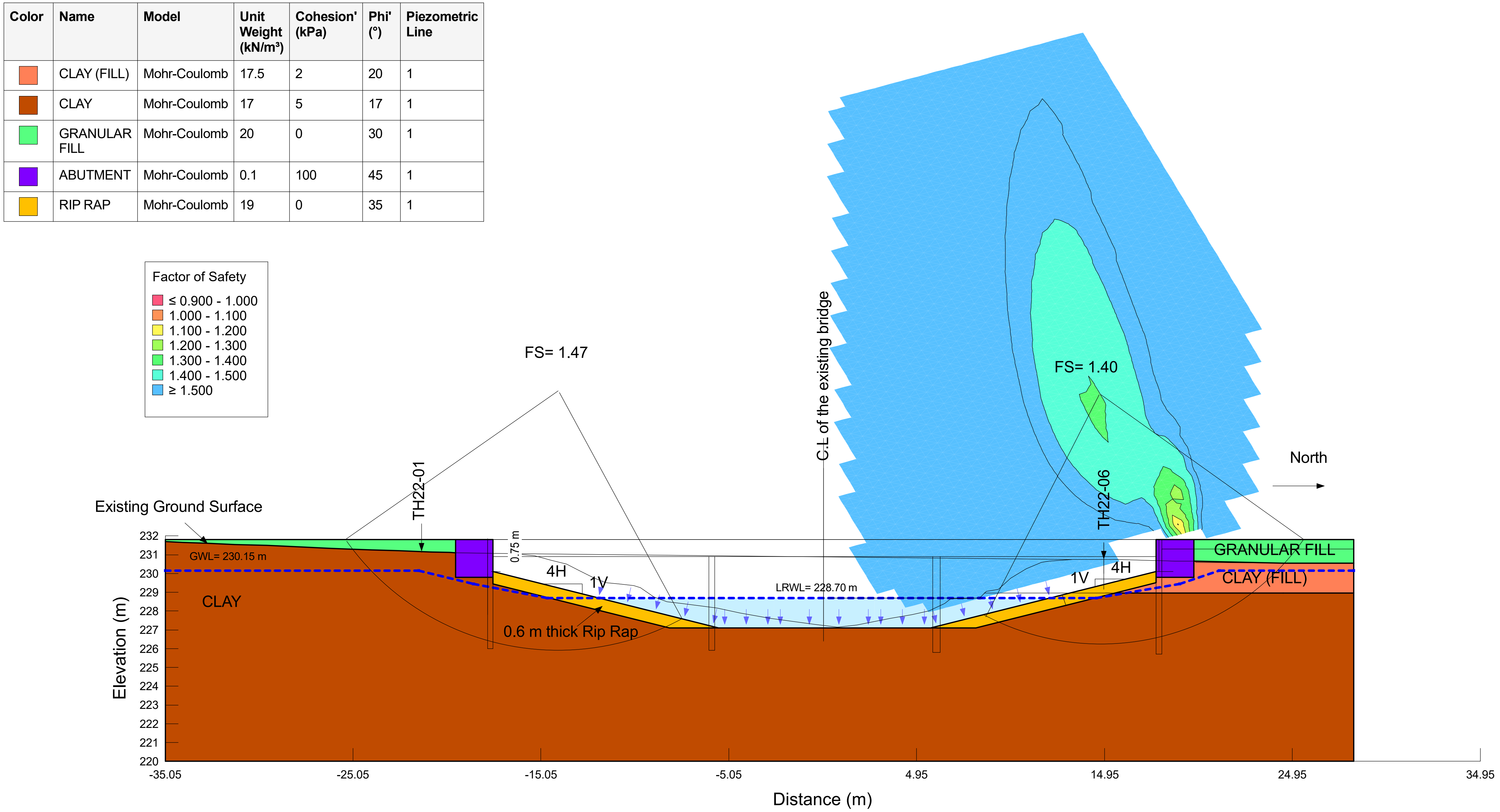
Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)
Normal conditions

0035 110 00
Morrison Hershfield Ltd.
Creek Bend Road Bridge Replacement

Tabloid (279mm x 432mm)

SAVED: 2022-12-06 10:20:36 PM

SCALE: 1:221 (279mm x 432mm)



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\M006 Creek Bend road (4H to1V) - Extreme (reviewed MVH).gsz

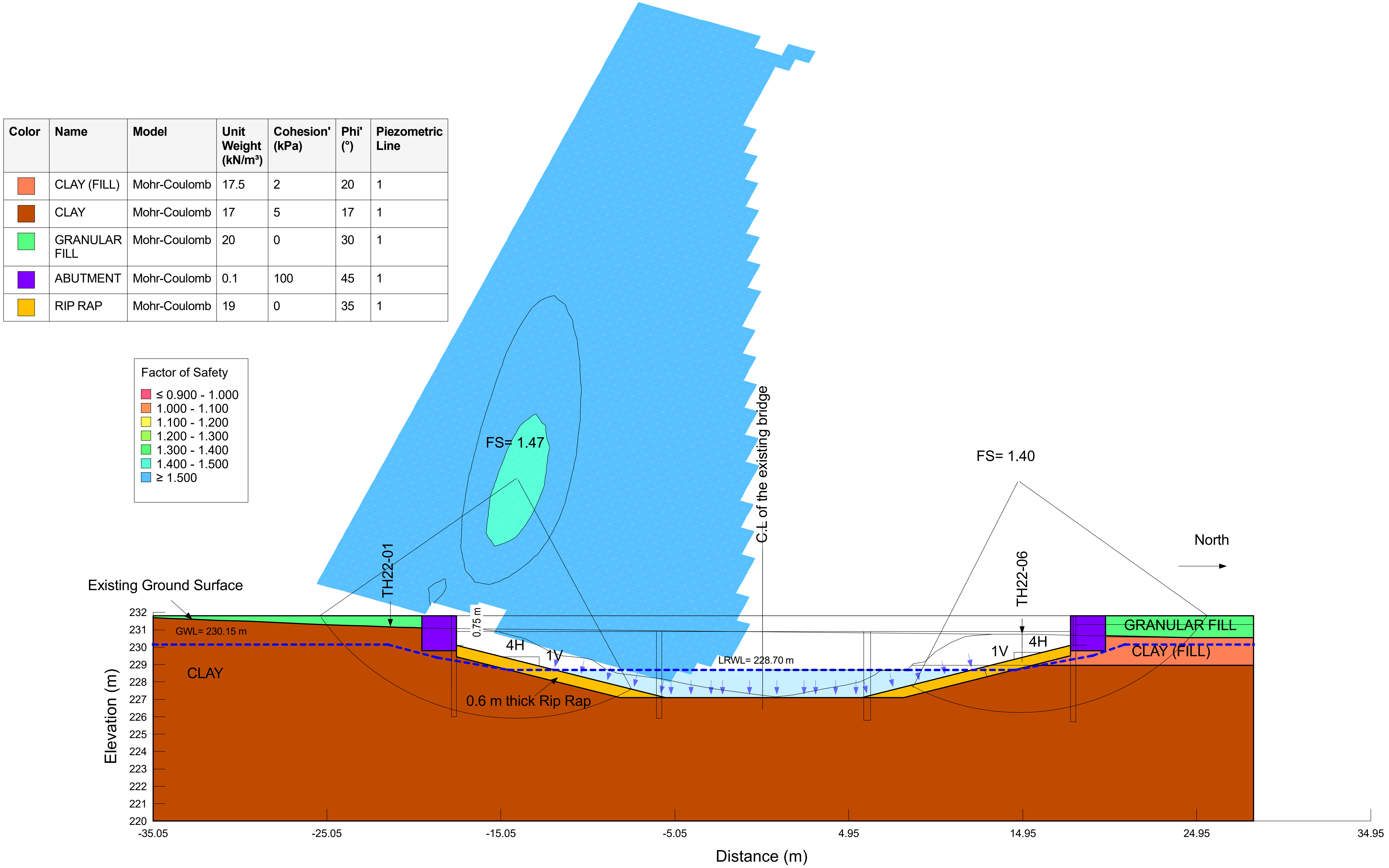
Figure B3

Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)
Extreme Conditions

Tabloid (279mm x 432mm)

SAVED: 2022-12-06 10:20:36 PM

SCALE: 1:221 (279mm x 432mm)



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\M006 Creek Bend road (4H to1V) - Extreme (reviewed MVH).gsz

Figure B4

Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)

Extreme Conditions

Tabloid (279mm x 432mm)

SAVED: 2022-12-09 2:57:29 PM

SCALE: 1:221 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

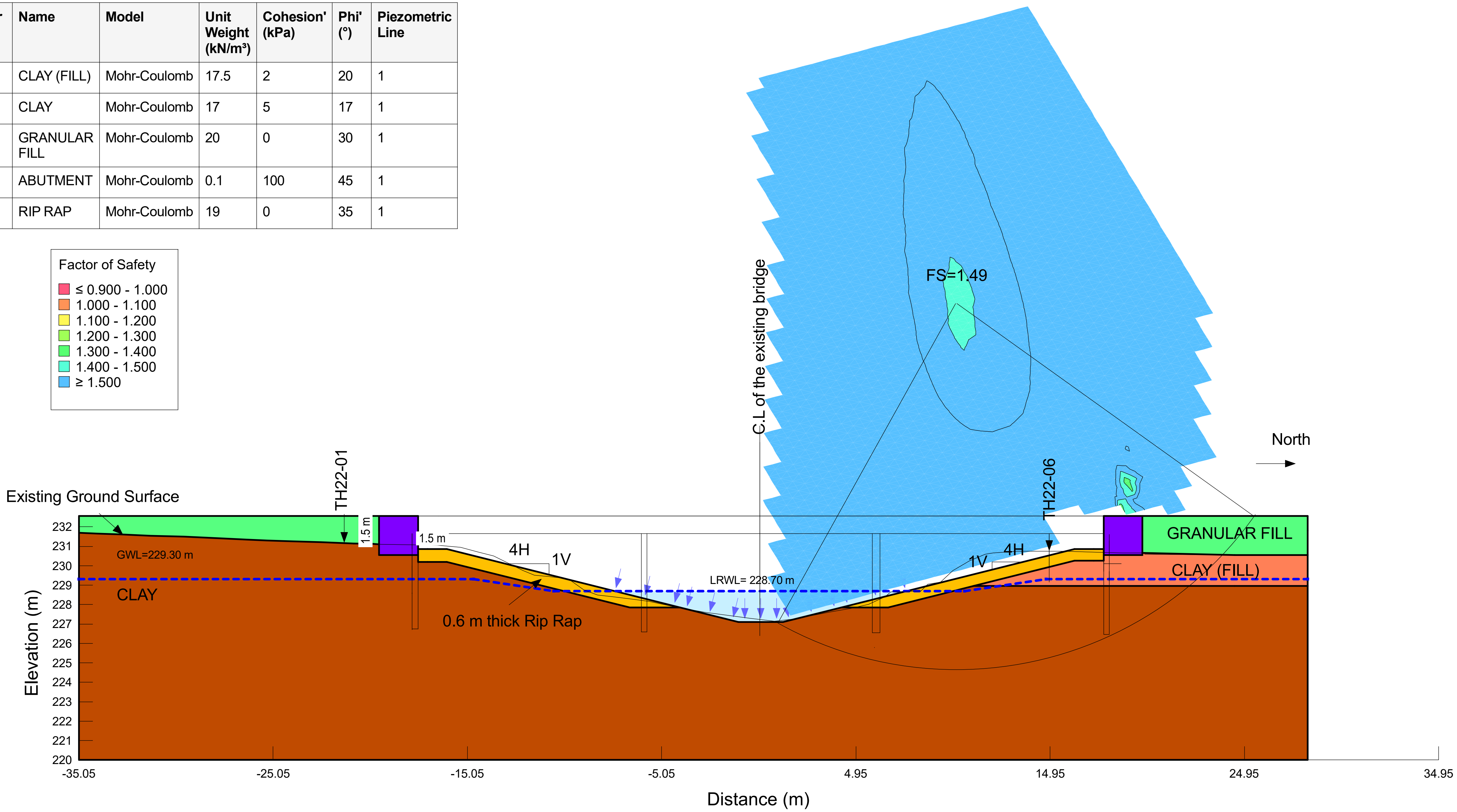


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Figure 1

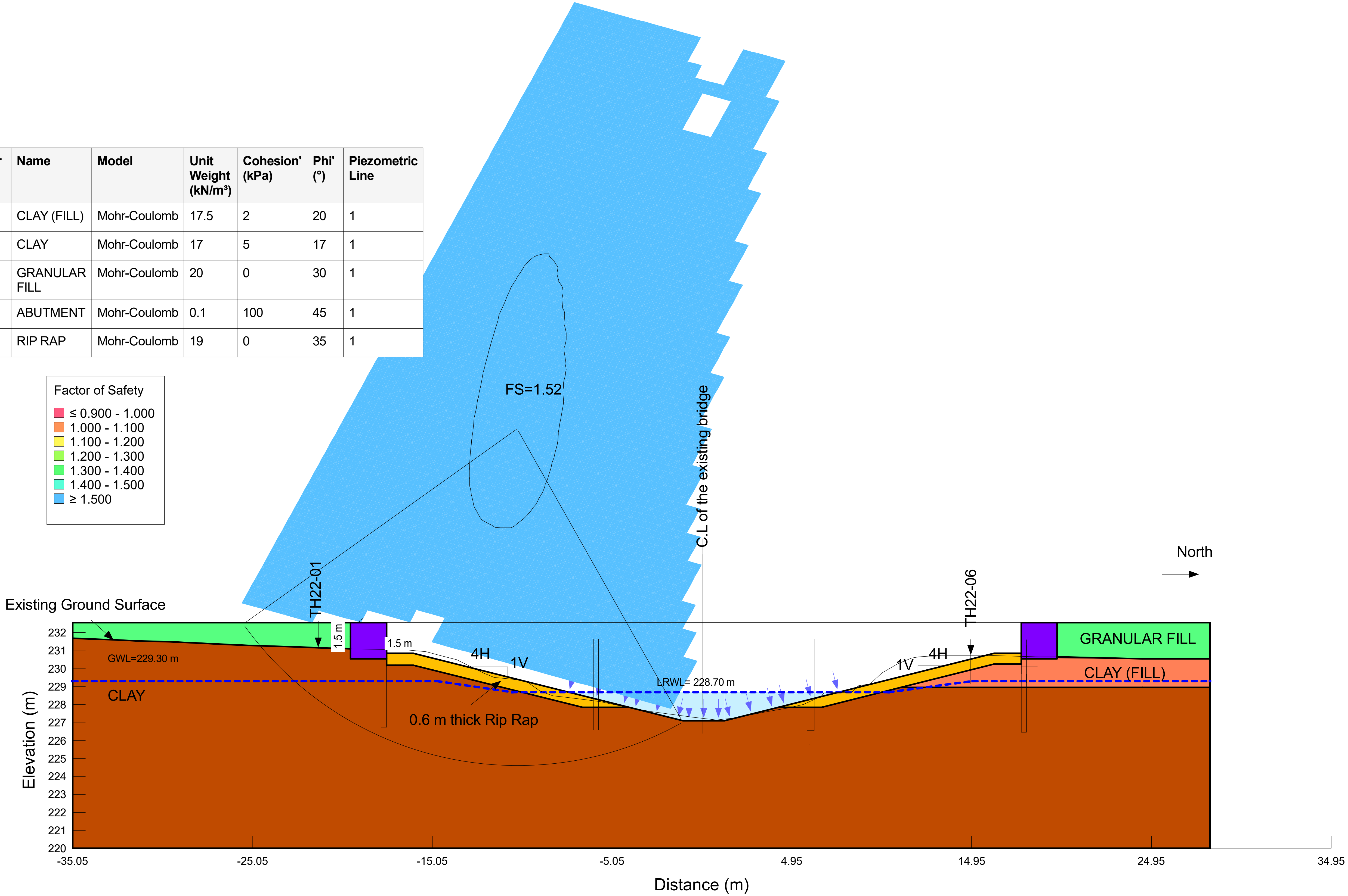
Figure B5

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)
Normal Conditions

Tabloid (279mm x 432mm)

SAVED: 2022-12-09 2:57:29 PM

SCALE: 1:221 (279mm x 432mm)



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

Factor of Safety
- 🟥 ≤ 0.900 - 1.000
- 🟧 1.000 - 1.100
- 🟨 1.100 - 1.200
- 🟩 1.200 - 1.300
- 🟩 1.300 - 1.400
- 🟦 1.400 - 1.500
- 🟦 ≥ 1.500

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\M013 Creek Bend road (4H to1V+ 1.5m Bench) - Normal Conditions.gsz

Figure B6

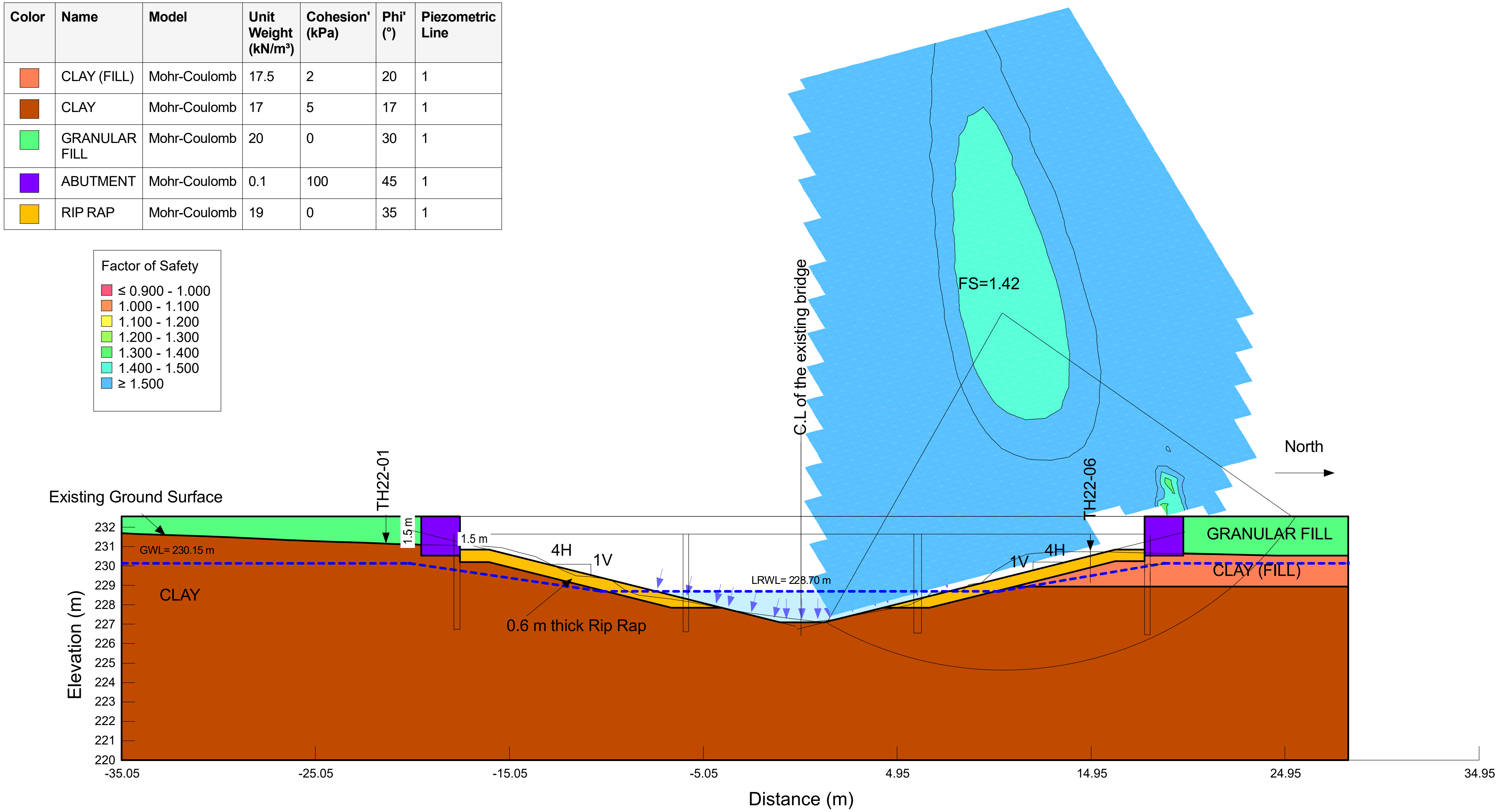
Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)

Normal Conditions

Tabloid (279mm x 432mm)

SAVED: 2022-12-06 11:30:13 PM

SCALE: 1:222 (279mm x 432mm)



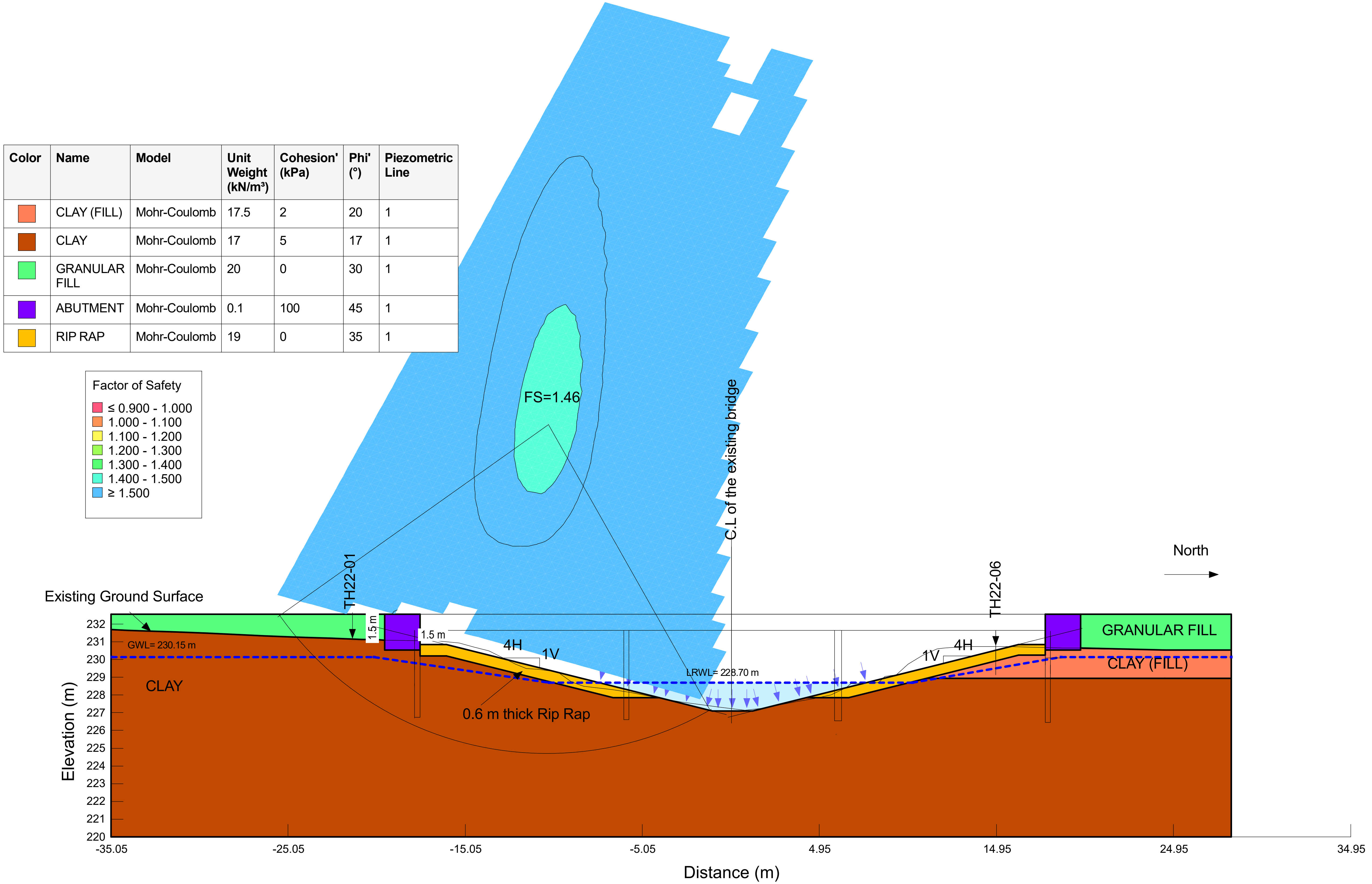
Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\M014 Creek Bend road (4H to1V+ 1.5m Bench) - Extreme Conditions.gsz

Figure B7

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)
Extreme Conditions

Tabloid (279mm x 432mm)
SAVED: 2022-12-06 11:30:13 PM
SCALE: 1:222 (279mm x 432mm)



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\M014 Creek Bend road (4H to1V+ 1.5m Bench) - Extreme Conditions.gsz

Figure B8

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)

Extreme Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-01-24 5:02:05 PM

SCALE: 1:179 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

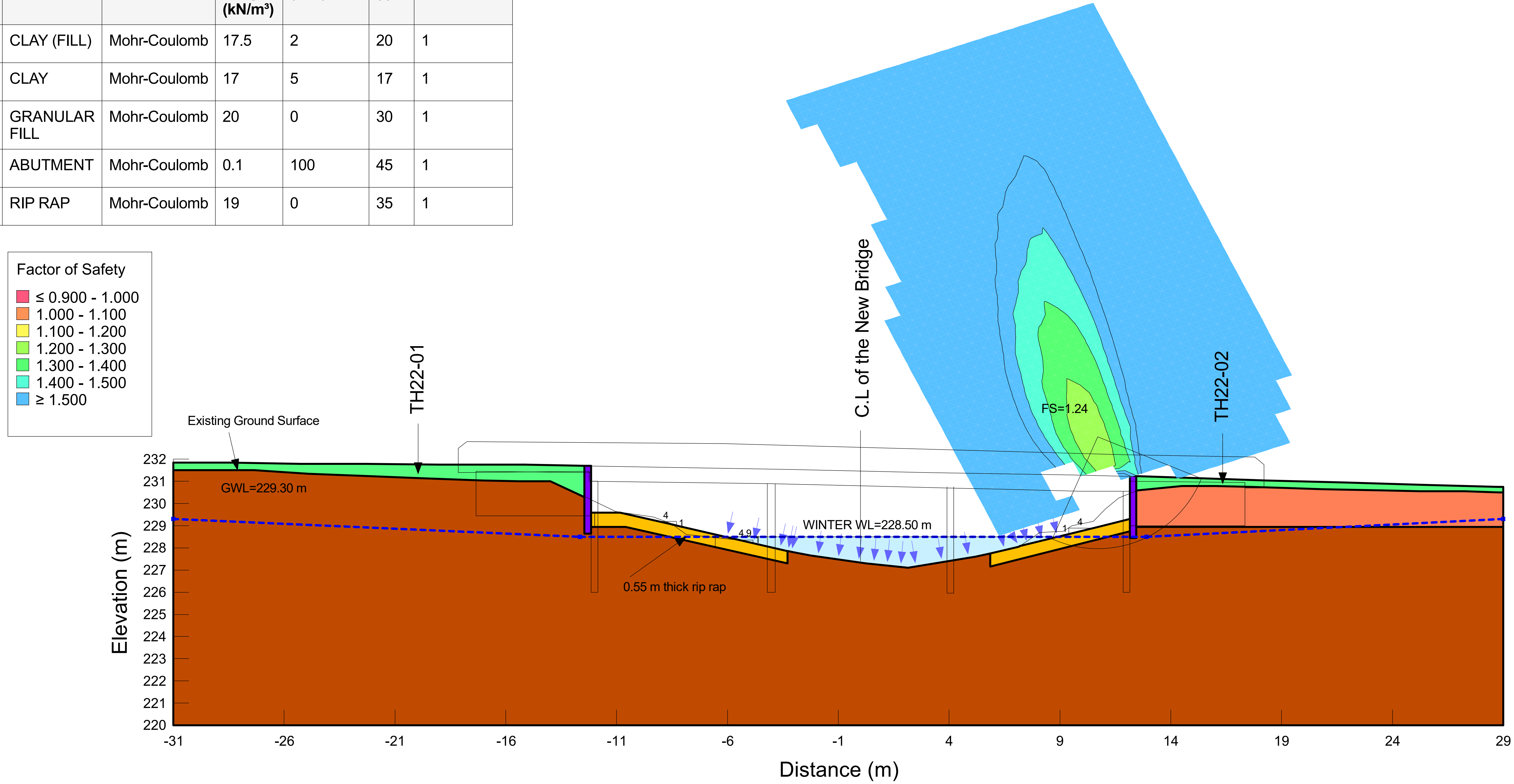


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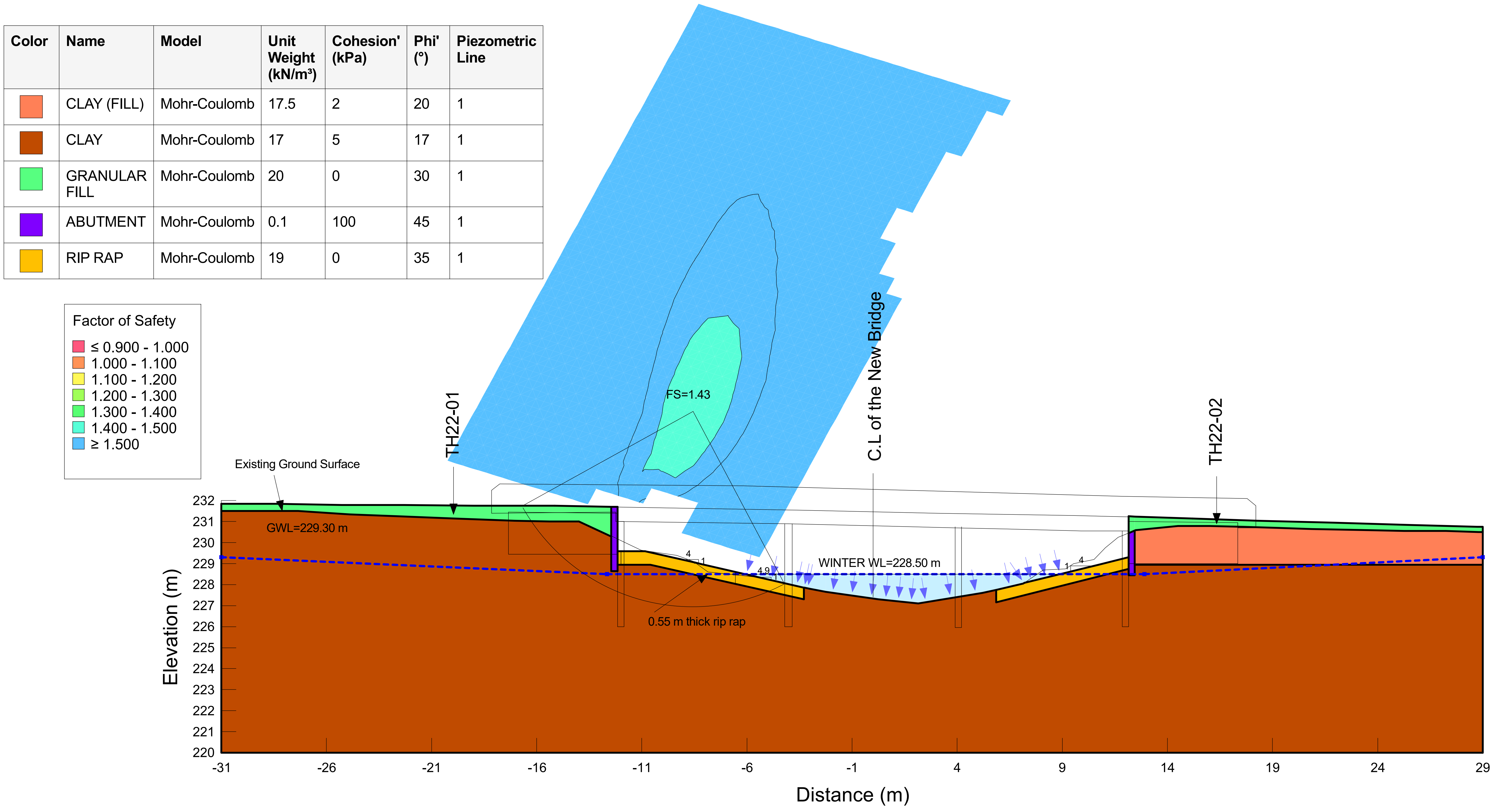
Figure B9
Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)
Normal Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-01-24 5:02:05 PM

SCALE: 1:179 (279mm x 432mm)



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\Bridge option Rev 1\M016 Creek Bend road (MHL Design) - Normal Conditions.gsz

Figure B10

Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)
Normal conditions

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1

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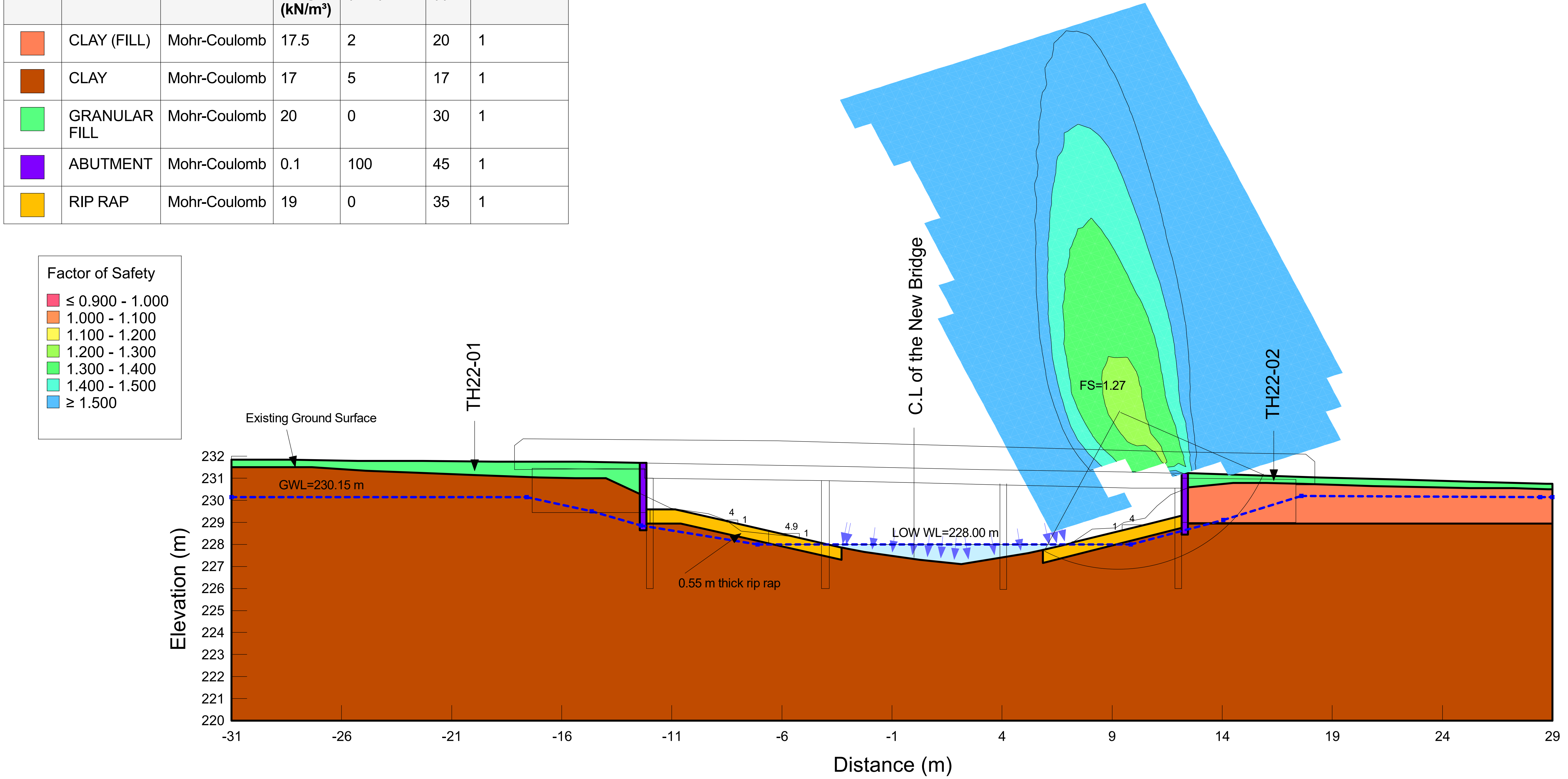


SCALE: 1:179 (279mm x 432mm)

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\Bridge option Rev 1\M015 Creek Bend road (MHL Design) - Extreme Conditions.gsz

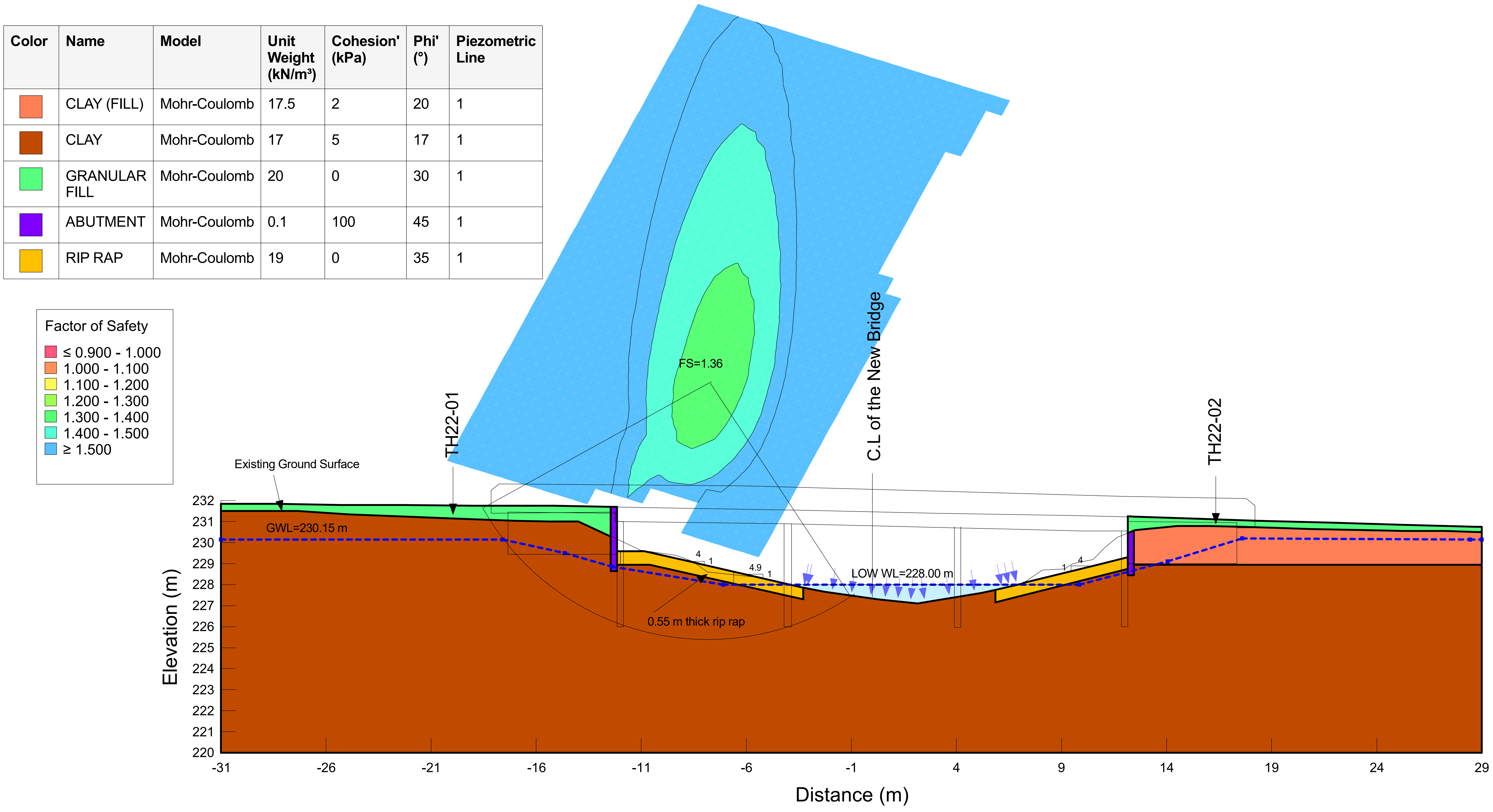
Figure B11
Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)
Extreme Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-01-24 4:54:19 PM

SCALE: 1:179 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1



FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 110 00 Creek Bend Road Bridge Replacement\2 Design\2.7 Modelling\Bridge option Rev 1\M015 Creek Bend road (MHL Design) - Extreme Conditions.gsz

Figure B12
Three Span Bridge with a 0.75 m roadway raise (4H:1V Slope)
Extreme Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-02-17 3:01:27 PM

SCALE: 1:179 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟧	RIP RAP	Mohr-Coulomb	19	0	35	1
🟨	CELLULAR CONCRETE	Mohr-Coulomb	4.5	50	45	1

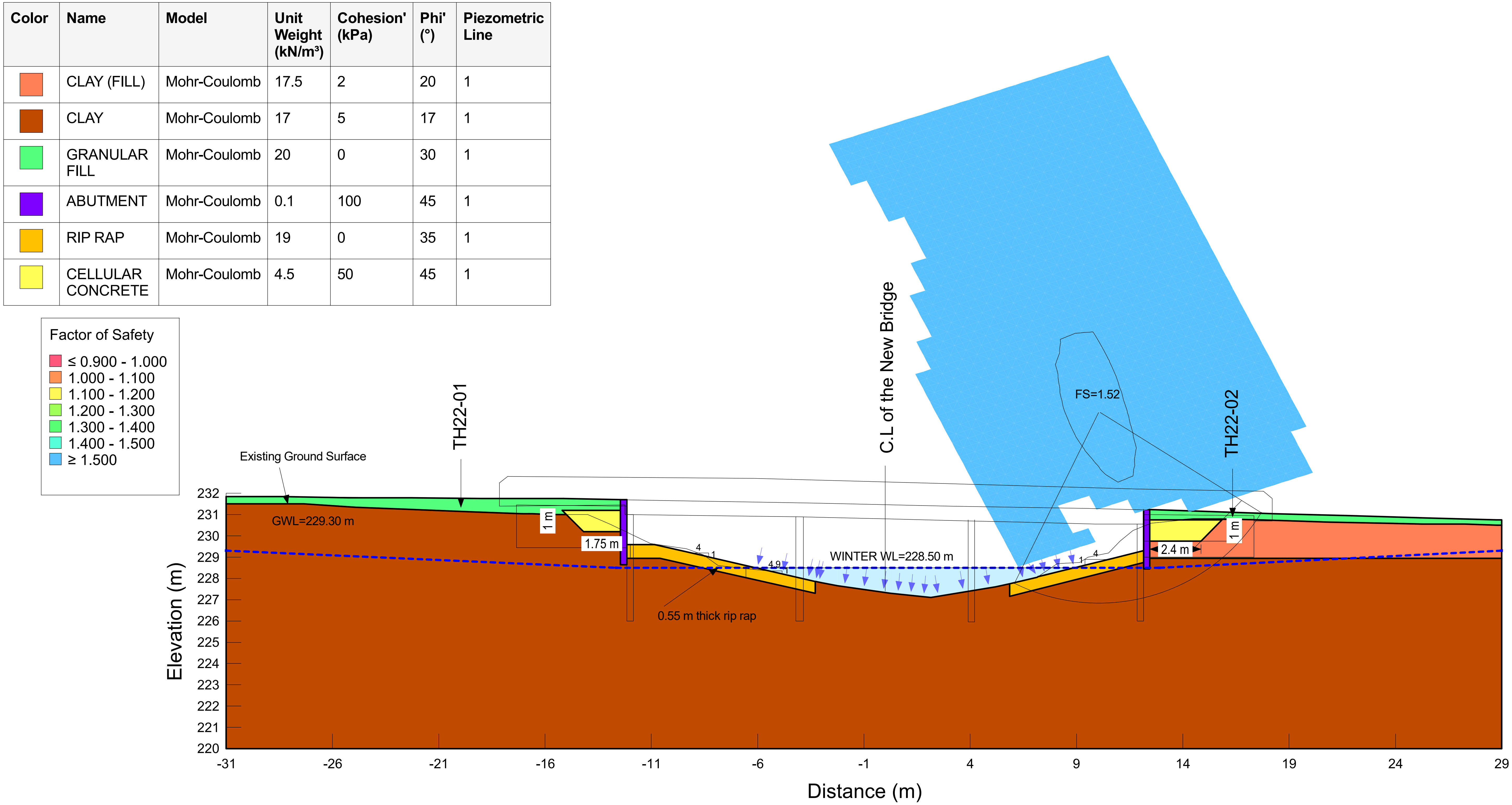


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Figure B13

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)

Normal Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-02-17 3:01:27 PM

SCALE: 1:179 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟧	RIP RAP	Mohr-Coulomb	19	0	35	1
🟨	CELLULAR CONCRETE	Mohr-Coulomb	4.5	50	45	1

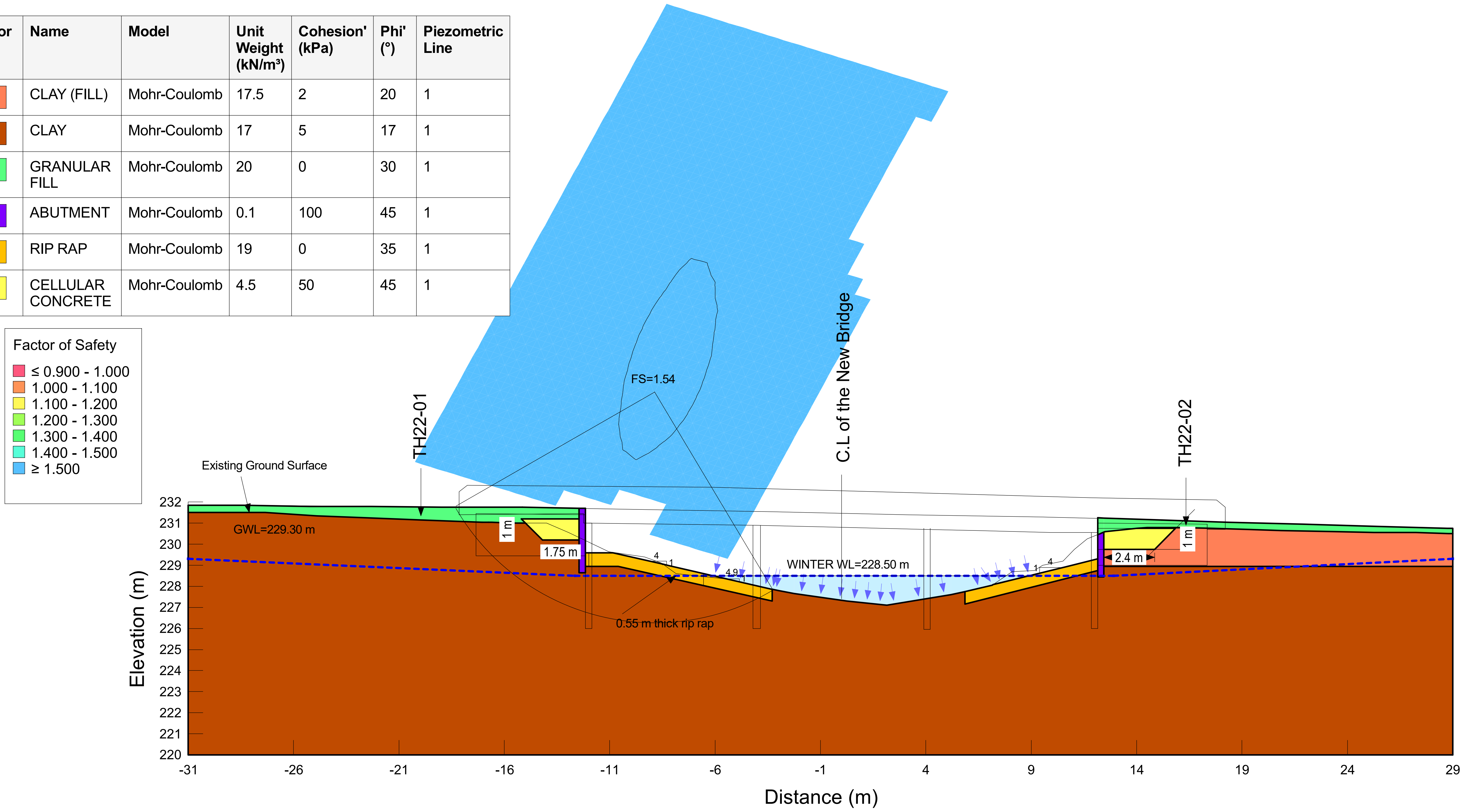

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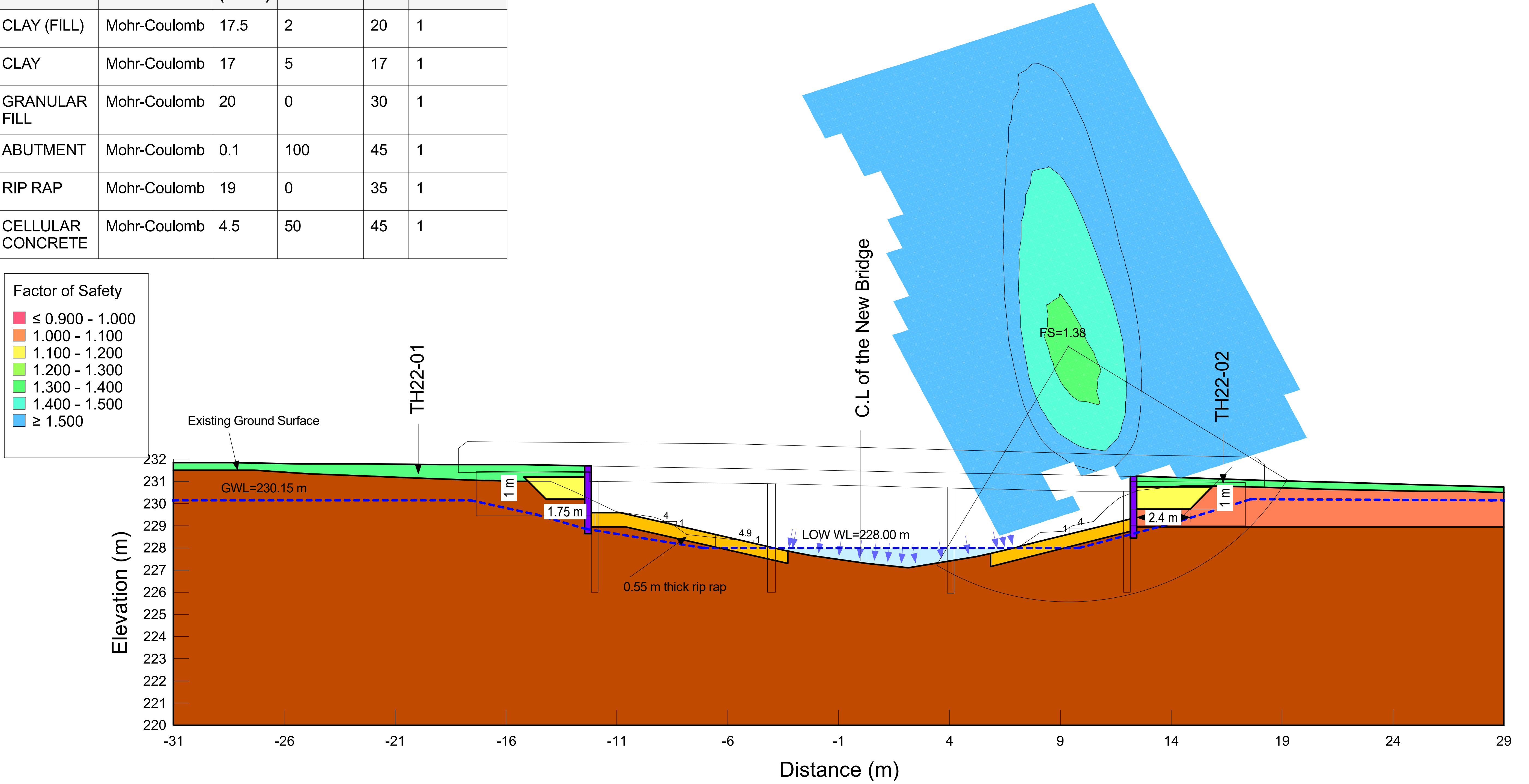
Figure B14

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)
Normal Conditions

SAVED: 2023-02-17 2:49:05 PM

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟧	RIP RAP	Mohr-Coulomb	19	0	35	1
🟨	CELLULAR CONCRETE	Mohr-Coulomb	4.5	50	45	1



SCALE: 1:179 (279mm x 432mm)

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Figure B15
Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)
Extreme Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-02-17 2:49:05 PM

SCALE: 1:179 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟧	RIP RAP	Mohr-Coulomb	19	0	35	1
🟨	CELLULAR CONCRETE	Mohr-Coulomb	4.5	50	45	1

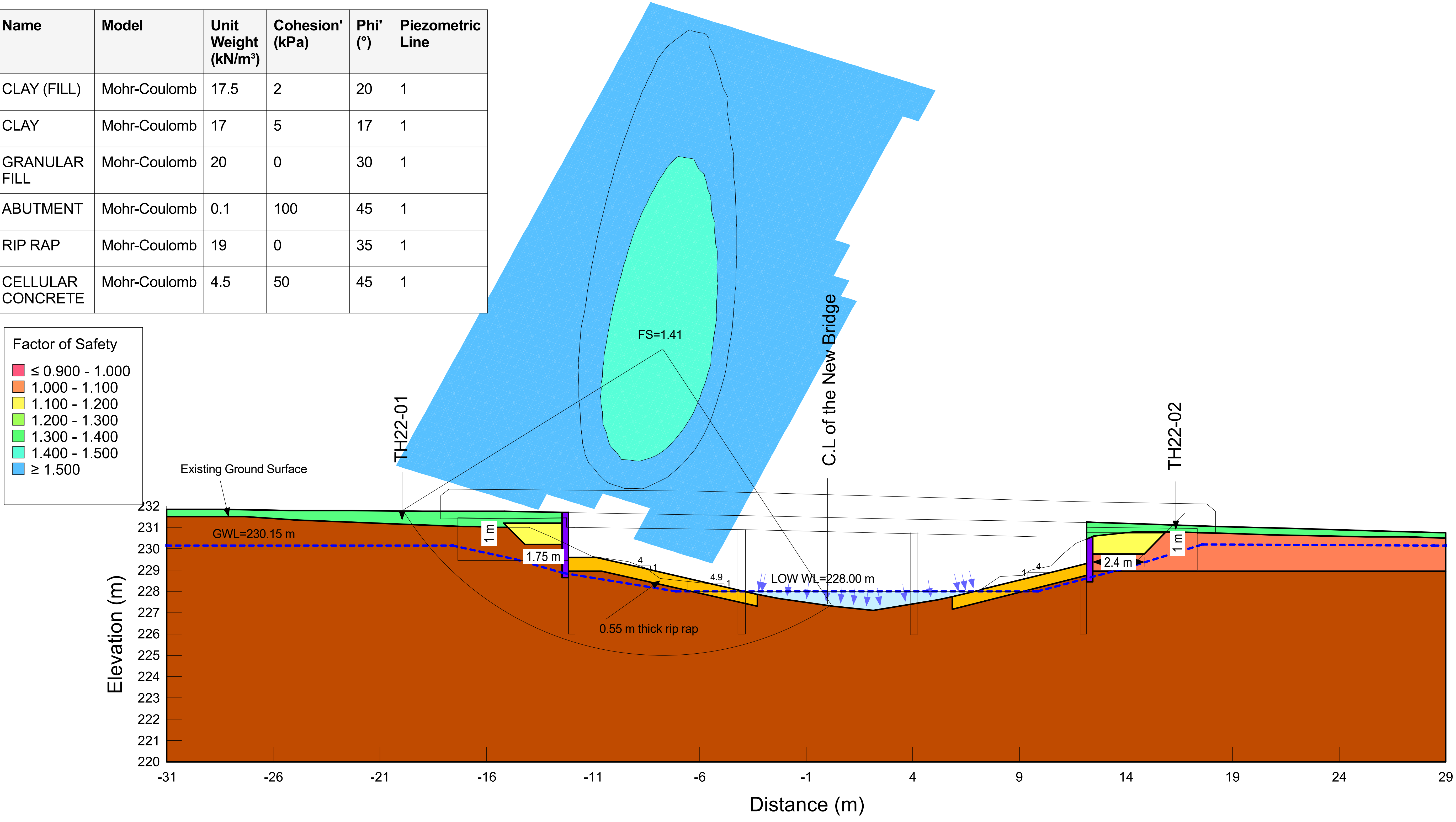

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Figure B16

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)
Extreme Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-02-15 4:25:27 PM

SCALE: 1:179 (279mm x 432mm)

Color	**Name**	**Model**	**Unit Weight (kN/m³)**	**Cohesion' (kPa)**	**Phi' (°)**	**Piezometric Line**
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1
🟦	EPS FOAM	Mohr-Coulomb	0.4	0	45	1

Factor of Safety

🟥 ≤ 0.900 - 1.000
🟧 1.000 - 1.100
🟨 1.100 - 1.200
🟩 1.200 - 1.300
🟩 1.300 - 1.400
🟦 1.400 - 1.500
🟦 ≥ 1.500

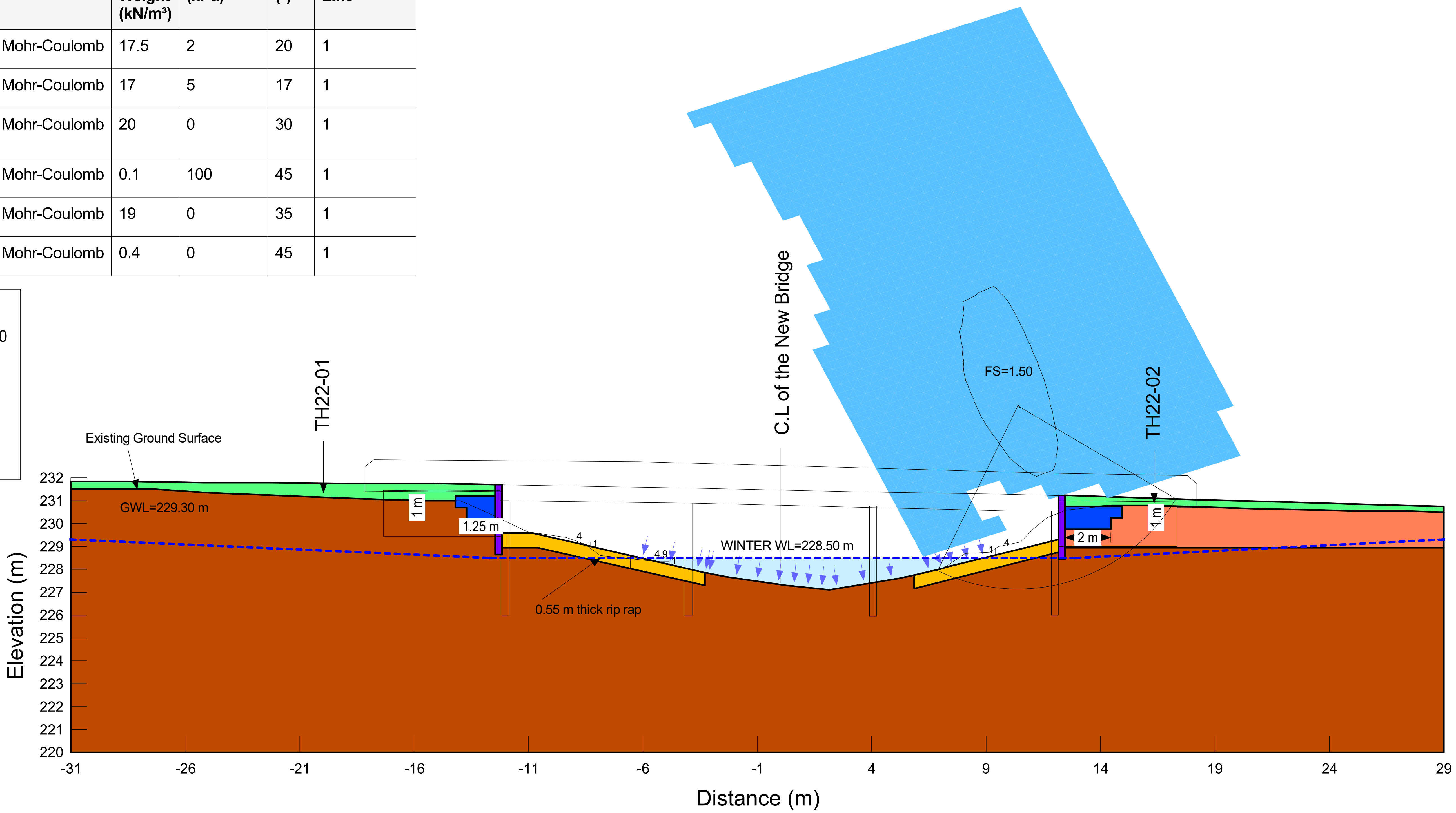

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Figure B17
Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)
Normal Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-02-15 4:25:27 PM

SCALE: 1:179 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1
🟦	EPS FOAM	Mohr-Coulomb	0.4	0	45	1

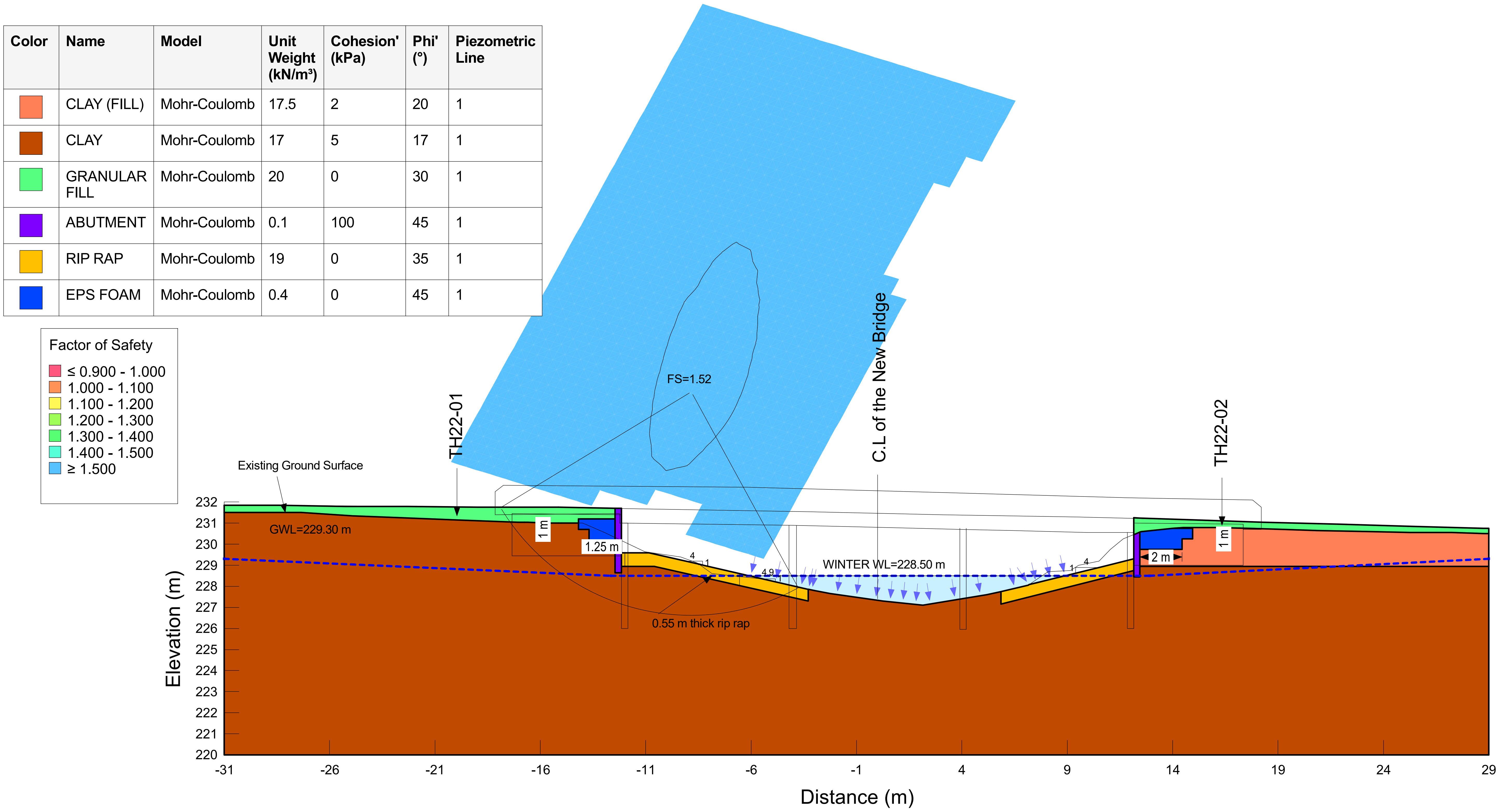

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Figure B18

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)

Normal Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-02-15 4:52:05 PM

SCALE: 1:179 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1
🟦	EPS FOAM	Mohr-Coulomb	0.4	0	45	1

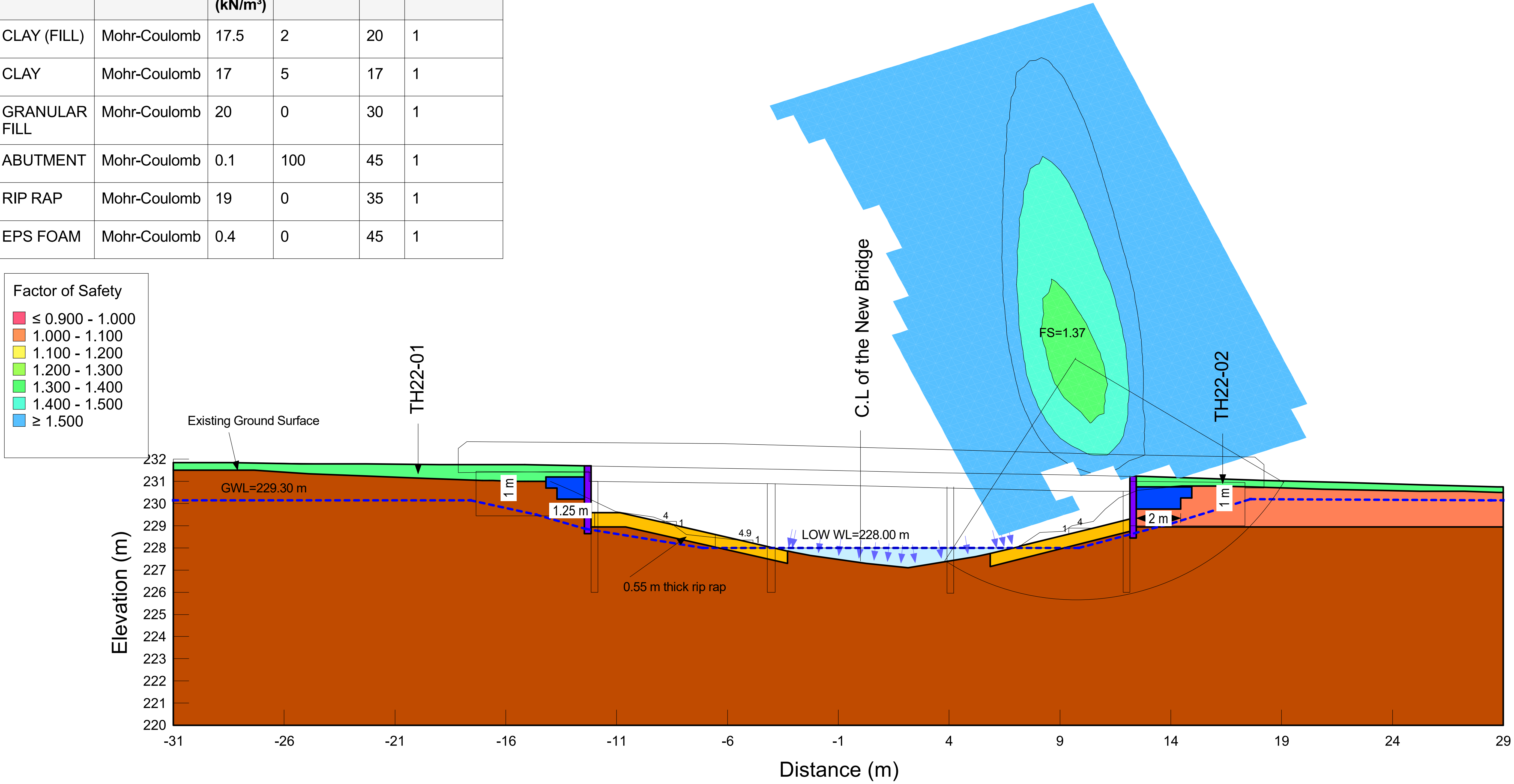

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Figure B19

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)
Extreme Conditions

Tabloid (279mm x 432mm)

SAVED: 2023-02-15 4:52:05 PM

SCALE: 1:179 (279mm x 432mm)

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟧	CLAY (FILL)	Mohr-Coulomb	17.5	2	20	1
🟫	CLAY	Mohr-Coulomb	17	5	17	1
🟩	GRANULAR FILL	Mohr-Coulomb	20	0	30	1
🟪	ABUTMENT	Mohr-Coulomb	0.1	100	45	1
🟨	RIP RAP	Mohr-Coulomb	19	0	35	1
🟦	EPS FOAM	Mohr-Coulomb	0.4	0	45	1

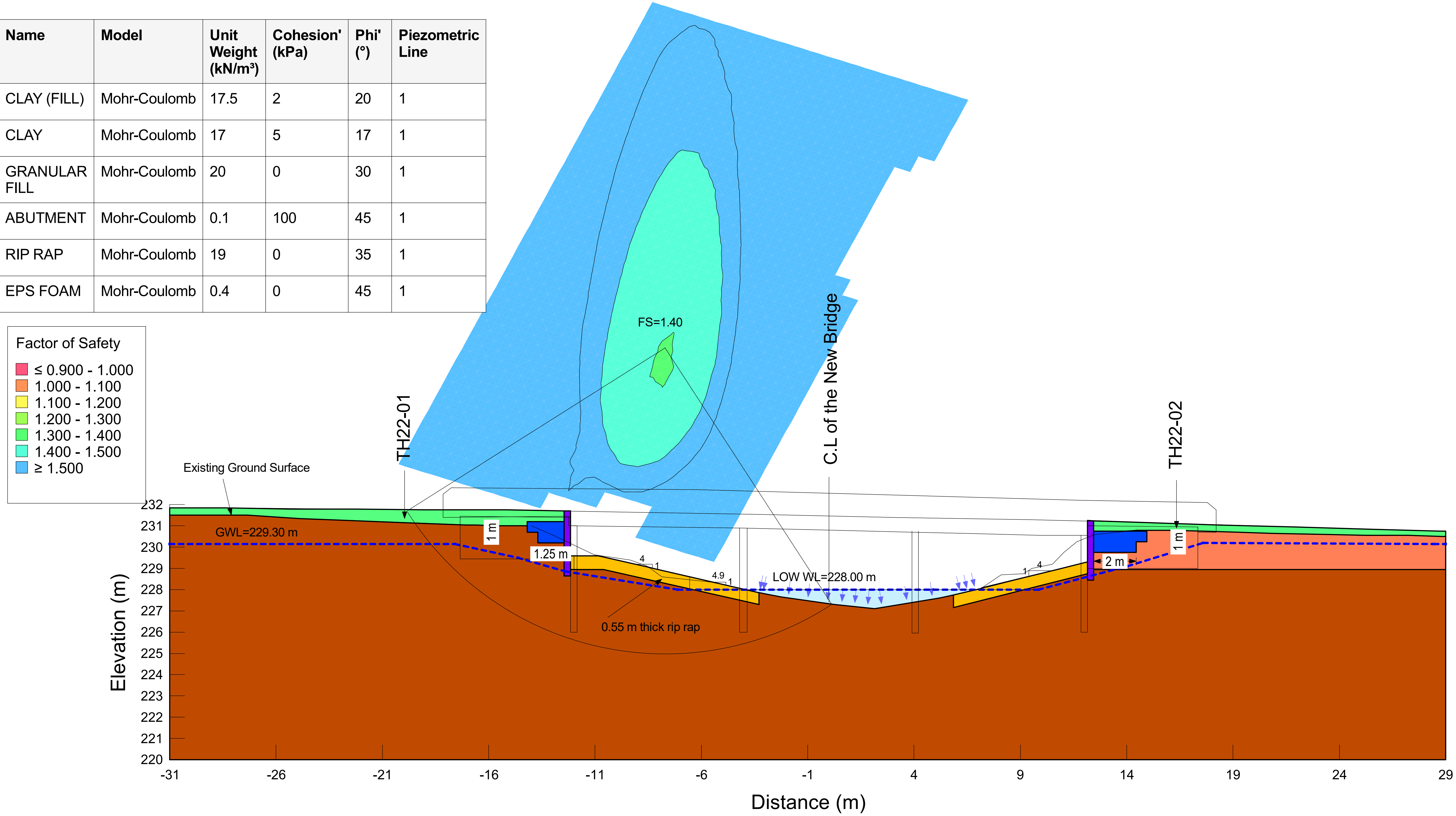

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Figure B20

Three Span Bridge with a 1.5 m roadway raise (4H:1V Slope+ 1.5m Bench)
Extreme Conditions