March 15, 2024

Fraser River Tunnel Project

R.F. Binnie and Associates Ltd.
205-4946 Canada Way
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V5G 4H7

Edmund Lee, P. Eng
Vice President, Transportation Engineering & Major Projects, Senior Principal

Re: Fraser River Tunnel Project
Highway 99 – Blundell to Steveston Interchange
Surcharge Project
Geotechnical Design Report – Issued for Tender (IFT)

Dear Mr. Lee,

BASIS Engineering is pleased to submit this IFT geotechnical report for the surcharge along Highway 99 Southbound. Please find attached the report.

Yours truly,

BASIS ENGINEERING LTD.

Stuart Childs, P.Geo.

Engineering Geologist

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1 INTRODUCTION

The BC Ministry of Transportation and Infrastructure (MoTI) is proceeding with the replacement of the aging George Massey Tunnel with a new eight-lane Immersed Tube Tunnel (ITT) crossing (the Fraser River Tunnel Project, the "Project"). A traffic widening for the southbound is required between Blundell Road and the Steveston Interchange to create a new "Bus on Shoulder" lane.

The BC MoTI has delegated management of the project to the Transportation Investment Corporation (TI Corp). TI Corp has retained RF Binnie and Associates (Binnie) to provide Owner's Engineering services for the Highway and onshore Civil Works aspects of the project. Binnie has retained BASIS Engineering Ltd (BASIS) to provide geotechnical and structural engineering services for the onshore works for the project.

To prepare for the main contract work on the Project, TI Corp has decided to proceed with advanced works which is split into two packages. Package 1 is the initial surcharge work for the Highway 99 Bus Lane Widening between Blundell Road and Steveston Highway. Package 2 is the Highway and Civil work between Westminster Highway and Steveston Highway. BASIS is providing detailed geotechnical design in support of this surcharge work for Package 1.

Package 2 will be delivered for all the remaining Highways and Civil work between Westminster Highway and Steveston Highway.

This geotechnical report documents the geotechnical design of the surcharge design (Package 1) for the highway widening. The location of the additional southbound lanes and surcharge is shown in Appendix I.

2 GEOTECHNICAL DESIGN CRITERIA

Geotechnical design has been conducted in accordance with the following documents, codes, and standards and have been applied in descending order of precedence:

1. BC MoTI Supplement to CAN/CSA-S6-19;
2. CAN/CSA-S6-19 (Canadian Highway Bridge Design Code, CHBDC);
3. MoTI Design Build Standard Specifications for Highway Construction, December 2018
4. EGBC Retaining Wall Design, Version 1.1, February 2020.
5. FHWA – Design and Construction of MSE walls and Reinforced Slopes (FHWA-NHI010-024)

As the structures detailed in this report are temporary, seismic loading was not considered.

2.1 Site Definition

In accordance S6-19, the following parameters were used to define the site:

- Degree of Understanding – Typical
- S6-19 Consequence Factor – Typical (consequence of failure is temporarily blocking HOV lane)
- Stability Condition = Temporary

2.2 Design Criteria

In accordance with the BC MoTI Supplement to CAN/CSA S6-19, Table 1, a Factor of Safety of 1.33 for global stability in the temporary condition was targeted.

The surcharge embankments are not subjected to live loads. Loading is provided from the surcharge material and therefore load combination factors were used as outlined below:

Table 1 - Load Factor Combinations (CAN/CSAS6-19, BC Supplement)

Load Source	α_E
	ULS Combination 1
Active Earth Pressure	1.25

The geotechnical resistance factors were taken from CAN/CSA-S6-19, Table 6.2 includes the relevant geotechnical resistance factors (ϕ_{gu}), for analysis and design of the structures to retain the surcharge.

Table 2 - Geotechnical Resistance Factors (CAN/CSAS6-19, BC Supplement)

Degree of Understanding	System	Limit State	ϕ_{gu}
			Static
Typical	Retaining Wall	Bearing	0.50
		Overturning	0.50
		Base sliding	0.80

3 SITE CHARACTERIZATION

3.1 General

A ground model was developed based on data available from geotechnical exploration programs conducted in 2014, 2015 and 2022 and based on surficial geological maps.

3.2 Available Geotechnical Information

The geotechnical test holes that were used to develop the ground model along the southbound highway alignment and within the project boundaries include:

- AH09-TEL11-22 (FRTP – Thurber Report 2010-03-11)
- AH15-04 to AH15-08 (GMT - Golder Report 2015-03-17)
- CPT15-03 (GMT - Golder Report 2015-03-17)
- CPT15-05 (GMT - GMT Golder Report 2015-12-03)
- CPT15-18 to 26 (GMT - GMT Golder Report 2015-12-03). Note only CPT15-03, 20, 21 and 22 were used due to their proximity to the site.
- 22GEO-DH007 (FRTP – GDR KCB Draft Geotechnical Data Report 2023-09-22)

Note that around the Steveston Interchange there are CPT boreholes from 2013 and 2014 but they have not been utilized for this package.

The plan locations of the boreholes are shown in Appendix I and the borehole logs are shown in Appendix II.

3.3 Available Laboratory Test Data

From the available boreholes, particle size distribution and moisture content tests were obtained. Consolidation testing of the fine-grained soils along the highway was not available. Consolidation properties were adopted from oedometer testing that was conducted on samples obtained from borehole 22GEO-DH007 (T-02), a test hole conducted at the Deas Island. An effective friction angle was also determined from a consolidated undrained triaxial test from the same borehole. The settlement properties from 22GEO-DH007 were used on the settlement analysis. The results were compared to the average historical settlement data north of Blundell (Section 7.1) and it was deemed that the soil properties used in Section 3.4.2 are appropriate. However, the settlement should be monitored, and the model calibrated to the actual measured settlement following surcharge placement and monitoring. The laboratory testing results are included in Appendix III.

3.4 Stratigraphy

Based on the available geotechnical information, the subsurface profile was partitioned into the following units:

Table 3 - Soil Units

Material	Southbound Thickness (m)	Moisture Content (%)	Density/Consistency	Plasticity Index "PI" (%)	Dynamic Cone Penetration Tests (blows/300mm)[2]
Unit A – Asphalt & Fill	0.3 to 0.80	2-5	Dense	-	-
Unit B – Sand (Possible Fill)	0.80 – 2.00	-	Loose to Compact	-	11-45
Unit C – Silt - Overbank	0.90 to 6.0[1]	20-43	-	15-71%	7-8
Unit D - FRS	19.0 – 28.0	-	-	-	-
Unit E – FRDS	>43	-	-	-	-

1- Thickness determined from CPT boreholes as full extent not proven in the conventional auger boreholes.

2- Taken from AH09-TEL15.

Based on the available information, BASIS developed a stratigraphic cross section along the alignment. The section location and geological cross section are shown in Appendix I.

3.4.1 Groundwater

The ground water levels measured in the boreholes are presented in Table 4. The groundwater level adopted was 2.0m below ground surface and 0.2m above the ditch level during typical conditions. During high rainfall events, it is likely that the existing ditch water level would be higher than typical therefore, a higher water level was modeled between 0.4m and 1.0m above existing ditch level.

Table 4 - Groundwater Depths from Auger Boreholes

Borehole	Groundwater Depth (m)
AH09-TEL22	2.1
AH15-07	1.7[1]
AH15-08	1.22[1]

1 – Borehole Seepage observation

3.4.2 Soil Properties (Consolidation)

Unit C (Overbank Deposits) is fine-grained in nature and will be subject to intermediate to long-term settlements (consolidation settlements). Units A, B and D are more likely to behave elastic in nature.

Table 5 presents the assumed settlement parameters used for the predicted settlement analysis. Although no testing was avalible from the boreholes along the highway, consolidation soil properties for Unit B were modelled using oedometer readings taken from 22GEO-DH007 (at the Deas Island). It was deemed appropriate as the Overbank tested in 22GEO-BH007 is geologically similar to the fine-grained soil present between Blundell and Steveston.

The Coefficient of Consolidation (Cv) (time-rate of consolidation) was obtained from oedometer testing. The Cv obtained was higher than typical for fine-grained soils. However, the fine-grained soils at this site have low plasticity indices, supporting the use of high drainage values. These values were also compared to Cv values from oedometer testing conducted on deep samples obtained by Golder in nearby test holes in 2015, the results of which support our assumed Cv values.

An overconsolidation ratio (OCR, a parameter representative of stress history) of 1 was conservatively assumed for the overbank deposits (Unit C).

Table 5 - Soil Parameters for the Settlement Analysis

Material	Thickness	Unit Weight (kN/m3)	Es (MPa)	Esur (MPa)	Cc	Cr	e0	OCR	Cv Cm2/s
Unit B – Sand (Possible Fill)	1.0-2.5m	18	35	35	-	-	-	-	-
Unit C – Silt - Overbank[1]	0.5-5.0m	18	10	10	0.178	0.020	1.077	1	0.095
Unit D - FRS	19-28.0m	18.5	25	25	-	-	-	-	-

1) 3m Overbank Oedometer 22-GEO-DH007
2) The Cc value obtained from within Unit C is representative of the overconsolidated nature of this soil and representative of the recompression index. This recompression index value was used with an OCR of 1 in the model.
3) Es = Elastic soil modulus; Esur = Unload Modulus; Cc = Compression Index; Cr = Recompression Index; e0 = Initial void ratio; OCR = Overconsolidation Ratio; Cv = Coefficient of consolidation.

4 EXISTING PAVEMENT STRUCTURE

In 2016, Tetra Tech produced a report detailing the Highway 99 Pavement Strength Testing between Bridgeport Road and the Steveston Underpass. The scope of the work included Falling Weight Deflectometer (FWD) testing on the northbound and southbound lanes as well as extracting cores and analysing the FWD data. As built drawings included in Appendix IV from July 10, 1980 (Drawing No. R1-117-16) shows the following southbound pavement structures from the north side of the George Massey Tunnel:

- 115mm ACP
- Levelling asphalt of variable thickness; and
- 225mm of 19mm crushed granular surfacing.

The Tetra Tech pavement thickness determination was performed by extracting cores from the centre of the outside through lanes in the southbound and northbound directions. The asphalt thickness between Blundell and Steveston Highway was measured to be between 215mm and 290mm. An average modulus of subgrade reaction was determined from FWD to be 35 MPa and 839MPa for the pavement modulus.

The Tetra Tech report describes the soils as silty sand to sand with some silt. BASIS used the Toronto Transportation Services pavement design and rehabilitation guideline (2019) for recommended Resilient Modulus values to evaluate the pavement condition. The figure below shows the southbound outer lane condition between Blundell Road and Steveston Interchange (Blue Box). The resilient modulus for typical silty sand subgrade conditions on the southbound outer lane generally appears to be in fair condition as of 2016.

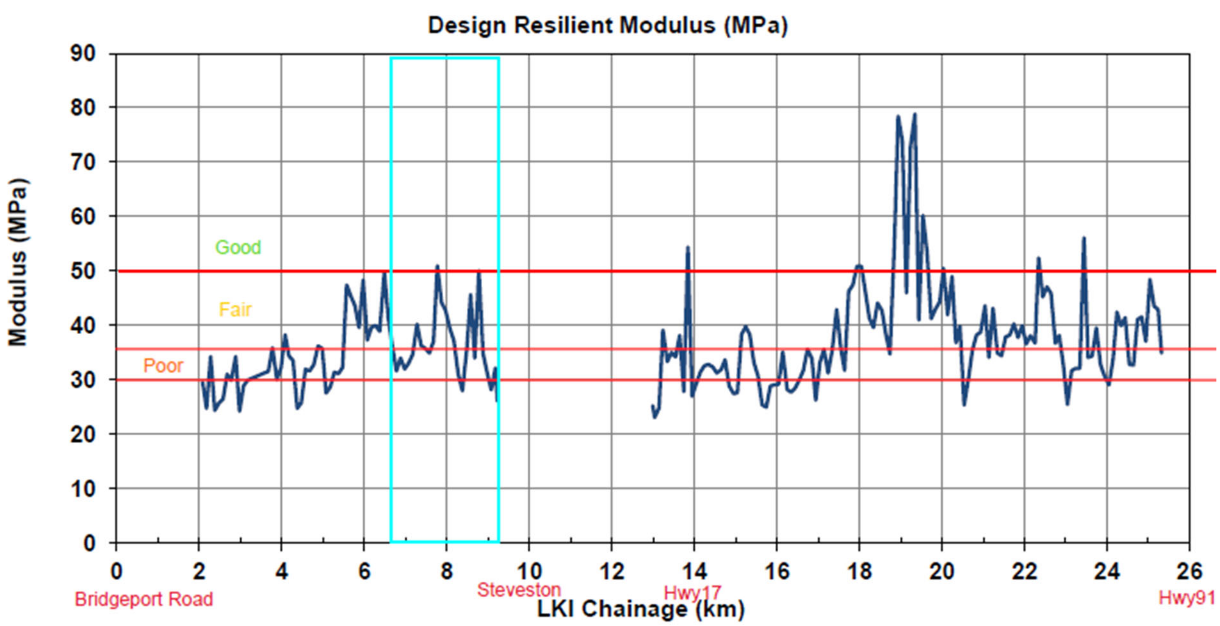

Figure 1 - Resilient Modulus (Mr) for the southbound outer lane.

5 PAVEMENT DESIGN RECOMMENDATIONS

5.1 Pavement Design Criteria

According to the Fraser River Tunnel Project Initial Draft DBA agreement (as of January 2024) the pavement design will be in accordance with Technical Circular T-01/15 for a "Pavement Structure Type A". The pavement structure type is determined to have a 20-year design life. The pavement design will be provided as part of Package 2 and not covered in this report. The settlement criteria for Package 2 structures and the ultimate pavement should be in accordance with the design build agreement.

Pavement Structure Type A follows the following criteria:

- High volume roads, truck lanes, speciality locations
- Greater or equal to 20,000,000 equivalent single axle load (ESALs)
- Greater or equal to 150mm typical asphalt concrete pavement thickness.

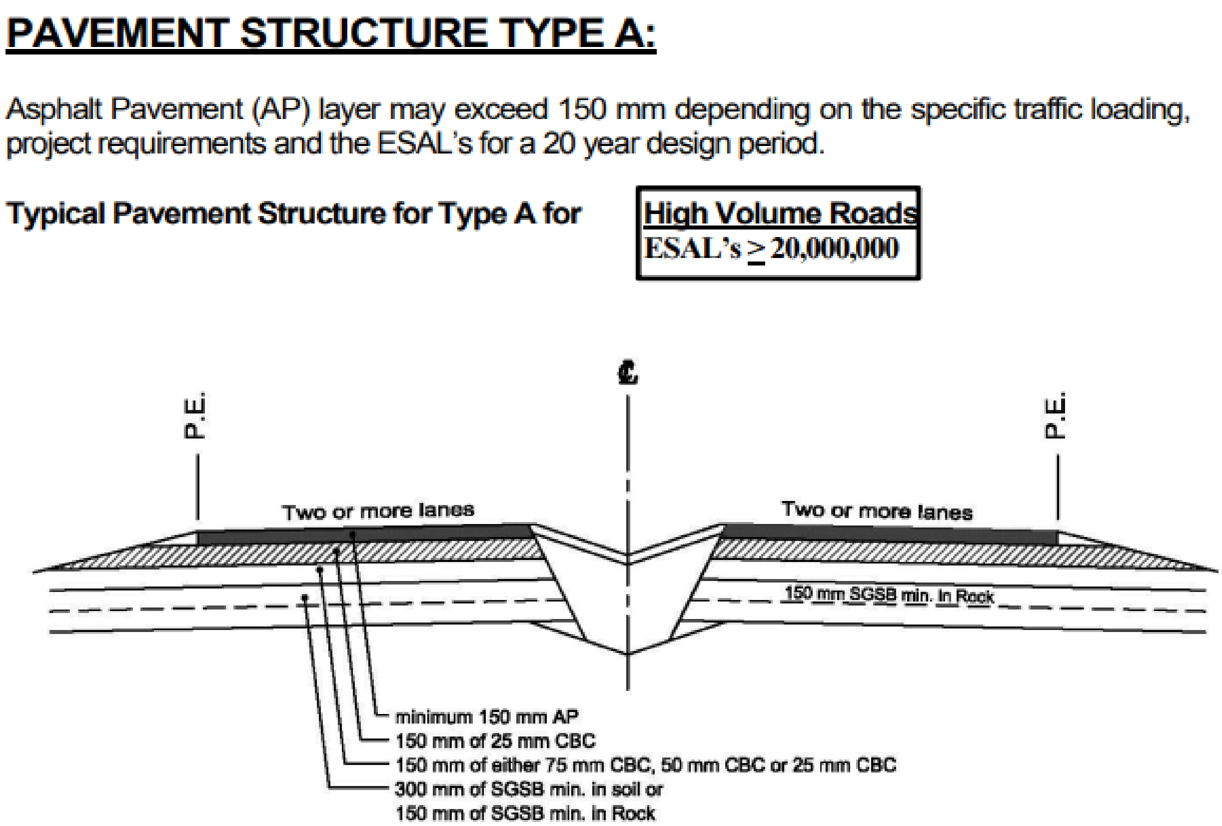

Figure 2 - Pavement Structure Type A

6 SURCHARGE RECOMMENDATONS

6.1 General

The soil conditions encountered at the project site comprise soft and compressible silt underlying granular fill. The primary geotechnical consideration for the ultimate construction of an additional southbound bus-on-shoulder lane is settlement due to compression of the underlying silt layer under loading of the proposed road/embankment fills.

Preloading (placement of a load on the ground surface prior to construction such that the imposed load is equivalent to the final project loading conditions) and surcharging (placement of a load on the ground surface prior to construction such that the imposed load is greater than the final project loading conditions) are effective means of mitigating the post-construction consequences associated with differential movements caused by increasing the load on compressible soils. To reduce post-construction settlement of the new bus-on-shoulder to tolerable levels, it is recommended that surcharging of the new bus on shoulder lane will be completed prior to placement of the final pavement structure. Surcharging of the entire width of the existing pavement and vegetated shoulder (ie. Encompassing as much areal width as possible) would limit post-construction settlements of the new bus on shoulder).

Historical surcharging was successfully performed between Westminster Highway and Blundell Road (North of the Project Extents) with the purpose of surcharging the existing southbound embankment and ditch between stationing 105+500 and 106+880 (1.34km). This surcharging comprised a 2m high surcharge berm with 1.5H:1V slopes. The aims and outcomes from the surcharge to the north of Blundell are like the scope of this project. As a result, the proposed surcharge geometry will be similar to this historical work. See section 7.1 for further details on the historical surcharge.

For this scope, the surcharge material is proposed to be placed 1.0m from the existing white line which delimits the outside edge of the HOV lane. The surcharge is proposed to have an approximate height of 2.0m with slopes at 1.5H:1V.

Where the surcharge soils are likely to encroach the existing drainage ditch, structural solutions are required instead of using other means such as temporary or permanent culverts.

It should be noted that there are three gaps proposed in the surcharge as part of Package 1:

- From STA 4020+30 to 4020+80 - Gap in the surcharge due to the existing Blundell road structure.
- From STA 4020+80 to STA 4021+26 - Gap in the surcharge for the existing gas and watermain utilities. The surcharge was selected to start at STA 4021+26 to avoid any impacts on the utilities. This is discussed in section 7.7.
- From STA 4035+05 to 4035+22.5 - Gap to avoid deformations to the existing arch culvert at STA 4035+15.

Table 6 indicates the proposed surcharge requirements along the alignment. Typical sections of the proposed surcharge dimensioning are shown on Binnie drawing R1-1113-301 to 302.

Table 6 - Surcharge alignment requirements

Approximate Stationing	Requirements	Typical Section (Drawing Package Number R1-1113-301 to 302) [1]
4019+80 (Start of Package 1 Construction) to 4020+30	Surcharge to cover entire ditch. Temporary culvert placement for drainage.	See typical section on drawing R1-1113-301
4021+26 to 4023+60	4 lock block high wall (S5 Line Wall)	See S5 wall typical section on drawing R1-1113-301
4023+60 to 4025+23	3 high lock block wall (S10 Line Wall)	Similar to S10 wall typical section on drawing R1-1113-301
4025+23 to 4032+49	Surcharge to connect with crest of slope	See typical section on drawing R1-1113-302
4032+49 to 4032+61	2 high lock block wall (S30 Line Wall)	Similar to S30 wall typical section on drawing R1-1113-301
4032+61 to 4033+18	Surcharge to connect with crest of slope	Similar to typical section on drawing R1-1113-302
4033+18 to 4035+04	3 high lock block wall (S40 Line Wall)	Similar to S40 wall typical section on drawing R1-1113-301
4035+04 to 4035+22.5	Arch Culvert Gap	-
4035+22.5 to 4037+98	Surcharge to connect with crest of slope	Similar to typical section on drawing R1-1113-302
4037+98 to 4041+32 (Limit of Package 1)	4 lock block high wall (S50 Line Wall)	Similar to S50 wall typical section on drawing R1-1113-302

1- See table 10 for wall details.

6.2 Site Preparation

Where no structural solution is required, BASIS recommend that stripping of up to 0.3m of unsuitable soils such as topsoil or organic matter should be performed, and the subgrade be inspected prior to placing the surcharge material. The exposed subgrade should be compacted to dense and unyielding conditions using a 10 tons vibratory roller.

Where structural solutions are required, such as the 2, 3 or 4 high lock block walls, excavation will be required to facilitate their placement. This is discussed in Section 8.2.

Prior to the placement of any surcharge the existing shoulder should be saw cut as per the drawings. This saw cut will function as a mitigation measure against existing shoulder/travelled lane deformation.

6.3 Settlement Gauges

Settlement gauges should be placed on the native subgrade surface prior to placement of any surcharge material. Settlement gauges and the adjacent fill elevation should be surveyed prior to placement of any fill, daily during placement of any fill, and as per the schedule outlined in Section 10.

Settlement gauges should be installed every 50m along the alignment. Depending on the length of the crest, the require number of settlement gauges will vary. The gauge locations are laid out on Binnie drawing no R1-1113-101 to 106 and a drawing of the recommended settlement plate can be found on drawing R1-1113-302.

6.4 Surcharge Material

The surcharge material should be placed after the site preparation work has been completed and the settlement gauge installation is completed.

It is understood that the surcharge material is to comprise dredged Fraser River Sand. The quality requirements are specified in the Schedule 3 Special Provisions. As Fraser River Sands will be used, the surcharge material will need to be removed in its entirely and disposed of before the ultimate pavement is constructed.

As an alternative, granular material could be used, and it would be reasonable to use Select Granular Subbase (SGSB) quality material as it can be used in the ultimate pavement design at a later time. The selected granular material should be approved by a geotechnical engineer prior to its use.

If free draining Fraser River Sands is used it should contain a fines content of less than 5%. Sieve analyses should be performed on the sand to confirm its grading. Based on COWI (2022) preliminary geotechnical interpretive report, the Fraser River Sand has been assumed to have an in-situ friction angle of 35 degrees with a density ranging from loose to compact.

A geotechnical engineer should inspect the subgrade prior to surcharge placement. The surcharge material should then be placed up to approximately 2m above existing ground level in level lifts of 600mm intervals. The contractor shall perform compaction of the surcharge material to increase the density of the material. Each lift shall be sufficiently graded, rolled, and sealed with a smooth wheel/drum roller weighing not less than 5,400kg. The requirements for placement of surcharge adjacent to the retaining wall is discussed in section 8.

Once at design elevation, the surface of the surcharge should be checked to ensure it is sloped at a nominal 2 percent to allow surface water runoff.

At this stage, the time in which the surcharge material will be in place is unknown however, it is estimated to have a duration of 2 years. The time is unknown because Phase 2 of the works is planned to be delivered by the Progressive Design- Builder, however the timeline to complete such works is to be confirmed during the design early works agreement.

7 PREDICTED SETTLEMENTS

7.1 Historical Settlement

Historical surcharging was successfully performed between Westminster Highway and Blundell Road (North of the Project Extents) between stationing 105+500 and 106+880. Graphical representation of the data is included in Appendix V, Figure 1. The settlement data from the surcharging was only recorded for between 238 days and 333 days. The settlement gauges placed on the east of the surcharge exhibited an average total settlement of 130mm after approximately 2 years with 20mm occurring after day 1 of placement. The settlement gauges on the western side of the surcharge exhibited up to 190mm of average total settlement after approximately 2 years with approximately 35mm occurring after day 1 of placement. The total average for all settlement gauges was 160mm. It is generally assumed that the expected settlement between the stationing in this report will be comparable to the aforementioned.

7.2 Soil Stratigraphy

The soil stratigraphy used in model was developed based on the southbound shoulder investigation results as well as the historic drawing showing the existing pavement structure. The stratigraphy is summarized Section 3.4 and based on the cross section in Appendix I.

7.3 Presence of Overbank Deposits

One-dimensional consolidation laboratory testing was conducted by Klohn Crippen Berger in 2023. The draft results for the laboratory testing performed on 22GEO-DH007 (T-02) have been made available. This included consolidation testing of the Silt Overbank deposits (Unit C). The results of this laboratory test are presented in Appendix III.

Soil properties used for the settlement analysis are presented in Section 3.4.2

7.4 Surcharge Settlement Analysis

Settle3, developed by Rocscience, was used to estimate the settlements of the underlying soils. This program uses one-dimensional settlement theory to estimate settlements under three-dimensional loading. The settlements were estimated using elastic (immediate) settlement and time-dependent consolidation soil models.

The settlements calculated are “free-field” settlements modelled as flexible soils and loading, and do not consider the stiffness of the existing utilities, or existing roadway structures.

The settlement at 7 representative zones were modelled for comparative purposes. For each section the surcharge load was applied at existing ground surface (assumed to be 0m bgl) and the settlement was analysed transverse to the highway. The surcharge was given a unit weight of 18.5kN/m^3 and the concrete lock blocks 24kN/m^3. The results of the settlement analysis are shown in Appendix V (Figures 2-4).

Each section is described below:

- Section 1 - Representative section at STA 4020+10.
- Section 2 - Representative section at STA 4021+30.
- Section 3 - Representative section at STA 4024+40.

- Section 4 - Representative section at STA 4025+90.
- Section 5 – Representative section at STA 4034+20
- Section 6 - Representative section at STA 4036+70.
- Section 7 - Representative section at STA 4038+30.

The geological model used in the settlement analysis was based the boreholes outlined in Section 3.2 and the cross section in Appendix I. The geological model assumed all boreholes had a ground elevation of 0m. The base of the silt was estimated to be at -6m elevation where it was not proven. This was based on the data from CPT boreholes at the northern and southern extents of the site. The boreholes on the southbound shoulder are widely spaced so there is likely inherent geological variability in the thickness of the overbank deposits. The existing traffic loading outside of the surcharge area has not been included as part of the analysis.

The surcharge duration is assumed to be 2 years. Table 7 shows the estimated settlements 6 months and 24 months following surcharge placement directly under the surcharge. The results are shown in Table 7 and Appendix V (Figure 2).

Table 7 – Estimated Total Settlement after 6 months and 2 years

Time	Settlement- With Surcharge							
	Section 1 STA 4020+10	**Section 2 STA 4021+30**	**Section 3 STA 4024+40**	**Section 4 STA 4025+90**	**Section 5 STA 4034+20**	**Section 6 STA 4036+70**	**Section 7 STA 4038+30**	**Average across 7 zones**
6 Months (Max total Settlement	120	100	140	95	95	100	155	115
6 Months (Mean Value)	90	90	115	70	80	75	130	95
6 Months (Mean value +50%)	135	135	175	105	120	115	195	140
2 Years (Max total Settlement)	130	110	150	105	105	110	165	125
2 Years (Mean Value)	100	100	125	80	90	85	140	105
2 Years (Mean value +50%)	150	150	190	120	135	130	210	155

The models suggest that at placement elevation (0m El), estimated settlements will vary along the entire length of the surcharge alignment. The average expected settlement after 6 months and 2 years was 115mm and 125mm respectively. The variation in the surcharge loading and uncertainty associated with the presence of overbank deposits along the alignment are the primary reason for the range of settlement estimates. It is predicted that differential settlements will occur transversely to the surcharge. This is due to the slopes of the surcharge being at 1.5H:1V and the crest length varying, therefore the underlying soils will experience varying proportions of loading.

The settlement estimates above are conventionally assumed to have an accuracy of 50% to 200% of the calculated values for well understood soil conditions. The estimated settlement duration is approximate, and settlement magnitudes and rates in Table 7 are estimates only. Therefore, as boreholes along the corridor will have inherent spatial variability, the average 6 months and 2 year estimated values have been increased by 50%, as shown Table 7.

An assessment was conducted of the resultant average post construction settlement at 2 years post removal (4 years since initial placement) and 25 years after surcharge removal (27 years since initial placement). The removal of the surcharge will result in the soil rebounding and the total settlement reducing. Therefore, the average total settlement across all zones range from 75mm to 110mm 2 years post removal, reducing to 65mm to 100mm 25 years post removal.

It is likely that there will be zones along the alignment where the settlement will be greater or lower than the predictions. As a result, the settlement should be monitored during construction and compared to settlement models to further verify and calibrate these models.

7.5 Existing Highway

Due to the surcharging of the embankment and shoulder adjacent to Highway 99, settlements are expected in relation to the adjacent highway. The approximate average total settlements expected at the existing lane line (EX.WL on typical sections) is expected to vary between 40mm and 60mm after 6 months. However, a mitigation method is to saw cut ahead of the CRB (start of the surcharge) as this will de couple the surcharge zone from the existing pavement structure. As a result, this should limit the pavement deformations experienced from the ambient surcharge settlement. BASIS recommend that settlement monitoring points be set up along the southbound shoulder to monitor the settlement experienced by the pavement structure. BASIS also proposes that a precondition inspection in the form of pavement photography/crack mapping and FWD testing be performed to get a baseline condition for the highway.

7.6 Existing Blundell Structure

A historical drawing (Appendix IV) provides the Blundell Road Underpass layout drawing dated May 1959. The drawings indicate spread footings at both abutments. The abutments themselves are 7-8m high. The drawing also notes that surcharge was placed on top of the fill, but it is not clear how long for/when it was removed. This indicates that the soils underlying the abutments will have historically been consolidated. Due to access restrictions and the soils underlying the west abutment having been loaded historically, no surcharge will be placed between approximate STA 4020+30 to STA 4020+80 (approximate extents of the existing structure).

On the north side of Blundell Road, the surcharge will extend to from approximate STA 4019+80 to STA 4020+30, at which point it will be terminated. The end of the surcharge will be sloped at 1.5H:1V. The toe of the existing west abutment is approximately 3m from the end of the surcharge. At this location, the settlement after 2 years is expected to be between approximately 30-50mm at existing ground elevation (Appendix V –

Figure 3B). The existing spread footings are approximately 15m off the end of the surcharge (at a higher elevation). At the spread footing location, the ground surface settlements are expected to be negligible.

On the south side of Blundell Road, the surcharge is to be placed at approximate STA 4021+26 which is approximately 50m from the toe of the slope and 70m from the spread footings. At this distance the impact to the existing west abutment is negligible.

If the toe of the north side does settle due to surcharging, there is likely to be differential settlement between the north and south side. Therefore, BASIS recommends that the abutment structure on the north and south sides of the west abutment be monitored to ensure differential and excessive settlements of the existing west abutment are not experienced.

A future settlement analysis will be required for the placement of the surcharge on the south side of Blundell in the gap between STA 4020+80 to STA 4021+26. This will need to analyse the potential settlement impacts on the existing abutment as well as the utilities in the area. Coordination between the application of the surcharge in this area and the construction of the widening at Blundell should also be considered ahead of Package 2.

7.7 Settlement Analysis – Utilities & Drainage

Existing utilities and drainage are located along the alignment:

- STA 4020+80 – Utilities
  - 600mm diameter DP Gas within 152mm diameter steel casing pipe
  - 300mm diameter steel Watermain within 406mm diameter steel casing pipe
  - 406mm diameter IP Gas within 508mm diameter steel casing pipe
  - 1500mm diameter Storm Sewer
- STA 4035+15 - Drainage
  - Corrugated Steel Pipe (CSP) arch culvert. Assumed 1500mm.

7.7.1 STA 4020+80 – Utilities

At STA 4020+80 several utilities are located running west to east to the south of Blundell Road. BASIS were directed to avoid surcharging the utilities to facilitate placement of the overall surcharge. This was due to the time frames associated with obtaining the relevant permits. A potholing exploration program is to be conducted in the Spring of 2024 to determine the depths of these utilities. As the utilities will extend directly beneath and in proximity to the future surcharge, the utilities will likely experience significant settlements.

For this phase of the project, a settlement analysis was performed transverse to the utilities/parallel the surcharge loading to determine the distance required for the intermediate pressure gas line to experience nominal settlements. The results of the settlement analysis is presented in Appendix V, Figure 3A/B. From this analysis, the limit of surcharge was identified to be 35m from the edge of the 1500mm Storm Sewer. Therefore, the surcharge will commence at STA 4021+26.

To avoid future differential settlement of the highway, BASIS recommends future surcharging of the shoulder above the utilities prior to placement of the ultimate pavement. There will need to be coordination with the utility owners in advance of Package 2 to ensure this zone can be surcharged.

7.7.2 STA 4035+15 – Arch Culvert

At STA 4035+15 a corrugated steel pipe (CSP) arch culvert is present extending from east to west beneath Highway 99. The condition of the steel pipe culvert is unknown at this stage. BASIS understands from Binnie that the culvert is like the culvert closer to the Steveston Highway at approximate STA 4042+40. However, due to time constraints a condition assessment has not been performed on the culvert at STA 4035+15.

Binnie have informed BASIS that the approximate maximum allowable settlement is 60mm for the arch culvert. BASIS modelled the cross section at STA 4035+10 and estimated the total maximum settlement exceeds the maximum allowable threshold. Therefore, for this phase of the project a gap was required to avoid failure of the arch culvert. Therefore, BASIS have defined a gap of 4m to the north of the centre of the culvert and 5m to the south of the culvert.

Although the arch culvert itself will not have surcharge material over the top, the culvert should be monitored as it is likely that the culvert will experience ambient settlements from the surrounding loading. BASIS recommends that the arch culvert be surveyed prior to placing the surcharge material. Whilst the surcharge is in place the culvert should also be surveyed regularly to ensure the culvert is not experiencing settlements which would jeopardise its structural integrity.

To avoid differential settlement of the ultimate pavement configuration, the gap over the culvert should be surcharged once the condition of the culvert is known and actual maximum allowable settlement tolerances of the culvert has been set. At this point, the surcharge should be placed over the culvert and settlement gauges be installed at regular spacing along the culvert, surveyed at regular intervals during construction, and compared to the established thresholds. There will need to be coordination with the culvert owners in advance of Package 2 to ensure this zone can be surcharged.

8 TEMPORARY RETAINING WALLS

To facilitate surcharge placement where the material will encroach into the existing drainage ditch/neighbouring properties, structural solutions are required instead of using other means such as temporary or permanent box culverts. The different structural options recommended are as follows:

- 2 high lock block walls
- 3 high lock block walls
- 4 high lock block walls

Additionally, 'U' shaped temporary walls are being proposed to protect the existing electrical infrastructure along the alignment which is discussed in Section 8.3.

The stationing of the different structural solutions are indicated in Table 6.

8.1 Material Properties

A summary of the material properties used in the earth pressures calculations are as follows:

Table 8 - Material Properties

Material	Unit Weight (kN/m3)	Friction Angle	Ka[1]	Kp[1]
Surcharge (FRS)	18.5	35	0.27	3.69
Unit B – Sand (Possible Fill)	18	31	0.32	3.12
Unit C – Silt - Overbank	18	34	0.28	3.54
Unit D - FRS	18.5	35	0.27	3.69

1 – Adopting Rankine

8.2 Temporary Battered Lock Block Gravity Wall

8.2.1 Construction Methodology

The location of lock block walls are summarised in Table 6. Two, three and four high lock block walls are recommended to maintain the existing drainage ditch. The lock blocks to be used in the retaining wall will be temporary and have a life span of the surcharge (2 years anticipated). However, if the blocks are to have a future permanent use the lock blocks used should meet the MoTI SS 942 Precast Concrete Interlocking Modular Blocks requirement. As defined by the boreholes along the alignment, the surficial soils at the lock block foundation level would comprise Unit B (Granular Possible Fill) overlying cohesive Overbank Silts (Unit C) which in turn overly the Fraser River Sands (Unit D). The ground conditions relevant to the wall stability are understood to have a typical degree of understanding.

BASIS recommends the following:

- Stripping of up to 0.3m of unsuitable soils such as topsoil or organic matter to expose the suitable subgrade.
- Excavation at 1H:1V to form a bench to construct the lock block wall. This may involve the excavation of some of the existing asphalt. The bench should be carried through to the crest of the slope.
- Prior to placement of the lock blocks the exposed subgrade should be roller compacted and levelled. The foundation soils will need to be inspected prior to placing the lock blocks. If loose material is encountered during these inspections, over excavation and replacement with compacted fill will be recommended.
- A 150mm levelling pad should be placed below the lock blocks and the lock blocks should be placed such that they are offset from each other with a batter of 1H:10V.
- Place the geogrid straps as per the typical section drawings and as outlined in Table 10. The straps should be placed at 0.75m intervals (height of 1 block) from the backside of the wall. The geogrid straps should have a minimum length of 0.7H. Strap length details are discussed in Table 10. The wall backfill (surcharge material) should be placed as noted in schedule 3.
- The bottom block for any lock block section should be wrapped by the geogrid to prevent failure of the block at foundation level.
- Subdrains at the lowest point of the sub-excavation behind the wall are required to avoid ponding and softening of soils behind and below the wall.

8.2.2 Analysis

The four failure mechanisms that were considered are:

- Sliding
- Overturning
- Bearing Capacity
- Deep Seated global stability

The self weight of the surcharge and the self weight of the concrete lock blocks were considered. An analysis of static temporary global stability of the lock block wall is discussed in Section 9.

Preliminary bearing resistances were calculated using Vesic (1975) bearing capacity formulations. A conservative friction angle of 31 degrees was assumed for Unit B. Considering the effective lock block footing dimensions, the loads are lower than the factored bearing resistance and a factor of safety of >2.0 was calculated. This meets the typical factors of safety specified by the EGBC retaining wall design guidelines.

A sliding failure and overturning check was completed for the lock block wall which is relying on the weight of the wall and soil to counteract the force of the retained surcharge soil. Based on retained height of 3.00m the factored sliding FoS was determined to be 2.1. For overturning the factored FoS was 3.6. This analysis did not consider the batter of the lock blocks and therefore the FoS for overturning is likely to be greater. These both meet the typical factors of safety specified by the EGBC retaining wall design guidelines.

8.3 Temporary "U" Shaped Lock Block Wall

To protect the existing highway signage infrastructure along the corridor, "U" shaped lock block walls are proposed. A typical section is show on drawing R1-1113-302, the installation of the lock block walls should be a "field fit" based on access/maintenance requirements. BASIS recommends that once the field fit location for the lock block arrangement has been coordinated, any soft unsuitable bearing soils should be removed. The subgrade should be inspected by a geotechnical engineer and be levelled prior to block placement.

9 GLOBAL STABILITY OF SURCHARGE AND RETAINING WALL STRUCTURES

2D Limit Equilibrium analysis was carried out for typical cross-sections along the surcharge alignment:

- Section A – STA 4020+10 – no structure
- Section B – STA 4021+30 – 4 High Lock Block Wall
- Section C – STA 4024+20 – 3 High Lock Block Wall
- Section D – STA 4028+90 – no structure
- Section E – STA 4032+20 – no structure
- Section F – STA 4032+50 – 2 High Lock Block Wall
- Section G – STA 4033+50 - 3 High Lock Block Wall
- Section H – STA 4038+30 – 4 High Lock Block Wall

The geometry for the slope stability sections was developed using line cross section produced by Binnie. The stratigraphy was estimated using the available boreholes. The water table was taken as 2m below existing ground level in all cases with a nominal amount of water in the ditch being approximately 0.2m above ditch level. A sensitivity analysis was also performed whereby the ditch water level was increased to between 0.4m and 1.0m depending on the ditch geometry.

The analysis was conducted using the computer program SLIDE2 (Rocscience, 2020), using the Morgenstern-Price method, which solves for both force and moment equilibrium.

In accordance with the BC MoTI Supplement to CAN/CSA S6-19, Table 6.2b a minimum target FoS of 1.33 was selected.

9.1 Material Properties

A summary of the soil parameters used in the slope stability analysis is presented in Table 10. Based on the DCP tests along the northbound shoulder a lower bound friction angle of 35 degrees could be assumed however, the strength of Unit B was conservatively based on back analysis of the existing ditch slope on the west side of Highway 99 and assumed as 31 degrees. The friction angle for Unit C was determined using a triaxial test on a sample of overbank silt/clay from 22GEO-DH007. The material properties for the surcharge were taken from those of the Fraser River Sand (FRS) unit, which is the soil that will be used as surcharge material.

Table 9 - Material Properties

Unit	Unit Weight (kN/m3)	Friction Angle Phi (deg)	Undrained Shear Strength (kPa)	Cohesion (kPa)
Asphalt	21	45	-	0
Surcharge (FRS)	18.5	35	-	0
Unit B – Sand (Possible Fill)	18	31	-	0
Unit C – Silt/Clay - Overbank	18	34	70	0

9.1.1 Geogrid Reinforcement

Tensar UX1100HS MSE Geogrid was modelled. The tensile strength was based on the following (FHWA-NHI-10-024):

- Ultimate Tensile Strength = 58 kN/m
- Reduction Factor for Installation Damage (RFID) = 1.2
- Reduction Factor for Creep =1.0 (Temporary case)
- Reduction Factor for Durability (RFD) = 1.1
- Maximum Allowable Strength for Temporary Case = 44 kN/m

For the slope stability sections, the geogrid was applied to SLIDE 2 with maximum pull out resistance of 25 degrees, a maximum unfactored strength of 44 kN/m.

Specifications for Tensar UX1100HS MSE can be found in Appendix VI.

9.2 Analysis and Results

A global stability analysis was carried out to check the location of any potential slip surfaces passing within the surcharge structure that may have a factor of safety (FoS) in the static condition of less than 1.33. The stability analysis results are shown in Appendix VII and Table 10.

Table 10 - Global Stability Analyses Results

Stationing	Global Factor of Safety			Block Height (m)	Recommendation
	L to R	R to L	R to L (High WT)		
Section A – STA 4020+10 No structure	>1.33 (Drained & Undrained)	1.34	-	-	No support required as surcharge is covering the existing ditch
Section B – STA 4021+30 4 High Lock Block Wall	1.43 (Drained Case)	1.53	1.42 (Drained Case) 1.93	3 (4 blocks high)	3no 2.1m (0.7H) long UX1100 geogrid straps required spaced at 0.75m. Measured from the back of the block.

	2.1 (Undrained Case)		(Undrained case)		The geogrid is to be wrapped around the bottom block.
Section C – STA 4024+40 3 High Lock Block Wall	1.41 (Drained Case) 2.10 (Undrained Case)	1.56	1.40 Drained Case) 2.10 (Undrained Case)	2.25 (3 blocks high)	2no UX1100 geogrid straps spaced at 0.75m. Upper strap 2.5m long, lower strap 1.6m (0.7H). Measured from the back of the block. The geogrid is to be wrapped around the bottom block.
Section D – STA 4025+90 No structure	1.57 (Drained case) 1.57 (Undrained case)	1.49	1.57 (Drained case) 1.57 (Undrained case)	-	2no UX100 Geogrid required straps at the backslope of the surcharge. Placed at 600mm intervals. Straps are 2.30m long. Localised excavation may be required to facilitate geogrid placement.
Section E – STA 4032+20 No structure	1.38 (Drained case) 1.41 (Undrained case)	1.35	1.33 (Drained case) 1.41 (Undrained case)	-	2no UX100 Geogrid required straps at the backslope of the surcharge. Placed at 600mm intervals. Straps are 2.30m long. Localised sub excavation may be required to facilitate geogrid placement.
Section F – STA 4032+50 2 High Lock Block Wall	1.51 (Drained case) 1.62 (Undrained case)	1.42	1.46 Drained Case) 1.62 (Undrained Case)	1.5 (2 blocks high)	2no UX1100 geogrid straps required spaced at 0.75m. Upper strap 2.5m long, lower strap 1.1m (0.7H). Measured from the back of the block. The geogrid is to be wrapped around the bottom block.
Section G – STA 4033+50 3 High Lock Block Wall	1.36 (Drained Case) 3.01 (Undrained Case)	1.59	1.34 Drained Case) 3.01 (Undrained Case)	2.25 (3 blocks high)	2no UX1100 geogrid straps spaced at 0.75m. Upper strap 2.5m long, lower strap 1.6m (0.7H). Measured from the back of the block. The geogrid is to be wrapped around the bottom block.
Section H – STA 4038+30 4 High Lock Block Wall	1.36 (Drained case) 1.79 (Undrained case)	1.39	1.33 (Drained case) 1.79 Undrained case)	3 (4 blocks high)	3no 2.1m (0.7H) long UX1100 geogrid straps required spaced at 0.75m. Measured from the back of the block. The geogrid is to be wrapped around the bottom block.

10 RECOMMENDATIONS

BASIS recommends the following:

1. Following stripping of the organics, BASIS Engineers should be present on site to inspect the subgrade for the placement of lock blocks as well as prior to surcharge placement.
2. It is recommended that the existing shoulder adjacent to the saw cut line be monitored for signs of deformation during placement of the surcharge and for 1 year post placement. Monitoring should include visual assessment and survey prior to surcharge placement, during placement and whilst surcharge is in place.
3. The settlement gauge locations are outlined on the drawings but should be confirmed by the geotechnical engineer prior to their placement.
4. Settlement Gauges should be monitored:
    a. Baseline survey prior to surcharge placement
    b. Daily during placement of surcharge
    c. Daily for the first two (2) weeks following surcharge placement.
    d. Every two (2) weeks for the following six (6) months
    e. Monthly thereafter
5. Weekly readings to be provided until termination of the Contract.
6. The surcharge condition and temporary lock block walls should be inspected by a geotechnical engineer following large rainfall events (>10mm in 24 hours). This criterion should be reviewed throughout the project timeline.
7. If time allows and prior to surcharge placement, a better understanding of the nature and extent of the overbank deposits could be obtained through further geotechnical investigations and laboratory testing at the utility culvert location, specifically to assess settlement potential at the utility and culvert locations.
8. It is recommended that surveyed monitoring of the existing Blundell structure be performed as a baseline prior to surcharge placement, during placement and whilst the surcharge is in place.

11 CLOSING

This report is an instrument of service of BASIS Engineering Ltd (BASIS). The report has been prepared for the exclusive use of RF Binnie and Associates (Client) for the specific application to the Highway 99 Additional Southbound Lanes Project (Part of the Fraser River Tunnel Project), and it may not be relied upon by any other party without BASIS's written consent.

BASIS has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. BASIS makes no warranty, express or implied.

Should you have any questions regarding the contents of this report, please call us.

BASIS Engineering Ltd.

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2024-3-15

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Engineering Geologist

Reviewed by:

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2024-03-15

PERMIT TO PRACTICE
BASIS ENGINEERING LTD.
PERMIT NUMBER: 1000338
ENGINEERS AND GEOSCIENTISTS BC

James Williams, P.Eng.
Principal, Lead Geotechnical Engineer

Bruce Hamersley, P.Eng, FEC.

President, Principal Engineer

12 REFERENCES

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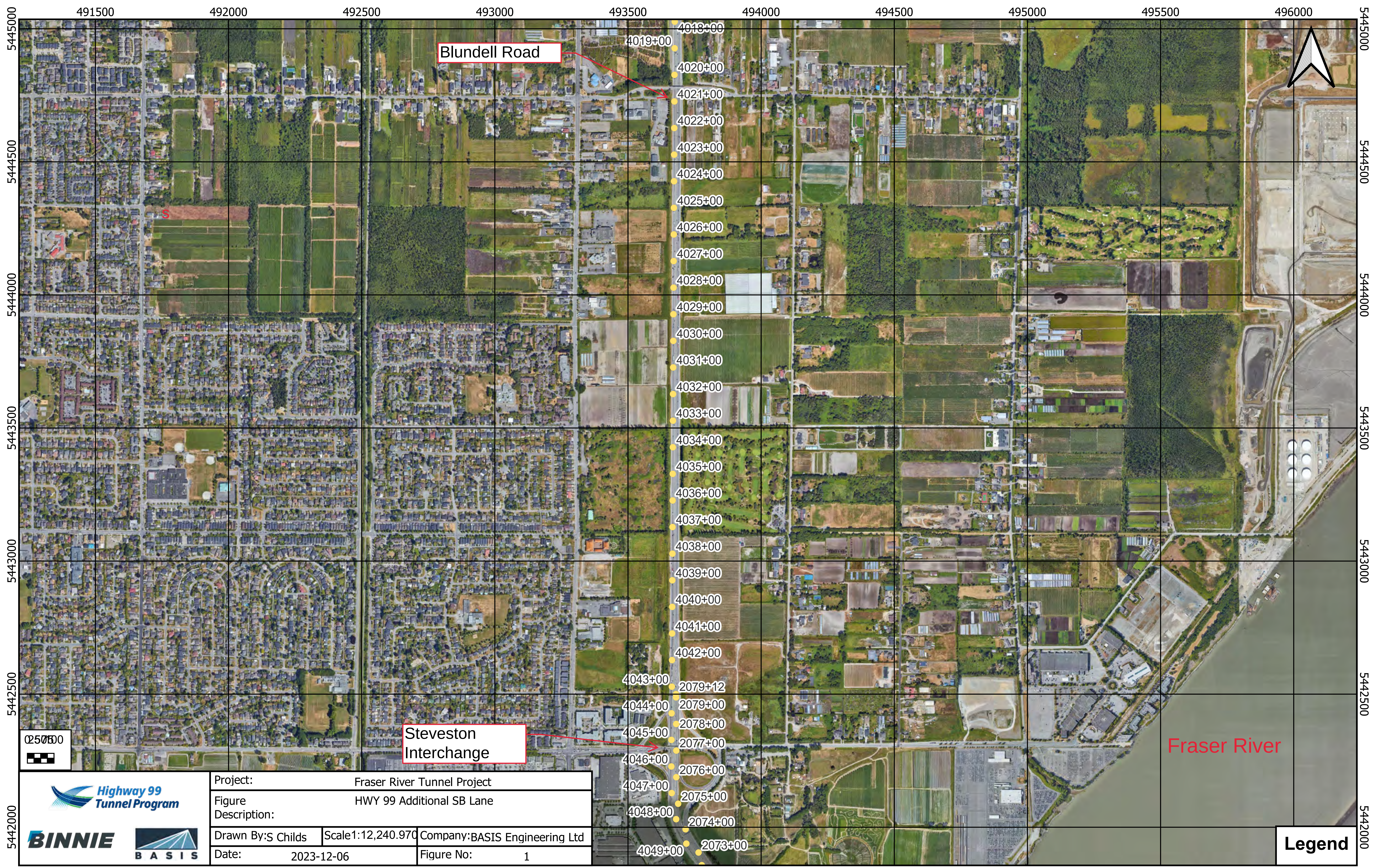
APPENDIX I – SITE PLAN AND CROSS SECTION



491500
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494500
495000
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496000
5445000
5444500
5444000
5443500
5443000
5442500
5442000
Blundell Road
Steveston Interchange
Fraser River
4018+00
4019+00
4020+00
4021+00
4022+00
4023+00
4024+00
4025+00
4026+00
4027+00
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Highway 99 Tunnel Program
BINNIE
BASIS
Project: Fraser River Tunnel Project
Figure Description: HWY 99 Additional SB Lane
Drawn By: S Childs
Scale 1:12,240.970
Company: BASIS Engineering Ltd
Date: 2023-12-06
Figure No: 1
Legend

Project:	Fraser River Tunnel Project		
Figure Description:	Site Plan		
Drawn By: S Childs	Scale 1:3,986.0255	Company: BASIS Engineering Ltd	
Date: 2023-11-15		Figure No: 2	

Highway 99 Tunnel Program
BINNIE
BASIS

Legend

Geotechnical Test Holes

- 2009_Thurber_Exploration
- 2014_GMT_Exploration
- 2015_GMT_Exploration

Highway 99 Tunnel Program

BINNIE

BASIS

Project:	Fraser River Tunnel Project		
Figure Description:	Site Plan		
Drawn By: S Childs	Scale 1:3,986.0255	Company: BASIS Engineering Ltd	
Date: 2023-11-15		Figure No:	3

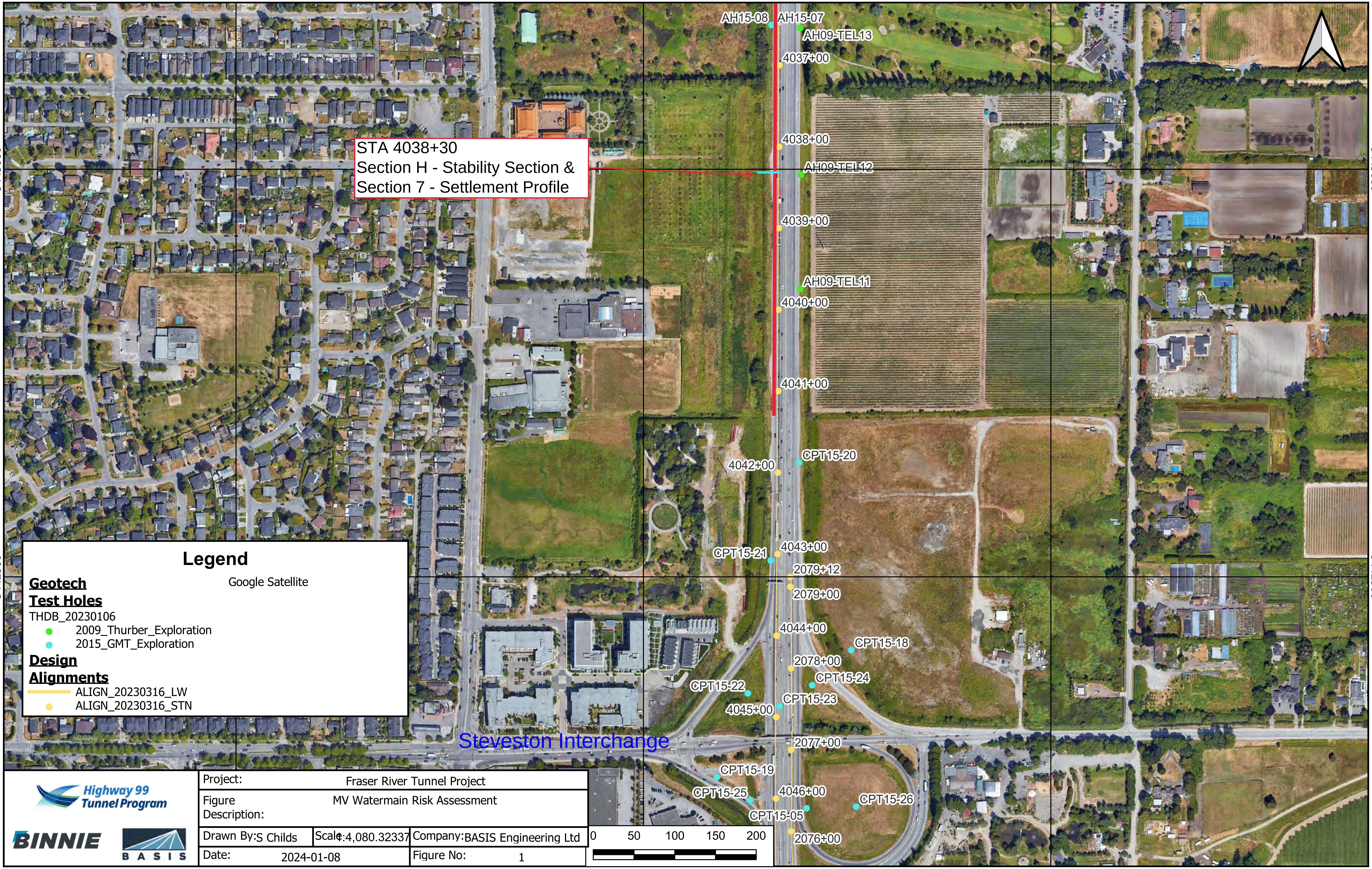
Legend

Geotechnical Test Holes

- 2009_Thurber_Exploration
- 2015_GMT_Exploration

Contours LiDAR

- SRVY_2016_SRLD_0001 - 1 m Contours

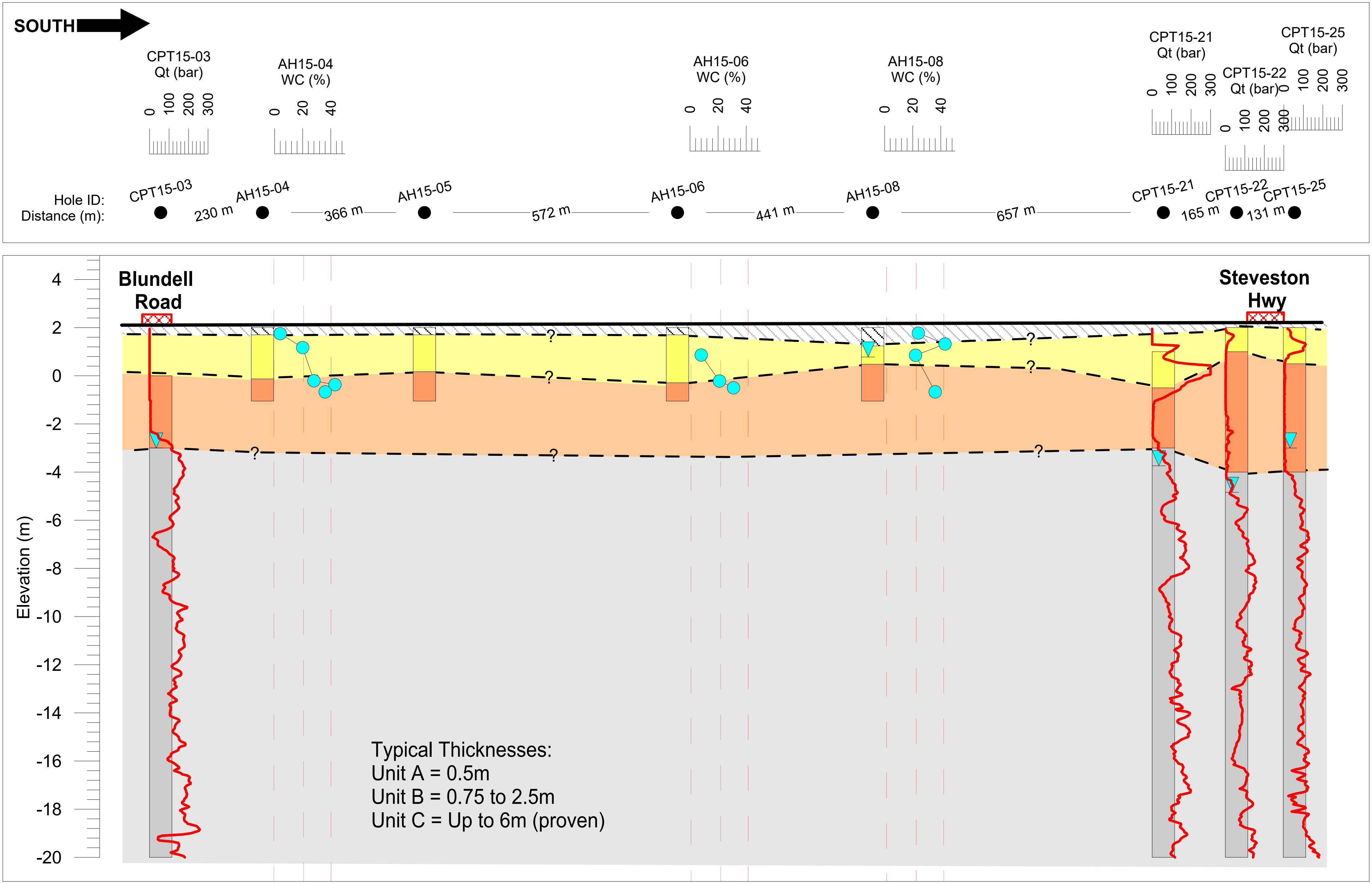


Highway 99 Tunnel Program

BINNIE

BASIS

Project:	Fraser River Tunnel Project		
Figure Description:	MV Watermain Risk Assessment		
Drawn By: S Childs	Scale: 1:4,080.32337	Company: BASIS Engineering Ltd	
Date:	2024-01-08	Figure No:	1



1) Strata boundaries are indicative
2) Ground profile uniformally chosen at 2m elevation
3) AH = Auger borehole
CPT = Cone penetration test
4) AH15-08 Water level = borehole seepage

TESTS

- Natural Water Content (%)
- CPT corrected tip resistance, Qt (bar)

STRATUM

- Unit A - Asphalt/Fill/Topsoil
- Unit B - Sand (Possible Fill)
- Unit C - Silt/Clay - Overbank
- Unit D - FRS

BASIS

Blundell to Steveston Southbound

APPENDIX II – BOREHOLES

LOG OF TEST HOLE

TEST HOLE NO. **09-11**

THURBER

LOCATION: See Dwgs. 19-598-323-1 to 20
Sta. 200+230

TOP OF HOLE ELEV: 2.1 m (est.)

METHOD: Solid Stem Auger

DRILLING CO.: On-Track Drilling Inc.

INSPECTOR: MJL

CLIENT: ISL Engineering and Land Services Ltd.

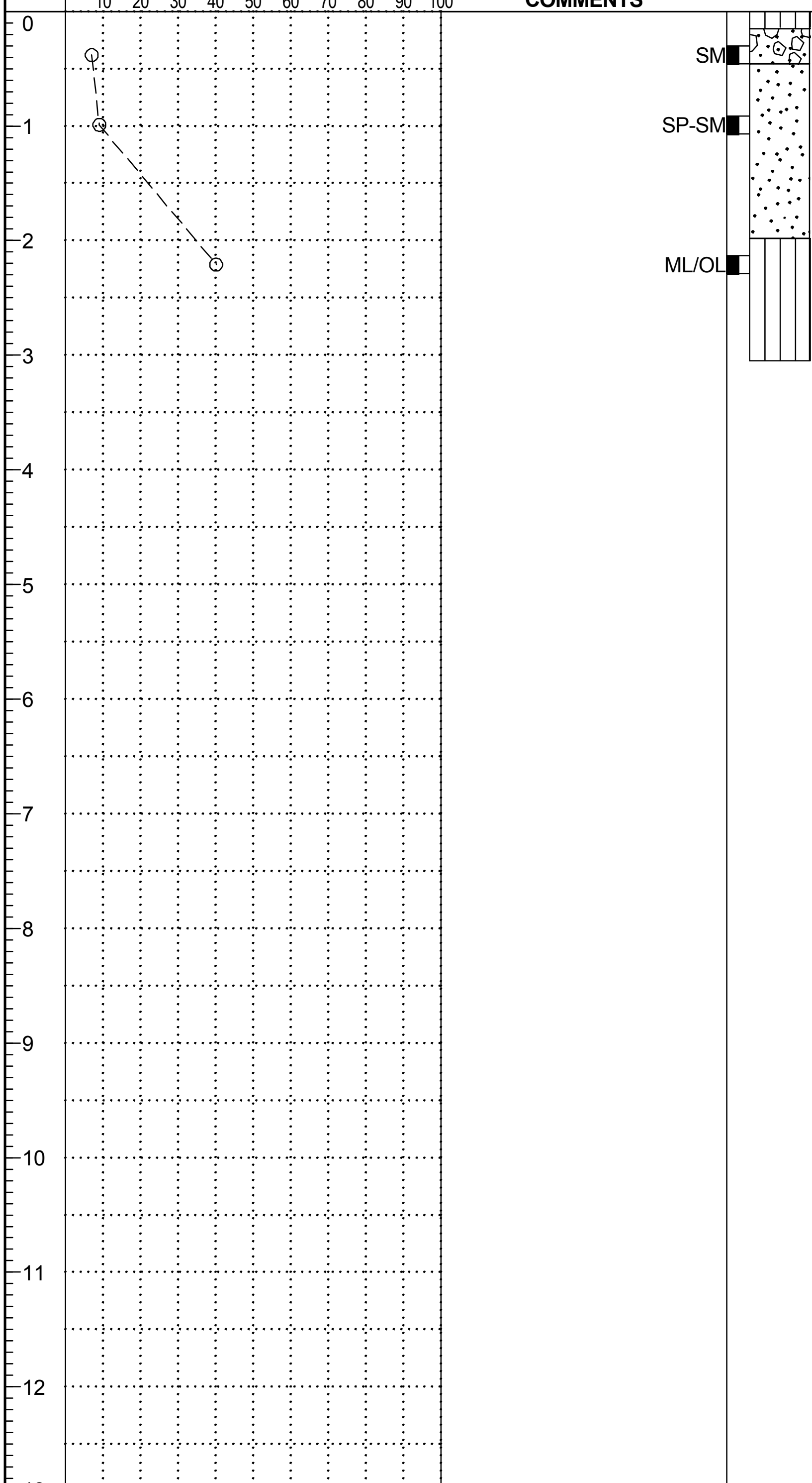
PROJECT: Highway 99 Shoulder Bus Lanes
Richmond

DATE: October 6, 2009

FILE NO.: 19-598-323

REVIEWED BY:

Legend: PENETRATION (blows/300 mm); WATER CONTENT (%) ○ Disturbed ● Undisturbed, Plastic Limit – Liquid Limit; WATER LEVEL; SAMPLES ◧ Disturbed ■ Undisturbed ☒ No Recovery; UNDRAINED SHEAR STRENGTH (kPa) ◆ Peak ◇ Residual; GRAIN SIZE (%) ▲ Passing #200 sieve △ Passing #4 sieve; SOIL HEADSPACE READING (ppm) GASTECH reading, PID reading



DEPTH (m)	COMMENTS / Sample	SOILS DESCRIPTION	ELEVATION (m)
0		Organic TOPSOIL.	2
	SM	Grey-brown, gravelly SAND with some silt and a trace of organics (Fill).	
1	SP-SM	Brown SAND with traces of silt and organics.	1
		- grey below 1.7 m	
2	ML/OL	Grey-brown SILT with some clay, a trace to some organics and a trace of sand.	0
3		End of hole at required depth.	-1

Sheet 1 of 1

LOG OF TEST HOLE

TEST HOLE NO. **09-12**

LOCATION: See Dwgs. 19-598-323-1 to 20
Sta. 200+370

TOP OF HOLE ELEV: 2.1 m (est.)

METHOD: Solid Stem Auger

DRILLING CO.: On-Track Drilling Inc.

INSPECTOR: MJL

THURBER

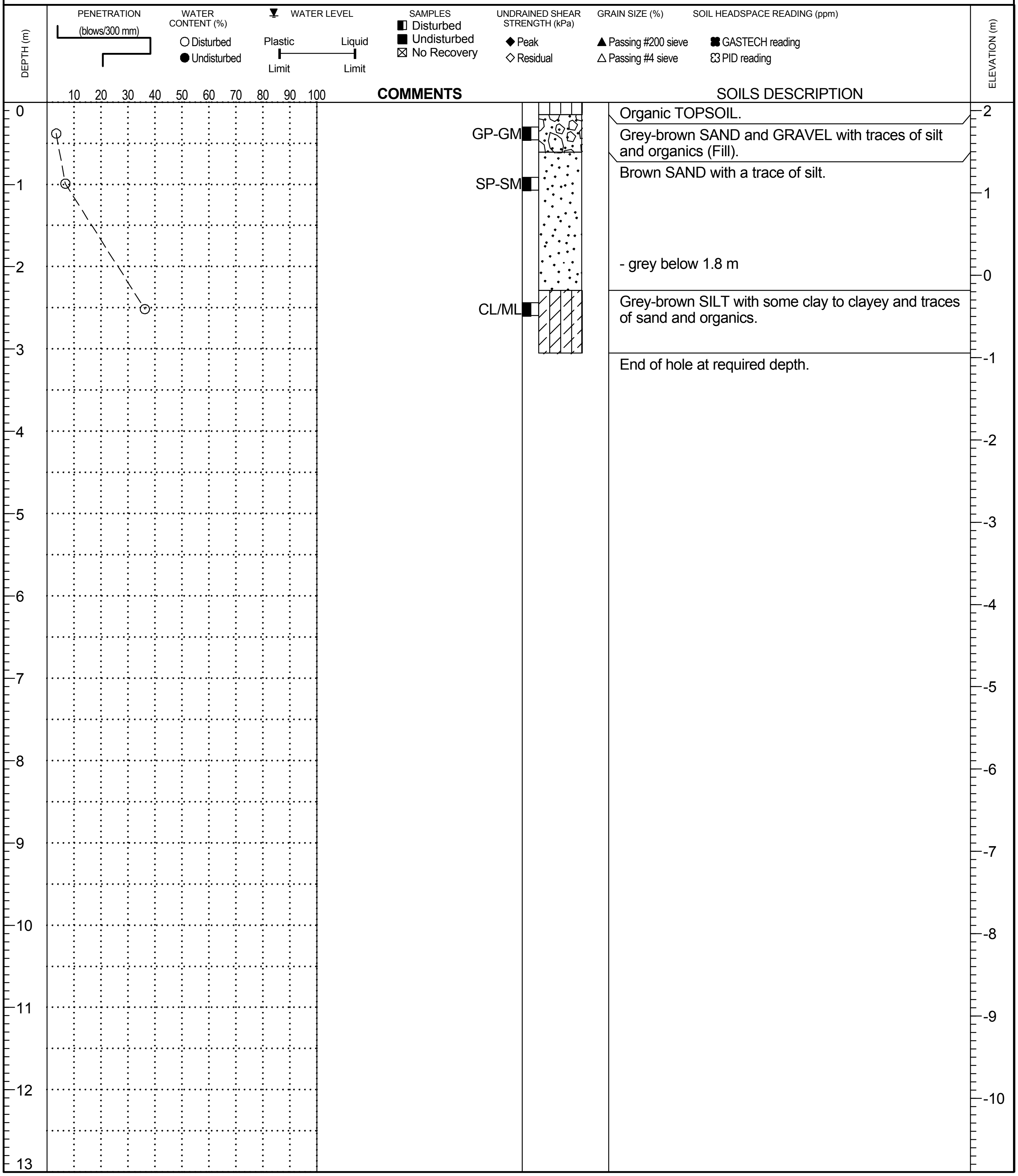
CLIENT: ISL Engineering and Land Services Ltd.

PROJECT: Highway 99 Shoulder Bus Lanes
Richmond

DATE: October 6, 2009

FILE NO.: 19-598-323

REVIEWED BY:



LOG OF TEST HOLE 19-598-323.GPJ THURBER BC.GDT 3-11-10- THURBER BC.GLB

LOG OF TEST HOLE

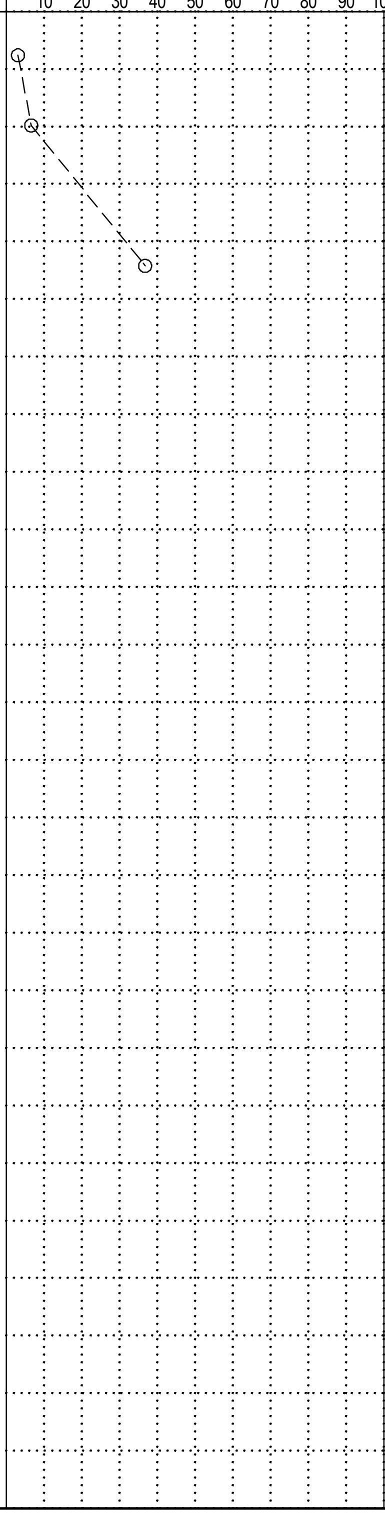
TEST HOLE NO. **09-13**

THURBER

LOCATION:	See Dwgs. 19-598-323-1 to 20 Sta. 200+570	**CLIENT:**	ISL Engineering and Land Services Ltd.
TOP OF HOLE ELEV:	2.2 m (est.)	**PROJECT:**	Highway 99 Shoulder Bus Lanes Richmond
METHOD:	Solid Stem Auger	**DATE:**	October 6, 2009
DRILLING CO.:	On-Track Drilling Inc.	**FILE NO.:**	19-598-323
INSPECTOR:	MJL	**REVIEWED BY:**	

Legend: PENETRATION (blows/300 mm) — WATER CONTENT (%): ○ Disturbed, ● Undisturbed; Plastic Limit, Liquid Limit — WATER LEVEL — SAMPLES: ◧ Disturbed, ■ Undisturbed, ⊠ No Recovery — UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak, ◇ Residual — GRAIN SIZE (%): ▲ Passing #200 sieve, △ Passing #4 sieve — SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

DEPTH (m) 0–13; scale 10 20 30 40 50 60 70 80 90 100; ELEVATION (m) 2 to -10



Depth (m)	Sample	SOILS DESCRIPTION
0 – 0.1		Organic TOPSOIL.
0.1 – 0.6	GW-GM	Brown SAND and GRAVEL with a trace of silt (Fill).
0.6 – 1.9	SP	Brown SAND with a trace of silt.
1.8		- 75 mm layer of stiff organic silt with a trace of wood at 1.8 m
1.9 – 3.0	ML/CL	Grey-brown, clayey SILT with a trace of organics.
3.0		End of hole at required depth.

Sheet 1 of 1

LOG OF TEST HOLE

TEST HOLE NO. **09-14**

THURBER

LOCATION: See Dwgs. 19-598-323-1 to 20
Sta. 200+720

TOP OF HOLE ELEV: 2.5 m (est.)

METHOD: Solid Stem Auger

DRILLING CO.: On-Track Drilling Inc.

INSPECTOR: MJL

CLIENT: ISL Engineering and Land Services Ltd.

PROJECT: Highway 99 Shoulder Bus Lanes
Richmond

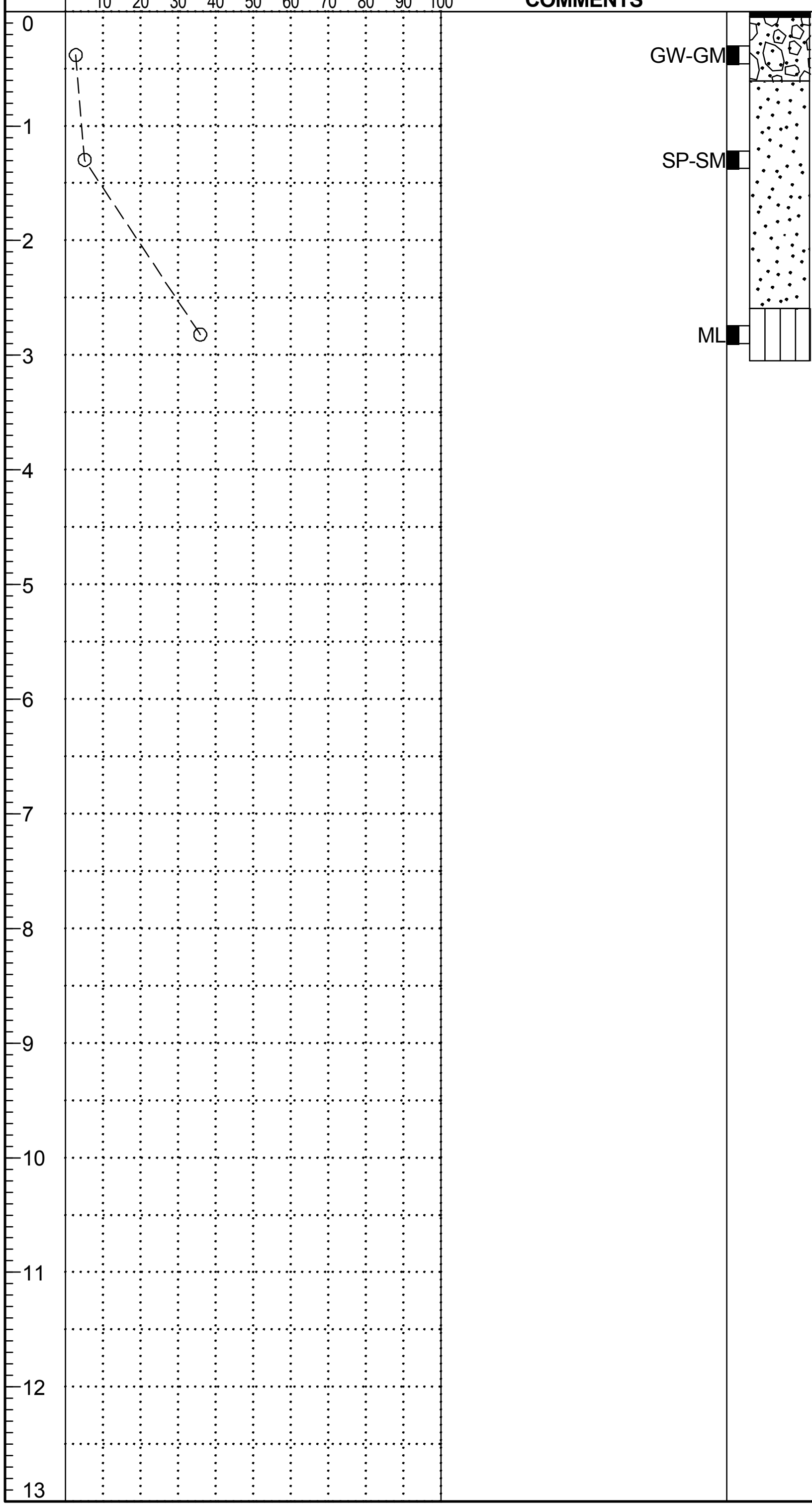
DATE: October 6, 2009

FILE NO.: 19-598-323

REVIEWED BY:

DEPTH (m) | PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed, ● Undisturbed; Plastic Limit, Liquid Limit | WATER LEVEL | SAMPLES: ◧ Disturbed, ■ Undisturbed, ⊠ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak, ◇ Residual | GRAIN SIZE (%): ▲ Passing #200 sieve, △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading | ELEVATION (m)

10 20 30 40 50 60 70 80 90 100 | **COMMENTS** | SOILS DESCRIPTION



SOILS DESCRIPTION
ASPHALT.
Brown SAND and GRAVEL with a trace of silt (Fill).
Brown SAND with a trace of silt. - grey below 2.3 m
Grey-brown SILT with some clay and traces of sand and organics.
End of hole at required depth.

LOG OF TEST HOLE

TEST HOLE NO. **09-15**

THURBER

LOCATION: See Dwgs. 19-598-323-1 to 20
Blundell U/P East Abutment

TOP OF HOLE ELEV: 6.3 m (est.)

METHOD: Solid Stem Auger

DRILLING CO.: On-Track Drilling Inc.

INSPECTOR: MJL

CLIENT: ISL Engineering and Land Services Ltd.

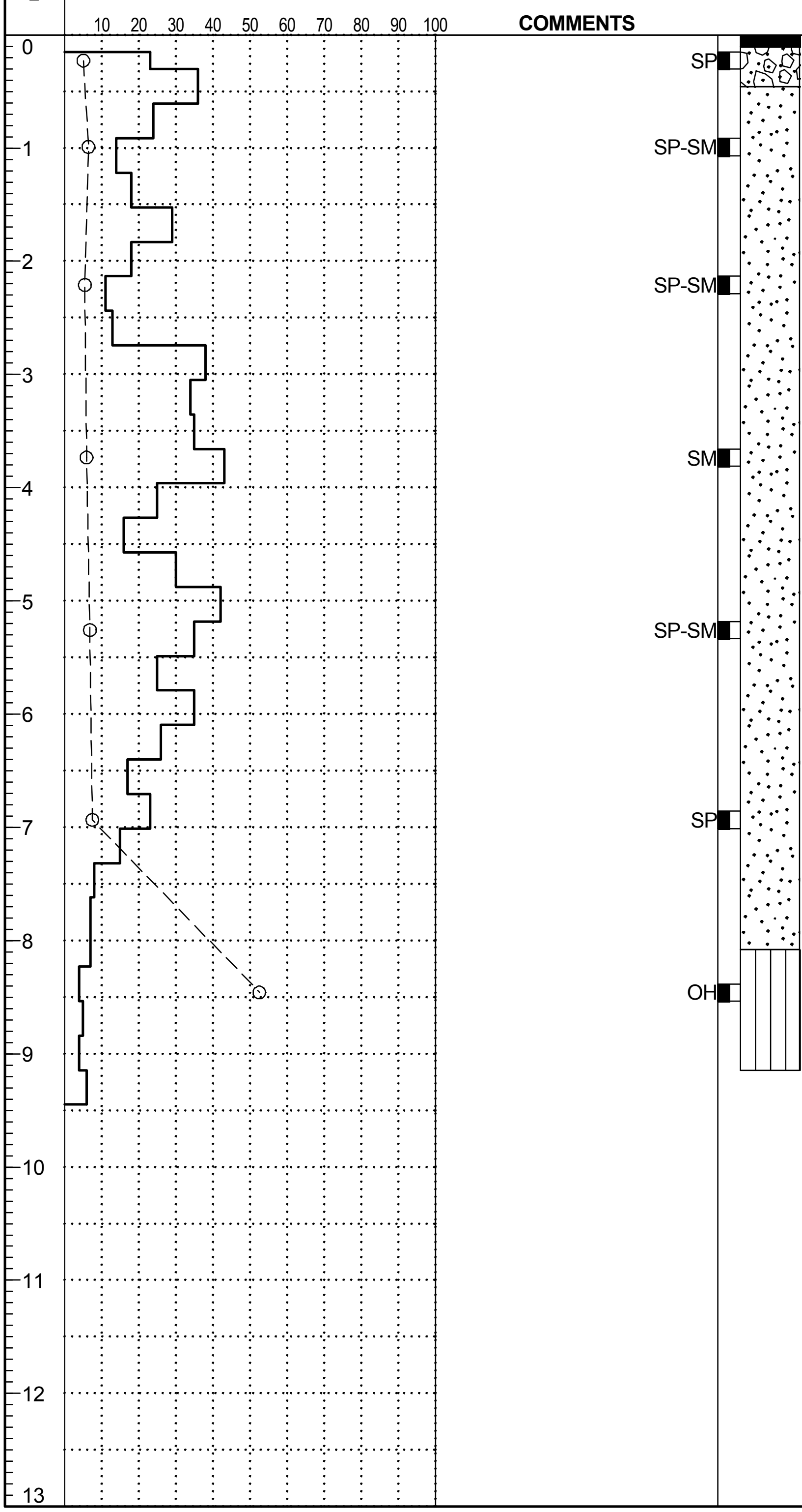
PROJECT: Highway 99 Shoulder Bus Lanes
Richmond

DATE: October 7, 2009

FILE NO.: 19-598-323

REVIEWED BY:

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed, ● Undisturbed; Plastic Limit – Liquid Limit | WATER LEVEL | SAMPLES: ◧ Disturbed, ■ Undisturbed, ⊠ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak, ◇ Residual | GRAIN SIZE (%): ▲ Passing #200 sieve, △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading



COMMENTS

SOILS DESCRIPTION

Depth (m)	Description
0	ASPHALT.
	Compact to dense, brown, gravelly SAND with traces of silt and organics (Fill).
	Compact, brown SAND with traces of silt, gravel and organics (Fill).
	- compact to dense below 3.0 m
~8.1	Firm to stiff, grey-brown SILT with some clay and traces of sand and organics.
~9.2	End of hole at required depth.

Sheet 1 of 1

LOG OF TEST HOLE

TEST HOLE NO. **09-16**

THURBER

LOCATION: See Dwgs. 19-598-323-1 to 20
Sta. 200+900

TOP OF HOLE ELEV: 2.6 m (est.)

METHOD: Solid Stem Auger

DRILLING CO.: On-Track Drilling Inc.

INSPECTOR: MJL

CLIENT: ISL Engineering and Land Services Ltd.

PROJECT: Highway 99 Shoulder Bus Lanes
Richmond

DATE: October 7, 2009

FILE NO.: 19-598-323

REVIEWED BY:

Legend: PENETRATION (blows/300 mm); WATER CONTENT (%): ○ Disturbed, ● Undisturbed; Plastic Limit – Liquid Limit; WATER LEVEL; SAMPLES: Disturbed, Undisturbed, No Recovery; UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak, ◇ Residual; GRAIN SIZE (%): ▲ Passing #200 sieve, △ Passing #4 sieve; SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

DEPTH (m) | 10 20 30 40 50 60 70 80 90 100 | COMMENTS | SOILS DESCRIPTION | ELEVATION (m)

Depth (m)	Sample	Soils Description
0		Organic TOPSOIL.
~0.3	SP-SM	Brown, gravelly SAND with a trace to some silt (Fill).
~0.6–2.6	SP (~0.9)	Brown SAND with a trace of silt.
~2.6–3.0	OL/OH (~2.8)	Grey-brown SILT with some clay, a trace to some organics and a trace of sand.
~3.0		End of hole at required depth.

Depth scale: 0 to 13 m. Elevation scale: 2 to -10 m.

LOG OF TEST HOLE 19-598-323.GPJ THURBER BC.GDT 3-11-10- THURBER BC.GLB

LOG OF TEST HOLE

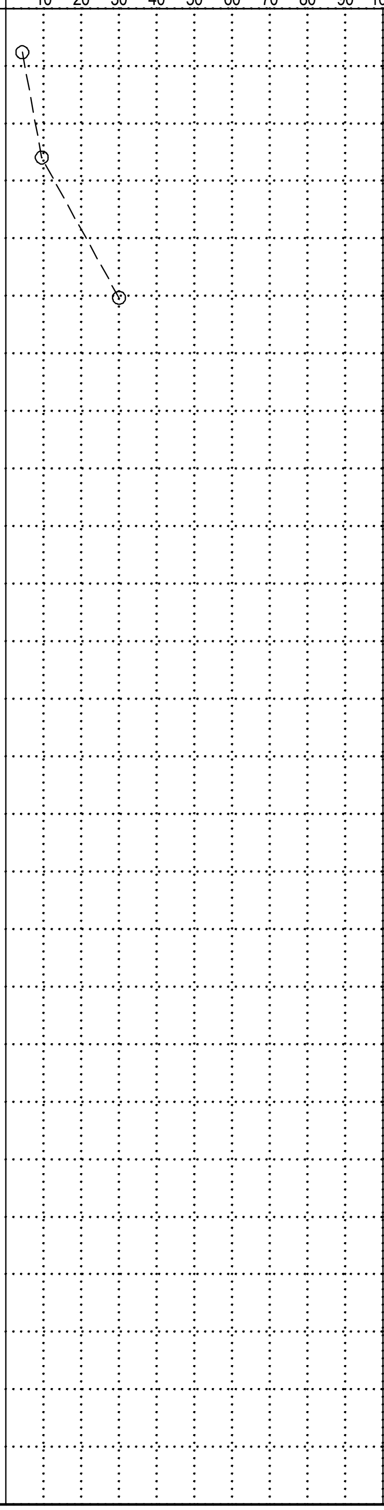
TEST HOLE NO. **09-17**

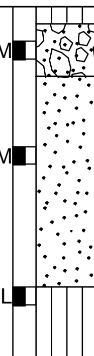
THURBER

LOCATION:	See Dwgs. 19-598-323-1 to 20 Sta. 201+100	**CLIENT:**	ISL Engineering and Land Services Ltd.
TOP OF HOLE ELEV:	2.7 m (est.)	**PROJECT:**	Highway 99 Shoulder Bus Lanes Richmond
METHOD:	Solid Stem Auger	**DATE:**	October 7, 2009
DRILLING CO.:	On-Track Drilling Inc.	**FILE NO.:**	19-598-323
INSPECTOR:	MJL	**REVIEWED BY:**	

PENETRATION (blows/300 mm) | WATER CONTENT (%): ○ Disturbed, ● Undisturbed; Plastic Limit — Liquid Limit | WATER LEVEL | SAMPLES: Disturbed, Undisturbed, ☒ No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak, ◇ Residual | GRAIN SIZE (%): ▲ Passing #200 sieve, △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

DEPTH (m) | 10 20 30 40 50 60 70 80 90 100 | COMMENTS | SOILS DESCRIPTION | ELEVATION (m)





Sample	Soils Description
	Organic TOPSOIL.
GP-GM	Grey-brown GRAVEL and SAND with a trace of silt (Fill).
SP-SM	Brown SAND with a trace to some silt.
ML/OL	Grey-brown SILT with some organics and a trace to some clay.
	End of hole at required depth.

Depth (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

Elevation (m): 2, 1, 0, -1, -2, -3, -4, -5, -6, -7, -8, -9, -10

LOG OF TEST HOLE

TEST HOLE NO. **09-18**

THURBER

LOCATION:	See Dwgs. 19-598-323-1 to 20 Sta. 201+290	**CLIENT:**	ISL Engineering and Land Services Ltd.
TOP OF HOLE ELEV:	2.7 m (est.)	**PROJECT:**	Highway 99 Shoulder Bus Lanes Richmond
METHOD:	Solid Stem Auger	**DATE:**	October 7, 2009
DRILLING CO.:	On-Track Drilling Inc.	**FILE NO.:**	19-598-323
INSPECTOR:	MJL	**REVIEWED BY:**	

Legend: PENETRATION (blows/300 mm); WATER CONTENT (%) ○ Disturbed ● Undisturbed; Plastic Limit, Liquid Limit; WATER LEVEL; SAMPLES: Disturbed, Undisturbed, No Recovery; UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual; GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve; SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

DEPTH (m) | 10 20 30 40 50 60 70 80 90 100 | **COMMENTS** | SOILS DESCRIPTION | ELEVATION (m)

Sample	Soils Description
	Organic TOPSOIL.
GP-GM	Brown GRAVEL and SAND with a trace of silt (Fill).
SP-SM	Brown SAND with a trace of silt. -grey below 2.1 m
ML/OL	Grey-brown SILT with some clay, a trace to some organics and a trace of sand.
	End of hole at required depth.

Depth scale (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

Elevation scale (m): 2, 1, 0, -1, -2, -3, -4, -5, -6, -7, -8, -9, -10

LOG OF TEST HOLE

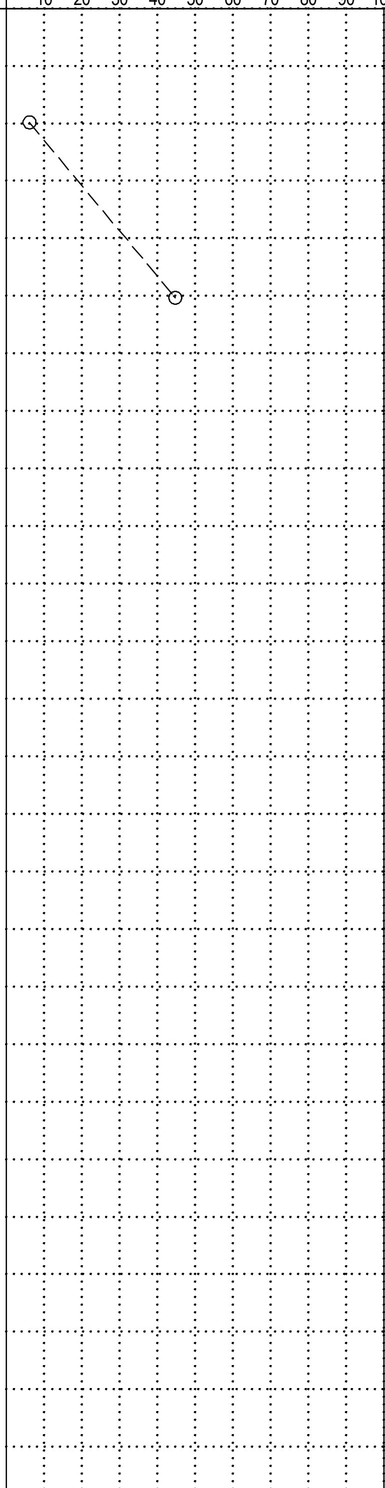
TEST HOLE NO. **09-19**

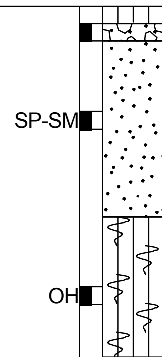
THURBER

LOCATION:	See Dwgs. 19-598-323-1 to 20 Sta. 201+500
TOP OF HOLE ELEV:	2.3 m (est.)
METHOD:	Solid Stem Auger
DRILLING CO.:	On-Track Drilling Inc.
INSPECTOR:	MJL
CLIENT:	ISL Engineering and Land Services Ltd.
PROJECT:	Highway 99 Shoulder Bus Lanes Richmond
DATE:	October 7, 2009
FILE NO.:	19-598-323
REVIEWED BY:	

DEPTH (m) — PENETRATION (blows/300 mm) — WATER CONTENT (%): ○ Disturbed, ● Undisturbed; Plastic Limit, Liquid Limit — WATER LEVEL — SAMPLES: Disturbed, Undisturbed, No Recovery — UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak, ◇ Residual — GRAIN SIZE (%): ▲ Passing #200 sieve, △ Passing #4 sieve — SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading — ELEVATION (m)

10 20 30 40 50 60 70 80 90 100 — **COMMENTS** — SOILS DESCRIPTION





Depth (m)	Soils Description
0	Organic TOPSOIL.
	Brown GRAVEL and SAND with traces of silt and organics (Fill).
	Brown SAND with a trace of silt.
~1.8	Grey-brown SILT with some organics to organicy and a trace to some clay.
~3.0	End of hole at required depth.

Depth scale (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

Elevation scale (m): 2, 1, 0, -1, -2, -3, -4, -5, -6, -7, -8, -9, -10

LOG OF TEST HOLE

TEST HOLE NO. **09-20**

THURBER

LOCATION:	See Dwgs. 19-598-323-1 to 20 Sta. 201+700	**CLIENT:**	ISL Engineering and Land Services Ltd.
TOP OF HOLE ELEV:	2.3 m (est.)	**PROJECT:**	Highway 99 Shoulder Bus Lanes Richmond
METHOD:	Solid Stem Auger	**DATE:**	October 7, 2009
DRILLING CO.:	On-Track Drilling Inc.	**FILE NO.:**	19-598-323
INSPECTOR:	MJL	**REVIEWED BY:**	

DEPTH (m)

PENETRATION (blows/300 mm)

WATER CONTENT (%): ○ Disturbed ● Undisturbed; Plastic Limit, Liquid Limit

WATER LEVEL

SAMPLES: ◧ Disturbed ■ Undisturbed ☒ No Recovery

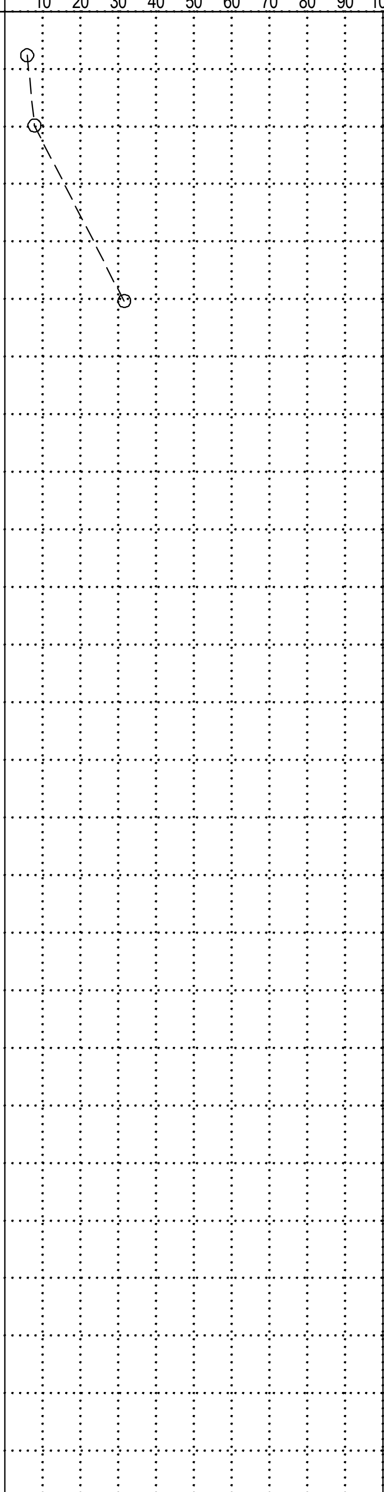
UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual

GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve

SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading

ELEVATION (m)

10 20 30 40 50 60 70 80 90 100

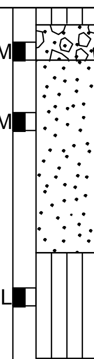


COMMENTS

GP-GM

SP-SM

ML/OL



SOILS DESCRIPTION

Depth (m)	Description
0	Organic TOPSOIL.
	Grey-brown SAND and GRAVEL with traces of silt and organics (Fill).
	Brown SAND with traces of silt and organics.
2	Grey-brown SILT with trace to some clay and organics and a trace of sand.
3	End of hole at required depth.

Depth scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13

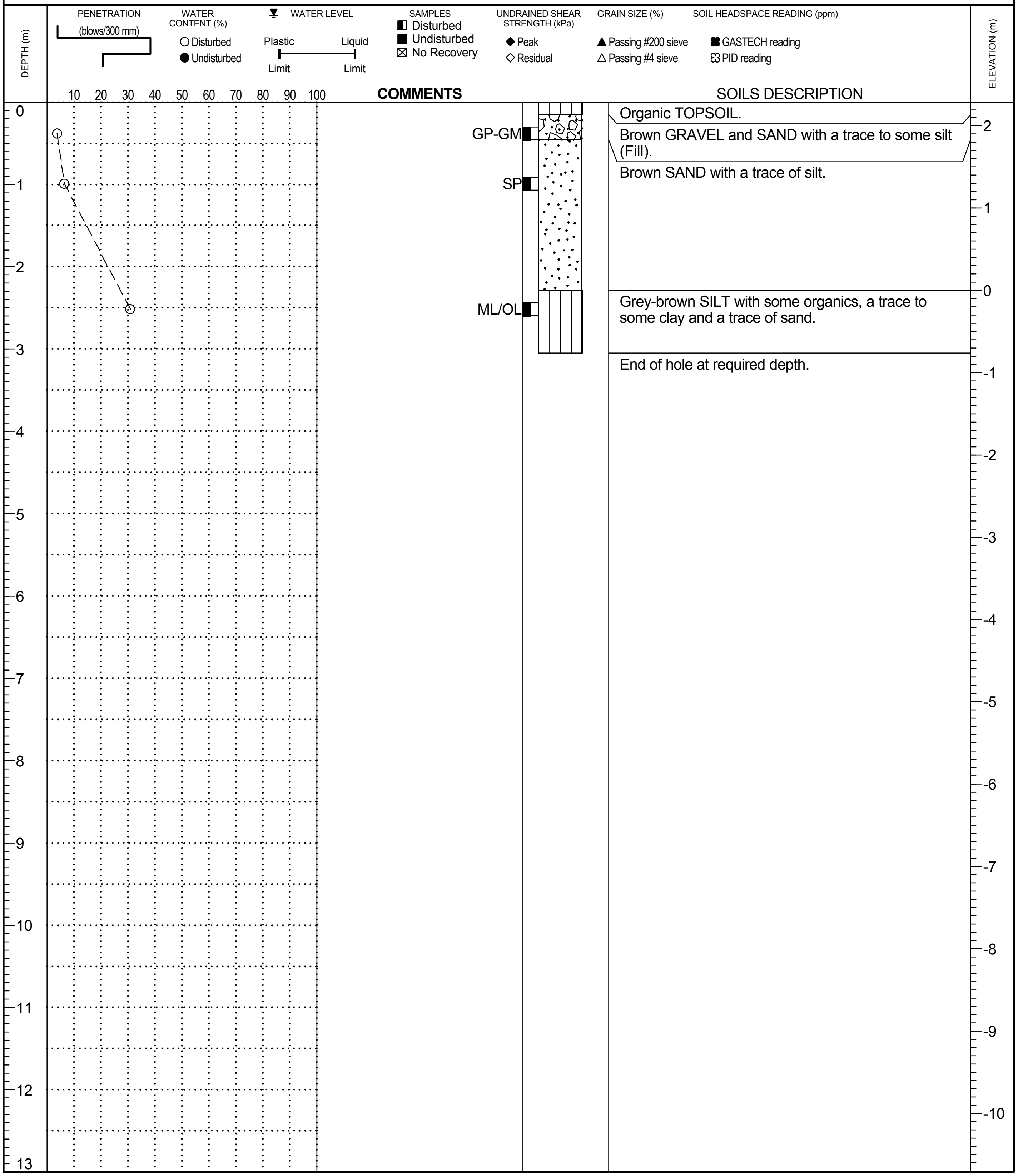
Elevation scale: 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10

LOG OF TEST HOLE

TEST HOLE NO. 09-21

THURBER

LOCATION:	See Dwgs. 19-598-323-1 to 20 Sta. 201+920	**CLIENT:**	ISL Engineering and Land Services Ltd.
		PROJECT:	Highway 99 Shoulder Bus Lanes Richmond
TOP OF HOLE ELEV:	2.3 m (est.)		
METHOD:	Solid Stem Auger	**DATE:**	October 7, 2009
DRILLING CO.:	On-Track Drilling Inc.	**FILE NO.:**	19-598-323
INSPECTOR:	MJL	**REVIEWED BY:**	



Sheet 1 of 1

LOG OF TEST HOLE

TEST HOLE NO. **09-22**

THURBER

LOCATION: See Dwgs. 19-598-323-1 to 20
Sta. 202+100

TOP OF HOLE ELEV: 2.1 m (est.)

METHOD: Solid Stem Auger

DRILLING CO.: On-Track Drilling Inc.

INSPECTOR: MJL

CLIENT: ISL Engineering and Land Services Ltd.

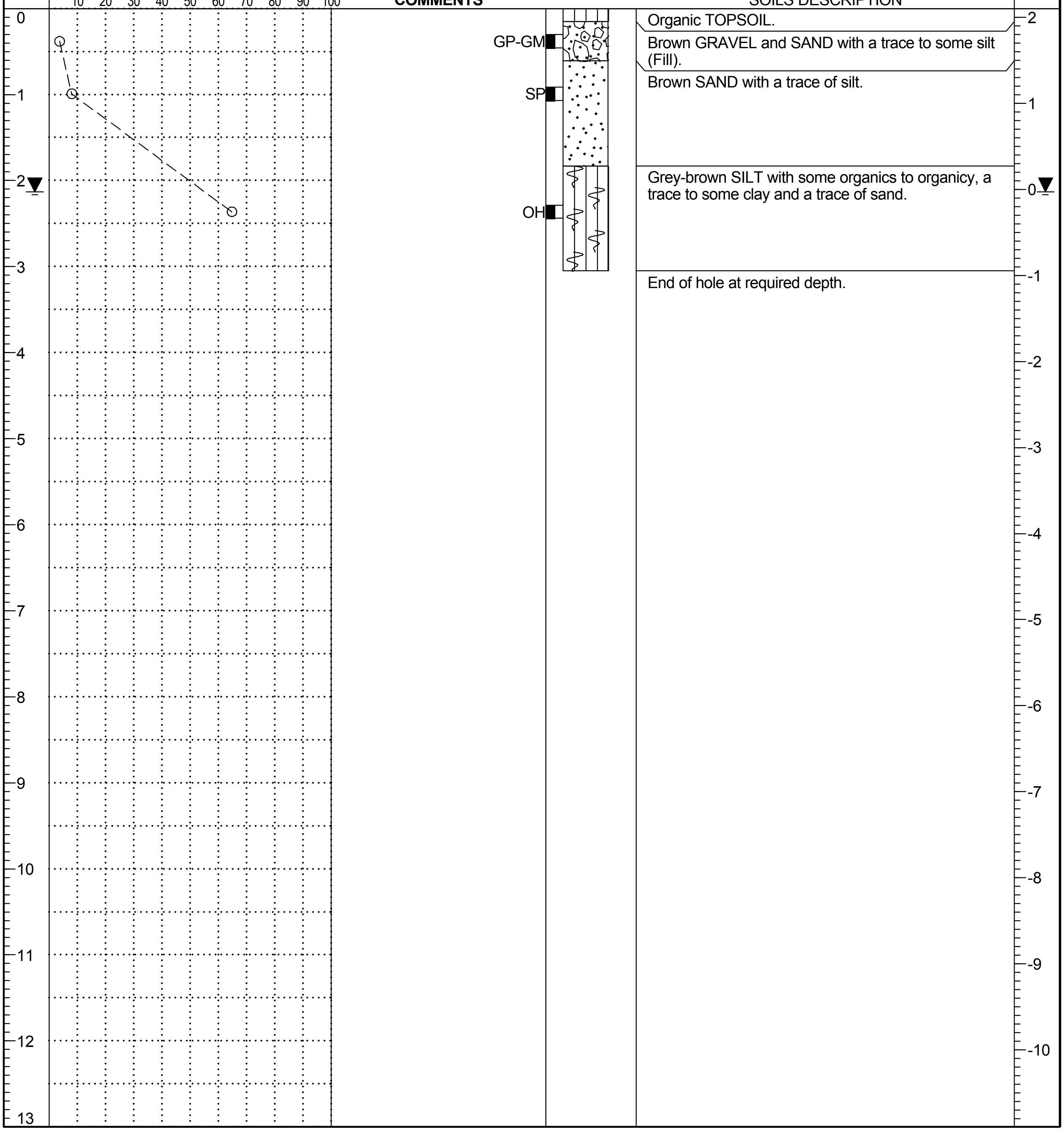
PROJECT: Highway 99 Shoulder Bus Lanes
Richmond

DATE: October 7, 2009

FILE NO.: 19-598-323

REVIEWED BY:

PENETRATION (blows/300 mm) | WATER CONTENT (%) ○ Disturbed ● Undisturbed; Plastic Limit – Liquid Limit | WATER LEVEL | SAMPLES: Disturbed, Undisturbed, No Recovery | UNDRAINED SHEAR STRENGTH (kPa): ◆ Peak ◇ Residual | GRAIN SIZE (%): ▲ Passing #200 sieve △ Passing #4 sieve | SOIL HEADSPACE READING (ppm): GASTECH reading, PID reading



Depth (m)	Sample	SOILS DESCRIPTION	Elevation (m)
0		Organic TOPSOIL.	2
	GP-GM	Brown GRAVEL and SAND with a trace to some silt (Fill).	
1	SP	Brown SAND with a trace of silt.	1
2	OH	Grey-brown SILT with some organics to organicy, a trace to some clay and a trace of sand.	0
3		End of hole at required depth.	-1

LOG OF TEST HOLE 19-598-323.GPJ THURBER BC.GDT 3-11-10- THURBER BC.GLB

Ministry of Transportation and Infrastructure

SUMMARY LOG

Geotechnical and Materials Branch

TEST HOLE No. AH15-04

Project: George Massey Tunnel Replacement Project

Location: Hwy 99 - Westminster Hwy to Steveston Hwy - Southbound Shoulder

Coordinates: N 5444556 E 493666

Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

Driller: Sea to Sky Drilling Ltd.

Inspector: JB - Golder Associates Ltd.

Equipment: Truck Mounted B53 - Solid Stem Auger

Date(s): February 12, 2015

Drilling, Well Installation and Blow Count Details	Depth (m)	DCPT (Blows/0.3m)	Sample Type	SPT N (Blows/0.3m)	Recovery (m)	Shear Strength (kPa)	Gradation % Gravel	Gradation % Sand	Gradation % Fines	Index Properties w_L	Index Properties w_P	Index Properties w	Other Tests	Classification	Description
	0.0		AS		0.15		34	61	5			4		SP	ASPHALTIC CONCRETE. (0.10 m) SAND and GRAVEL, trace silt, fine to coarse; brown to grey; non-cohesive, dense. [ROAD BASE FILL] (0.30 m)
			AS		0.15		0	93	7			20		SP	SAND, poorly graded, trace silt, fine to medium; grey; non-cohesive, compact. [POSSIBLE FILL]
	1.0														
	2.0		AS		0.15							28		ML	(2.13 m) Sandy SILT, low plasticity, with organics; grey; cohesive.
			AS		0.15							43		OL	(2.29 m) ORGANIC SILT, low plasticity, some fine to medium sand; grey and brown; cohesive.
			AS		0.15							36		CL	(2.44 m) SILTY CLAY, medium plasticity; grey; cohesive.
	3.0														3.05m END OF HOLE. Groundwater seepage level not recorded.
	4.0														
	5.0														
	6.0														
	7.0														
	8.0														
	9.0														

SAMPLE TYPE
AS - Auger
C - Core
D - Denison
G - Grab
SS - Split Spoon
ST - Shelby Tube
PT - Piston Tube
W - Wash

SHEAR STRENGTH kPa
U - Unconfined Compression
Fv - Field Vane
Lv - Lab Vane
R - Remoulded

TESTS
M - Mechanical Analysis
H - Hydrometer Analysis
Q.R.S - Triaxial Compression
C - Consolidation
DS - Direct Shear
w_L,w_P - Liquid, Plastic Limits
w - Moisture Content

FILE No. 14-1447-0012 (5000)

PREPARED BY: - Golder Associates

SHEET 1 of 1

Ministry of Transportation and Infrastructure

SUMMARY LOG

Geotechnical and Materials Branch

TEST HOLE No. AH15-05

Project: George Massey Tunnel Replacement Project

Location: Hwy 99 - Westminster Hwy to Steveston Hwy - Southbound Shoulder

Coordinates: N 5444190 E 493664

Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

Driller: Sea to Sky Drilling Ltd.

Inspector: JB - Golder Associates Ltd.

Equipment: Truck Mounted B53 - Solid Stem Auger

Date(s): February 12, 2015

Drilling, Well Installation and Blow Count Details	Depth (m)	DCPT (Blows/0.3m)	Sample Type	SPT N (Blows/0.3m)	Recovery (m)	Shear Strength (kPa)	Gradation % Gravel	Sand	Fines	Index Properties w_L	w_P	w	Other Tests	Classification	Description
	0.0														ASPHALTIC CONCRETE. — 0.12 m
			AS		0.15									SP-GP	GRAVEL and SAND, fine to coarse; greyish brown; dense. [ROAD BASE FILL] — 0.30 m
			AS		0.15										
	1.0													SP	SAND, poorly graded, fine to medium; grey; loose to compact. [POSSIBLE FILL] — 1.83 m
	2.0		AS		0.15									ML-MH	Sandy SILT, low to medium plasticity, fine to medium sand, with organics; grey; cohesive.
			AS		0.15										
	3.0														3.05m END OF HOLE. Groundwater seepage level not recorded.
	4.0														
	5.0														
	6.0														
	7.0														
	8.0														
	9.0														

SAMPLE TYPE
AS - Auger
C - Core
D - Denison
G - Grab
SS - Split Spoon
ST - Shelby Tube
PT - Piston Tube
W - Wash

SHEAR STRENGTH kPa
U - Unconfined Compression
Fv - Field Vane
Lv - Lab Vane
R - Remoulded

TESTS
M - Mechanical Analysis
H - Hydrometer Analysis
Q.R.S - Triaxial Compression
C - Consolidation
DS - Direct Shear
w_L,w_P - Liquid, Plastic Limits
w - Moisture Content

FILE No. 14-1447-0012 (5000)

PREPARED BY: - Golder Associates

SHEET 1 of 1

Ministry of Transportation and Infrastructure

SUMMARY LOG

Geotechnical and Materials Branch

TEST HOLE No. AH15-06

Project: George Massey Tunnel Replacement Project

Location: Hwy 99 - Westminster Hwy to Steveston Hwy - Southbound Shoulder

Coordinates: N 5443618 E 493662

Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

Driller: Sea to Sky Drilling Ltd.

Inspector: JB - Golder Associates Ltd.

Equipment: Truck Mounted B53 - Solid Stem Auger

Date(s): February 12, 2015

Drilling, Well Installation and Blow Count Details	Depth (m)	DCPT (Blows/0.3m)	Sample Type	SPT N (Blows/0.3m)	Recovery (m)	Shear Strength (kPa)	Gradation % Gravel	Sand	Fines	Index Properties w_L	w_P	w	Other Tests	Classification	Description
	0.0		AS		0.15										ASPHALTIC CONCRETE. (0.15 m)
														SP-GP	GRAVEL and SAND, trace silt, fine to coarse, sub-angular; brownish grey; dense. [ROAD BASE FILL] (0.30 m)
	1.0		AS		0.15							8		SP	SAND, poorly graded, trace silt, fine to medium; grey-brown; loose to compact.
	2.0		AS		0.15							21			(2.29 m)
			AS		0.15							31		CL	SILTY CLAY, low to medium plasticity, trace fine sand; grey-brown; cohesive.
	3.0														3.05m END OF HOLE. Groundwater seepage level not recorded.
	4.0														
	5.0														
	6.0														
	7.0														
	8.0														
	9.0														

SAMPLE TYPE
AS - Auger
C - Core
D - Denison
G - Grab
SS - Split Spoon
ST - Shelby Tube
PT - Piston Tube
W - Wash

SHEAR STRENGTH kPa
U - Unconfined Compression
Fv - Field Vane
Lv - Lab Vane
R - Remoulded

TESTS
M - Mechanical Analysis
H - Hydrometer Analysis
Q.R.S - Triaxial Compression
C - Consolidation
DS - Direct Shear
w_L,w_P - Liquid, Plastic Limits
w - Moisture Content

FILE No. 14-1447-0012 (5000)

PREPARED BY: - Golder Associates

SHEET 1 of 1

Ministry of Transportation and Infrastructure

SUMMARY LOG

Geotechnical and Materials Branch

TEST HOLE No. AH15-07

Project: George Massey Tunnel Replacement Project

Location: Hwy 99 - Westminster Hwy to Steveston Hwy - Southbound Shoulder

Coordinates: N 5443177 E 493660

Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

Driller: Sea to Sky Drilling Ltd.

Inspector: JB - Golder Associates Ltd.

Equipment: Truck Mounted B53 - Solid Stem Auger

Date(s): February 12, 2015

Drilling, Well Installation and Blow Count Details	Depth (m)	DCPT (Blows/0.3m)	Sample Type	SPT N (Blows/0.3m)	Recovery (m)	Shear Strength (kPa)	Gradation % Gravel	Gradation % Sand	Gradation % Fines	Index Properties w_L	Index Properties w_P	Index Properties w	Other Tests	Classification	Description
	0.0														ASPHALTIC CONCRETE. (0.15 m)
			AS		0.08		53	42	5			2		GP-SP	GRAVEL and SAND, trace silt, fine to coarse, subangular; brownish grey; dense. [ROAD BASE FILL] (0.23 m)
			AS		0.15							5		SP	SAND, poorly graded; brownish grey; loose to compact. [POSSIBLE FILL] (0.91 m)
	1.0		AS		0.15									SP_1	SAND, poorly graded, some silt; grey; loose. [POSSIBLE FILL] - wood chunk at 1.52 m depth (1.68 m)
			AS		0.15		0	28	72			40		ML	SILT, low plasticity; grey-brown; cohesive. (1.83 m)
	2.0													CL	SILTY CLAY, low plasticity; grey; cohesive.
			AS		0.15					38	23	39			
	3.0														3.05m END OF HOLE.
															Groundwater seepage encountered at 1.68 m depth in open augerhole.
	4.0														
	5.0														
	6.0														
	7.0														
	8.0														
	9.0														

SAMPLE TYPE
- AS - Auger
- C - Core
- D - Denison
- G - Grab
- SS - Split Spoon
- ST - Shelby Tube
- PT - Piston Tube
- W - Wash

SHEAR STRENGTH kPa
- U - Unconfined Compression
- Fv - Field Vane
- Lv - Lab Vane
- R - Remoulded

TESTS
- M - Mechanical Analysis
- H - Hydrometer Analysis
- Q.R.S - Triaxial Compression
- C - Consolidation
- DS - Direct Shear
- w_L,w_P - Liquid, Plastic Limits
- w - Moisture Content

FILE No. 14-1447-0012 (5000)

PREPARED BY: - Golder Associates

SHEET 1 of 1

National IM Server:GINT_GAL_NATIONAL IM Unique Project ID: Output Form:BC_MOT WITH DCPT (AUTO) AWood 3/5/15

SUMMARY LOG

Ministry of Transportation and Infrastructure
Project: George Massey Tunnel Replacement Project
Location: Hwy 99 - Westminster Hwy to Steveston Hwy - Southbound Shoulder
Driller: Sea to Sky Drilling Ltd.
Equipment: Truck Mounted B53 - Solid Stem Auger
Inspector: JB - Golder Associates Ltd.

Geotechnical and Materials Branch

TEST HOLE No. AH15-08

Coordinates: N 5443177 E 493657
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

Date(s): February 12, 2015

Depth (m)	DCPT (Blows/0.3m)	Sample Type	SPT N (Blows/0.3m)	Recovery (m)	Shear Strength (kPa)	Gravel	Sand	Fines	w_L	w_P	w	Other Tests	Classification	Description
0.0		AS		0.15							24		CL	SILTY CLAY, low plasticity, trace organics; brown-grey; cohesive. [POSSIBLE FILL] (to 0.46 m)
		AS		0.15							43		CL	SILTY CLAY, low plasticity, with organics; brown- black- grey; cohesive. [POSSIBLE FILL] (to 0.76 m)
1.0		AS		0.15							22		SP	SAND, poorly graded; brownish grey; loose to compact. [POSSIBLE FILL] (to 1.52 m)
		AS		0.15									CH	SILTY CLAY, high plasticity, with organics; black- brown- grey; cohesive. (to 1.68 m)
2.0													MH	CLAYEY SILT, high plasticity; grey; cohesive.
		AS		0.15							36			
3.0														3.05m END OF HOLE. Groundwater seepage encountered at 1.22 m depth in open augerhole.

Drilling, Well Installation and Blow Count Details: (none)

SAMPLE TYPE
AS - Auger
C - Core
D - Denison
G - Grab
SS - Split Spoon
ST - Shelby Tube
PT - Piston Tube
W - Wash

SHEAR STRENGTH kPa
U - Unconfined Compression
Fv - Field Vane
Lv - Lab Vane
R - Remoulded

TESTS
M - Mechanical Analysis
H - Hydrometer Analysis
Q.R.S - Triaxial Compression
C - Consolidation
DS - Direct Shear
w_L,w_P - Liquid, Plastic Limits
w - Moisture Content

FILE No. 14-1447-0012 (5000)

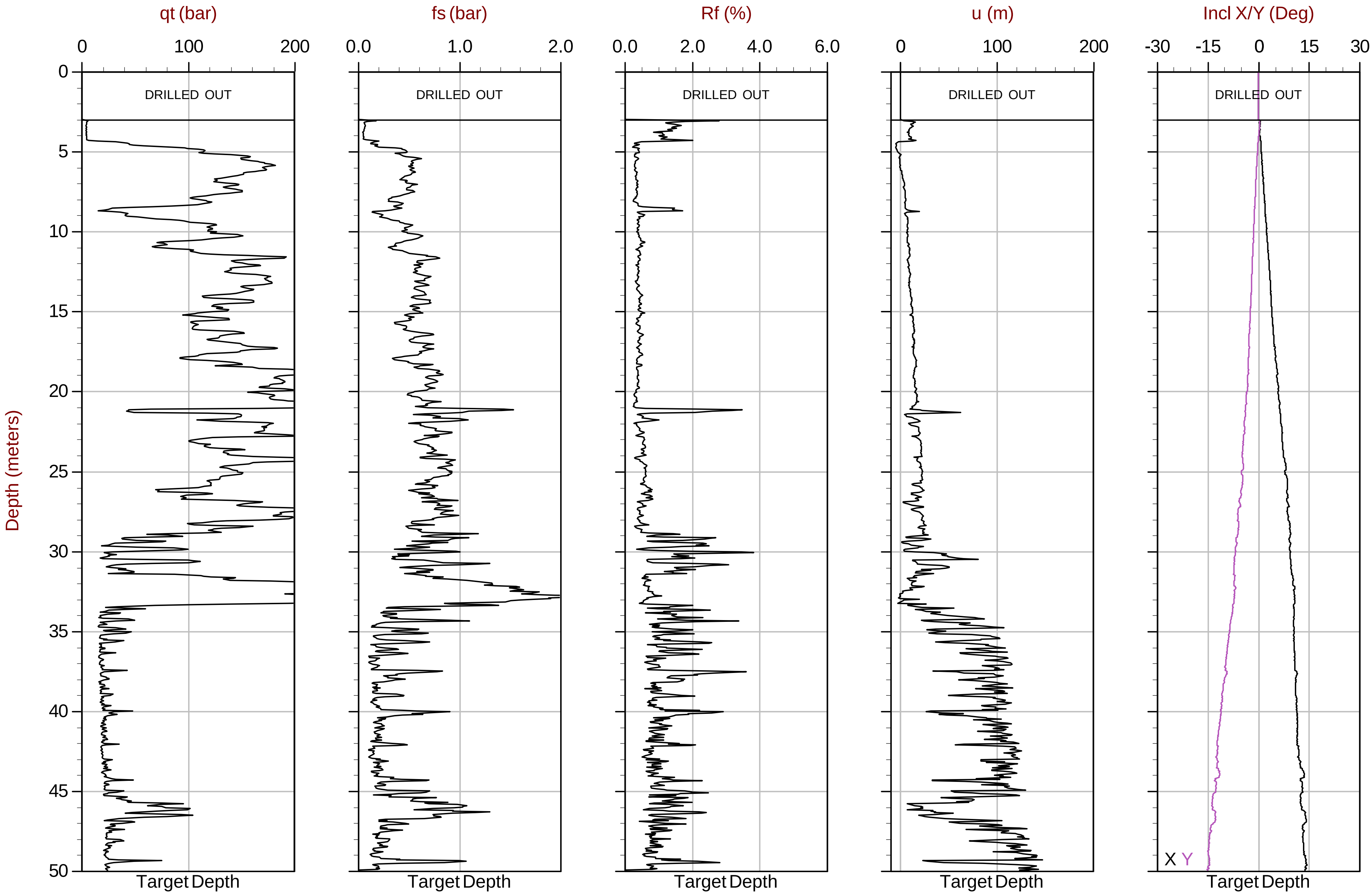
PREPARED BY: - Golder Associates

SHEET 1 of 1

ConeTec

Golder

Job No: 15-02002
Date: 02:04:15 20:41
Site: George Massey Tunnel Replacement
Sounding: CPT15-03
Cone: 408:T1500F15U500



Max Depth: 50.000 m / 164.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02002_CP03.COR
Unit Wt: SBT Chart Soil Zones
New Sounding

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10N N: 5444786m E: 493666m
Page No: 1 of 1

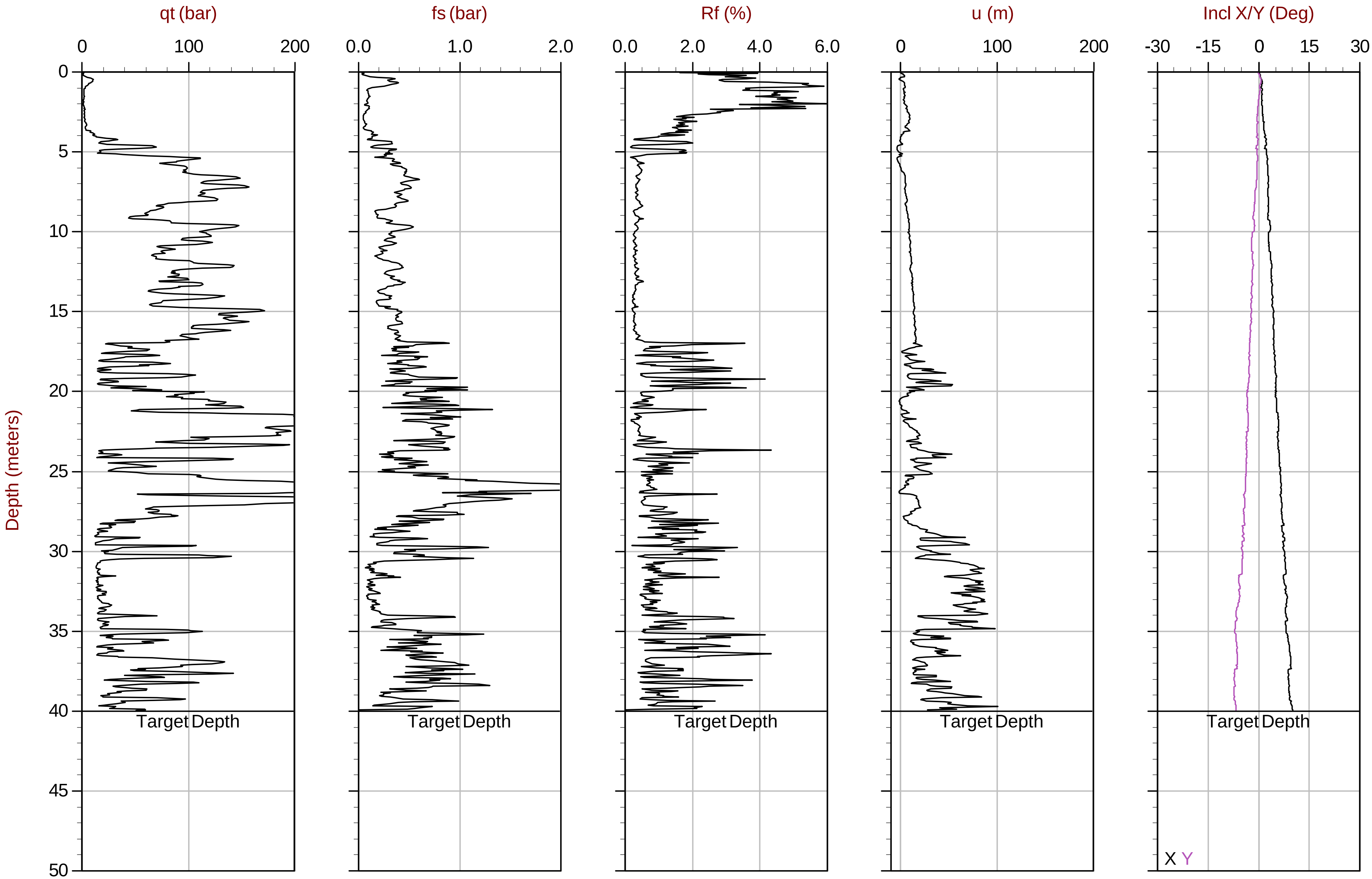
The reported coordinates were provided by the client.

CONETEC

Golder

Job No: 15-02002
Date: 02:05:15 20:28
Site: George Massey Tunnel Replacement

Sounding: CPT15-05
Cone: 408:T1500F15U500



Max Depth: 40.000 m / 131.23 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02002_CP05.COR
Unit Wt: SBT Chart Soil Zones
New Sounding

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM 10N N: 5442216m E: 493700m
Page No: 1 of 1

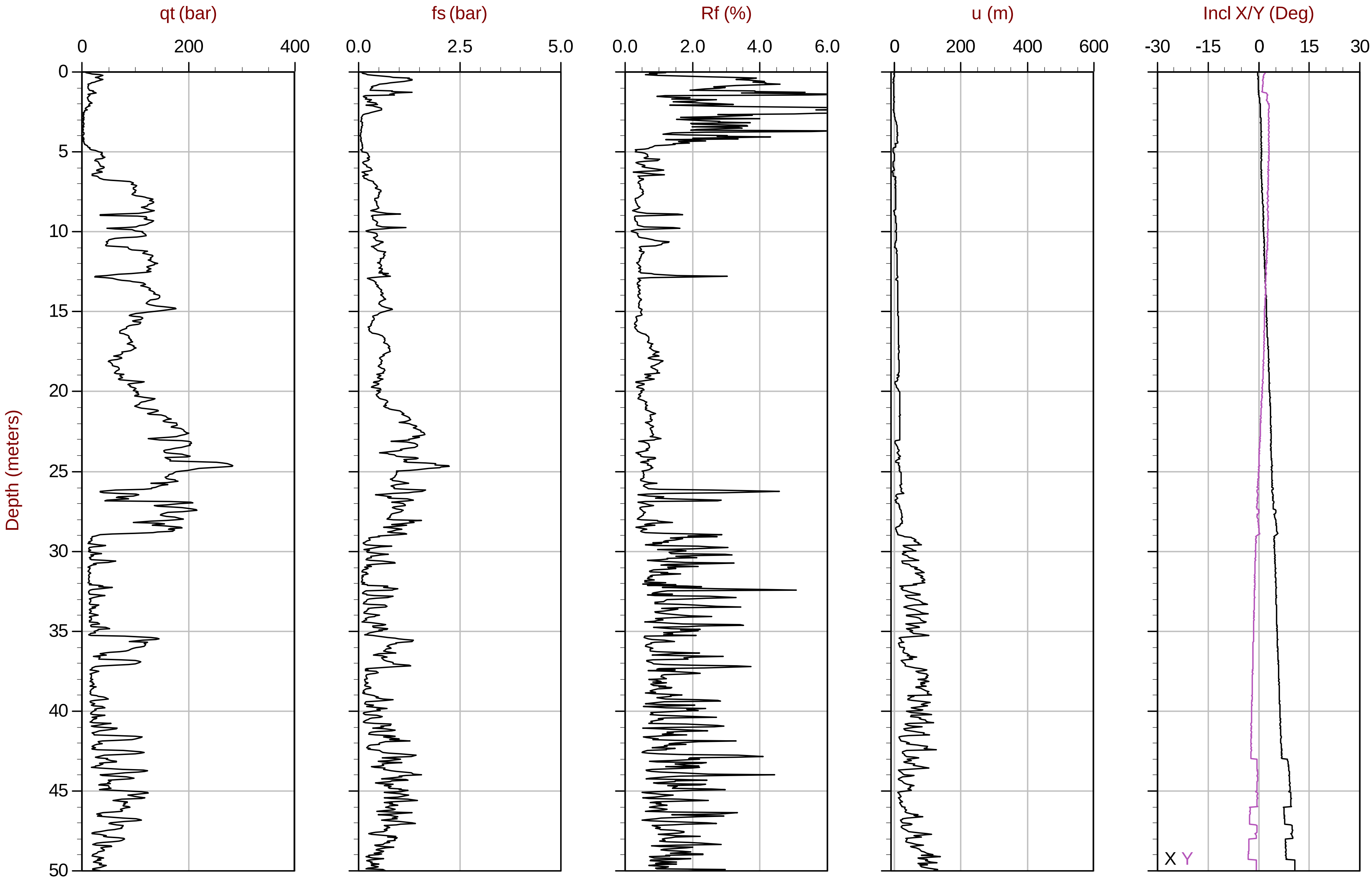
The reported coordinates were provided by the client.

CONETEC

Golder

Job No: 15-02090
Date: 09:16:15 08:32
Site: George Massey Tunnel Replacement

Sounding: CPT15-18
Cone: 274:T1500F15U500



Max Depth: 53.000 m / 173.88 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

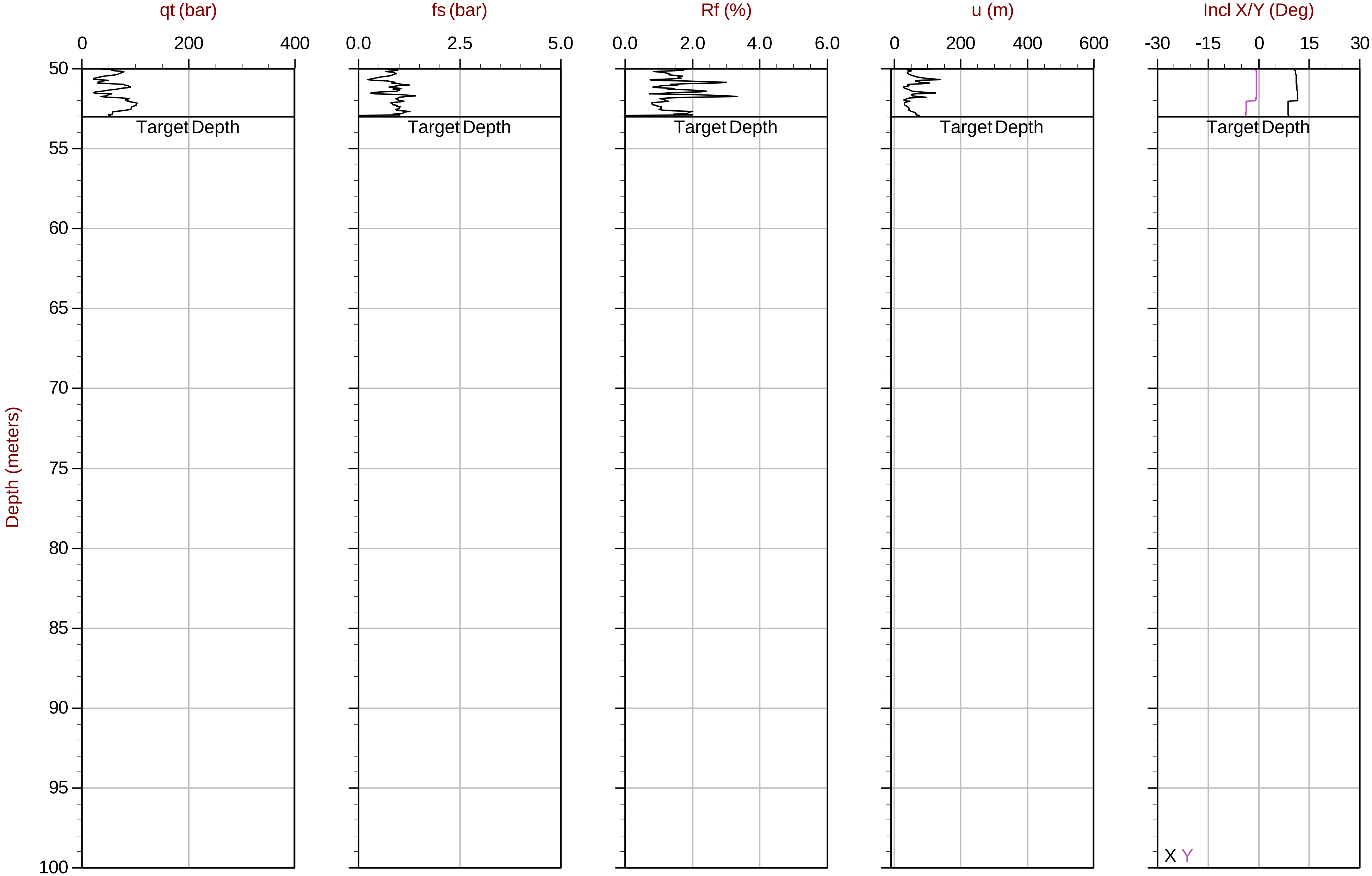
File: 15-02090_CP18.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442409.99m E: 493755.00m
Page No: 1 of 2

The reported coordinates were provided by the client.

Golder

Job No: 15-02090
Date: 09:16:15 08:32
Site: George Massey Tunnel Replacement
Sounding: CPT15-18
Cone: 274:T1500F15U500



Max Depth: 53.000 m / 173.88 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP18.COR
Unit Wt: SBT Zones
New Sounding

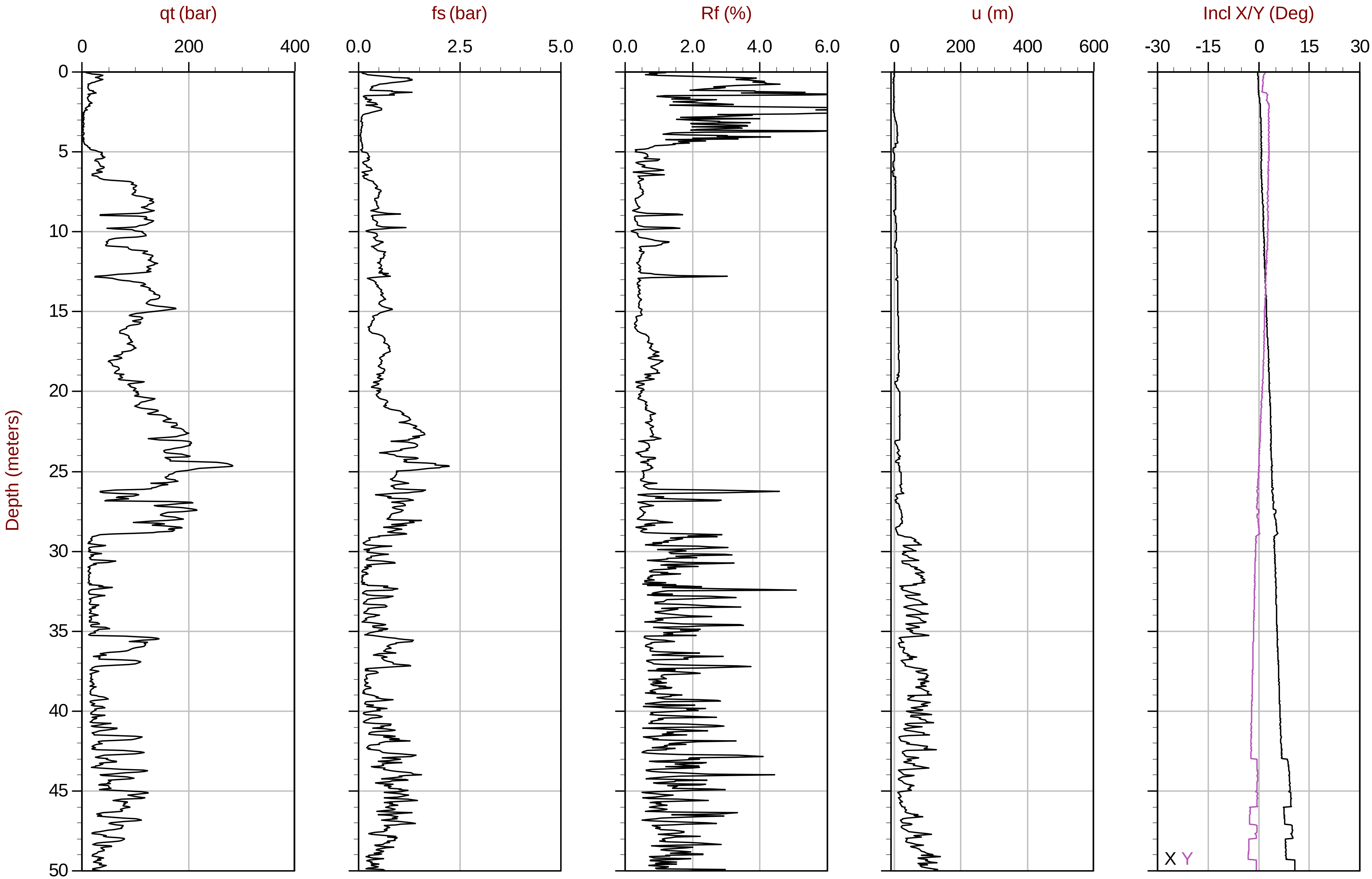
SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442409.99m E: 493755.00m

The reported coordinates were provided by the client.

CONETEC

Golder

Job No: 15-02090
Date: 09:16:15 08:32
Site: George Massey Tunnel Replacement
Sounding: CPT15-18
Cone: 274:T1500F15U500

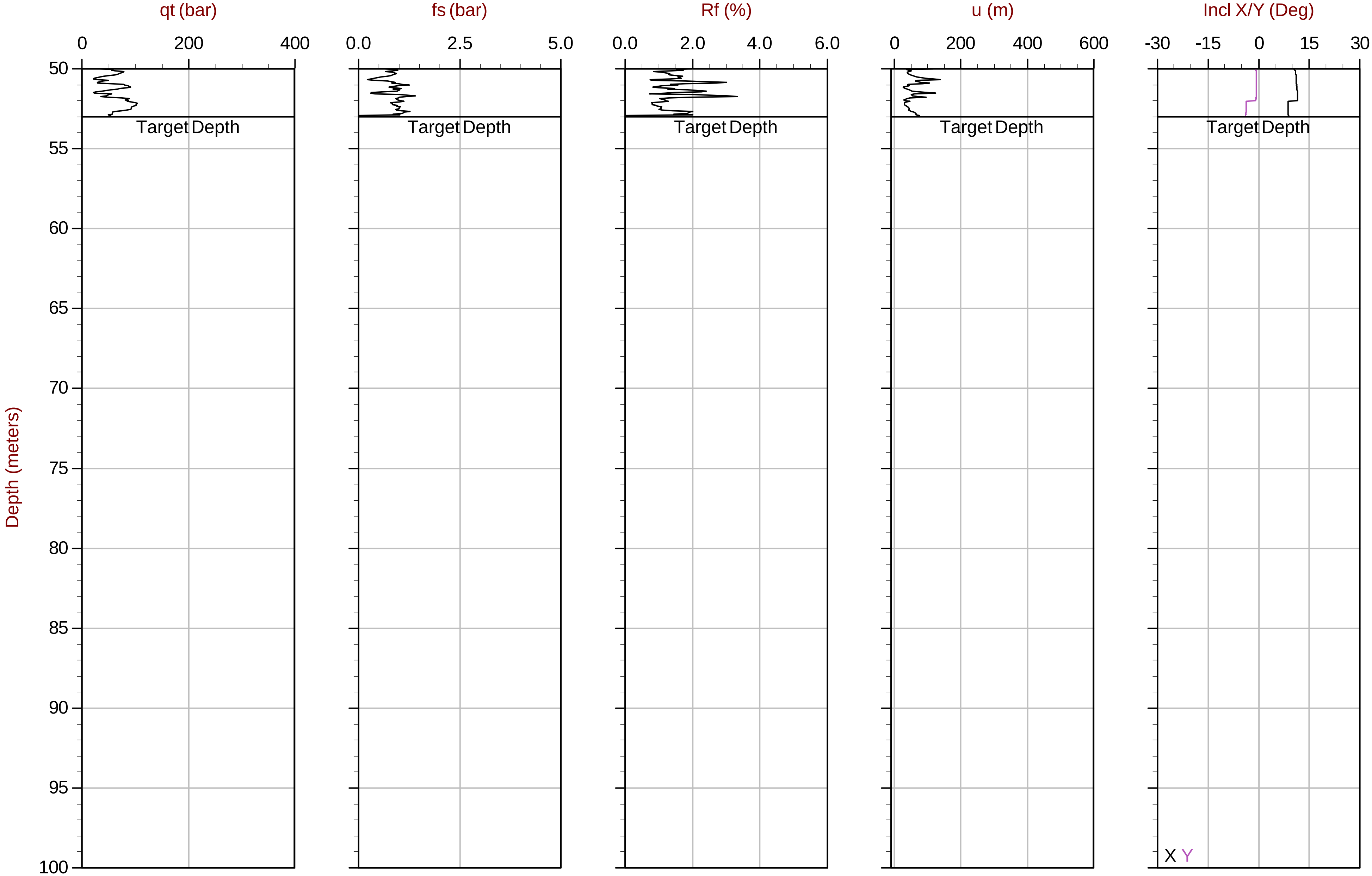


Max Depth: 53.000 m / 173.88 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP18.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442409.99m E: 493755.00m
Page No: 1 of 2

The reported coordinates were provided by the client.



Max Depth: 53.000 m / 173.88 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP18.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442409.99m E: 493755.00m

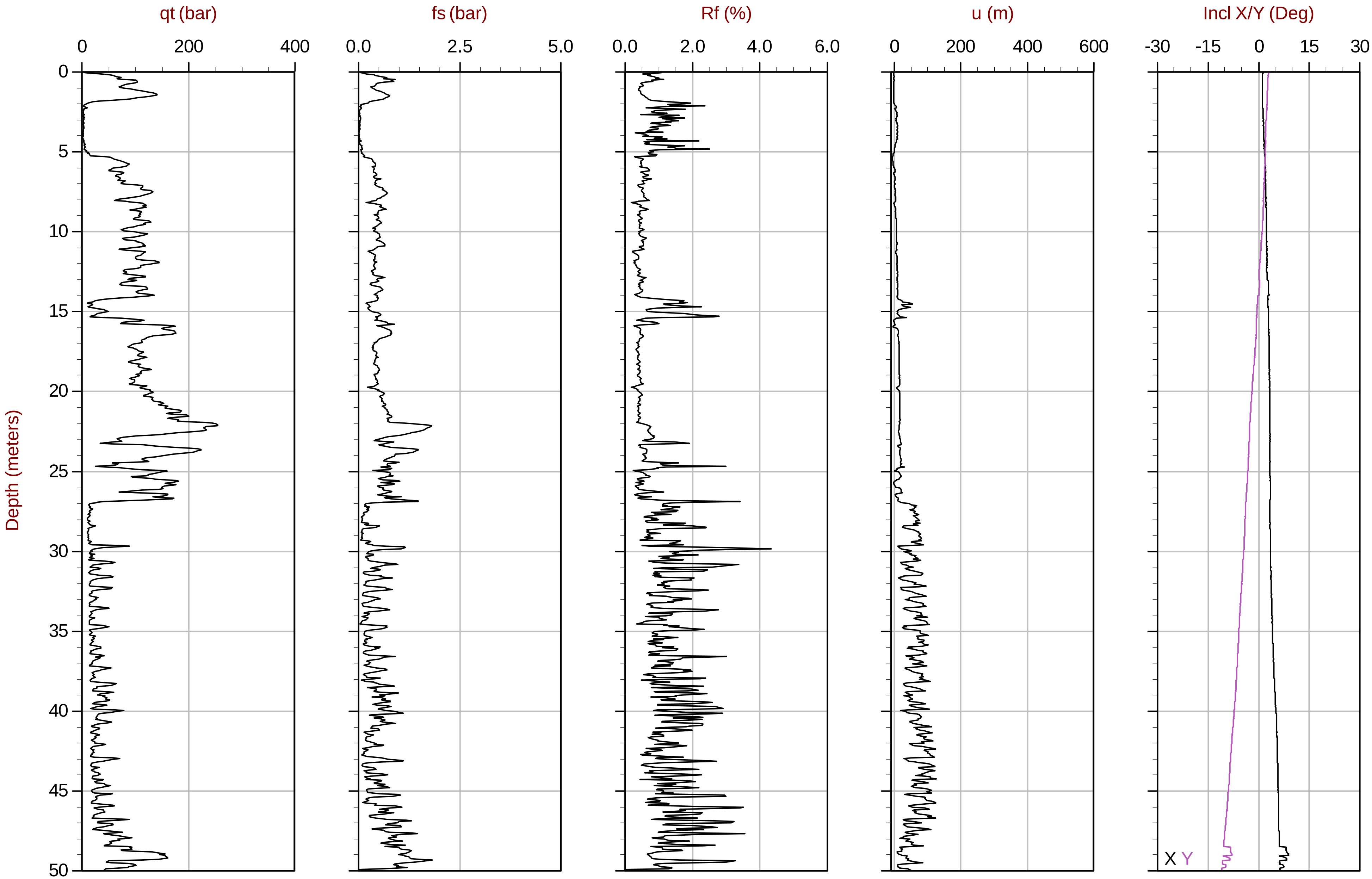
The reported coordinates were provided by the client.

CONETEC

Golder

Job No: 15-02090
Date: 09:16:15 13:11
Site: George Massey Tunnel Replacement

Sounding: CPT15-19
Cone: 274:T1500F15U500



Max Depth: 50.000 m / 164.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP19.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442253.88m E: 493589.89m
Page No: 1 of 1

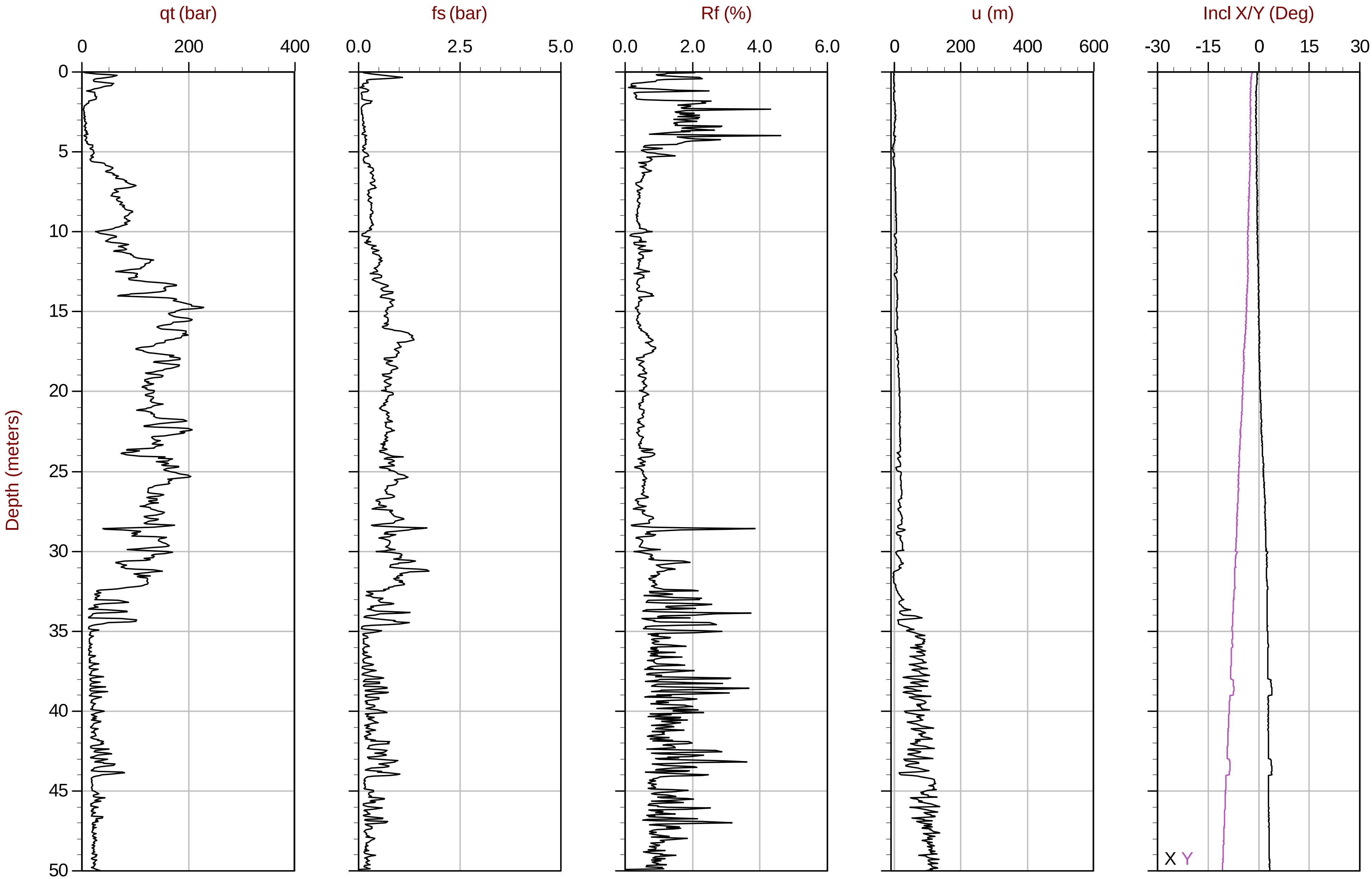
The reported coordinates were provided by the client.

ConeTec

Golder

Job No: 15-02090
Date: 09:17:15 22:04
Site: George Massey Tunnel Replacement

Sounding: CPT15-20
Cone: 274:T1500F15U500



Max Depth: 50.000 m / 164.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP20.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442639.96m E: 493691.00m
Page No: 1 of 1

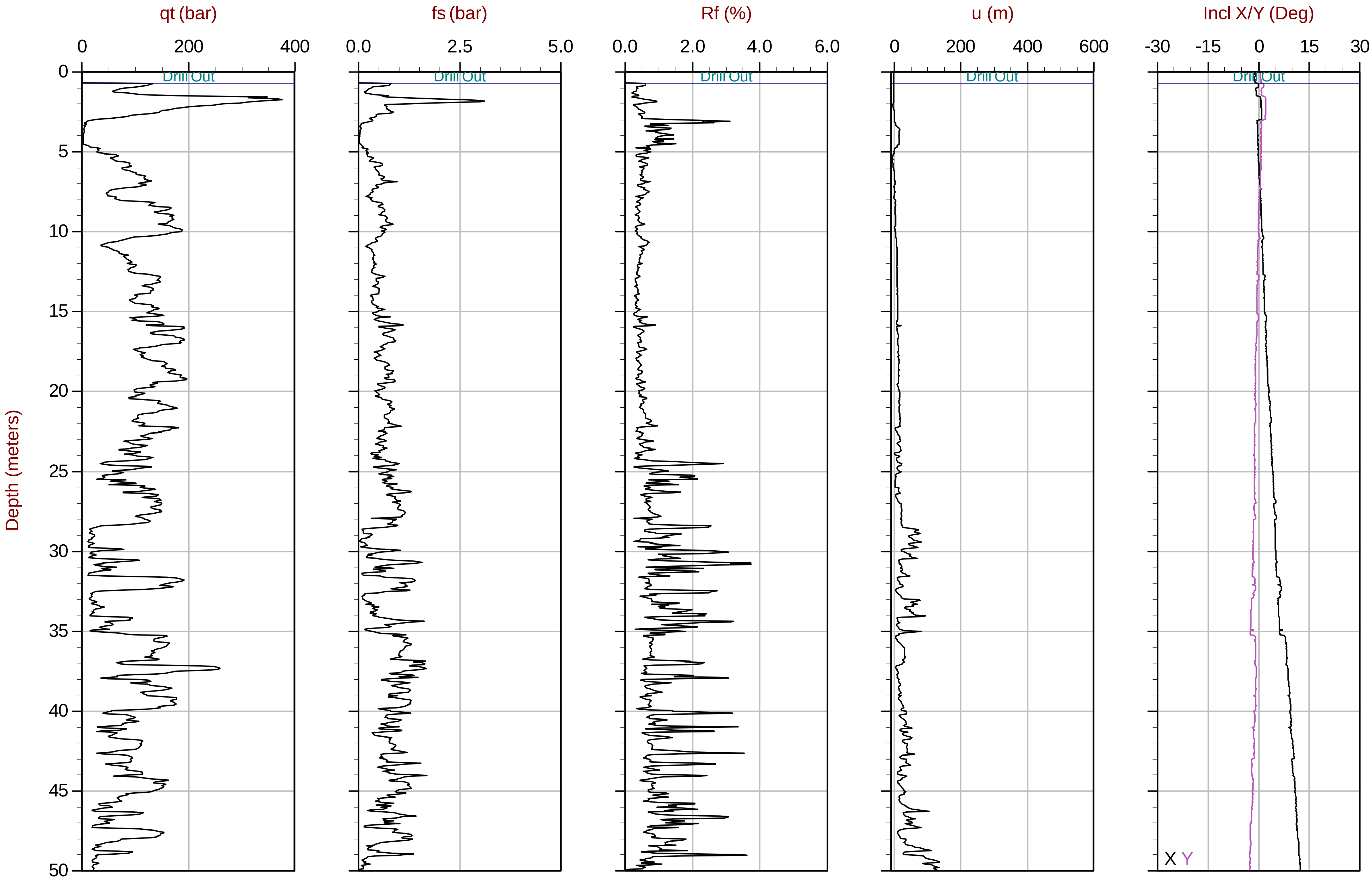
The reported coordinates were provided by the client.

ConeTec

Golder

Job No: 15-02090
Date: 09:18:15 21:24
Site: George Massey Tunnel Replacement

Sounding: CPT15-21
Cone: 274:T1500F15U500



Max Depth: 50.000 m / 164.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

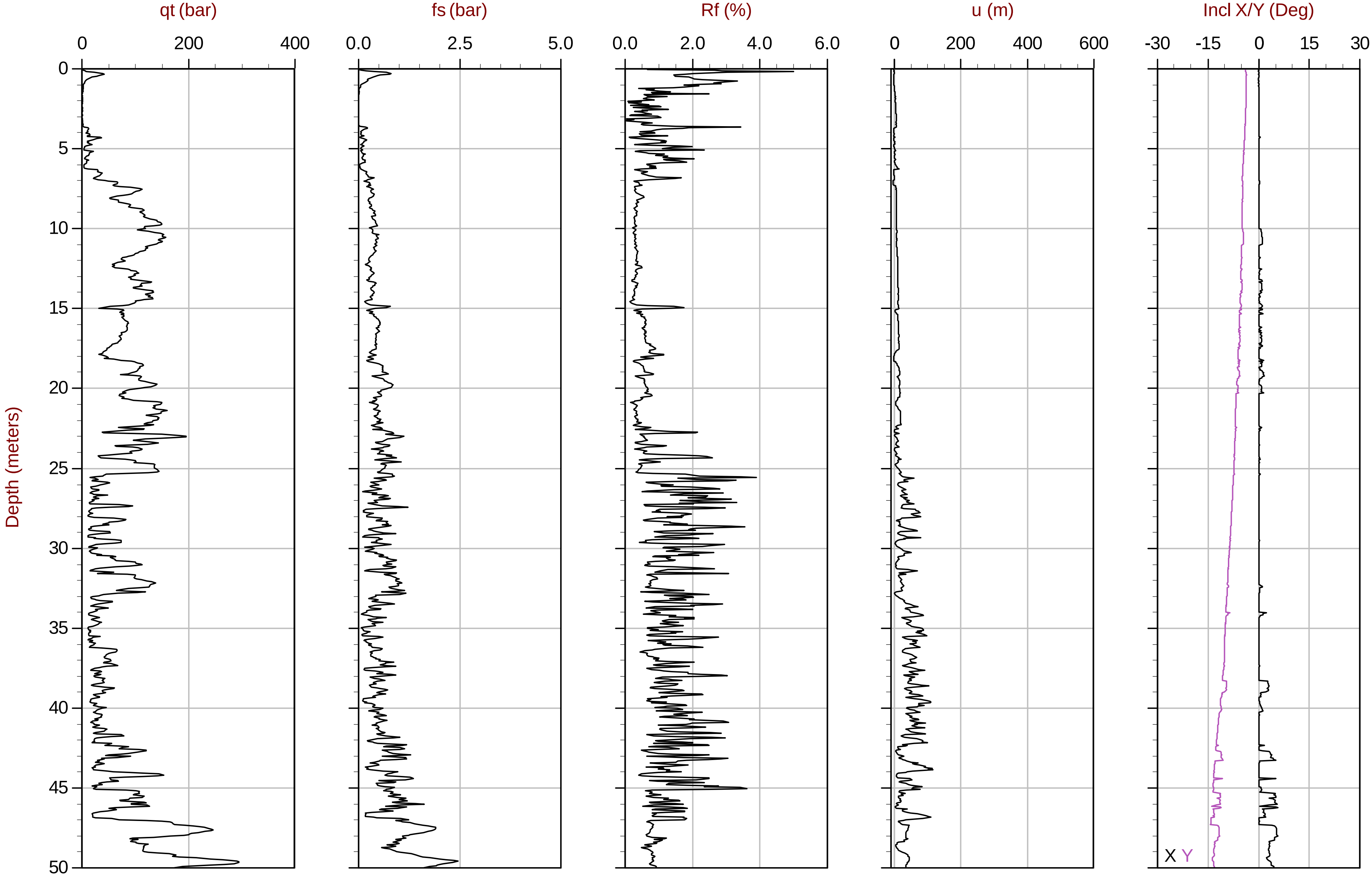
File: 15-02090_CP21.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442520.05m E: 493655.99m
Page No: 1 of 1

The reported coordinates were provided by the client.

Golder

Job No: 15-02090
Date: 09:21:15 08:16
Site: George Massey Tunnel Replacement
Sounding: CPT15-22
Cone: 274:T1500F15U500

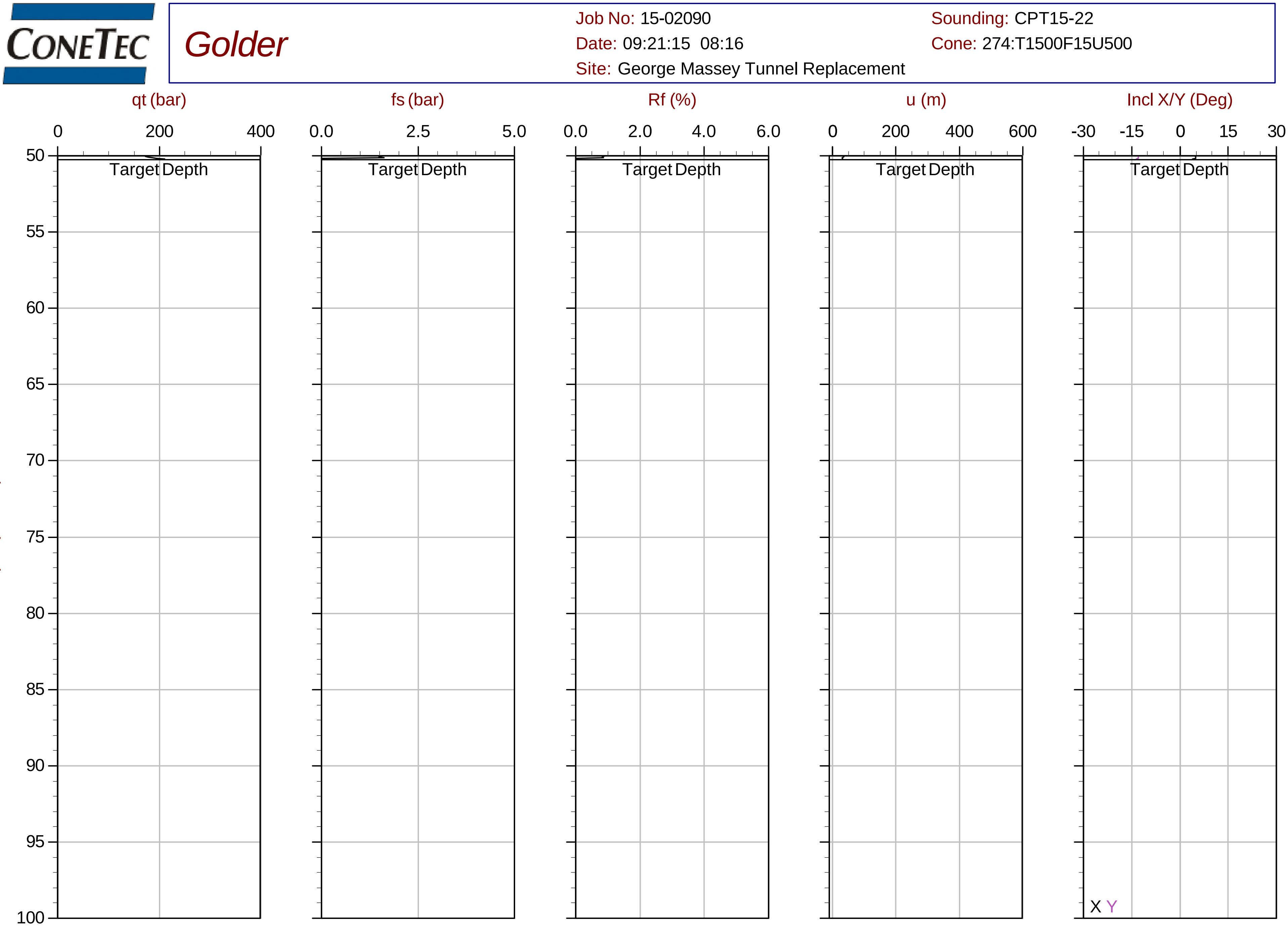


Max Depth: 50.250 m / 164.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP22.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442357.00m E: 493628.01m
Page No: 1 of 2

The reported coordinates were provided by the client.



Max Depth: 50.250 m / 164.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP22.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442357.00m E: 493628.01m

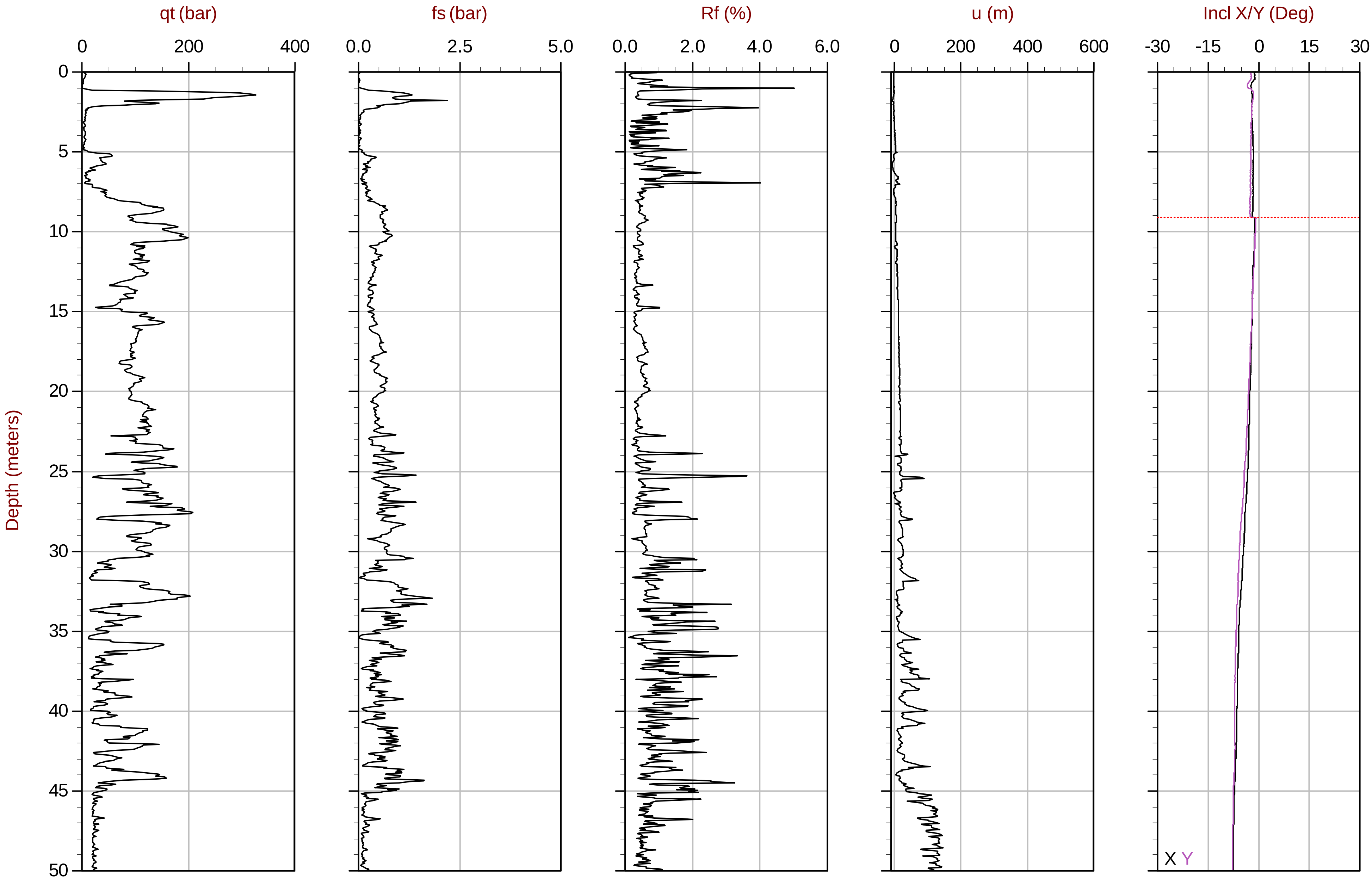
The reported coordinates were provided by the client.

ConeTec

Golder

Job No: 15-02090
Date: 10:16:15 21:01
Site: George Massey Tunnel Replacement

Sounding: CPT15-23
Cone: 409:T1500F15U1K



Max Depth: 74.350 m / 243.93 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP23.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442341.05m E: 493667.02m
Page No: 1 of 2

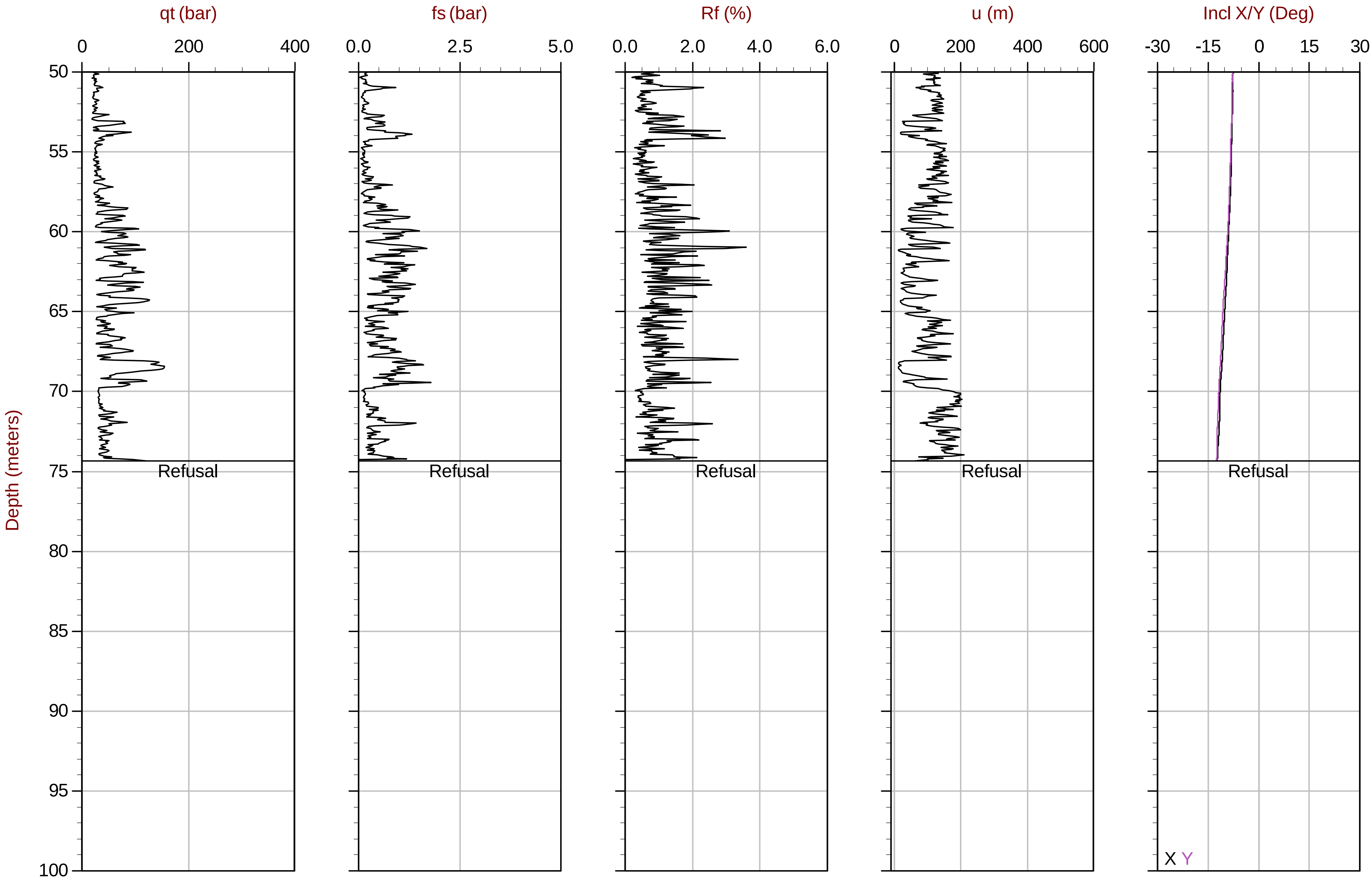
The reported coordinates were provided by the client.

ConeTec

Golder

Job No: 15-02090
Date: 10:16:15 21:01
Site: George Massey Tunnel Replacement

Sounding: CPT15-23
Cone: 409:T1500F15U1K



Max Depth: 74.350 m / 243.93 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP23.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442341.05m E: 493667.02m
Page No: 2 of 2

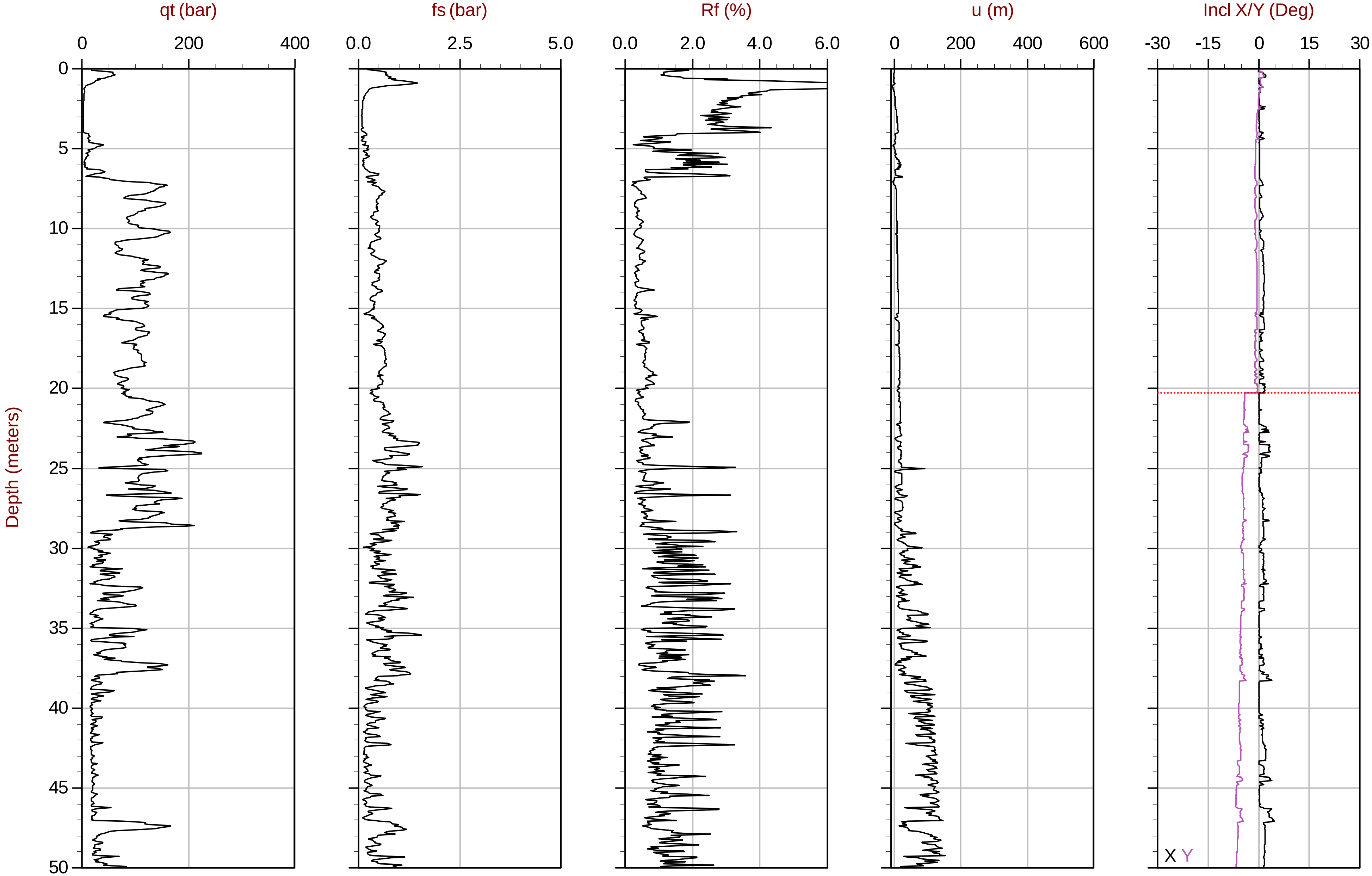
The reported coordinates were provided by the client.

CONETEC

Golder

Job No: 15-02090
Date: 09:22:15 07:19
Site: George Massey Tunnel Replacement

Sounding: CPT15-24
Cone: 274:T1500F15U500



Max Depth: 70.000 m / 229.66 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP24.COR
Unit Wt: SBT Zones
...... New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442367.02m E: 493707.03m
Page No: 1 of 2

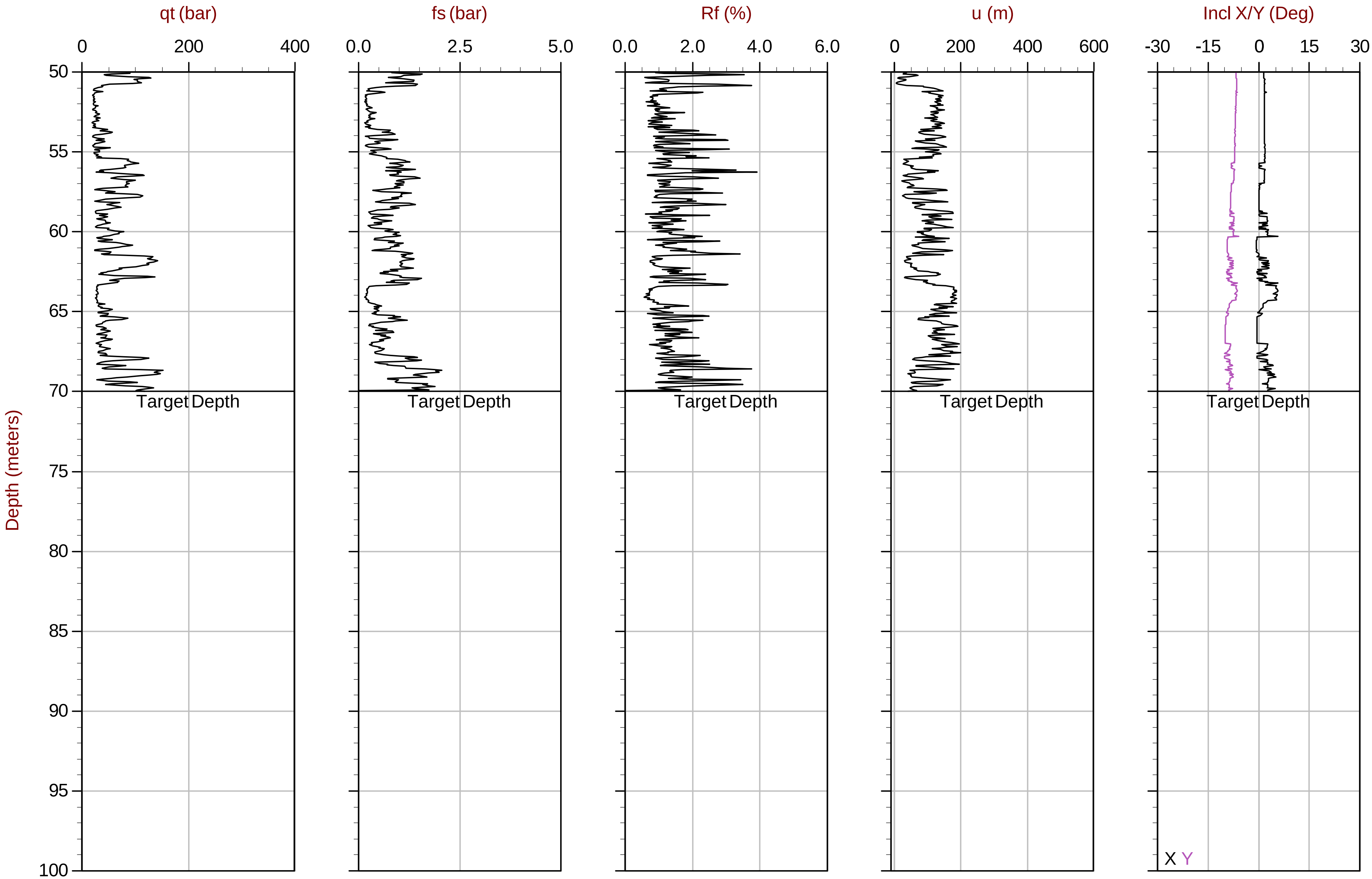
The reported coordinates were provided by the client.

ConeTec

Golder

Job No: 15-02090
Date: 09:22:15 07:19
Site: George Massey Tunnel Replacement

Sounding: CPT15-24
Cone: 274:T1500F15U500



Max Depth: 70.000 m / 229.66 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP24.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442367.02m E: 493707.03m
Page No: 2 of 2

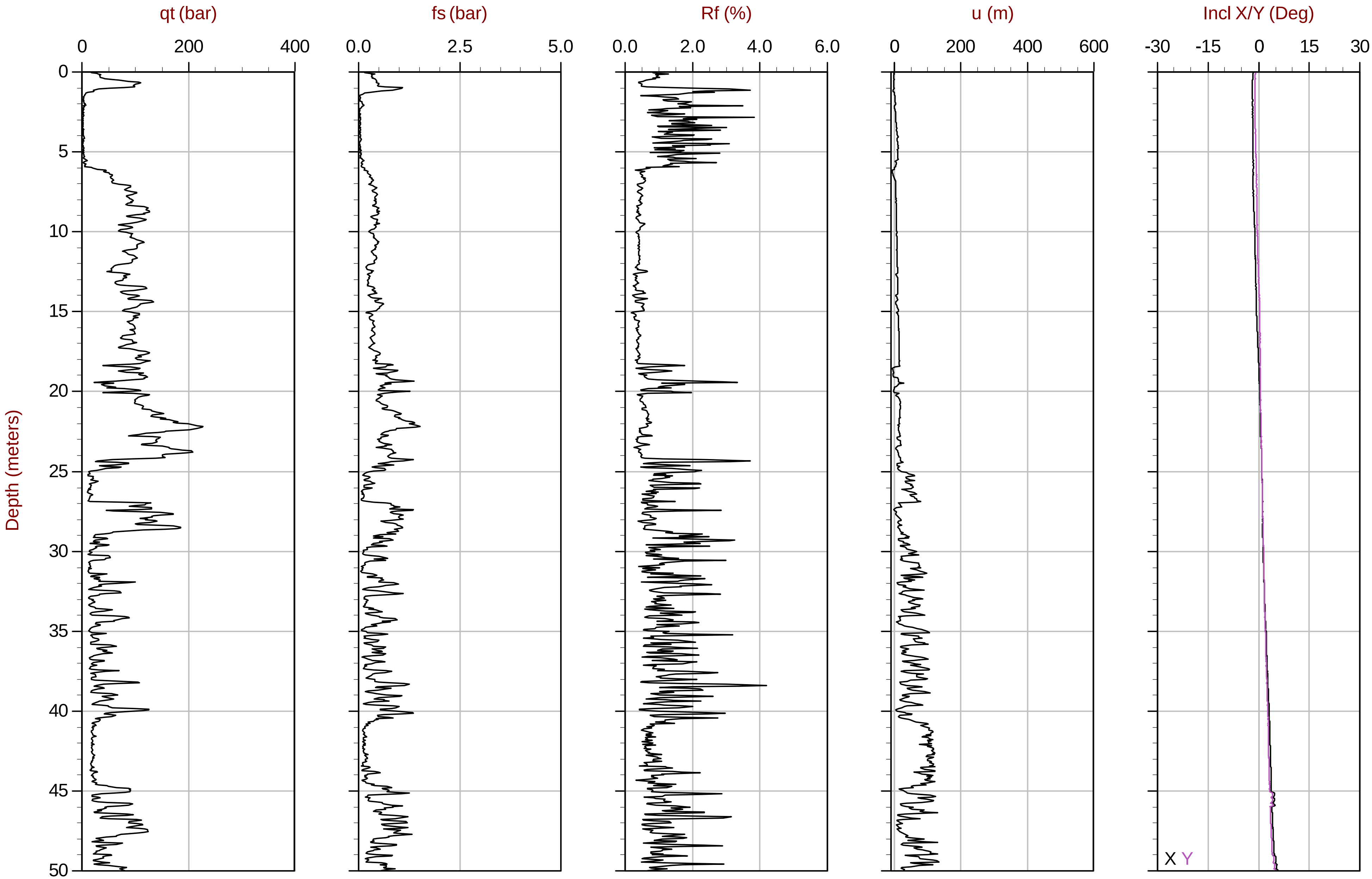
The reported coordinates were provided by the client.

CONETEC

Golder

Job No: 15-02090
Date: 10:15:15 07:21
Site: George Massey Tunnel Replacement

Sounding: CPT15-25
Cone: 293:T1500F15U500



Max Depth: 72.900 m / 239.17 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

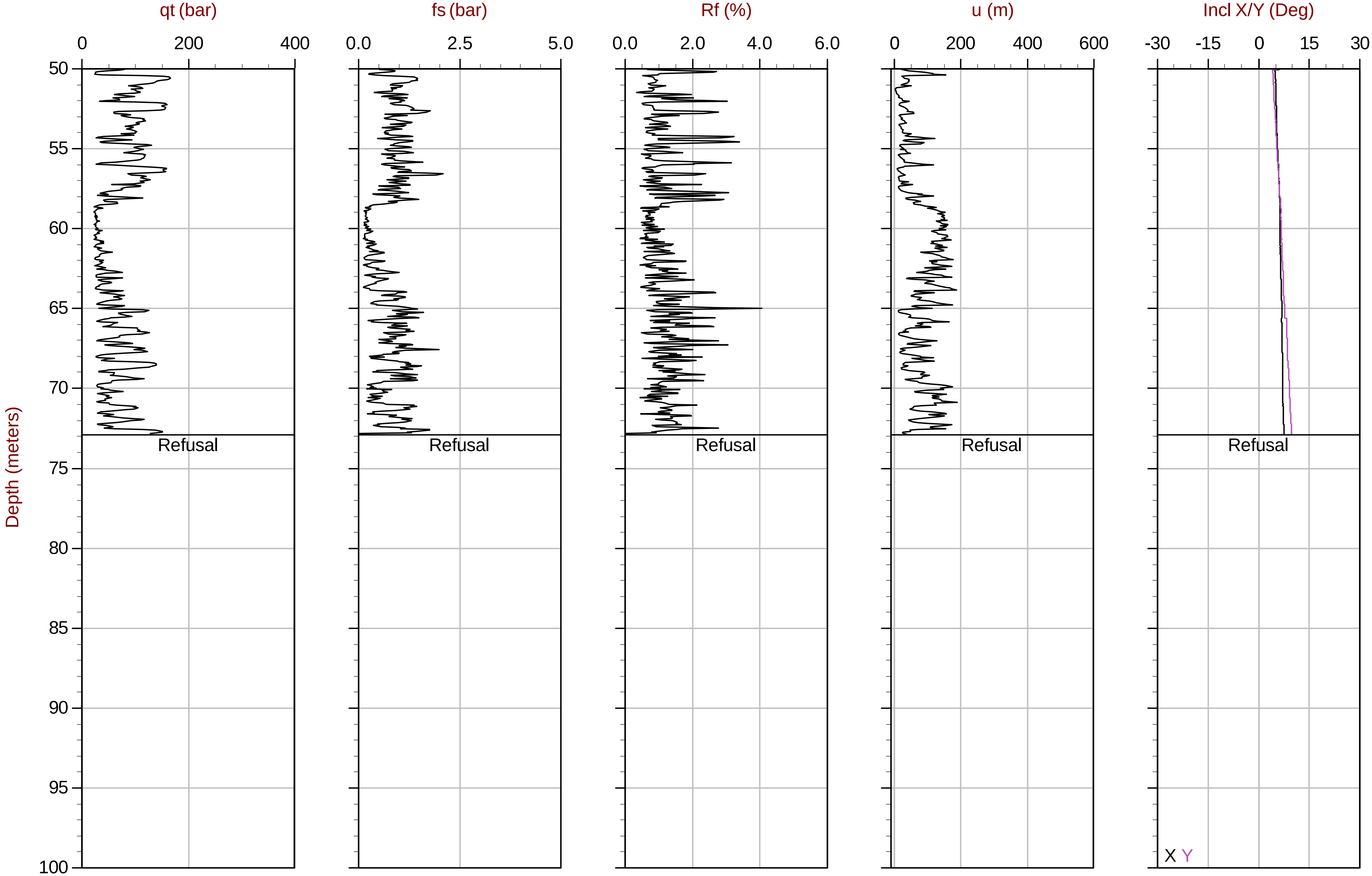
File: 15-02090_CP25.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442226.04m E: 493631.00m
Page No: 1 of 2

The reported coordinates were provided by the client.

Golder

Job No: 15-02090
Date: 10:15:15 07:21
Site: George Massey Tunnel Replacement
Sounding: CPT15-25
Cone: 293:T1500F15U500



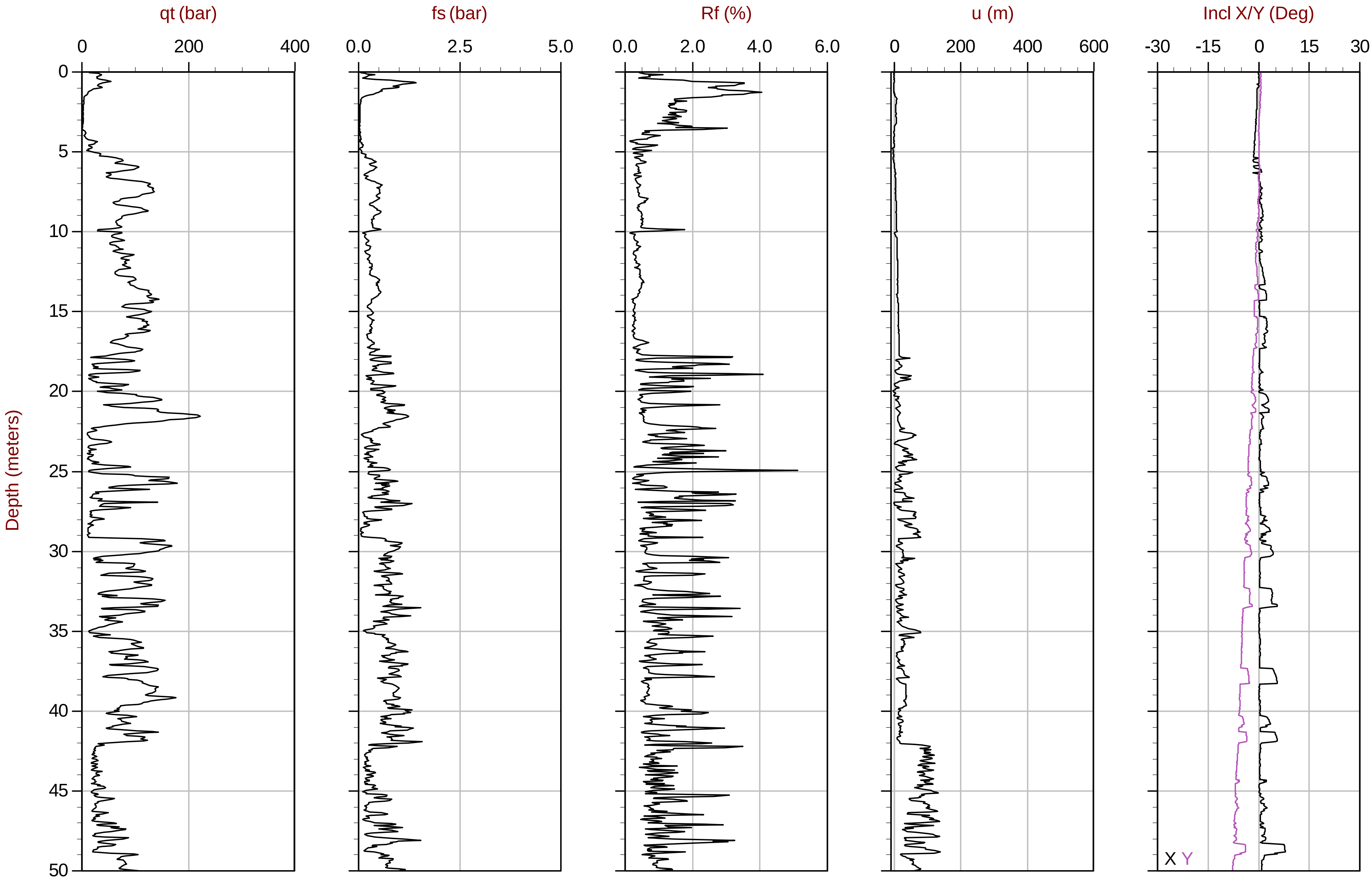
Max Depth: 72.900 m / 239.17 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP25.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442226.04m E: 493631.00m
Page No: 2 of 2

The reported coordinates were provided by the client.

Job No: 15-02090
Date: 09:22:15 14:37
Site: George Massey Tunnel Replacement
Sounding: CPT15-26
Cone: 274:T1500F15U500



Max Depth: 70.000 m / 229.66 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP26.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442218.22m E: 493760.91m
Page No: 1 of 2

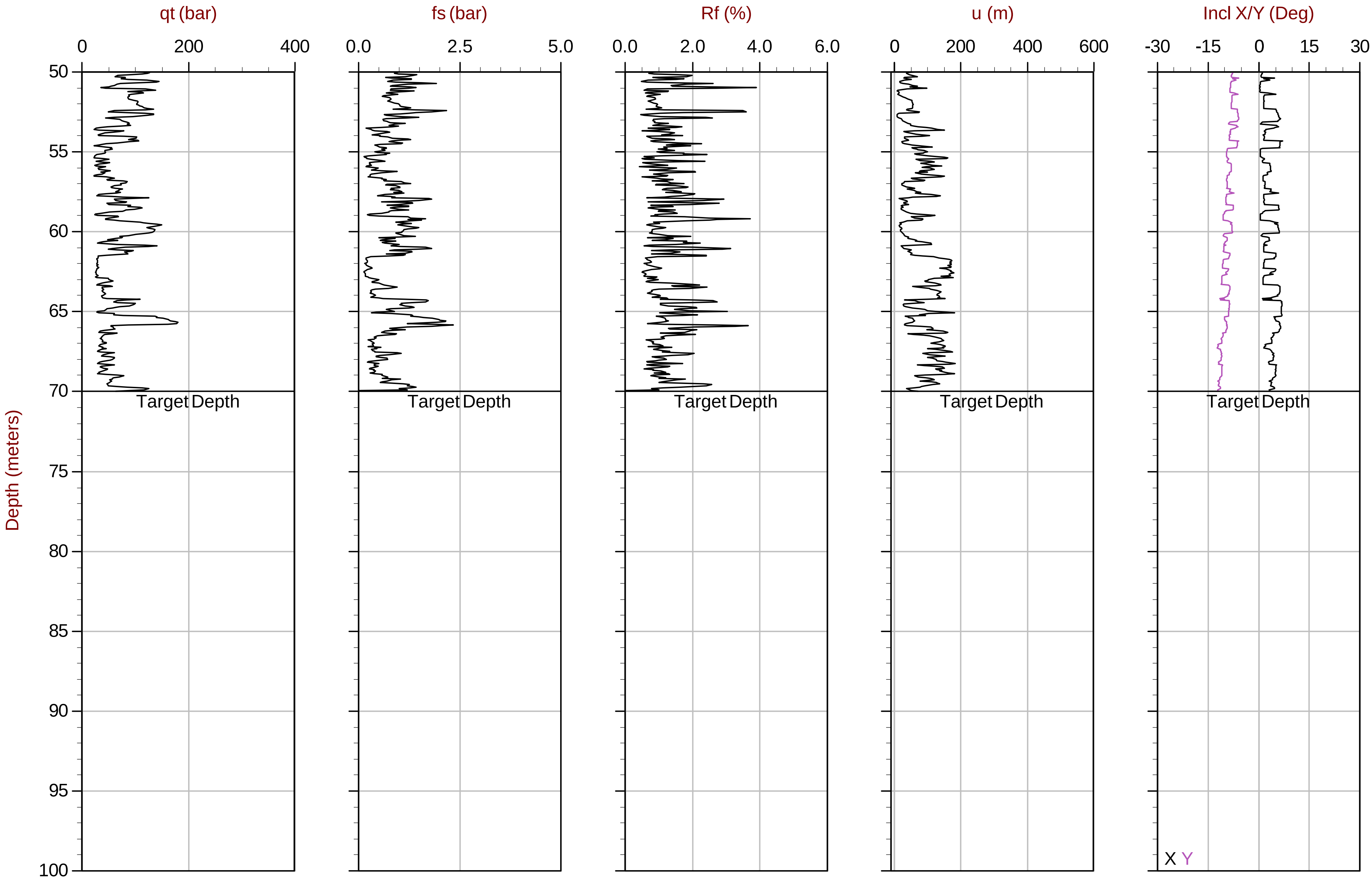
The reported coordinates were provided by the client.

ConeTec

Golder

Job No: 15-02090
Date: 09:22:15 14:37
Site: George Massey Tunnel Replacement

Sounding: CPT15-26
Cone: 274:T1500F15U500



Max Depth: 70.000 m / 229.66 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.200 m

File: 15-02090_CP26.COR
Unit Wt: SBT Zones
New Sounding

SBT: Robertson and Campanella, 1986
Coords: UTM 10N N: 5442218.22m E: 493760.91m
Page No: 2 of 2

The reported coordinates were provided by the client.

SUMMARY LOG

Ministry of Transportation and Infrastructure — British Columbia

Drill Hole #: 22GEO-DH007

Prepared by: P10419A01	Project: **Fraser River Tunnel Project**	Date(s) Drilled: August 2-7, 2022
Klohn Crippen Berger	Location: Deas Island, BC	Company: Mud Bay Drilling
Logged by: JM Reviewed by: KR	Datum: UTM Zone 10N	Driller: Cole
	Northing/Easting: 5440130 , 495233	Drill Make/Model: FRASTE XL C05-021
	Elevation: 2.15 m	Drilling Method: Mud Rotary
	Alignment:	
	Station/Offset:	

Chart heading: ✕ Pocket Penetrometer ✕ Shear Strength (kPa) 100 200 300 400; ▲ SPT "N" (BLOWS/300 mm) ▲; W_P% 20 40 W% 60 80 W_L%

DEPTH (m)	SPT blows	SPT "N" / W%	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING (Drillers Estimate {G % S % F %})	ELEVATION (m)
0 – 1.52						Drilled out.			2.15
1.52 – 2.13	1 2 2 1	N=4; W=24	Split Spoon	S-01	60	OL, ORGANIC SILT, low plasticity, trace sand, grey sand with brown stains, cohesive, w ~ PL, very soft.	OL	**Atterberg** (S-01): PL:25% LL:35%	0.63
2.13 – 3.96		W=32	Shelby Tube	T-01	80	ML, SILT and SAND, low plasticity silt, fine grained sand, grey, w>PL, very soft.	ML		0.02
			Shelby Tube	T-02	80			**Atterberg** (T-02): PL:30% LL:31% **Sieve** (T-02) G:% S:50% F:50%	
3.96 –	2 1 2 2	N=3	Split Spoon	S-02	50	SP, SAND, fine with trace medium grained, poorly graded, trace silt, grey, moist, very loose to compact.		**Sieve** (S-02) G:% S:90% F:10%	-1.81
	3 3 4 4	N=7	Split Spoon	S-03	50	From 6.1 m to 6.7 m, trace rootlets.		**Sieve** (S-03) G:% S:% F:6%	
	3 2 4 3	N=6	Split Spoon	S-04	50			**Sieve** (S-04) G:% S:% F:5%	
	4 5 3 5	N=8	Split Spoon	S-05	50	From 9.1 m to 9.7 m, trace gravel, coarse grained, subrounded.		**Sieve** (S-05) G:% S:% F:5%	

Backfill Information: Sand

Draft

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

SUMMARY LOG

Ministry of Transportation and Infrastructure — British Columbia

Drill Hole #: **22GEO-DH007**

Prepared by: P10419A01	Project: **Fraser River Tunnel Project**	Date(s) Drilled: August 2-7, 2022
Klohn Crippen Berger	Location: Deas Island, BC	Company: Mud Bay Drilling
Logged by: JM Reviewed by: KR	Datum: UTM Zone 10N; Alignment:	Driller: Cole
	Northing/Easting: 5440130 , 495233; Station/Offset:	Drill Make/Model: FRASTE XL C05-021
	Elevation: 2.15 m	Drilling Method: Mud Rotary

Depth (m)	SPT blows	SPT "N" (Blows/300 mm)	W%	Sample Type	Sample No	Recovery (%)	Soil Description	Classification	Comments / Testing (Drillers Estimate {G % S % F %})	Elevation (m)
10							SP, SAND, fine with trace medium grained, poorly graded, trace silt, grey, moist, very loose to compact. *(continued)*	SP		-8
11	4, 3, 5, 6	8		Split Spoon	S-06	50			**Sieve** (S-06) G:% S:% F:5%	-9
12.5	6, 5, 5, 7	10	32	Split Spoon	S-07	60			**Sieve** (S-07) G:% S:94% F:6%	-10
14	5, 4, 7, 8	11		Split Spoon	S-08	60			**Sieve** (S-08) G:% S:% F:4%	-12
15.5	6, 7, 7, 11	14		Split Spoon	S-09	40			**Sieve** (S-09) G:% S:% F:6%	-13
17	6, 6, 10, 11	16		Split Spoon	S-10	40			**Sieve** (S-10) G:% S:% F:6%	-15
18.5	6, 9, 12, 20	21		Split Spoon	S-11	50			**Sieve** (S-11) G:% S:% F:5%	-16
20										-17

Draft

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: **22GEO-DH007**

British Columbia — Ministry of Transportation and Infrastructure

Project: **Fraser River Tunnel Project**
Location: Deas Island, BC

Prepared by: P10419A01 Klohn Crippen Berger
Logged by: JM Reviewed by: KR

Datum: UTM Zone 10N
Northing/Easting: 5440130 , 495233
Elevation: 2.15 m
Alignment:
Station/Offset:

Date(s) Drilled: August 2-7, 2022
Company: Mud Bay Drilling
Driller: Cole
Drill Make/Model: FRASTE XL C05-021
Drilling Method: Mud Rotary

DEPTH (m)	SPT	SPT "N" (BLOWS/300 mm) / W%	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING (Drillers Estimate {G % S % F %})	ELEVATION (m)
20	12, 15, 12, 18	N = 27	Split Spoon	S-12	50	SP, SAND, fine with trace medium grained, poorly graded, trace silt, grey, moist, very loose to compact. *(continued)*		**Sieve** (S-12) G:% S:% F:6%	-18
21.5	3, 6, 5, 7	N = 11	Split Spoon	S-13	40	At 21.8 m, 0.2 cm pocket of trace organics.			-19, -20
23	9, 12, 18, 14	N = 30	Split Spoon	S-14	60			**Sieve** (S-14) G:% S:% F:7%	-21
24.5	3, 14, 15, 12	N = 29	Split Spoon	S-15	90	At 24.7 m, 10 cm lens ML, SILT lens, low plasticity, trace sand, grey, homogenous, cohesive, w ~ PL, firm. At 25 m, 2.5 cm lens ML, SILT lens, low plasticity, trace sand, grey, homogenous, cohesive, w >PL, firm.			-22, -23
26	8, 11, 14, 12	N = 25	Split Spoon	S-16	90			**Sieve** (S-16) G:% S:% F:8%	-24
26.52						CL, CLAY, low plasticity, some silt, grey, homogenous, cohesive, w ~ PL, firm.			-25
27.5			Shelby Tube	T-03	90				-26
29.2		W% = 34	Shelby Tube	T-04	95			**Atterberg** (T-04): PL:25% LL:31% **Sieve** (T-04) G:% S:1% F:99%	-27
30									

Backfill Information: Grout

Draft

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: **22GEO-DH007**

British Columbia Ministry of Transportation and Infrastructure

Project: **Fraser River Tunnel Project**
Location: Deas Island, BC

Prepared by: P10419A01
Klohn Crippen Berger
Logged by: JM Reviewed by: KR

Datum: UTM Zone 10N
Northing/Easting: 5440130 , 495233
Elevation: 2.15 m
Alignment:
Station/Offset:

Date(s) Drilled: August 2-7, 2022
Company: Mud Bay Drilling
Driller: Cole
Drill Make/Model: FRASTE XL C05-021
Drilling Method: Mud Rotary

DEPTH (m)	DRILLING DETAILS	SPT	Pocket Penetrometer / Shear Strength (kPa); SPT "N" (BLOWS/300 mm); Wp% W% WL%	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	BACKFILL INFORMATION	ELEVATION (m)
30								CL, CLAY, low plasticity, some silt, grey, homogenous, cohesive, w ~ PL, firm. *(continued)*				-28
30.5–31			W = 34	T-Shelby	T-05	75				**Atterberg** (T-05): PL:17% LL:17% **Sieve** (T-05) G:% S:28% F:72%		-29
32				T-Shelby	T-06	80						-30
33												-31
34									CL			-32
35				T-Shelby	T-07	85						-33
36												-34
37												-35
38				T-Shelby	T-08	85						-36
39												-37
40												

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: **22GEO-DH007**

Ministry of Transportation and Infrastructure, British Columbia

Prepared by: P10419A01	Project: **Fraser River Tunnel Project**	Date(s) Drilled: August 2-7, 2022
Klohn Crippen Berger	Location: Deas Island, BC	Company: Mud Bay Drilling
Logged by: JM Reviewed by: KR	Datum: UTM Zone 10N; Alignment:	Driller: Cole
	Northing/Easting: 5440130 , 495233; Station/Offset:	Drill Make/Model: FRASTE XL C05-021
	Elevation: 2.15 m	Drilling Method: Mud Rotary

Depth (m)	SPT	SPT "N" / W%	Sample Type	Sample No	Recovery (%)	Soil Description	Classification	Comments / Testing	Elevation (m)
40						CL, CLAY, low plasticity, some silt, grey, homogenous, cohesive, w ~ PL, firm. *(continued)*			-38
41	9, 12, 17, 18	N = 29	Split Spoon	S-17A	100				-39
41.45			Split Spoon	S-17B	100	41.45m SP, SAND, fine grained, poorly graded, trace silt, grey, moist, compact.	SP		
41.76						41.76m ML, SILT, low plasticity, sandy, grey, homogenous, cohesive, w > PL, very stiff.	ML		-40
44.5		W% = 33	Shelby Tube	T-09	70			**Atterberg** (T-09): PL:20% LL:23%; **Sieve** (T-09) G:% S:40% F:60%	-42
47.5	10, 12, 16, 24	N = 28	Split Spoon	S-18	100				-45
50									-47

Column headers: Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp% W% WL% 20 40 60 80; Backfill Information; Comments Testing – Drillers Estimate {G % S % F %}

Draft

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

SUMMARY LOG

Ministry of Transportation and Infrastructure — British Columbia

Prepared by: P10419A01	Project: **Fraser River Tunnel Project**	Drill Hole #: **22GEO-DH007**
Klohn Crippen Berger	Location: Deas Island, BC	Date(s) Drilled: August 2-7, 2022
Logged by: JM Reviewed by: KR	Datum: UTM Zone 10N	Company: Mud Bay Drilling
	Alignment:	Driller: Cole
	Northing/Easting: 5440130 , 495233	Drill Make/Model: FRASTE XL C05-021
	Station/Offset:	Drilling Method: Mud Rotary
	Elevation: 2.15 m	

Columns: DEPTH (m) | DRILLING DETAILS / SPT | Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); W_P% W% W_L% 20 40 60 80 | SAMPLE TYPE | SAMPLE NO | RECOVERY (%) | SOIL SYMBOL | SOIL DESCRIPTION | CLASSIFICATION | COMMENTS TESTING (Drillers Estimate {G % S % F %}) | BACKFILL INFORMATION | ELEVATION (m)

Depth (m)	SPT blows	SPT "N" / W%	Sample Type	Sample No	Recovery (%)	Soil Description	Classification	Comments / Testing
50.29m	9, 22, 30, 50	N = 52	Split Spoon	S-19	100	SP, SAND, fine grained, poorly graded, trace silt, low plasticity silt, grey, moist, dense to very dense.	SP	
~53.5	14, 15, 20, 18	N = 35; W = 26	Split Spoon	S-20	70			**Sieve** (S-20) G:% S:81% F:19%
53.95m						ML, SANDY SILT, low plasticity, fine grained sand, grey, w > PL, stiff to hard.		
~56.8			Shelby Tube	T-10	80			
~58.2	8, 3, 7, 14	N = 10; W = 32	Split Spoon	S-21	50			**Atterberg** (S-21): PL:23% LL:29% **Sieve** (S-21) G:% S:16% F:84%

Depth scale: 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60

Elevation scale: -48, -49, -50, -51, -52, -53, -54, -55, -56, -57

Draft

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: **22GEO-DH007**

Ministry of Transportation and Infrastructure, British Columbia

Project: **Fraser River Tunnel Project**
Location: Deas Island, BC
Datum: UTM Zone 10N
Northing/Easting: 5440130 , 495233
Elevation: 2.15 m
Alignment:
Station/Offset:

Prepared by: P10419A01
Klohn Crippen Berger
Logged by: JM Reviewed by: KR

Date(s) Drilled: August 2-7, 2022
Company: Mud Bay Drilling
Driller: Cole
Drill Make/Model: FRASTE XL C05-021
Drilling Method: Mud Rotary

DEPTH (m)	SPT	Pocket Penetrometer / Shear Strength (kPa); SPT "N" (BLOWS/300 mm); W%	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING (Drillers Estimate {G % S % F %})	ELEVATION (m)
70			T-Shelby Tube	T-14	80	ML, SANDY SILT, low plasticity, fine grained sand, grey, w > PL, stiff to hard. *(continued)*			-68
71									-69
72									-70
73	25 30 32 36	N = 62; W% = 28	S-Split Spoon	S-22	100		ML	**Sieve** (S-22) G:% S:19% F:81%	-71
74									-72
75									-73
76	15 33 45 50	N = 78	S-Split Spoon	S-23	100				-74
77									-75
78									-76
79	26 26 42 50	N = 68; W% = 27	S-Split Spoon	S-24	100			**Sieve** (S-24) G:% S:16% F:84%	-77
80									

Backfill Information: Sand (70–80 m)

Draft

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

SUMMARY LOG

Ministry of Transportation and Infrastructure — British Columbia

Drill Hole #:**22GEO-DH007**

Project: **Fraser River Tunnel Project**
Location: Deas Island, BC
Datum: UTM Zone 10N | Alignment:
Northing/Easting: 5440130 , 495233 | Station/Offset:
Elevation: 2.15 m

Prepared by: P10419A01
Klohn Crippen Berger
Logged by: JM Reviewed by: KR

Date(s) Drilled: August 2-7, 2022
Company: Mud Bay Drilling
Driller: Cole
Drill Make/Model: FRASTE XL C05-021
Drilling Method: Mud Rotary

DEPTH (m)	SPT	SPT "N" (BLOWS/300 mm)	W% (Wp% / WL%)	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	ELEVATION (m)
80							ML, SANDY SILT, low plasticity, fine grained sand, grey, w > PL, stiff to hard. *(continued)*			-78
82.6	23 / 50 / 50	100		Split Spoon	S-25	100				-80
85.6	13 / 20 / 23 / 38	43		Split Spoon	S-26	100				-83
88.6	3 / 19 / 22 / 27	41	28	Split Spoon	S-27	100			**Atterberg** (S-27): PL:19% LL:24% **Sieve** (S-27) G:% S:21% F:79%	-86
90										-88

Backfill information: Sand (80–90 m)

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: **22GEO-DH007**

BRITISH COLUMBIA — Ministry of Transportation and Infrastructure

Prepared by: P10419A01 Klohn Crippen Berger Logged by: JM Reviewed by: KR	Project: **Fraser River Tunnel Project** Location: Deas Island, BC Datum: UTM Zone 10N Northing/Easting: 5440130 , 495233 Elevation: 2.15 m Alignment: Station/Offset:	Date(s) Drilled: August 2-7, 2022 Company: Mud Bay Drilling Driller: Cole Drill Make/Model: FRASTE XL C05-021 Drilling Method: Mud Rotary

Column headings: DEPTH (m) | DRILLING DETAILS / SPT | Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp% W% WL% 20 40 60 80 | SAMPLE TYPE | SAMPLE NO | RECOVERY (%) | SOIL SYMBOL | SOIL DESCRIPTION | CLASSIFICATION | COMMENTS TESTING, Drillers Estimate *{G % S % F %}* | BACKFILL INFORMATION | ELEVATION (m)

Depth (m)	SPT	SPT "N"	Sample Type	Sample No	Recovery (%)	Soil Description	Elevation (m)
90						ML, SANDY SILT, low plasticity, fine grained sand, grey, w > PL, stiff to hard. *(continued)*	-88
91							-89
~91.5–92	20, 31, 25, 32	56	Split Spoon	S-28	100		
92						92.05m	-90

Notes:
1) Hole was terminated at target depth of 92.05 m.
2) Mud Rotary drilling was conducted by Mud Bay Drilling of Surrey, BC, using a FRASTE MULTIDRILL XL C05-021 drill rig.
3) Hole was backfilled with QUIKRETE Portland Cement Type (GU) to surface.
4) Coordinates were surveyed by ConeTec Investigation Ltd. using a Real Time Kinetic (RTK) GPS GNSS survey rod, manufactured by Trimble. Coordinates are in NAD83, UTM Zone 10N. Elevations are relative to CGVD28 HT_2.0 Datum.

Depth scale: 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
Elevation scale: -88, -89, -90, -91, -92, -93, -94, -95, -96, -97

Draft

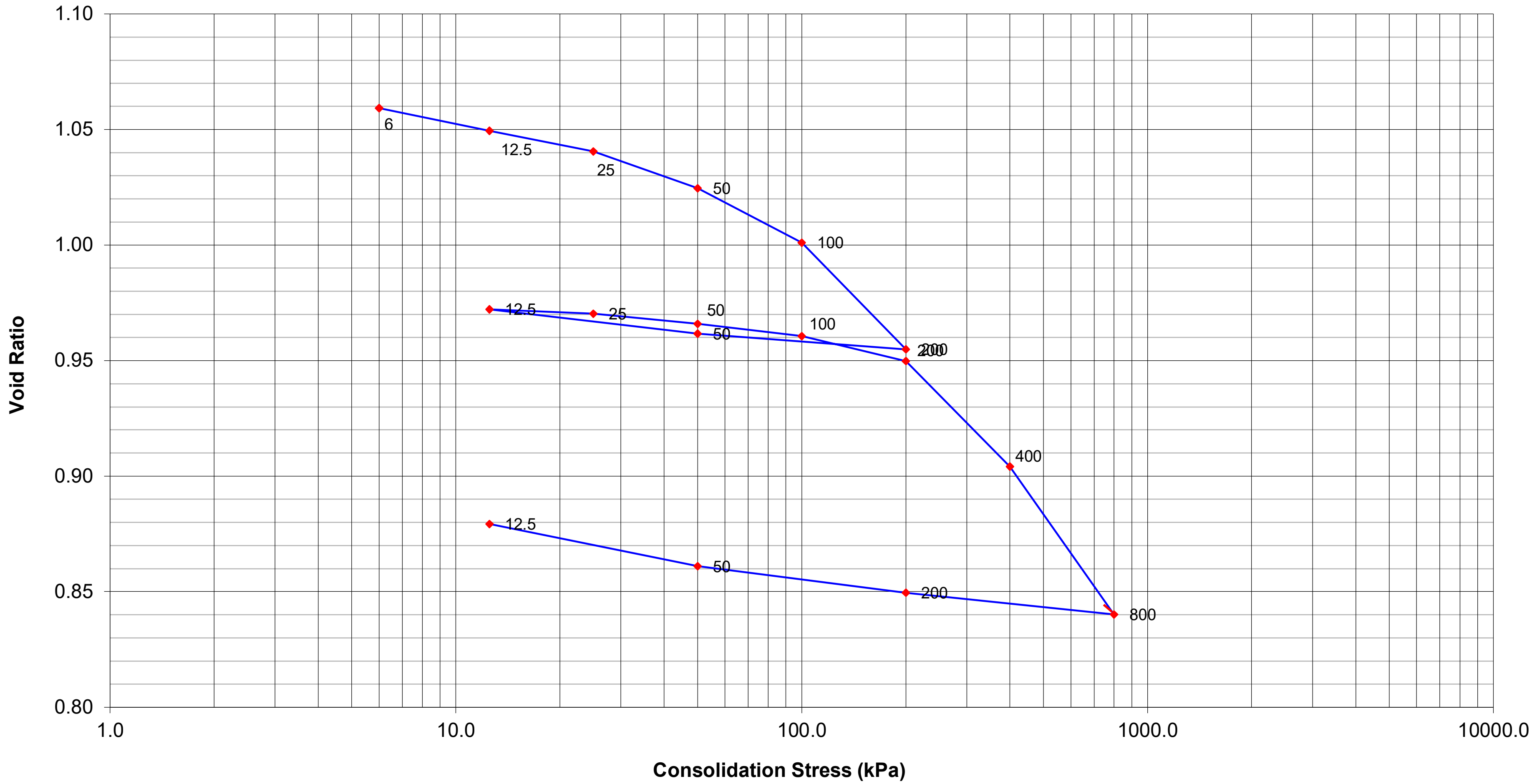
Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Legend Installation: Sand, Grout, Cement, Bentonite, Drill Cuttings, Slotted, Slough, Piezometer

Final Depth of Hole: 92.0 m
Depth to Top of Rock:

APPENDIX III – LAB TESTING DATA

Consolidation Test - Fraser River Tunnel OE-22GEO/DH007/T-02
e - log(p)



Klohn Crippen Berger	PROJECT NO.:	P10419A01		
	PROJECT:	Fraser River Tunnel OE		
	LOCATION:	BC	DATE TESTED:	2023-02-01
	SAMPLE NO.:	22GEO/DH007/T-02	DEPTH:	3.0 m
	TESTED BY:	MR	CHECKED BY:	JG

1D Consolidation - Based on ASTM 2435

PROJECT NO.:	P10419A01	**Test Specimen Information:**	
PROJECT:	Fraser River Tunnel OE	Initial water content:	40.12 %
SAMPLE NO.:	22GEO/DH007/T-02	Final water content:	34.72 %
DETAILS	0	Dry mass:	104.02 g
		Diameter	63.44 mm
		Area	31.61 cm^2
TEST NO.:	VT23005_CONS03	Specific Gravity	2.68
LOADING MACHINE NO.:	OED1 ID80		

Initial Specimen Height (mm):	25.50
Height of Solids (mm):	12.28
Initial void ratio:	1.077
Void Ratio Factor	0.0814

Notes:
*1: Estimated t_{50}

Pressure (kPa)		*Change in Height	Final	Change in	Change in	Void	t_{50} *1	Cv	Mv	k	Cc
From	To	Corrected (mm)	Height (mm)	Void Ratio	Void Ratio Acc	Ratio	(min)	(cm^2/sec)	(cm^2/N)	(cm/sec)	
0.0	**6.0**	0.214	25.286	0.0175	0.0175	**1.059**					
6.0	**12.5**	0.121	25.165	0.0098	0.0273	**1.049**	***0.12***	***4.4E-02***	***7.3E-03***	***3.1E-06***	***0.031***
12.5	**25.0**	0.109	25.056	0.0089	0.0362	**1.041**	***0.11***	***4.7E-02***	***3.5E-03***	***1.6E-06***	***0.029***
25.0	**50.0**	0.196	24.860	0.0160	0.0521	**1.025**	***0.10***	***5.1E-02***	***3.1E-03***	***1.6E-06***	***0.053***
50.0	**100.0**	0.289	24.571	0.0235	0.0756	**1.001**	***0.11***	***4.8E-02***	***2.3E-03***	***1.1E-06***	***0.078***
100.0	**200.0**	0.567	24.004	0.0462	0.1218	**0.955**	***0.12***	***4.0E-02***	***2.3E-03***	***9.1E-07***	***0.153***
200.0	**50.0**	-0.083	24.087	-0.0067	0.1151	**0.962**					
50.0	**12.5**	-0.130	24.217	-0.0106	0.1045	**0.972**					
12.5	**25.0**	0.023	24.194	0.0019	0.1064	**0.970**					
25.0	**50.0**	0.054	24.139	0.0044	0.1108	**0.966**	***0.06***	***8.0E-02***	***8.9E-04***	***7.0E-07***	***0.015***
50.0	**100.0**	0.065	24.075	0.0053	0.1161	**0.961**	***0.05***	***9.5E-02***	***5.4E-04***	***5.0E-07***	***0.018***
100.0	**200.0**	0.133	23.942	0.0108	0.1269	**0.950**	***0.04***	***1.2E-01***	***5.5E-04***	***6.2E-07***	***0.036***
200.0	**400.0**	0.561	23.381	0.0457	0.1726	**0.904**	***0.07***	***7.1E-02***	***1.2E-03***	***8.1E-07***	***0.152***
400.0	**800.0**	0.786	22.595	0.0640	0.2365	**0.840**	***0.05***	***8.5E-02***	***8.4E-04***	***7.0E-07***	***0.213***
800.0	**200.0**	-0.115	22.711	-0.0094	0.2272	**0.850**					
200.0	**50.0**	-0.141	22.851	-0.0115	0.2157	**0.861**					
50.0	**12.5**	-0.224	23.076	-0.0183	0.1974	**0.879**					

Klohn Crippen Berger

PROJECT NO.:	P10419A01		
PROJECT:	Fraser River Tunnel OE		
LOCATION:	BC	DATE TESTED:	2023-02-01
SAMPLE NO.:	22GEO/DH007/T-02	DETAILS	
TESTED BY:	MR	CHECKED BY:	JG

Triaxial CU Test - Summary

(ASTM D4767)

Test Number

VT23006 TX01

PROJECT NO. : P10419A01

PROJECT : Fraser River Tunnel OE - Deas Slough Bridge

SAMPLE : 22GEO-DH007 / T02 / 3.0 m

DETAILS: CIU 125 kPa, trimmed from thin-walled tube sample

DATE : 2023-03-16

LOCATION: Deas Island, BC

TESTED BY: BY

CHECKED BY: JG

SPECIMEN INFORMATION	UNITS	Initial	Saturation	B-value	End of 1st Consolidation	End of 2nd Consolidation	End of 3rd Consolidation	At Max. Stress Ratio	End of Shear	
Specimen Height	mm	150.84	150.84	150.41	149.69	148.90	147.47	133.53	105.59	
Specimen Diameter	mm	73.73	73.73	73.91	73.50	73.18	72.75	76.45	85.97	
Area	cm^2	42.69	42.70	42.90	42.43	42.06	41.56	45.90	58.05	
Volume	cm^3	643.97	644.053	645.226	635.141	626.322	612.937	612.94	612.94	
Wet Weight	g	1180.33	1170.08	1172.43	1162.34	1153.52	1140.14	1140.14	1140.14	
Water Content	%	40.35	39.13	39.41	38.21	37.16	35.57	35.57	35.57	
Dry Weight	g	840.99	840.99	840.99	840.99	840.99	840.99	840.99	840.99	
Wet Density	g/cm^3	1.833	1.817	1.817	1.830	1.842	1.860	1.860	1.860	
Dry Density	g/cm^3	1.306	1.306	1.303	1.324	1.343	1.372	1.372	1.372	
Specific Gravity of Solids	-	2.68	2.68	2.68	2.68	2.68	2.68	2.68	2.68	
Solids Volume	cm^3	313.802	313.802	313.802	313.802	313.802	313.802	313.802	313.802	
Void Volume	cm^3	330.168	330.251	331.423	321.338	312.519	299.134	299.134	299.134	
Water Volume	cm^3	339.340	329.090	331.437	321.352	312.533	299.148	299.148	299.148	
Void Ratio (e)	-	1.052	1.052	1.056	1.024	0.996	0.953	0.953	0.953	
Saturation Ratio (Sr)	%	102.78	99.65	100.00	100.00	100.00	100.00	100.00	100.00	
Effective Confining Stress	kPa				32	62	125			

Shearing (CU)		
Skempton's B Parameter		0.99
Back Pressure before shearing	kPa	300.0
Confining Stress (σ_3') before shearing	kPa	124.9
Shear Rate	mm / min	0.06

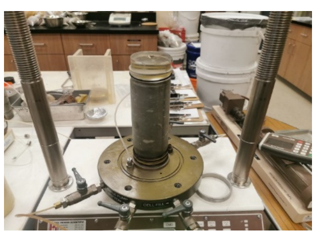
": using Cambridge method

At Maximum Deviator Stress:		
Axial Stain	%	**19.40**
Deviator Stress*	kPa	**147.8**
Φ '	°	34.5
c' (assumed)	kPa	**0**

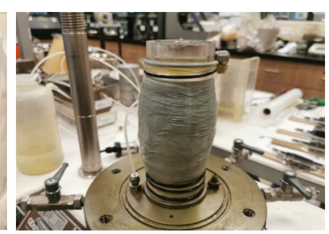
At Maximum Stress Ratio		
Axial Stain	%	**9.45**
Deviator Stress"	kPa	**123.8**
Φ '	°	36.9
c' (assumed)	kPa	0

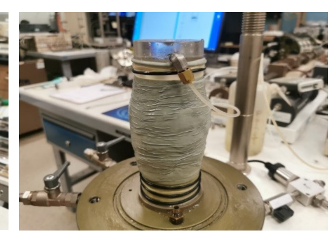
Photos:

Before Test



After Test

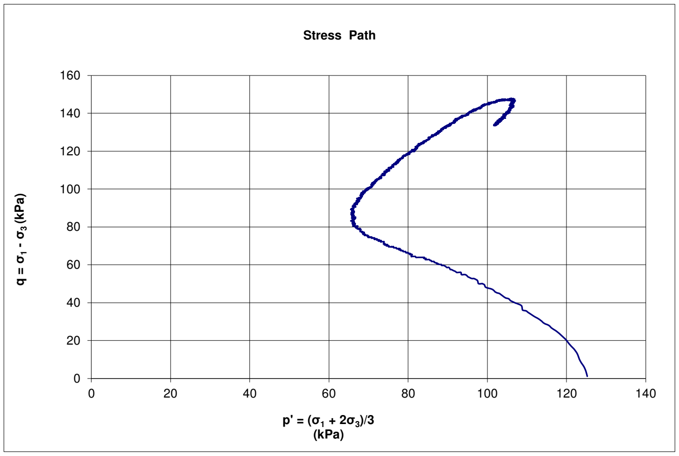


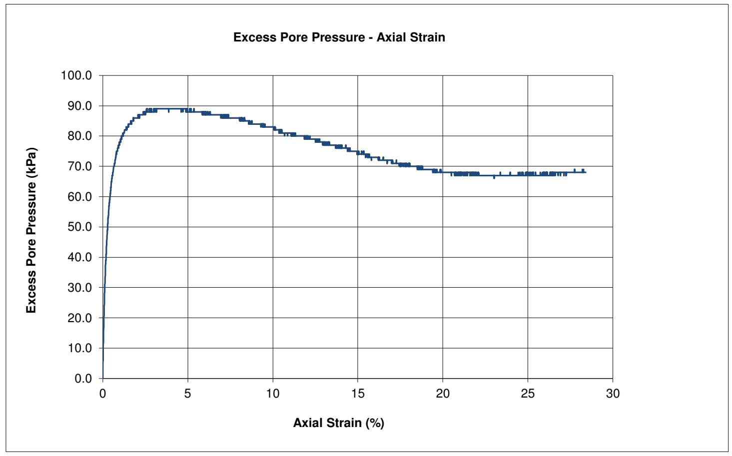


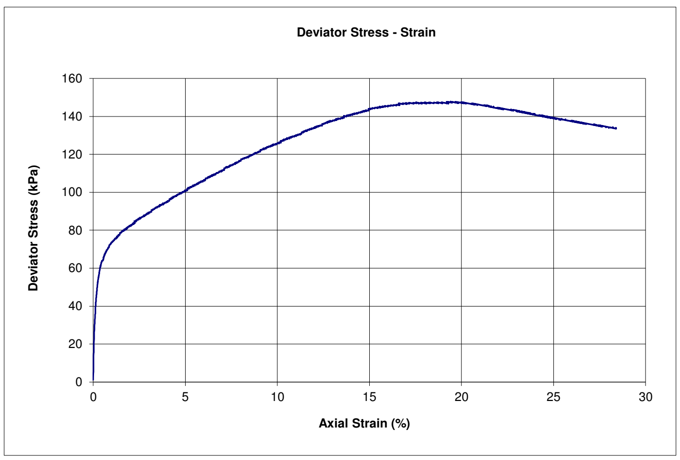
Triaxial CD Test - Charts

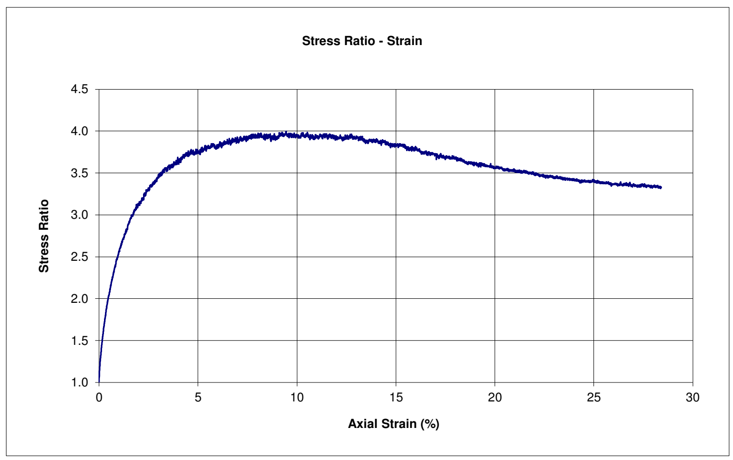
(ASTM D4767)

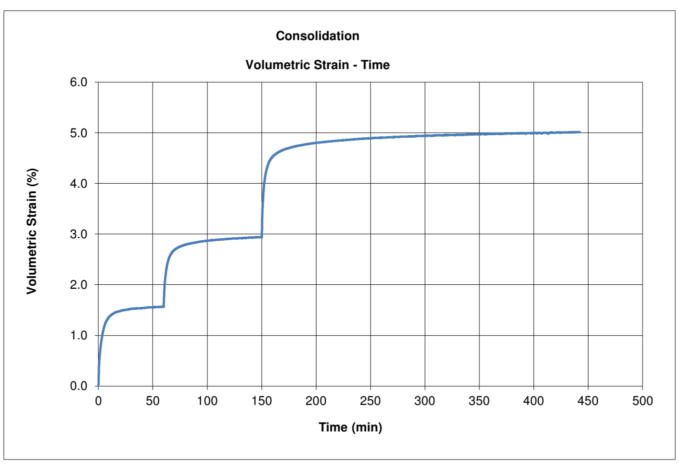
PROJECT NO. :	P10419A01	DATE :	2023-03-16
PROJECT :	Fraser River Tunnel OE - Deas Slough Bridge	LOCATION:	Deas Island, BC
SAMPLE :	22GEO-DH007 / T02 / 3.0 m	TEST BY:	BY
DETAILS:	CIU 125 kPa, trimmed from thin-walled tube sample	CHECKED BY:	JG

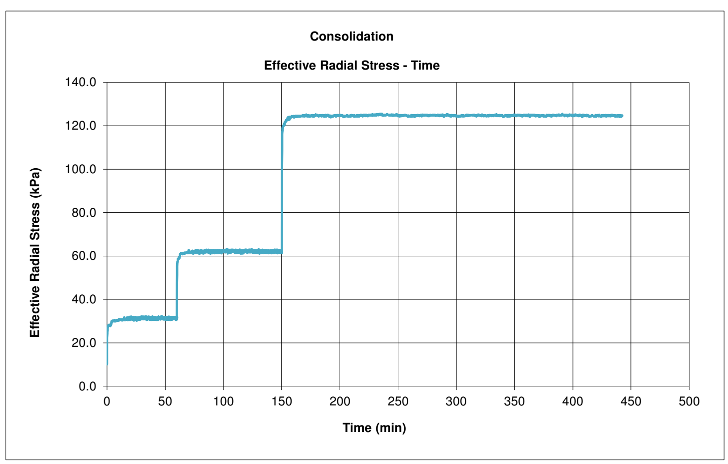




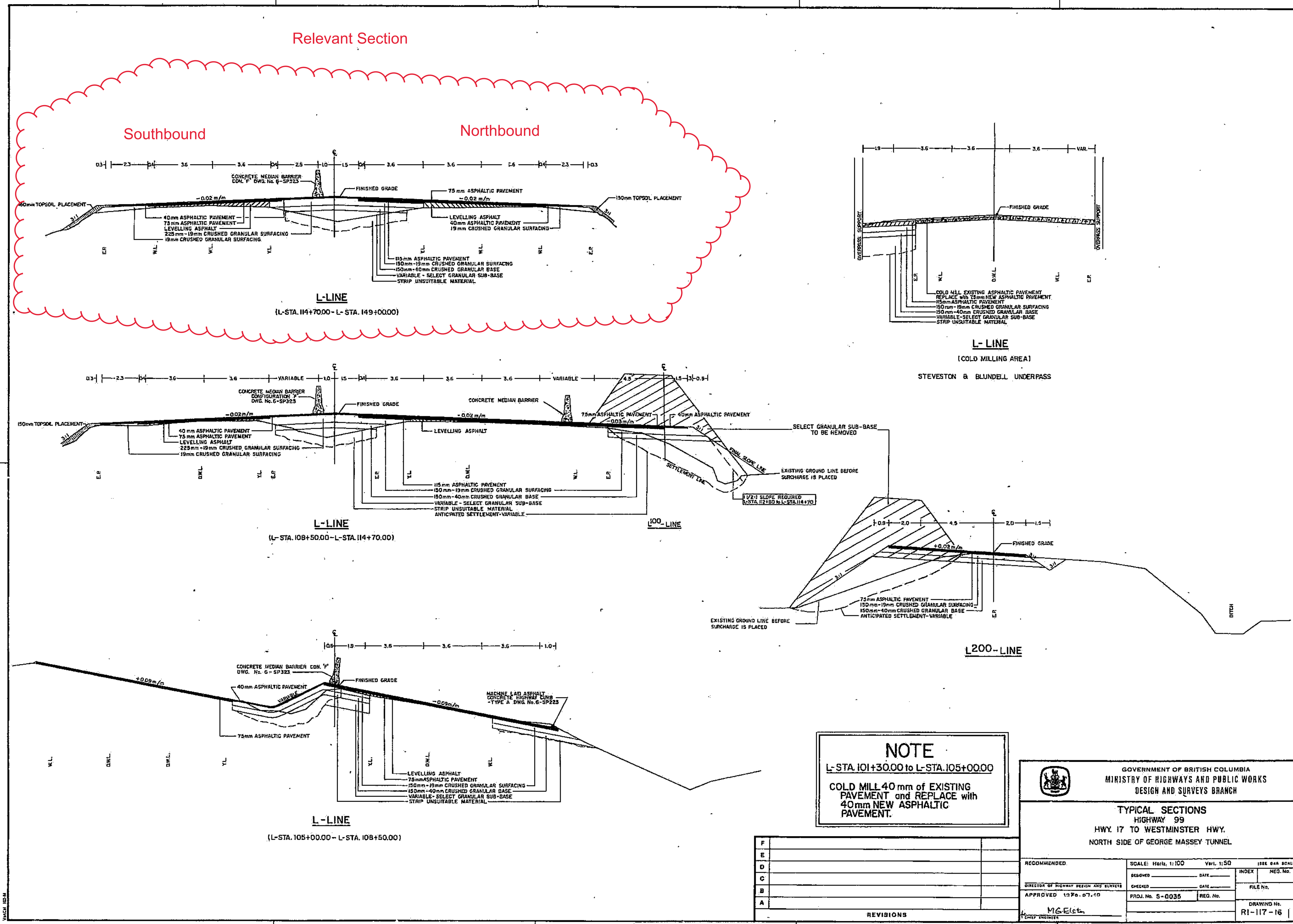


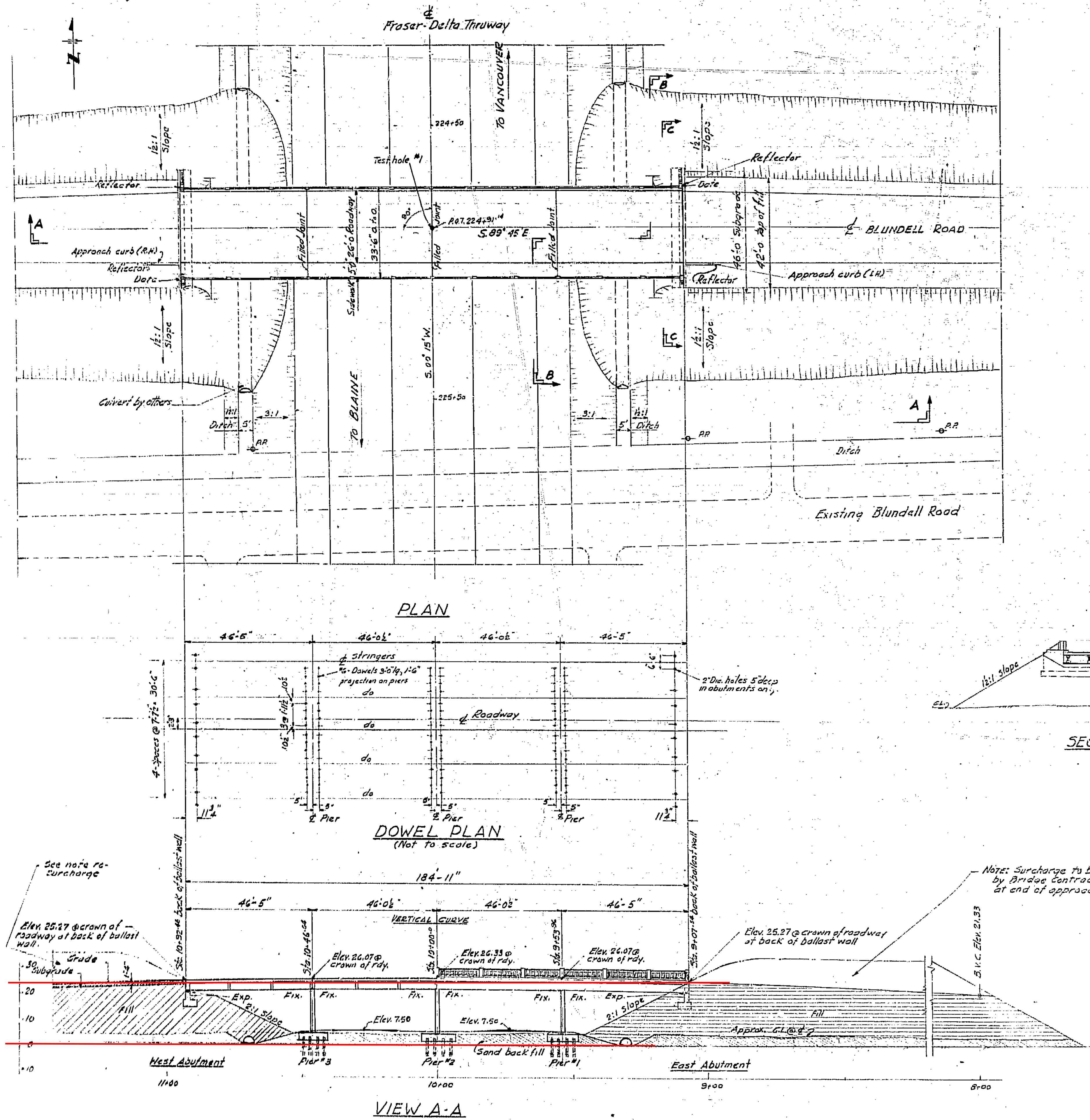


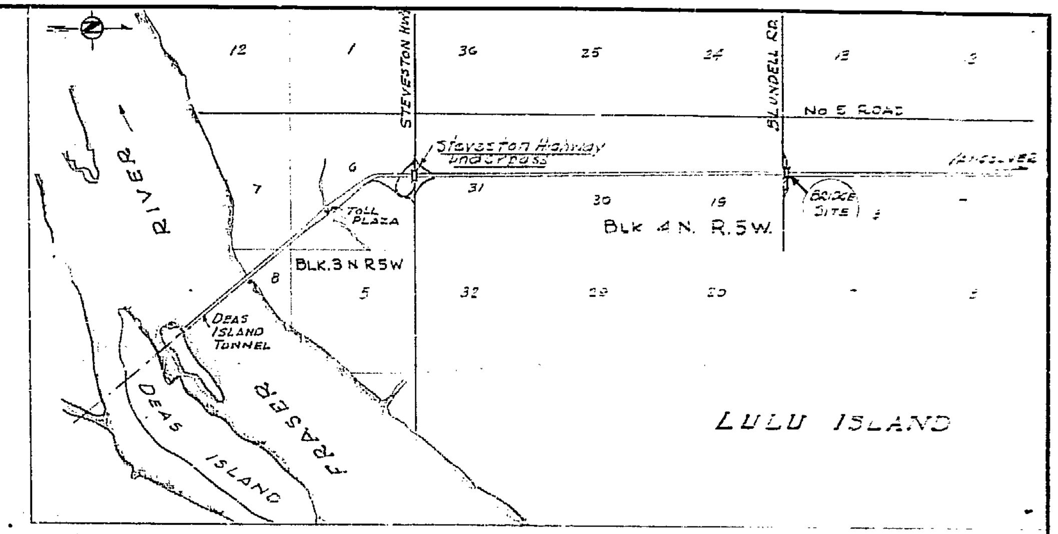




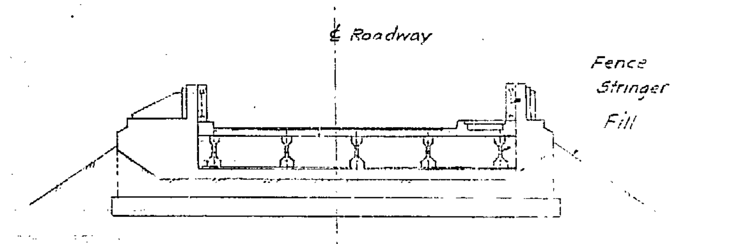
APPENDIX IV – HISTORICAL PAVEMENT DATA


Relevant Section
Southbound
Northbound
L-LINE
(L-STA. 114+70.00 - L-STA. 149+00.00)
L-LINE
(COLD MILLING AREA)
STEVESTON & BLUNDELL UNDERPASS
L-LINE
(L-STA. 108+50.00 - L-STA. 114+70.00)
L100-LINE
L200-LINE
L-LINE
(L-STA. 105+00.00 - L-STA. 108+50.00)
NOTE
L-STA. 101+30.00 to L-STA. 105+00.00
COLD MILL 40mm of EXISTING PAVEMENT and REPLACE with 40mm NEW ASPHALTIC PAVEMENT.
REVISIONS
GOVERNMENT OF BRITISH COLUMBIA
MINISTRY OF HIGHWAYS AND PUBLIC WORKS
DESIGN AND SURVEYS BRANCH
TYPICAL SECTIONS
HIGHWAY 99
HWY. 17 TO WESTMINSTER HWY.
NORTH SIDE OF GEORGE MASSEY TUNNEL
SCALE: Horiz. 1:100 Vert. 1:50
PROJ. No. S-0035
DRAWING No. R1-117-16
CANCEL PRINTS BEARING EARLIER LETTER



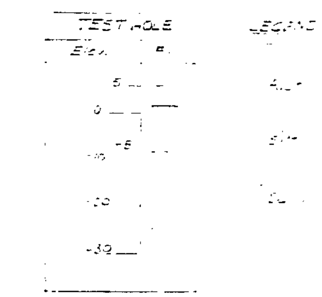


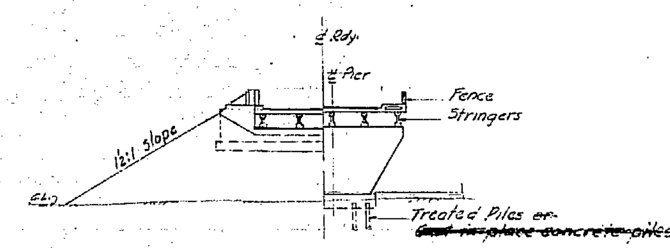
KEY MAP



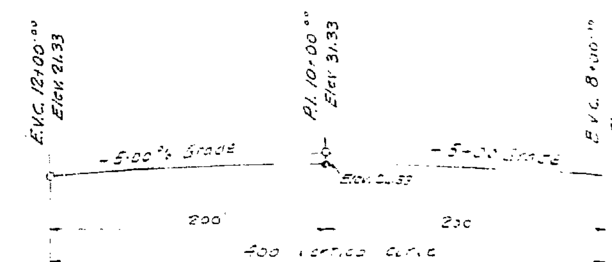
SECTION C-C

Scale: 1" = 10'





SECTION B-B



GRADE DIAGRAM

(Elevations - finished grade)

LIST OF DRAWINGS		
	DWG. No.	TITLE
	1593-2	Layout, Dowel Plan and Key Map
	-3	Abutments and Piers - Alternative A
	-4	Abutments and Piers - Alternative B
	-5	Prestressed concrete stringers
	-6	Deck Details
	-7	Lighting Details
	~~Misc. 597-7E~~	Standard Roadway Fence
2084	235 A-1	[illegible]

NOTES

Specifications: Dept. of Highways on [illegible]

Live Load: H-25-S20

Datum: Geodetic

B.M. #15 spike in No 5 road 1200' right of sta. 222+00 opposite house No 771, Elev. 8.28

Survey by: Photographic Survey Corp.

DELTA DISTRICT

FRASER-DELTA THRUWAY

BLUNDELL ROAD UNDERPASS

LAYOUT, DOWEL PLAN & KEY MAP

SCALE 1" = 20' AND AS NOTED

REVISIONS			
Rev.	Particulars	Init.	Date
A	Drains & catch basins added	[illegible]	[illegible]
B	Sidewalk placed on South side of bridge	[illegible]	[illegible]

GOVT. OF BRITISH COLUMBIA
DEPT. OF HIGHWAYS
BRIDGE ENGINEER'S OFFICE

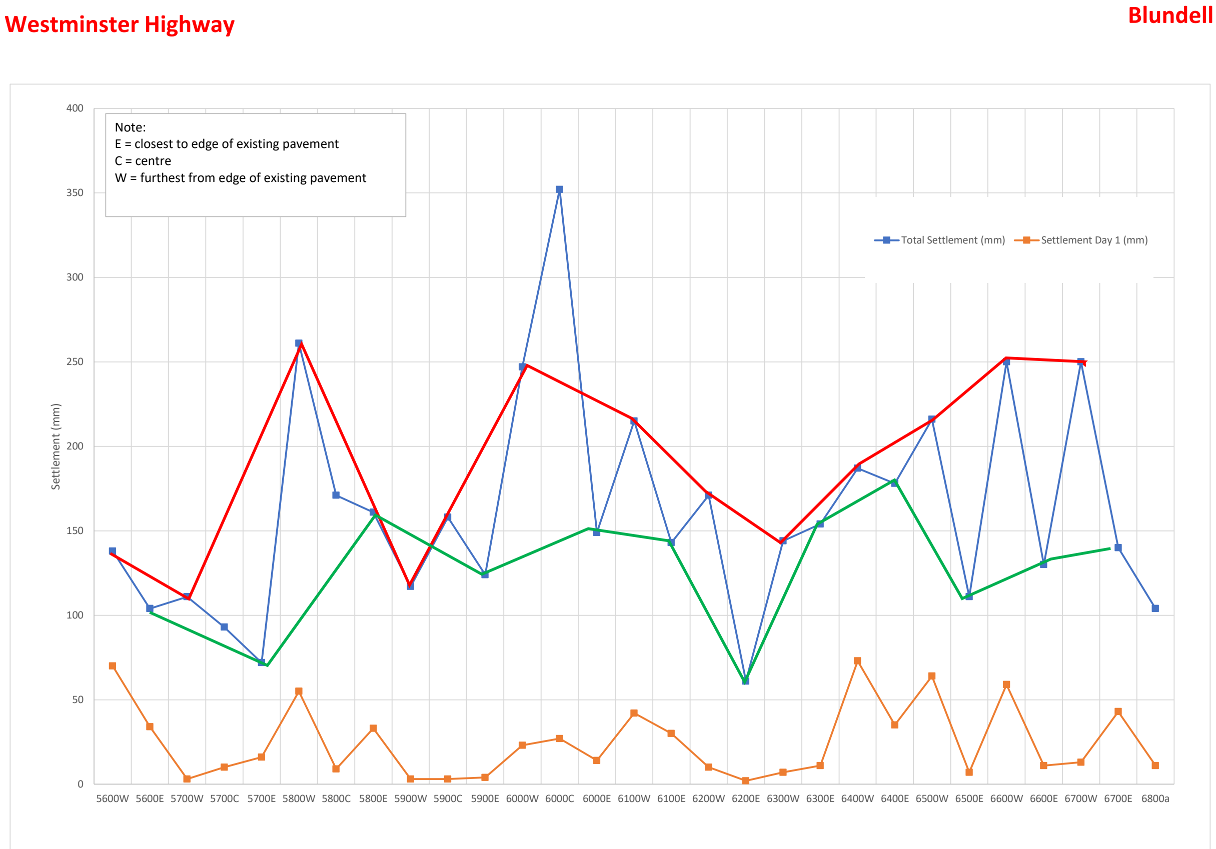
	Init.	Date
Made by	[illegible]	[illegible]
Checked by	[illegible]	[illegible]
Approved	[illegible]	

DRAWING NO. 1593-2 B

Cancel prints bearing earlier letter

APPENDIX V – SETTLEMENT GRAPHS

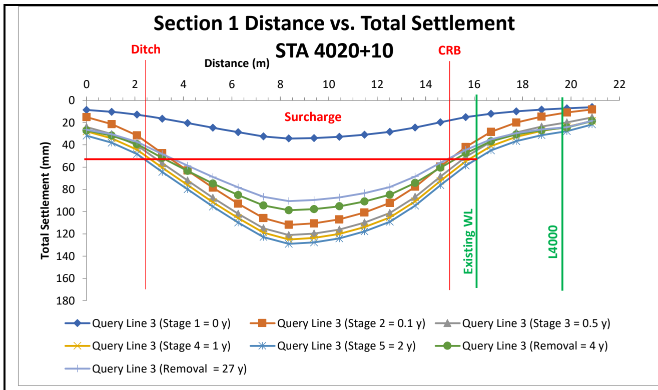
Historical Settlement Data north of Blundell

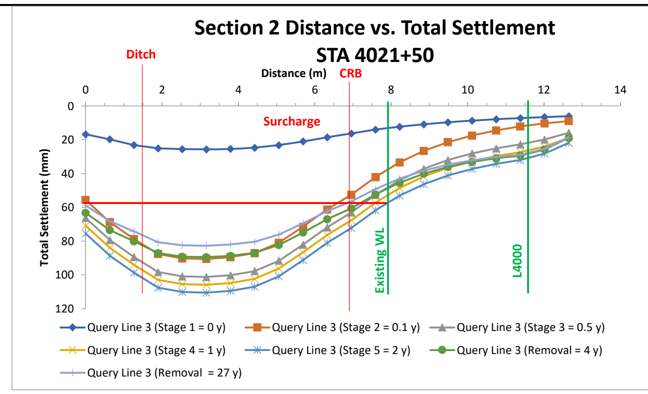


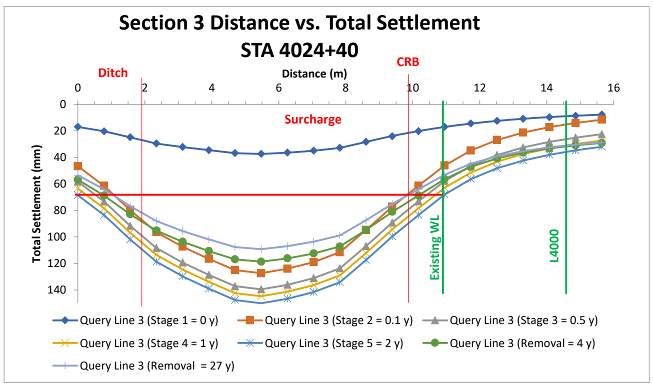
Notes:
Data extracted from 2018-April (2018-05-06) Richmond Weekly Settlement Readings

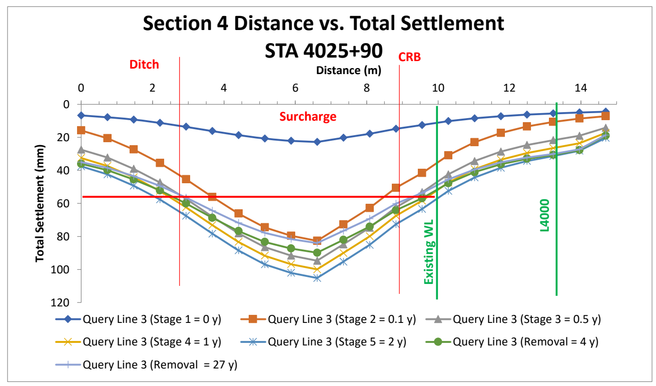
BASIS

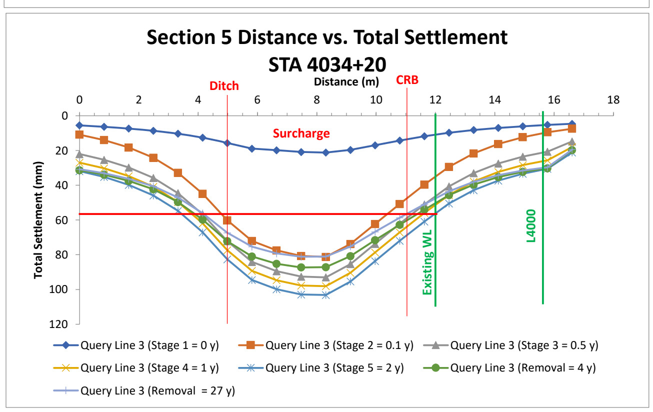
Figure 1

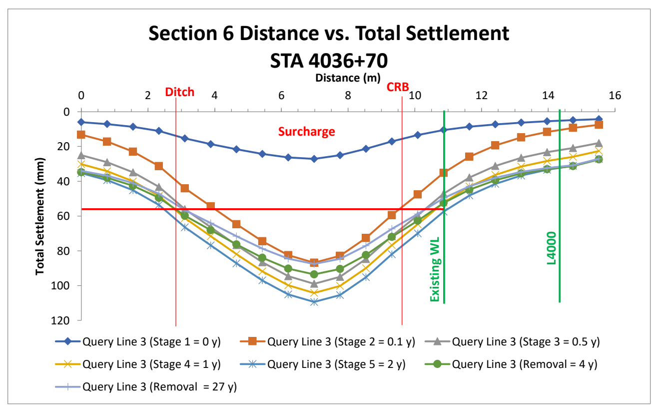


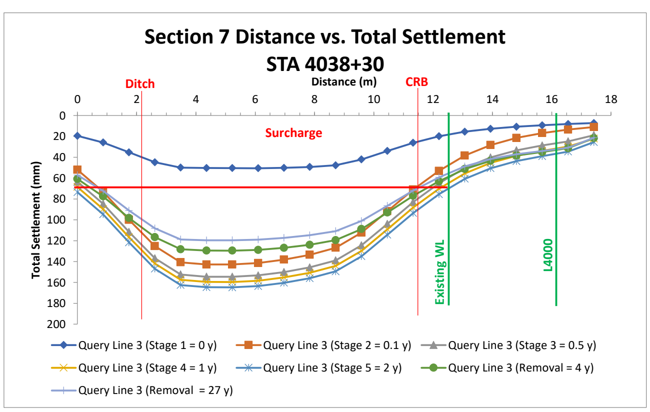












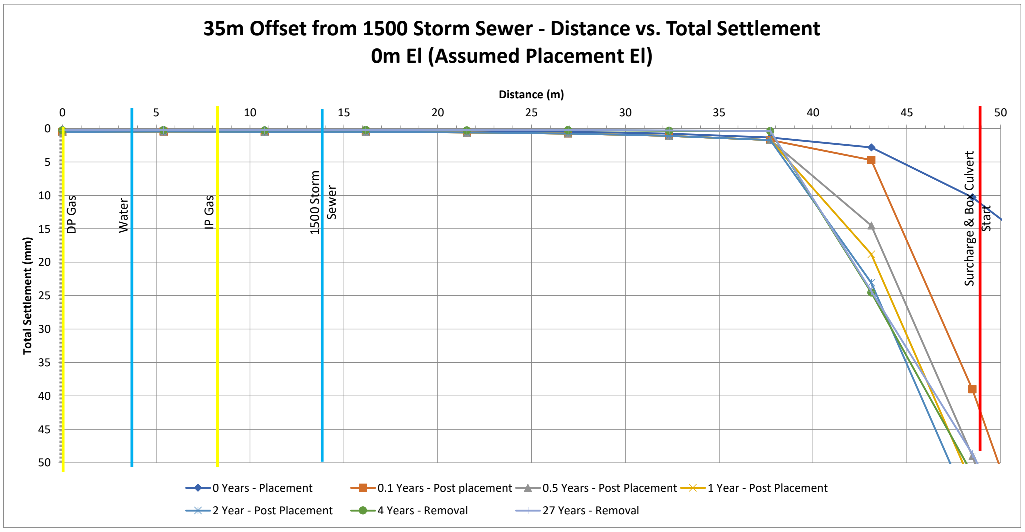
Notes:
Settlement data

All Sections are transverse to the southbound highway alignement.
Settlement data taken at placement elevation (Assumed 0m El)
0y = Placement
0.1y = 0.1 years after placement
0.5y = 0.5 years or 6 months after placement
1y = 1 years after placement
2y = 2 years after placement
Removal = 4y = Removal at 4 years after inital placement (2years after surcharge removal)
Removal = 27y = Removal at 27 years after inital placement (25 years after surcharge removal)

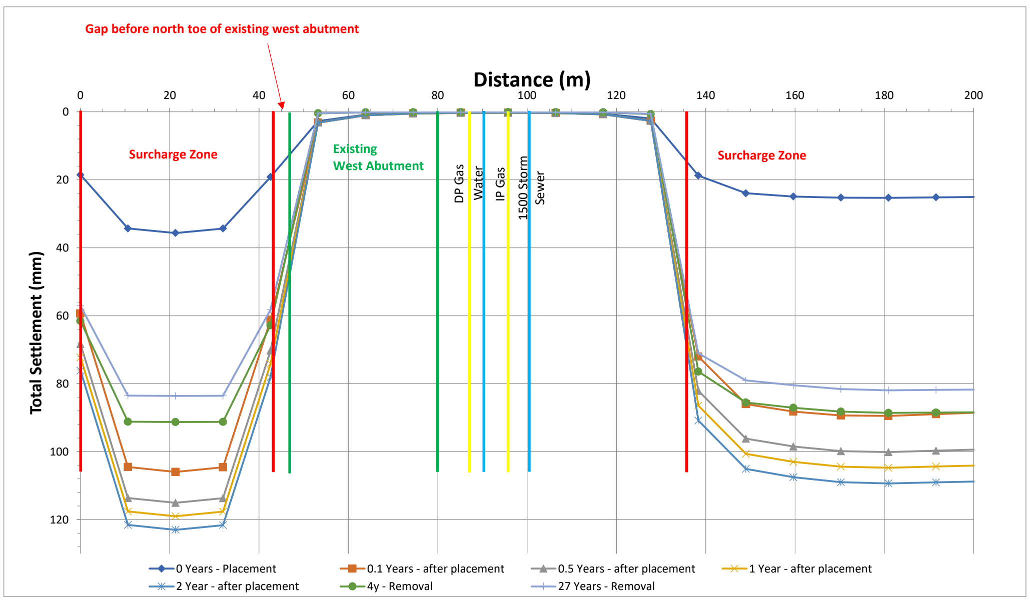
BASIS

Figure 2

A



B



Notes:
Settlement data
All Sections are transverse to the southbound highway alignement.
Settlement data taken at placement elevation (Assumed 0m El)
0y = Placement
0.1y = 0.1 years after placement
0.5y = 0.5 years or 6 months after placement
1y = 1 years after placement
2y = 2 years after placement
4y - Removal = Removal at 4 years after initial placement (2years after surcharge removal)
27 Years - Removal = Removal at 27 years after initial placement (25years after surcharge removal)

BASIS

Figure 3

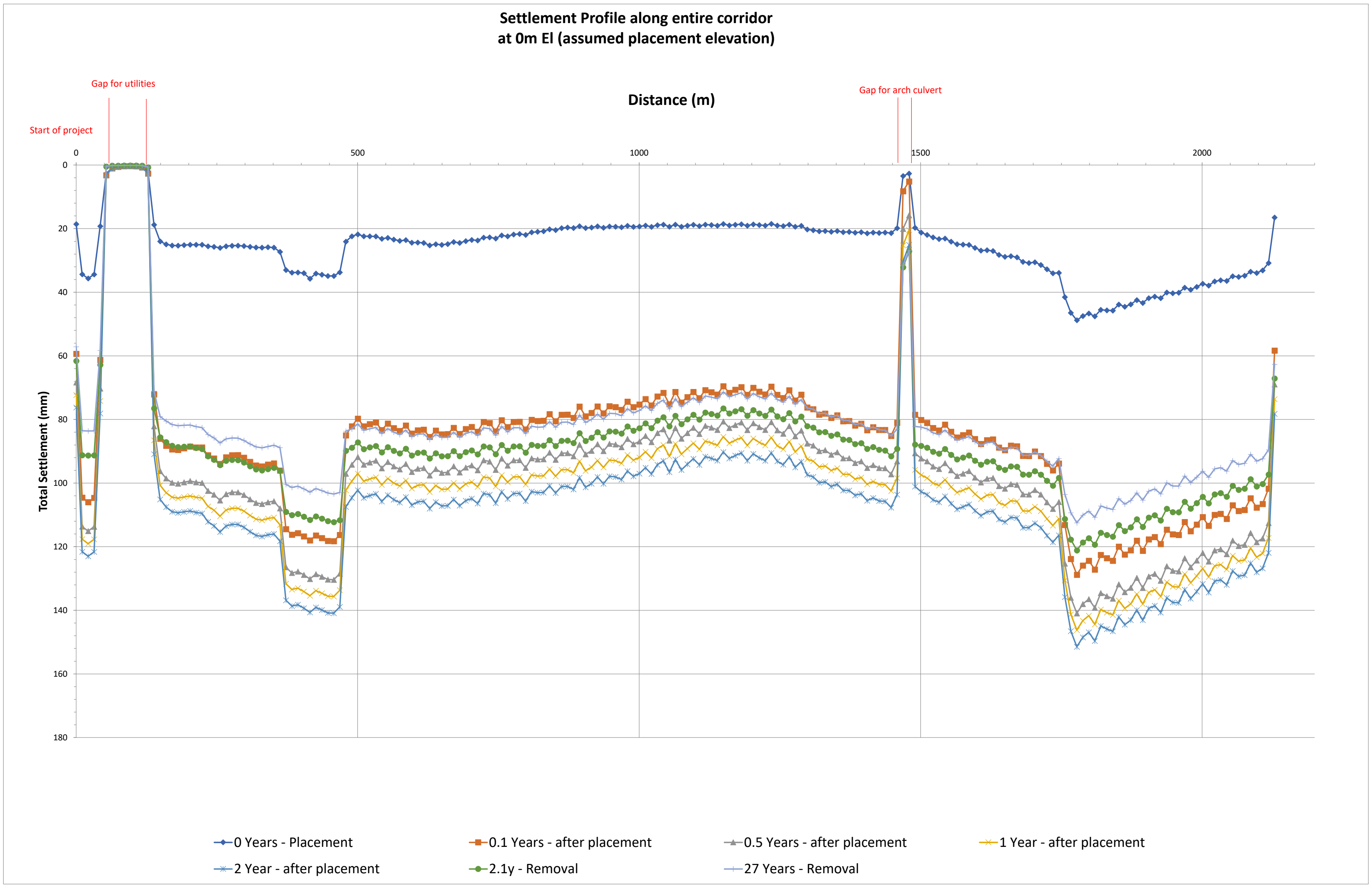

Settlement Profile along entire corridor
at 0m El (assumed placement elevation)
Distance (m)
Gap for utilities
Gap for arch culvert
Start of project
Total Settlement (mm)
0 Years - Placement
0.1 Years - after placement
0.5 Years - after placement
1 Year - after placement
2 Year - after placement
2.1y - Removal
27 Years - Removal

Figure 4

APPENDIX VI – GEOGRID

Tensar International Corporation
2500 Northwinds Parkway, Suite 500
Alpharetta, Georgia 30009-2247
Phone: 800-TENSAR-1
www.tensarcorp.com

Product Specification - Structural Geogrid UX1100MSE

Tensar International Corporation reserves the right to change its product specifications at any time. It is the responsibility of the specifier and purchaser to ensure that product specifications used for design and procurement purposes are current and consistent with the products used in each instance.

Product Type: **Integrally Formed Structural Geogrid**
Polymer: **High Density Polyethylene**
Load Transfer Mechanism: **Positive Mechanical Interlock**
Recommended Applications: **MESA System (Segmental Block Walls), SierraScape System (Welded Wire Walls)**

Product Properties

Index Properties	**Units**	**MD Values**[1]
▪ Tensile Strength @ 5% Strain[2]	kN/m (lb/ft)	27 (1,850)
▪ Ultimate Tensile Strength[2]	kN/m (lb/ft)	58 (3,970)
▪ Junction Strength[3]	kN/m (lb/ft)	54 (3,690)
▪ Flexural Stiffness[4]	mg-cm	500,000
Durability		
▪ Resistance to Long Term Degradation[5]	%	100
▪ Resistance to UV Degradation[6]	%	95
Load Capacity		
▪ Maximum Allowable Strength for 120-year Design Life[7]	kN/m (lb/ft)	21.2 (1,450)
Recommended Allowable Strength Reduction Factors[7]		
▪ Minimum Reduction Factor for Installation Damage (RF_{ID})[8]		1.05
▪ Reduction Factor for Creep for 120-year Design Life (RF_{CR})[9]		2.60
▪ Minimum Reduction Factor for Durability (RF_D)		1.00

Dimensions and Delivery

The structural geogrid shall be delivered to the jobsite in roll form with each roll individually identified and nominally measuring 1.33 meters (4.36 feet) in width and 76.2 meters (250.0 feet) in length. A typical truckload quantity is 432 rolls.

Notes:

1. Unless indicated otherwise, values shown are minimum average roll values determined in accordance with ASTM D4759-02. Brief descriptions of test procedures are given in the following notes.
2. True resistance to elongation when initially subjected to a load measured via ASTM D6637-10 Method A without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.
3. Load transfer capability determined in accordance with ASTM D7737-11.
4. Resistance to bending force determined in accordance with ASTM D7748-12, using one meter (minimum) long specimen.
5. Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments in accordance with EPA 9090 immersion testing.
6. Resistance to loss of load capacity or structural integrity when subjected to 500 hours of ultraviolet light and aggressive weathering in accordance with ASTM D4355-05.
7. Reduction factors are used to calculate the geogrid strength available for resisting force in long-term load bearing applications. Allowable Strength (T_{allow}) is determined by reducing the ultimate tensile strength (T_{ult}) by reduction factors for installation damage (RF_{ID}), creep (RF_{CR}) and chemical/biological durability ($RF_D = RF_{CD} \cdot RF_{BD}$) per GRI-GG4-05 [$T_{allow} = T_{ult}/(RF_{ID} \cdot RF_{CR} \cdot RF_D)$]. Recommended minimum reduction factors are based on product-specific testing. Project specifications, standard public agency specifications and/or design code requirements may require higher reduction factors. Design of the structure in which the geogrid is used, including the selection of appropriate reduction factors and design life, is the responsibility of the outside licensed professional engineer providing the sealed drawings for the project.
8. Minimum value is based on Installation Damage Testing in Sand, Silt, and Clay soils. Coarser soils require increased RF_{ID} values.
9. Reduction Factor for Creep determined for 120-year design life and in-soil temperature of 20°C using standard extrapolation techniques to creep rupture data obtained following the test procedure in ASTM D5262-04. Actual design life of the completed structure may differ.

Tensar International Corporation warrants that at the time of delivery the geogrid furnished hereunder shall conform to the specification stated herein. Any other warranty including merchantability and fitness for a particular purpose, are hereby excluded. If the geogrid does not meet the specifications on this page and Tensar is notified prior to installation, Tensar will replace the geogrid at no cost to the customer.

This product specification supersedes all prior specifications for the product described above and is not applicable to any products shipped prior to February 1, 2013.

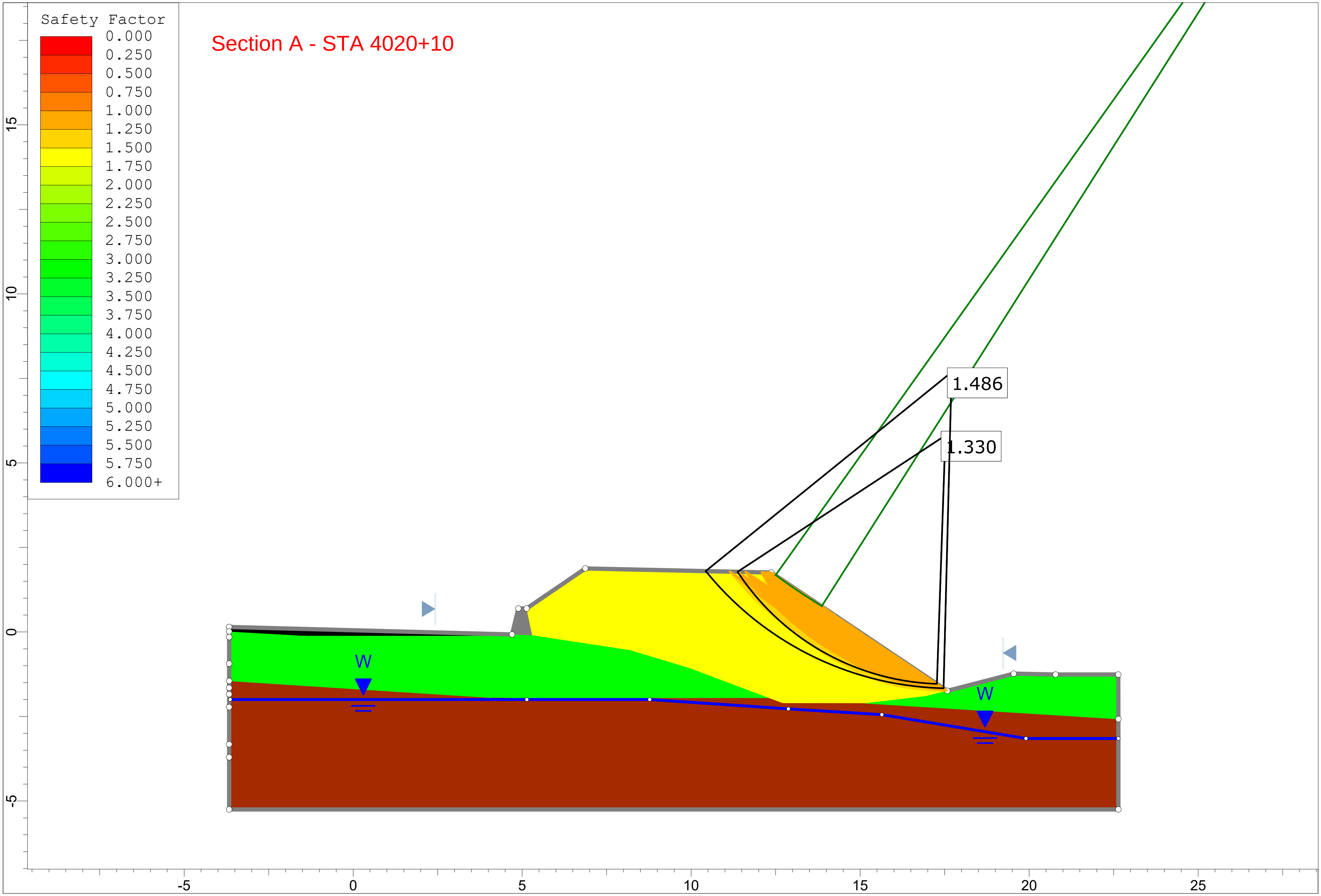
APPENDIX VII – STABILITY SECTIONS

Slide Material Paramters

Material Name	Color	Unit Weight (kN/ m3)	Sat. Unit Weight (kN/ m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Water Surface	Hu Type	Hu
Preload (FRS)		18.5		Mohr-Coulomb	0	35		Water Surface	Custom	1
Unit A-Ashpalt & Fill		21		Mohr-Coulomb	0	45		Water Surface	Custom	1
Unit B-Sand (Possible Fill)		18		Mohr-Coulomb	0	31		Water Surface	Custom	1
Unit C-Silt/Clay-Overbank		18	18	Mohr-Coulomb	0	34		Water Surface	Custom	1
Lockblock		20		Infinite strength			Yes	Water Surface	Custom	0

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Allow Sliding	Water Surface	Hu Type	Hu
Preload (FRS)		18.5	Mohr-Coulomb	0	35			Water Surface	Custom	1
Unit A - Ashpalt & Fill		21	Mohr-Coulomb	0	45			Water Surface	Custom	1
Unit B - Sand (Possible Fill)		18	Mohr-Coulomb	0	31			Water Surface	Custom	1
Lockblock		20	Infinite strength				Yes	Water Surface	Custom	0
Undrained		18	Undrained	70		Constant		Water Surface	Custom	1

Support Name	Color	Type	Force Application	Material Dependent	Adhesion (kPa)	Friction Angle (°)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Allowable Tensile Strength(kN/m)	Connection Strength Input	Connection Strength (kN/m)
UX1100MSE		Geosynthetic	Active (Method A)	No	0	25	Linear	Parallel to Reinforcement	Slope Face	100	44	Constant	44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5.250
5.500
5.750
6.000+
Section A - STA 4020+10
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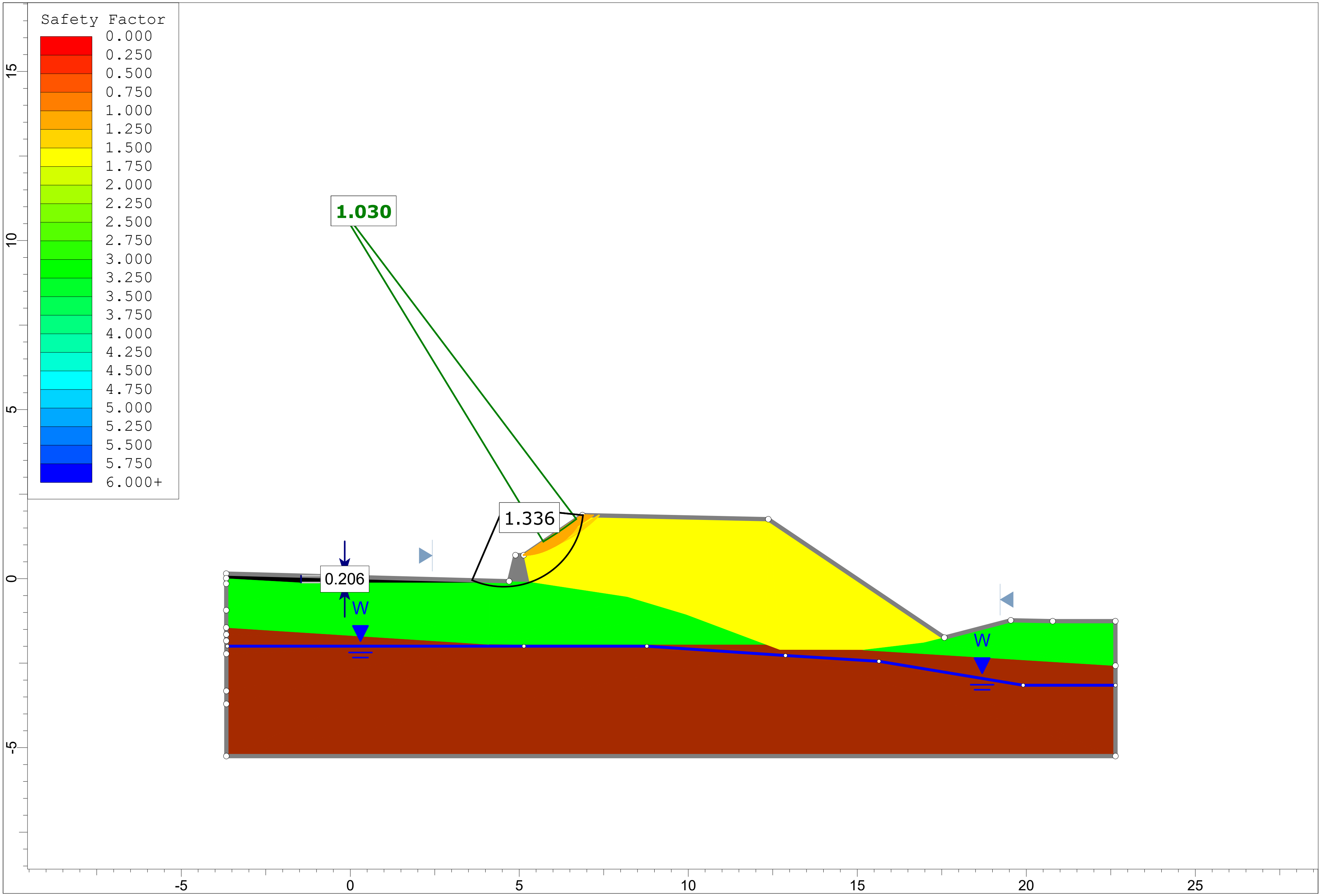

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5.250
5.500
5.750
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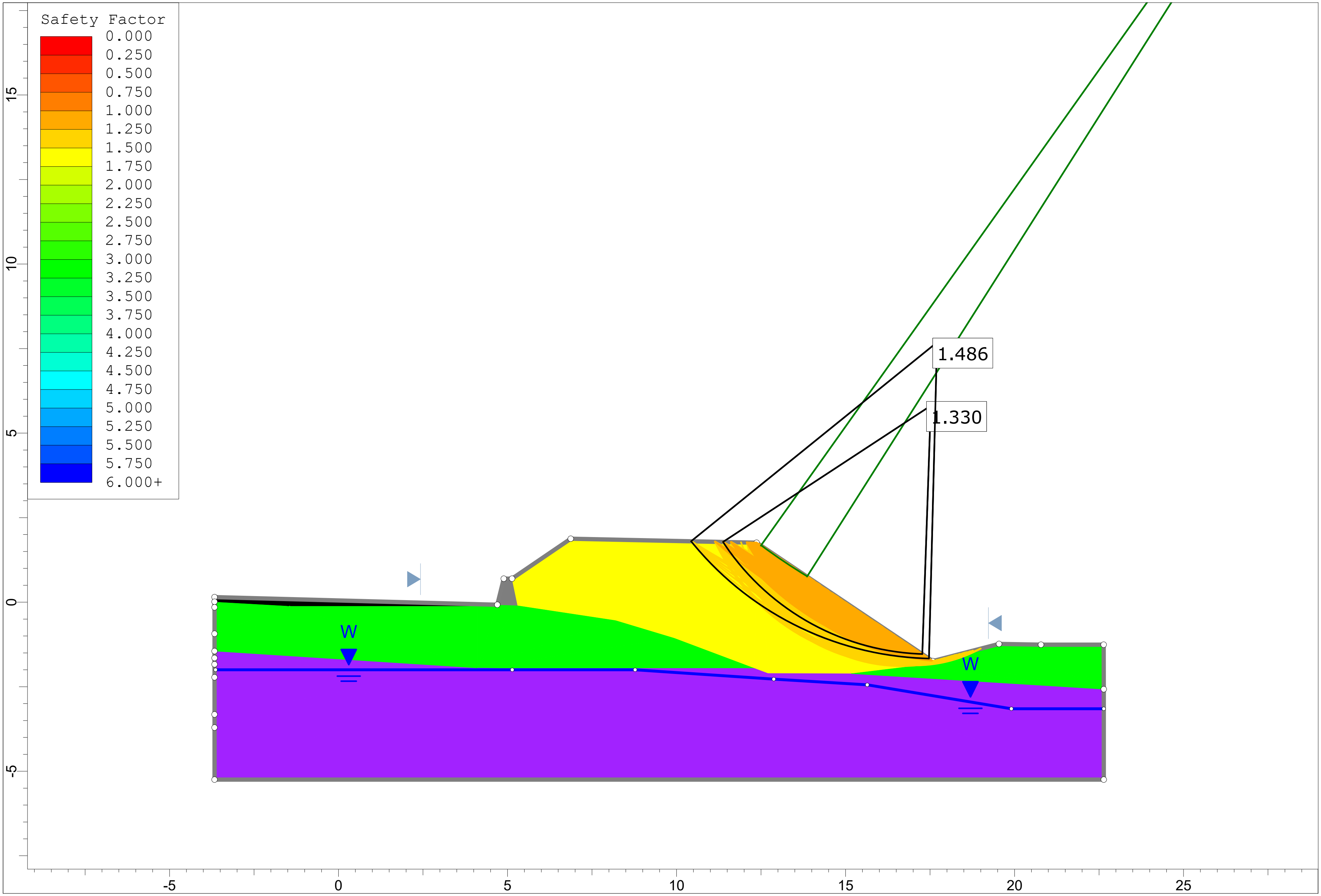

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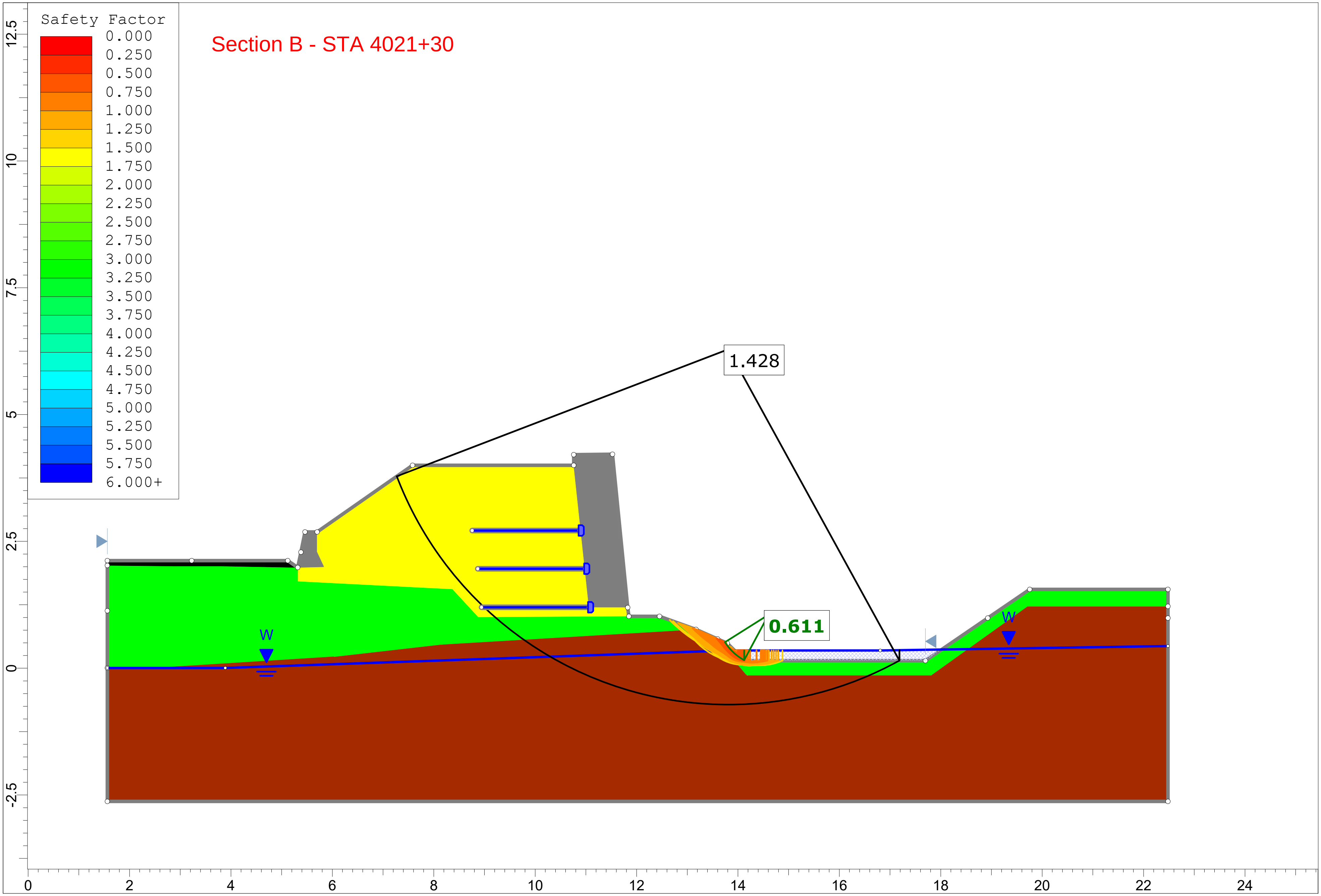
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4.750
5.000
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5.500
5.750
6.000+
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5.000
5.250
5.500
5.750
6.000+
1.534
W
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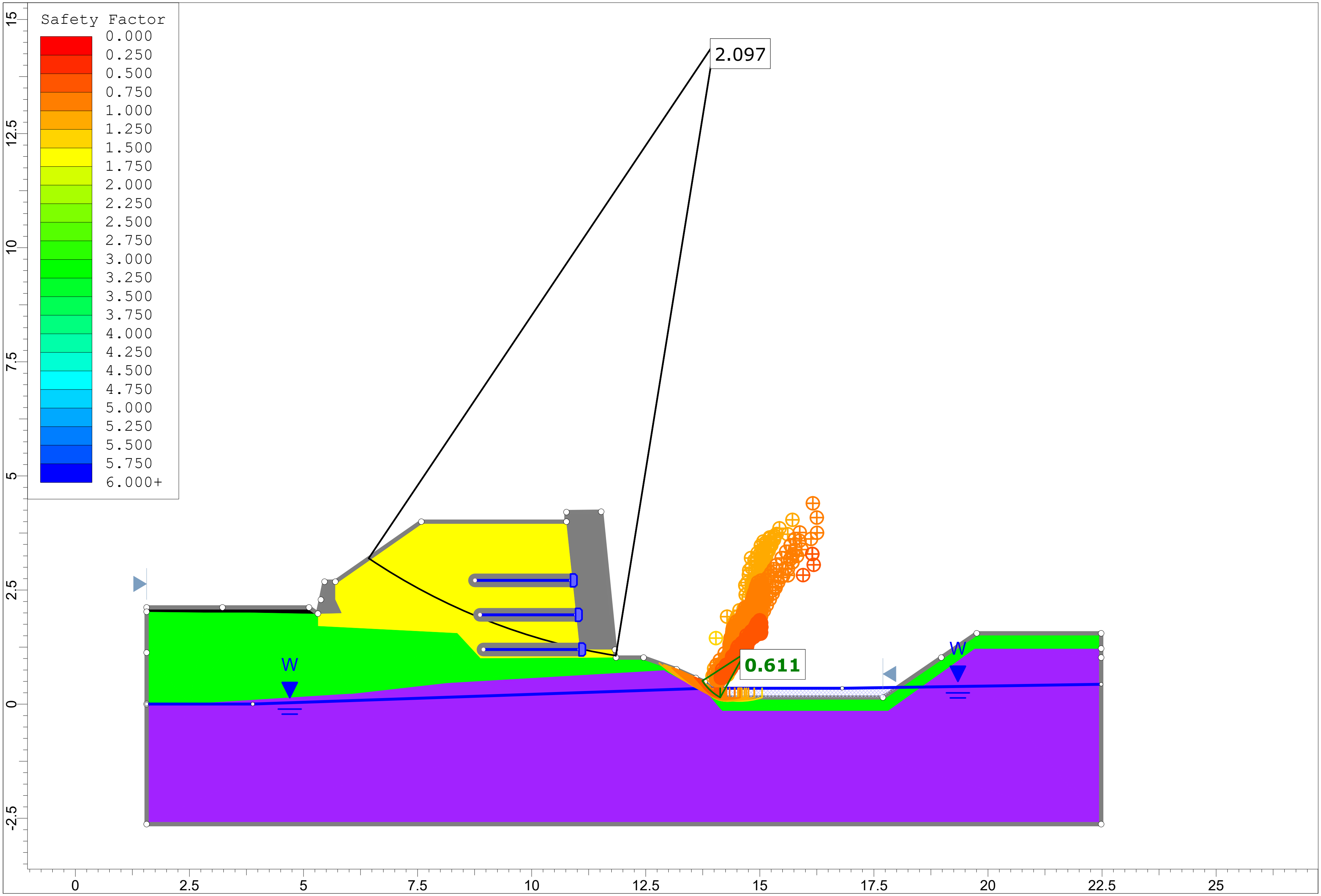

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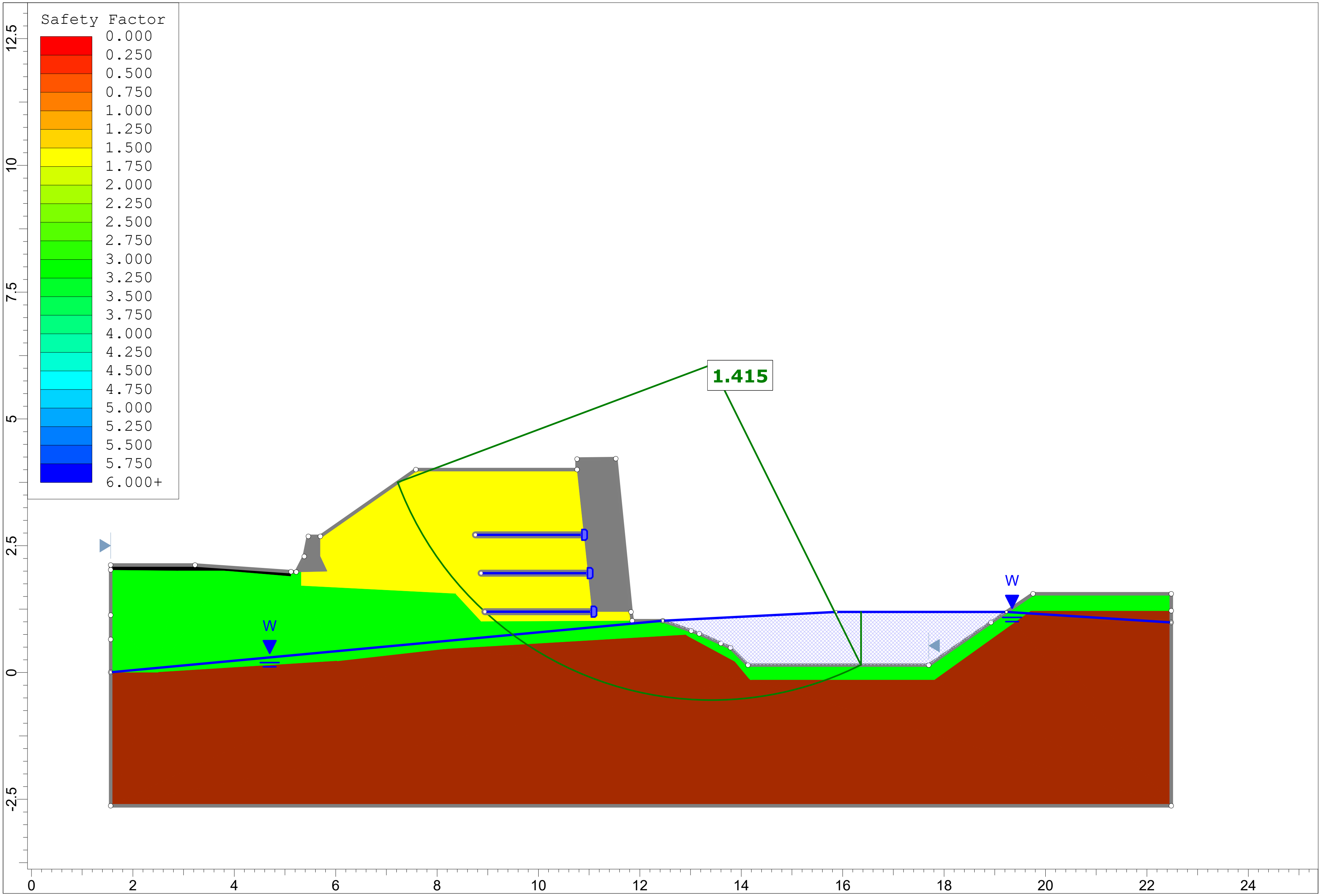
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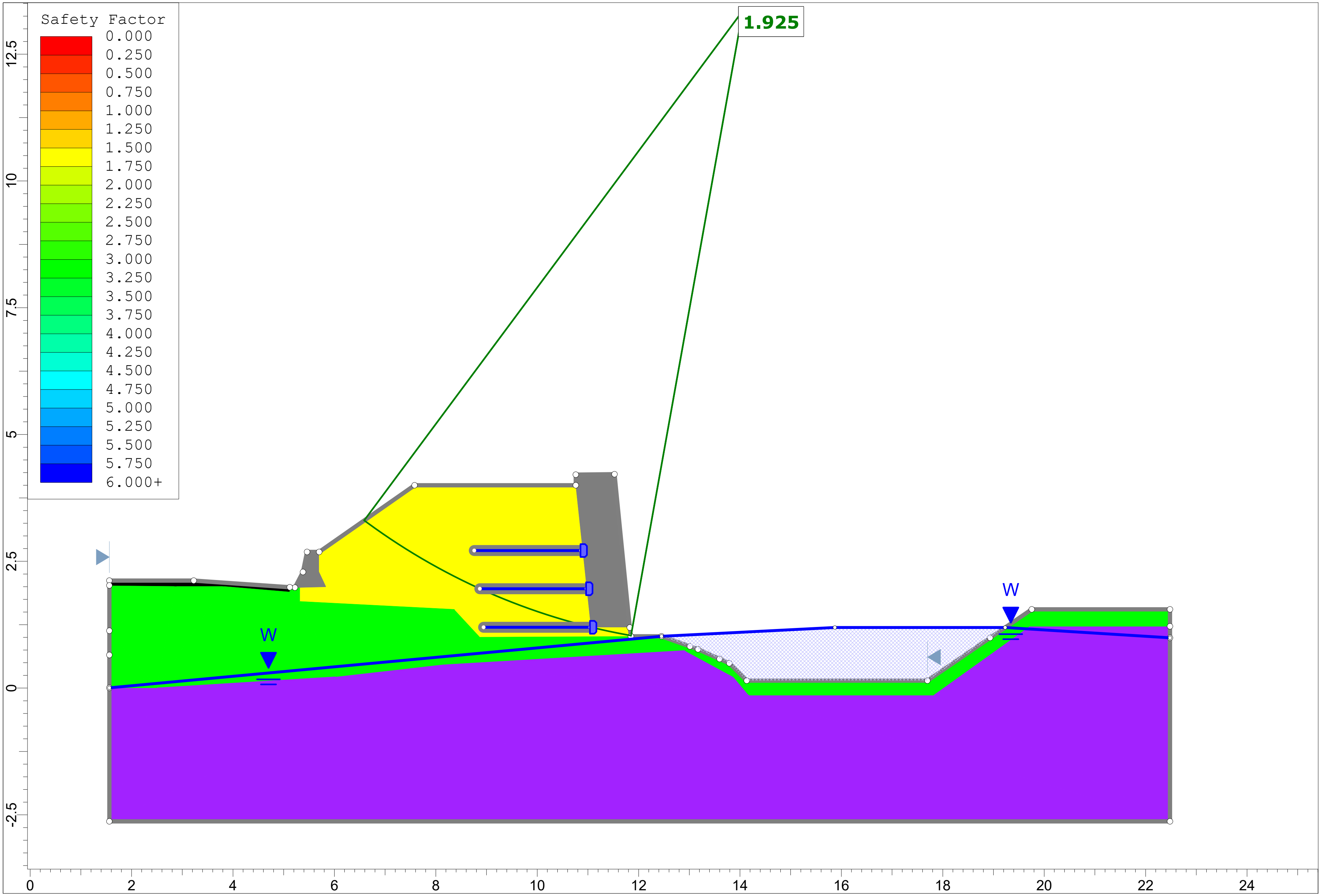

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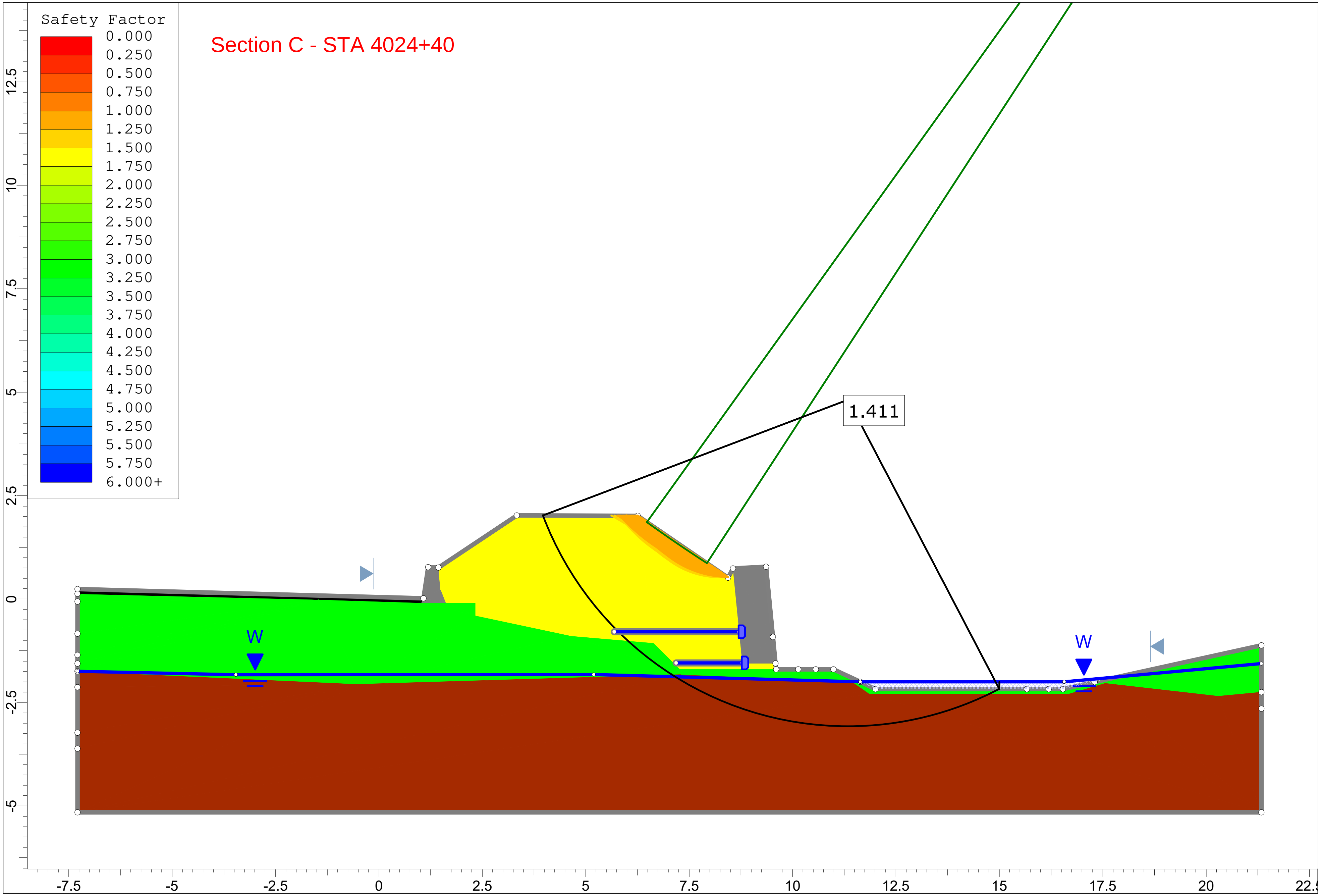
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5.500
5.750
6.000+
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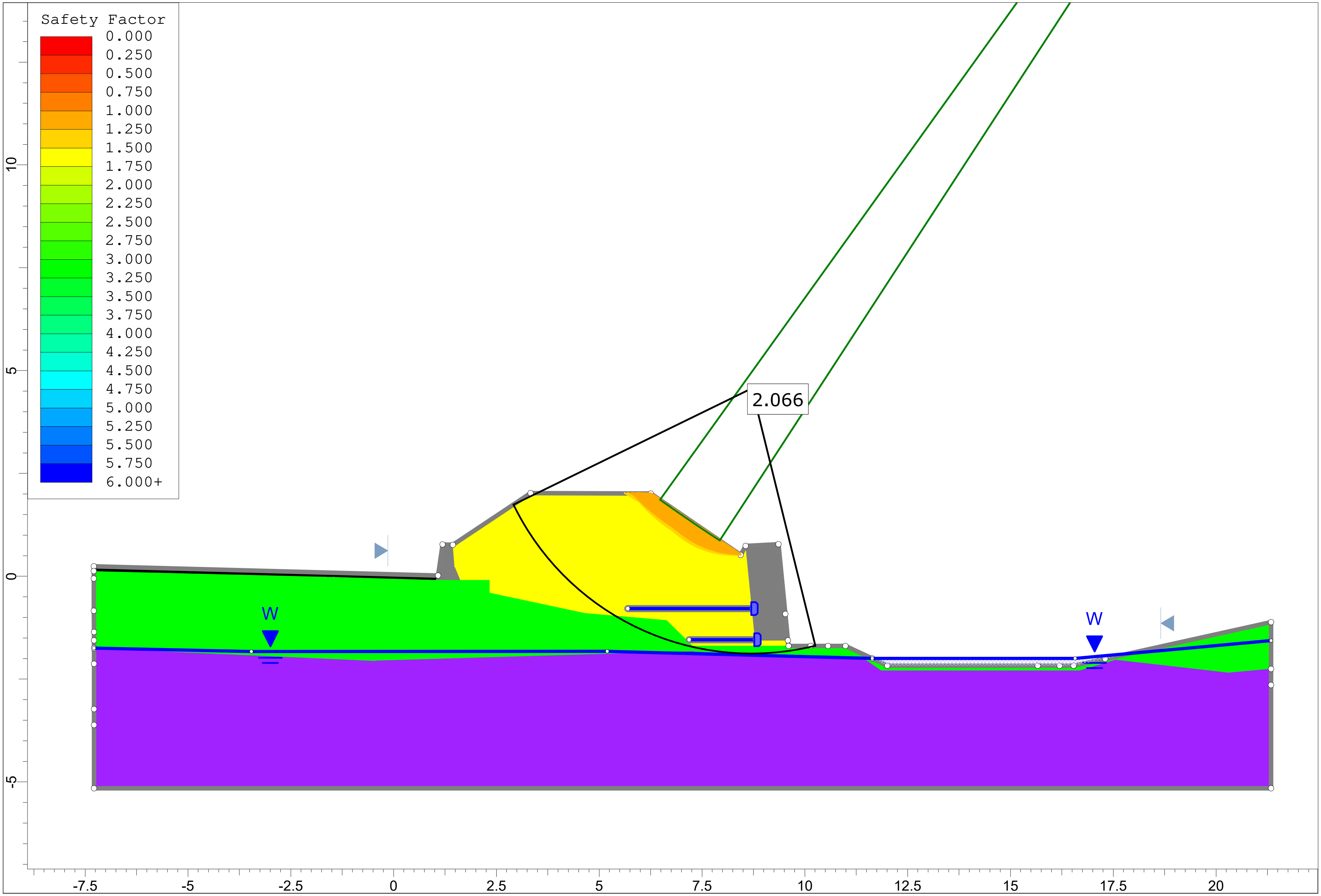

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5.750
6.000+
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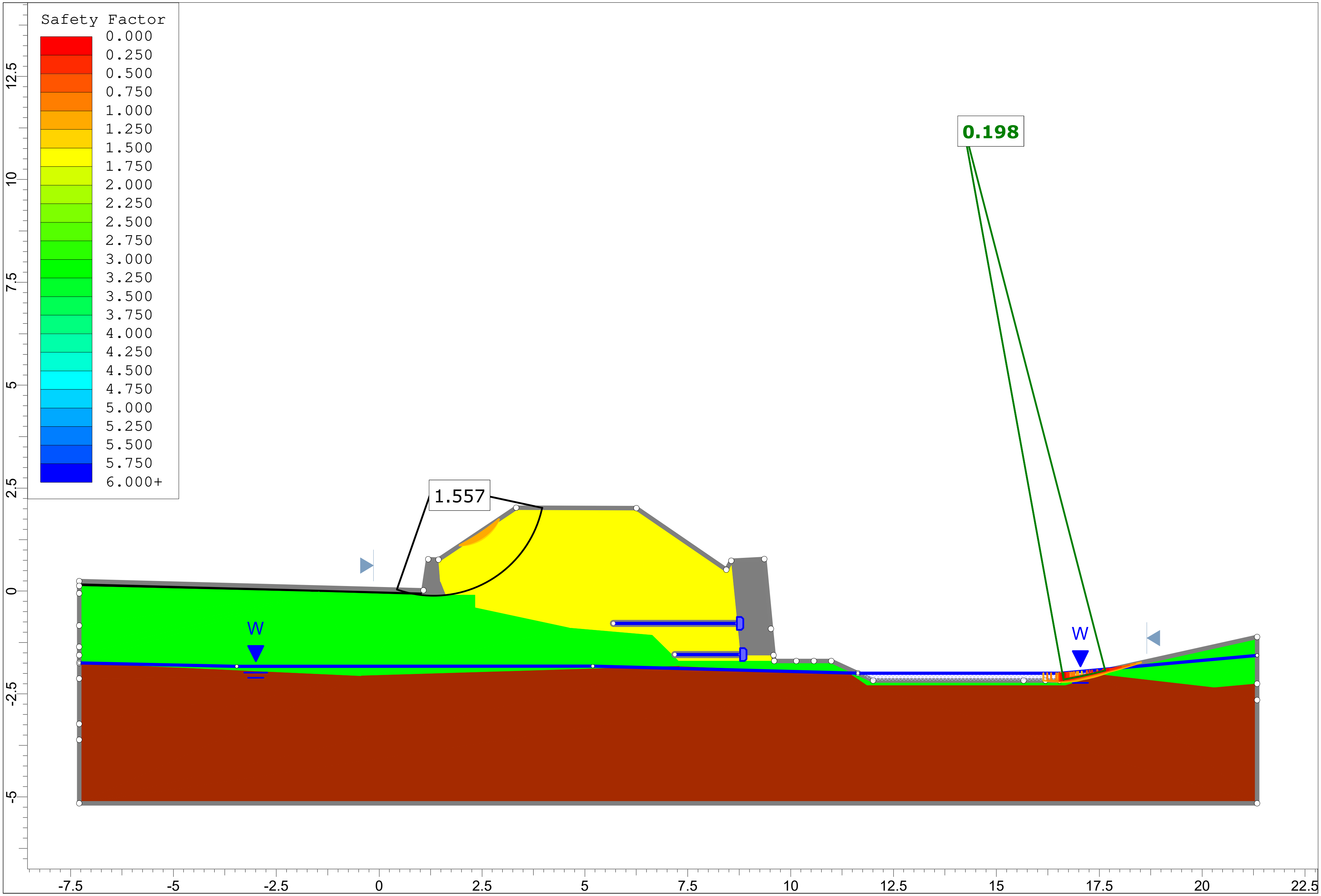

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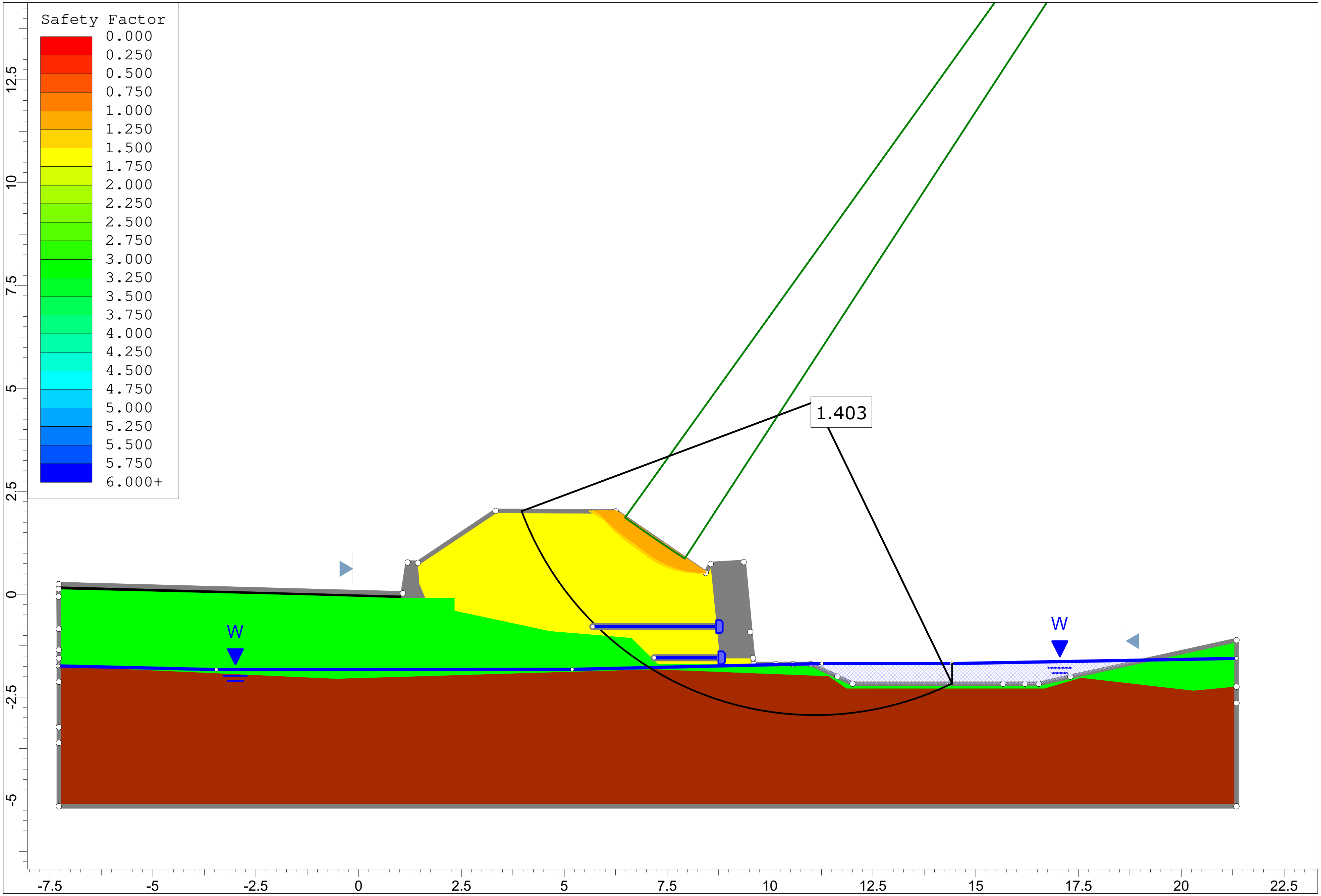

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6.000+
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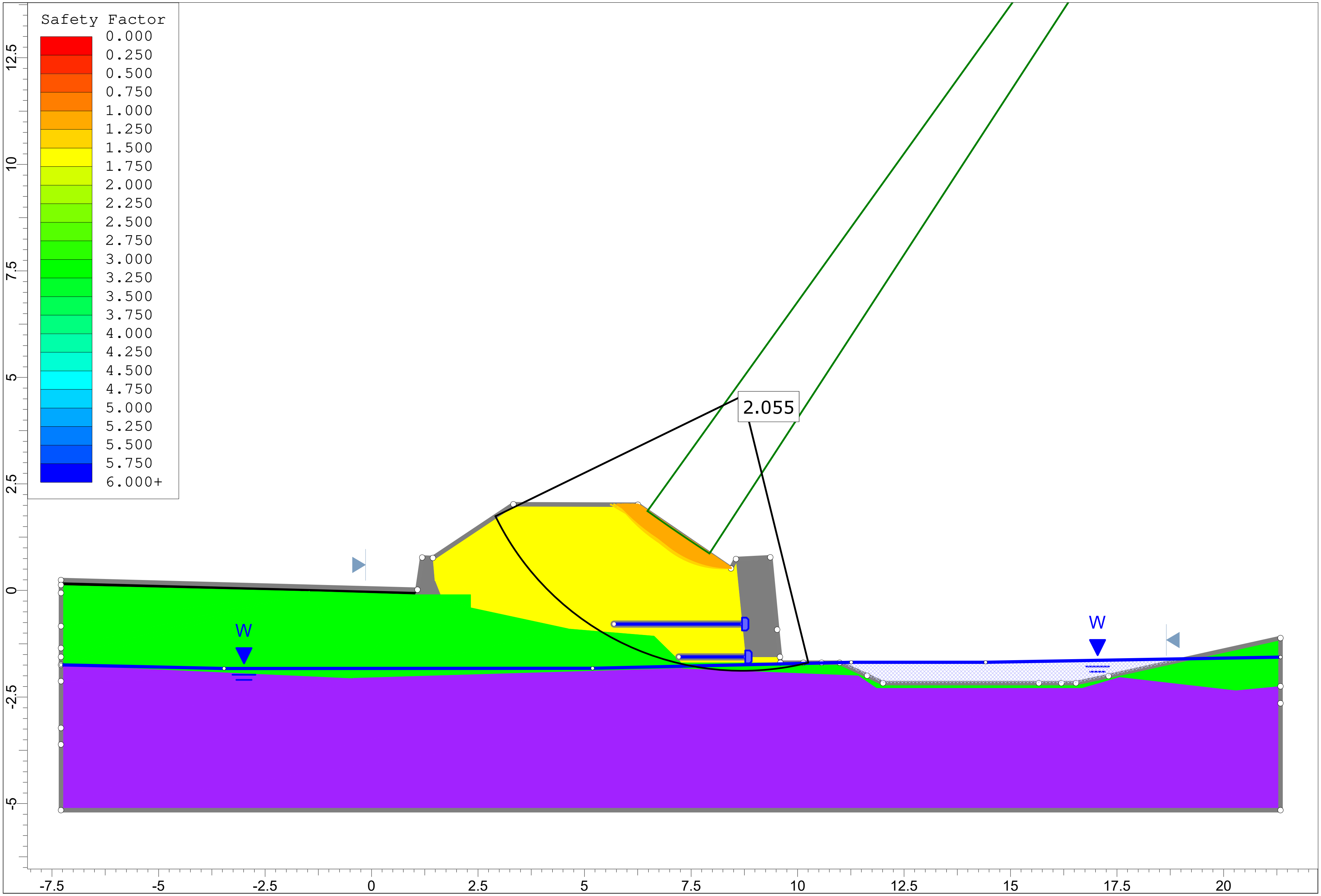

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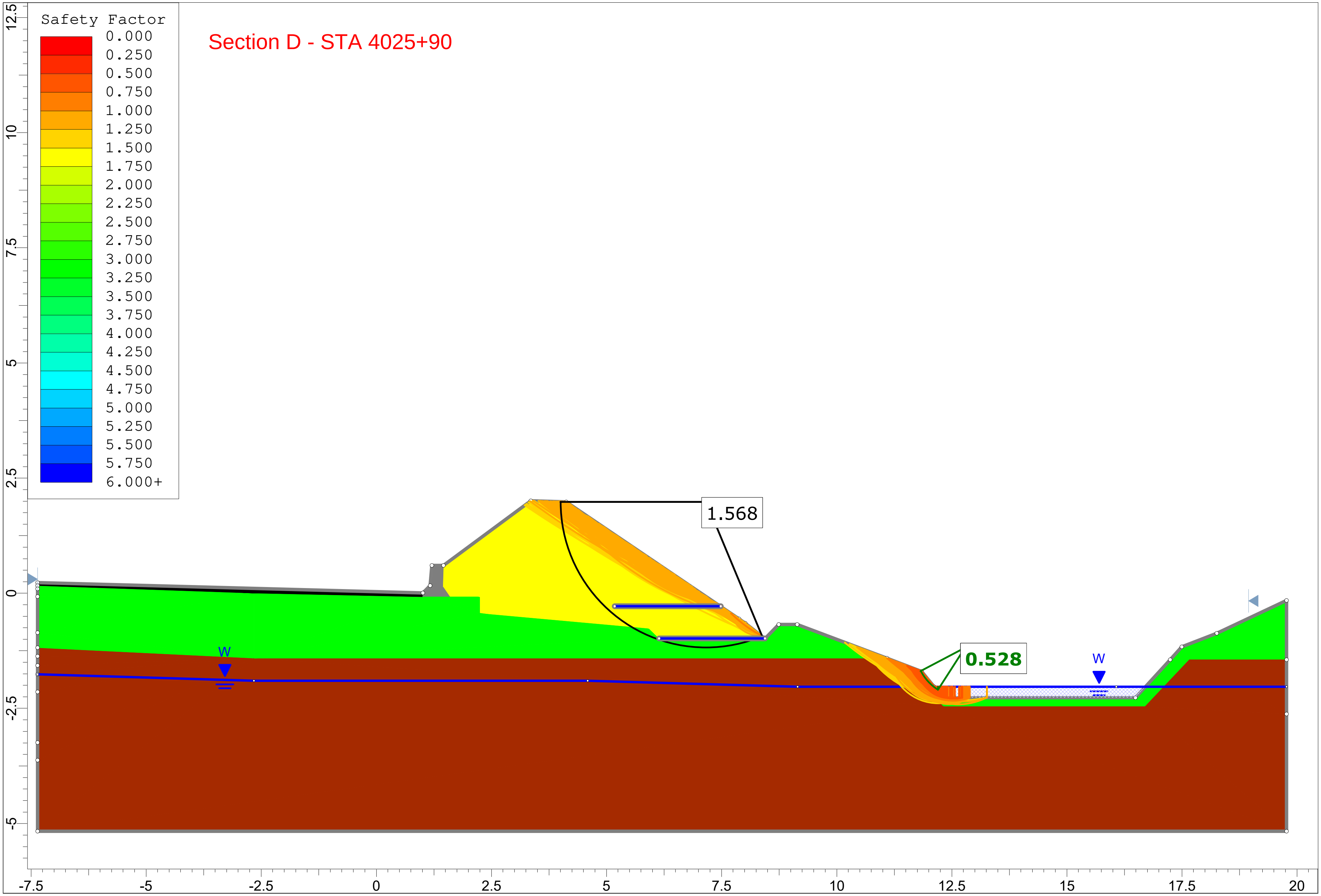

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5.250
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5.750
6.000+
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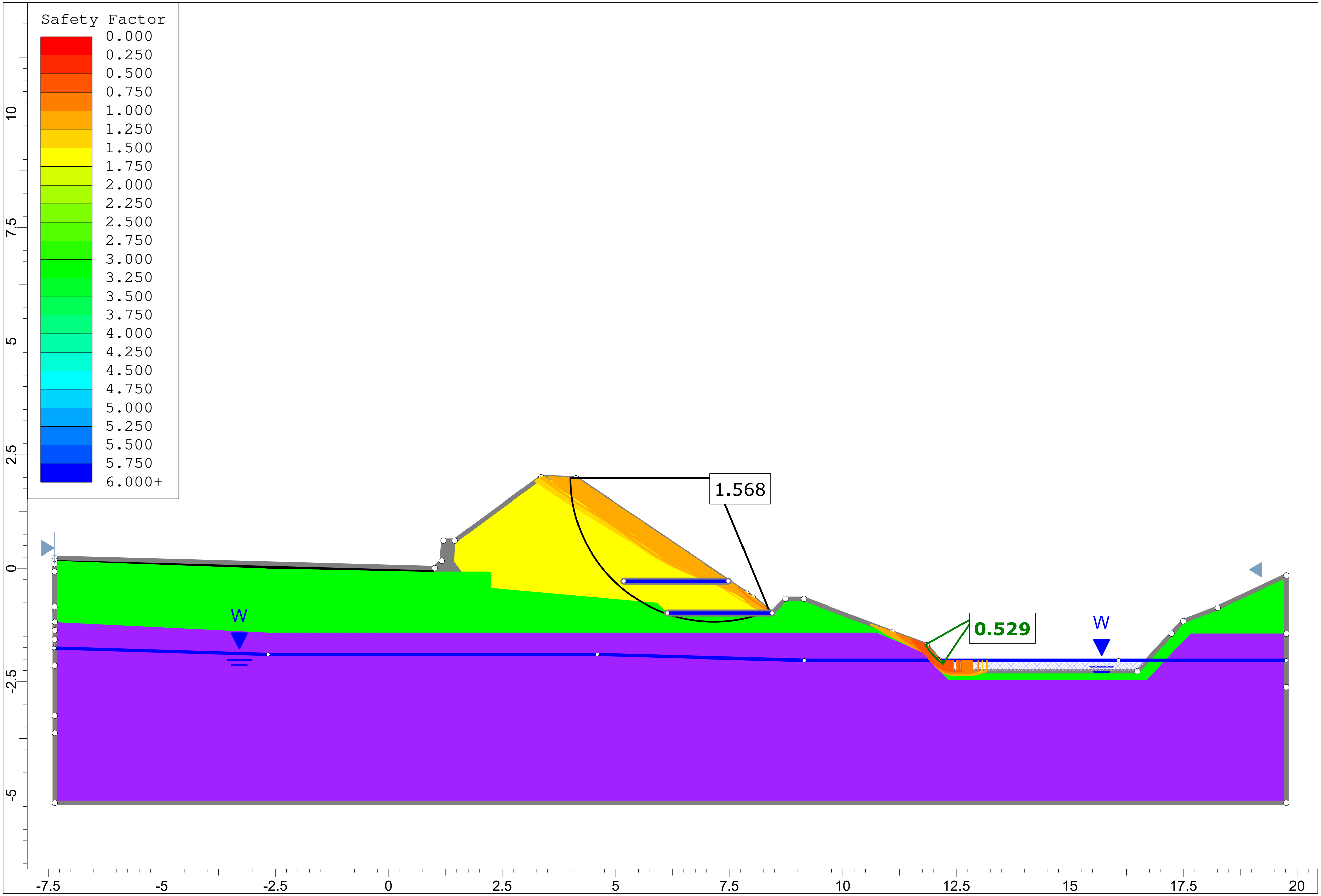
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5.250
5.500
5.750
6.000+
1.568
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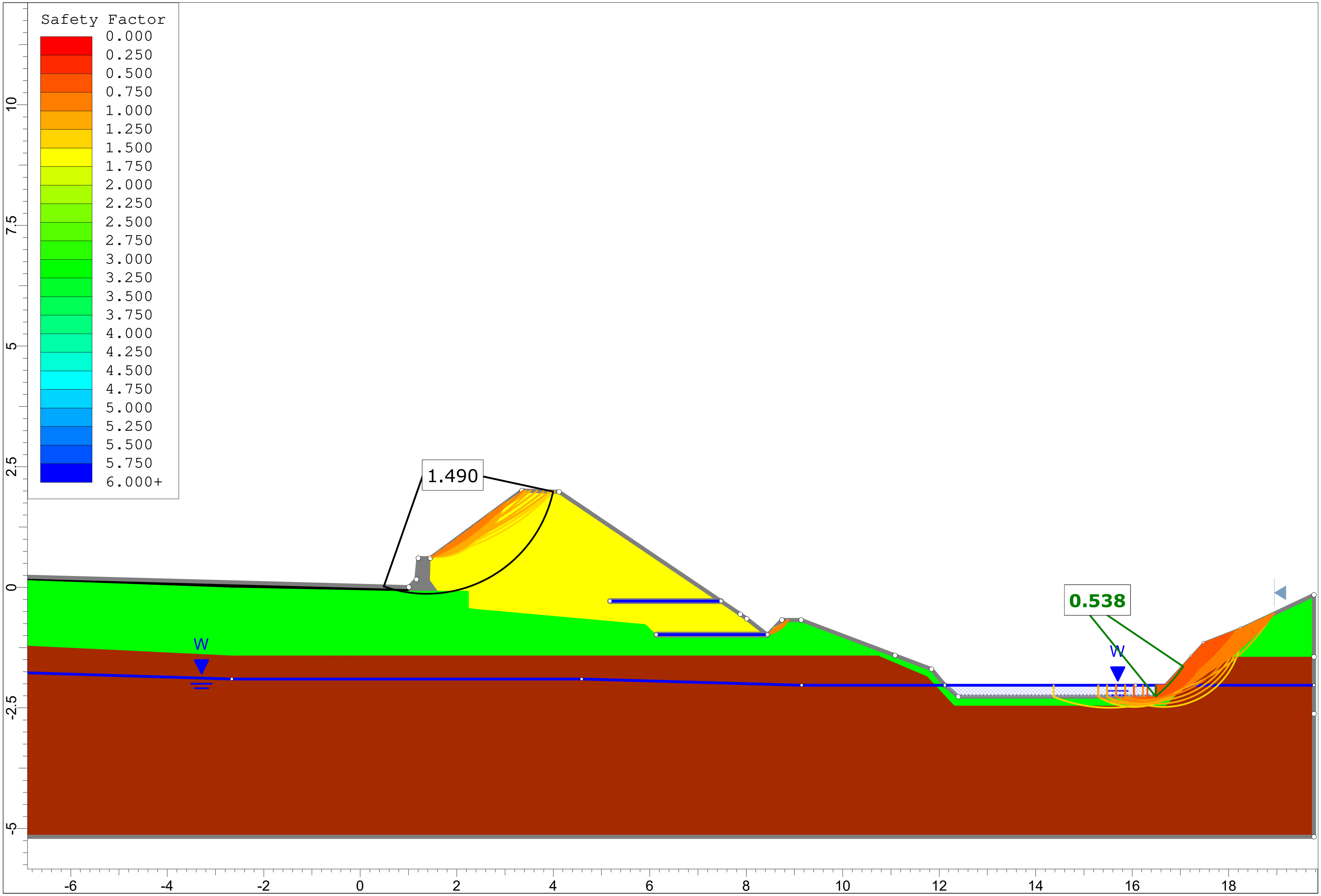
17.5
20



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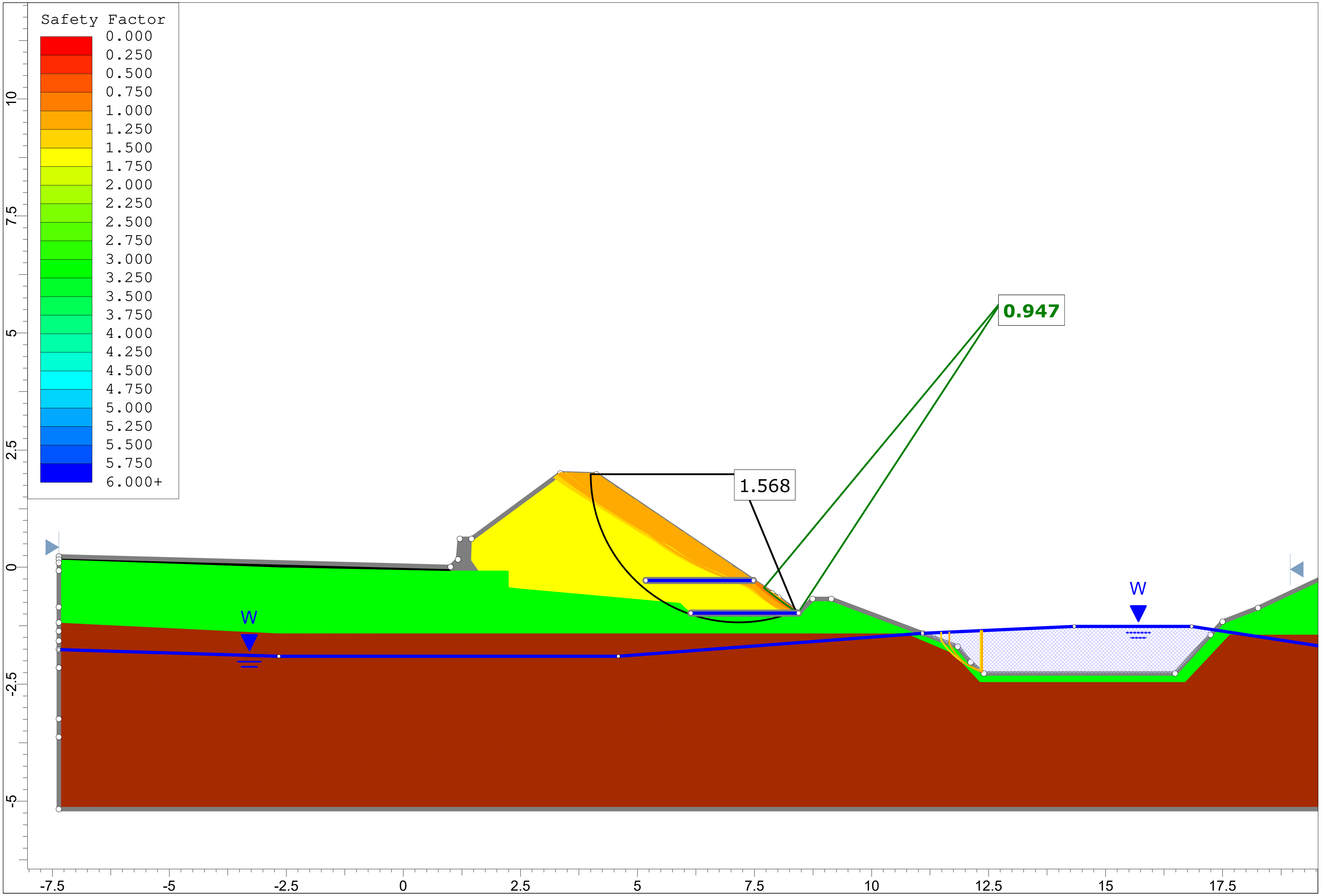

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1.250
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2.000
2.250
2.500
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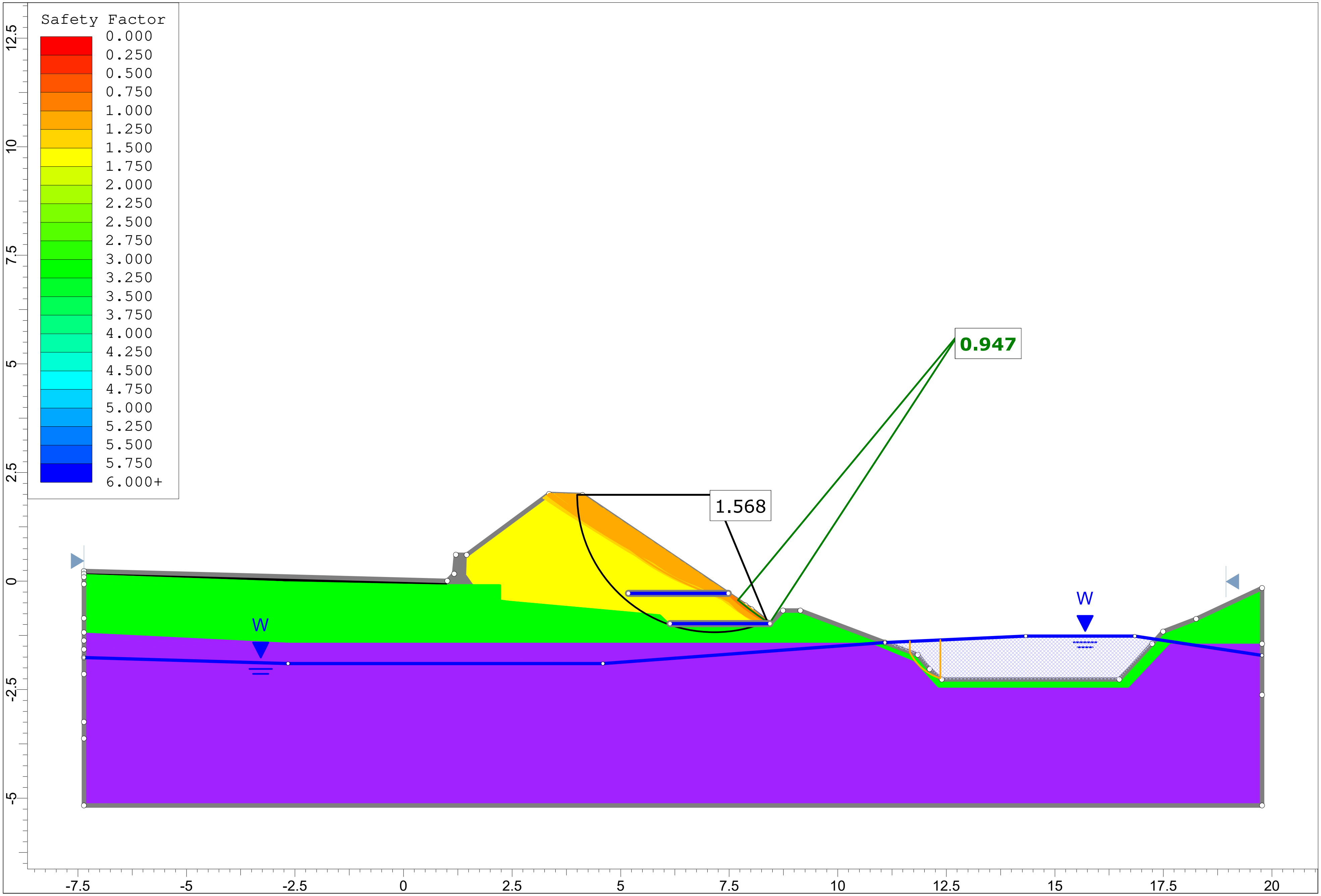
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.568
0.947
W
W
10
7.5
5
2.5
0
-2.5
-5
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5



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2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.568
0.947
W
W
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-5
-2.5
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2.5
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7.5
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12.5
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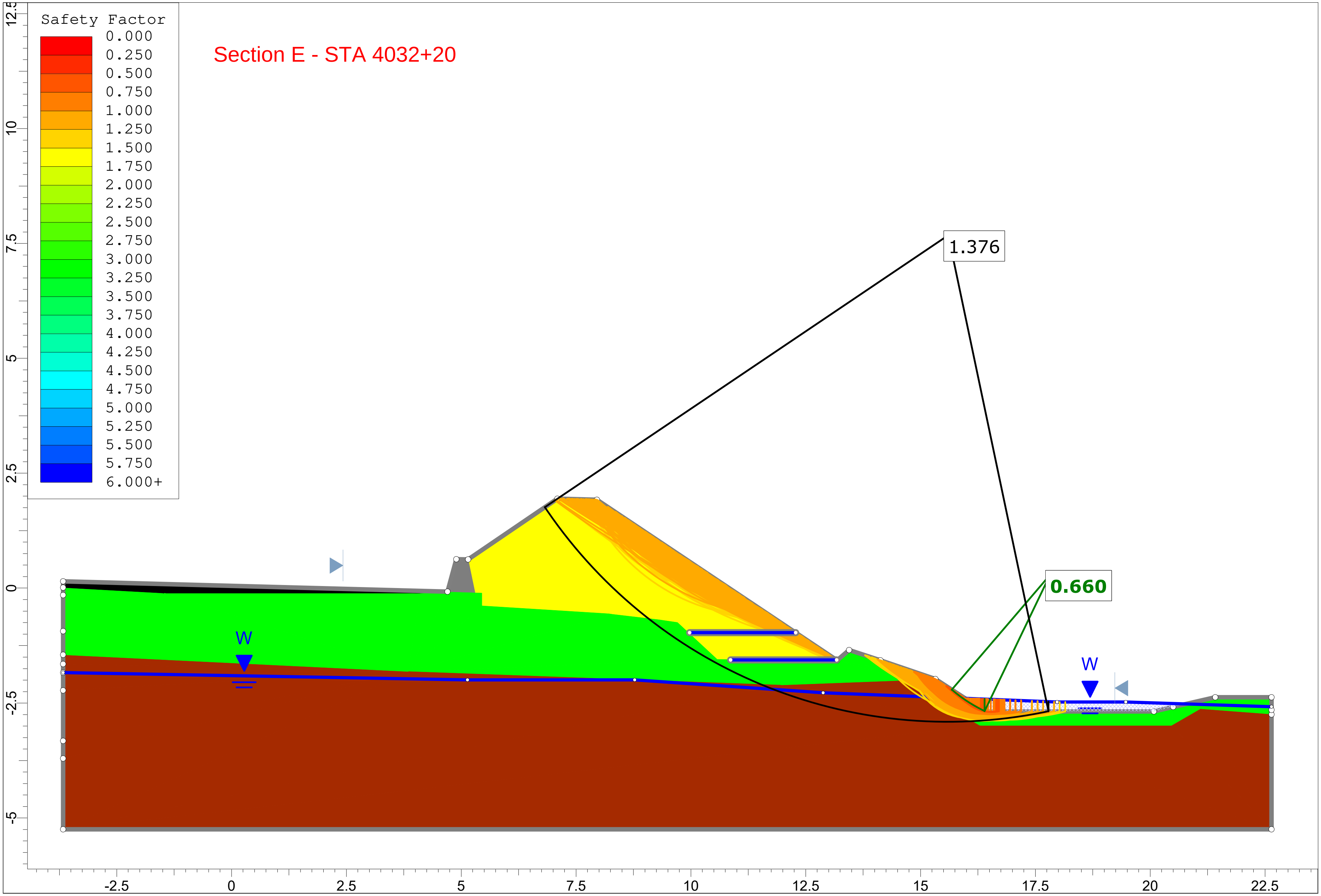
17.5
20



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1.250
1.500
1.750
2.000
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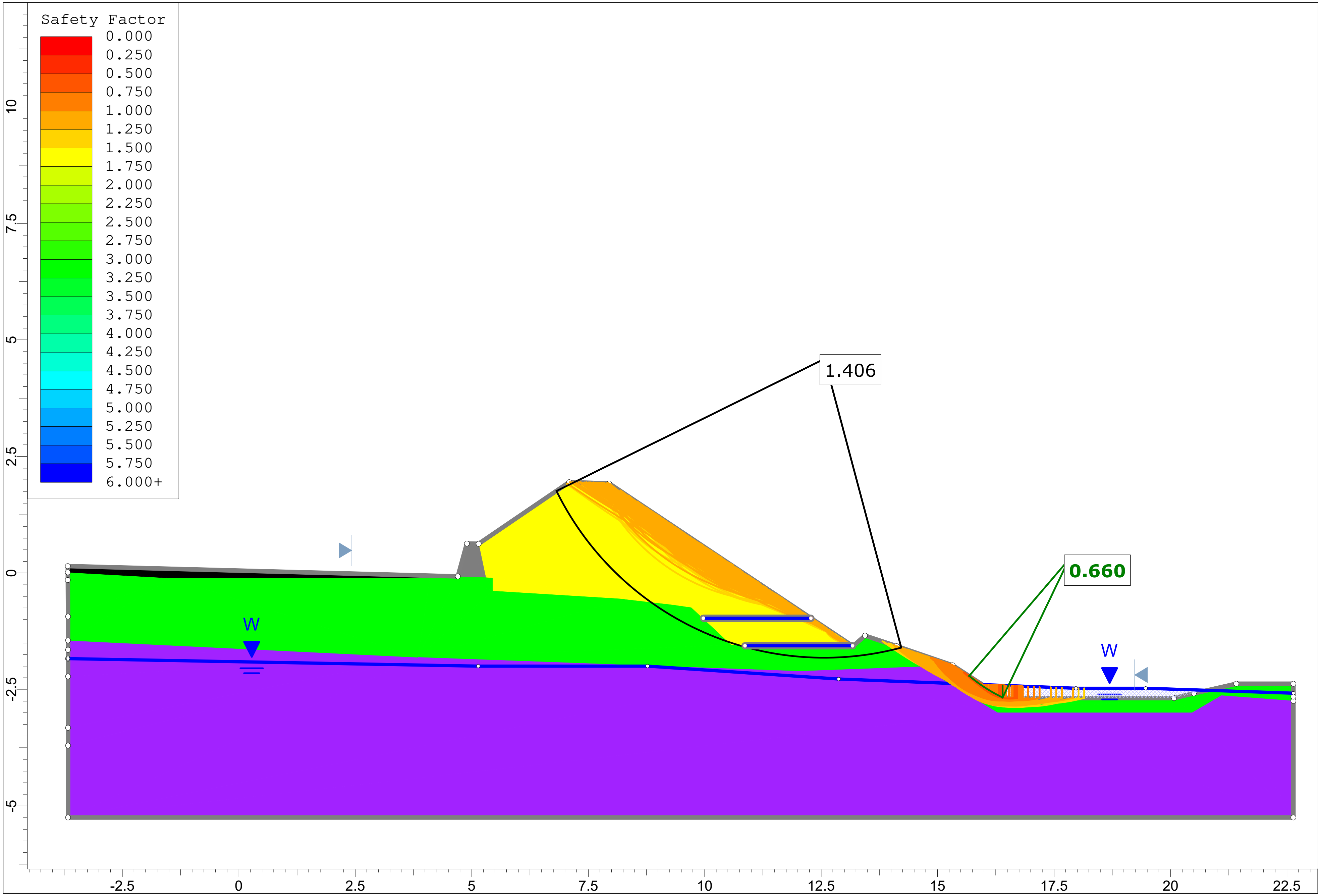
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Section E - STA 4032+20
1.376
0.660
W
W
12.5
10
7.5
5
2.5
0
-2.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5



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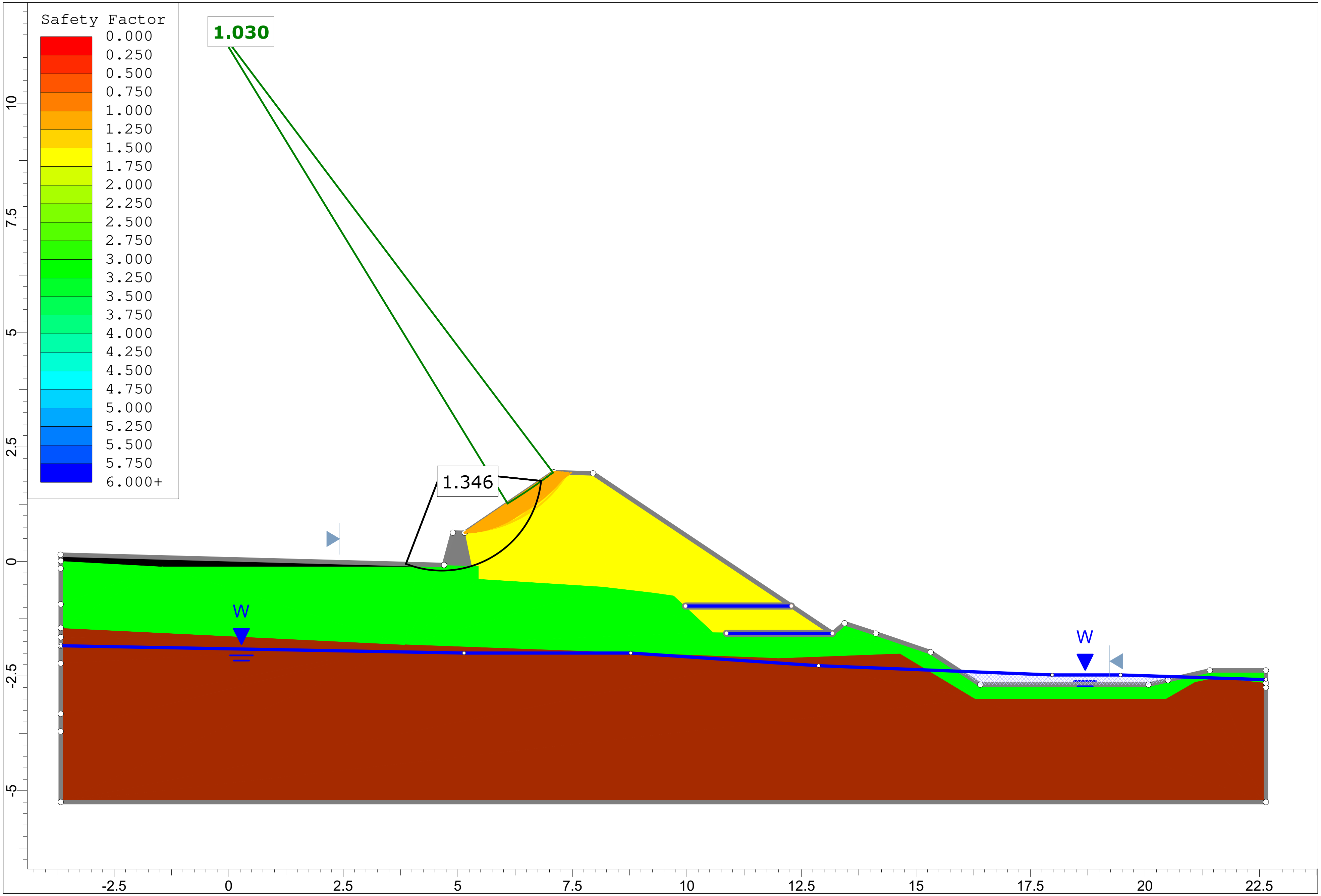
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.406
0.660
W
W
10
7.5
5
2.5
0
-2.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5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1.250
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2.250
2.500
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3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.030
1.346
W
W
10
7.5
5
2.5
0
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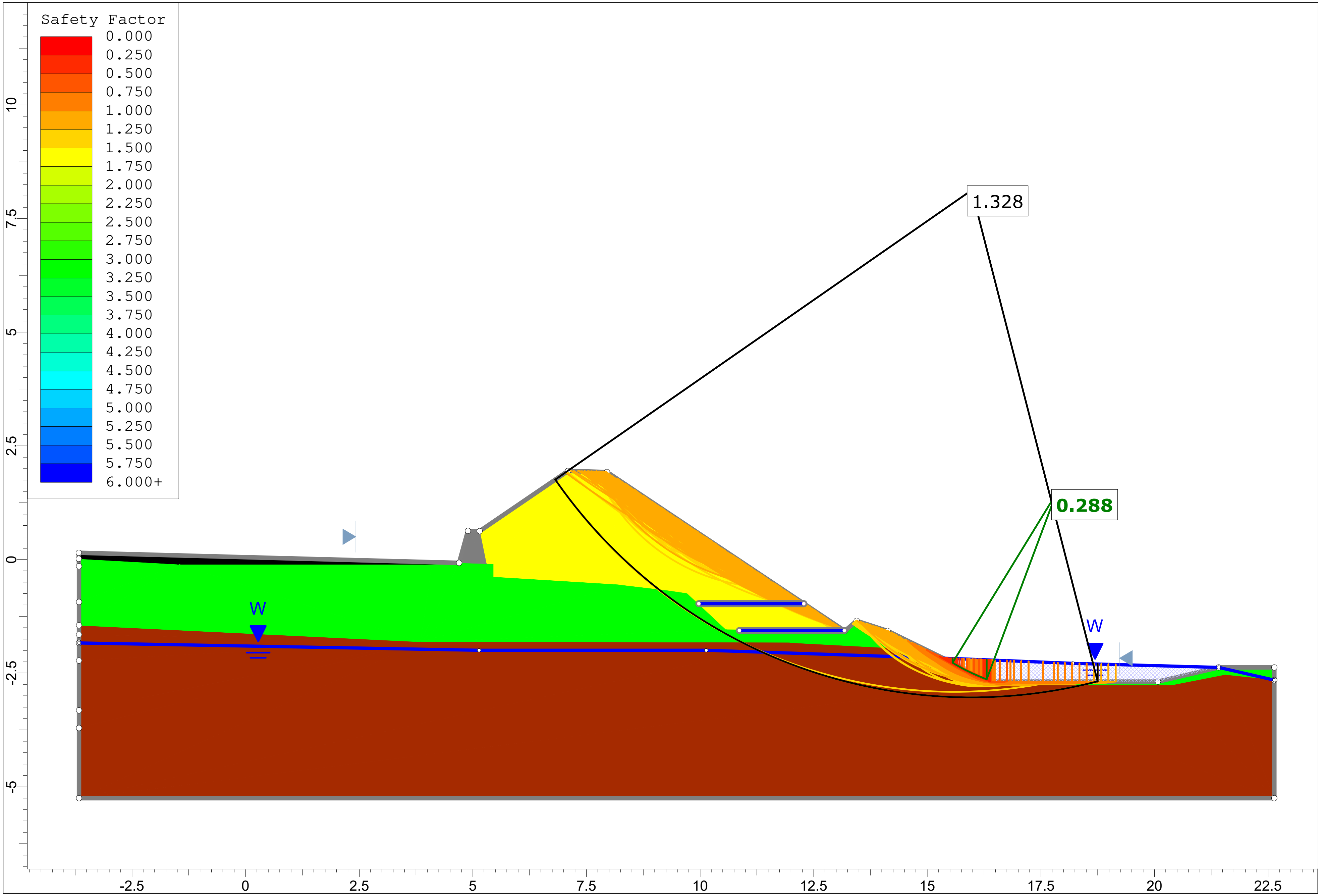
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5



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0.750
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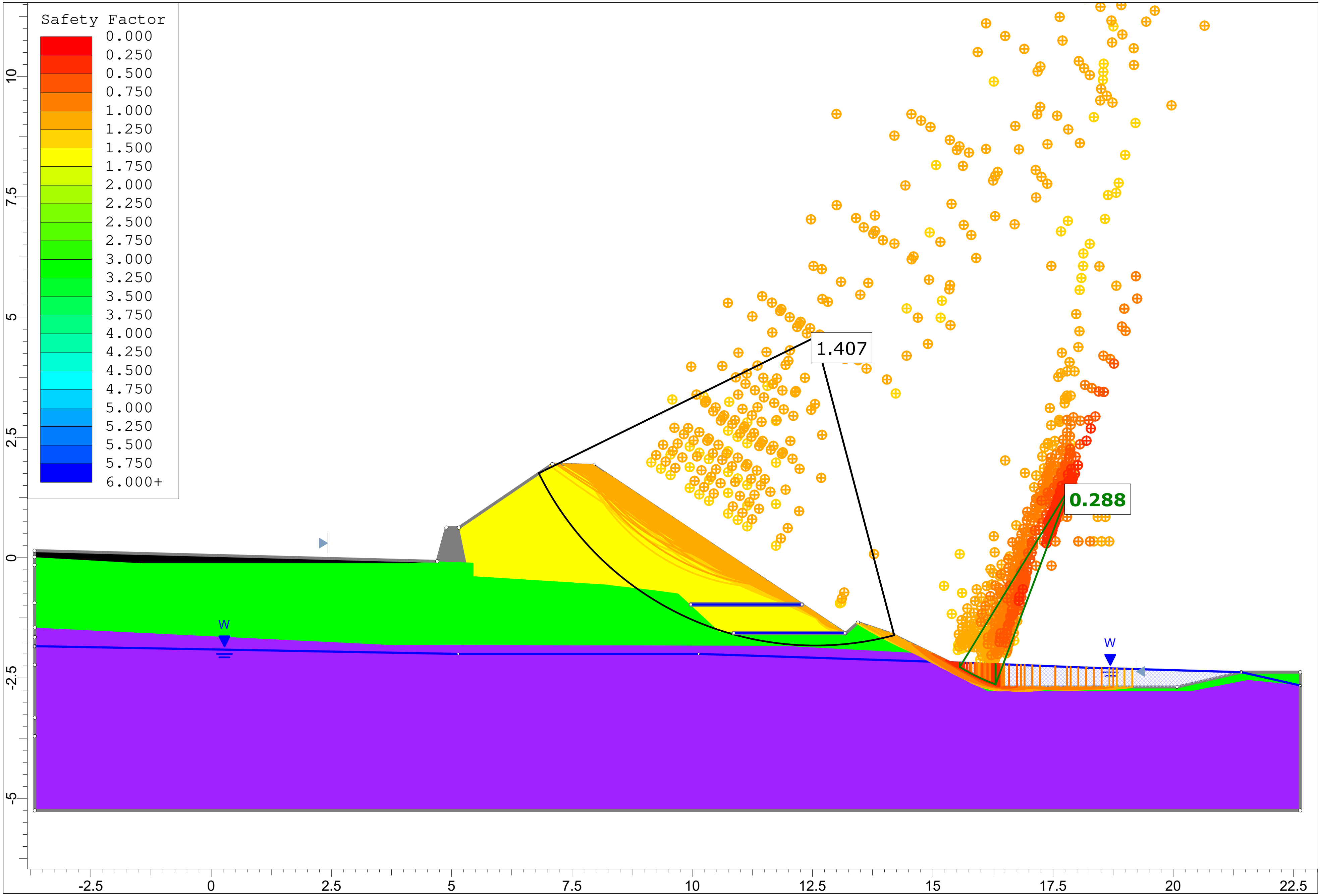
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.328
0.288
W
W
10
7.5
5
2.5
0
-2.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5



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0.750
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1.500
1.750
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2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.407
0.288
W
W
10
7.5
5
2.5
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0
2.5
5
7.5
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12.5
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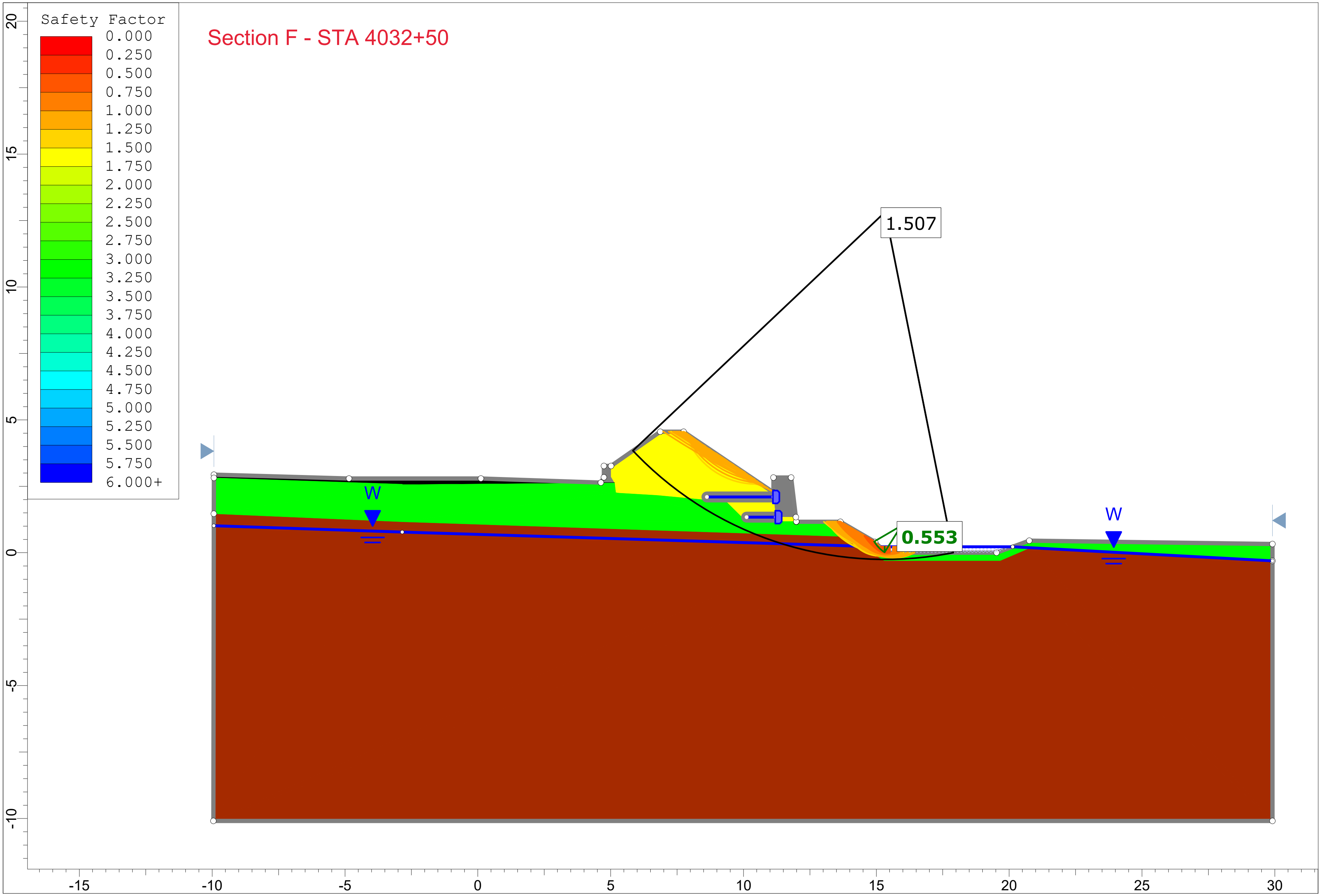
17.5
20
22.5


Section F - STA 4032+50
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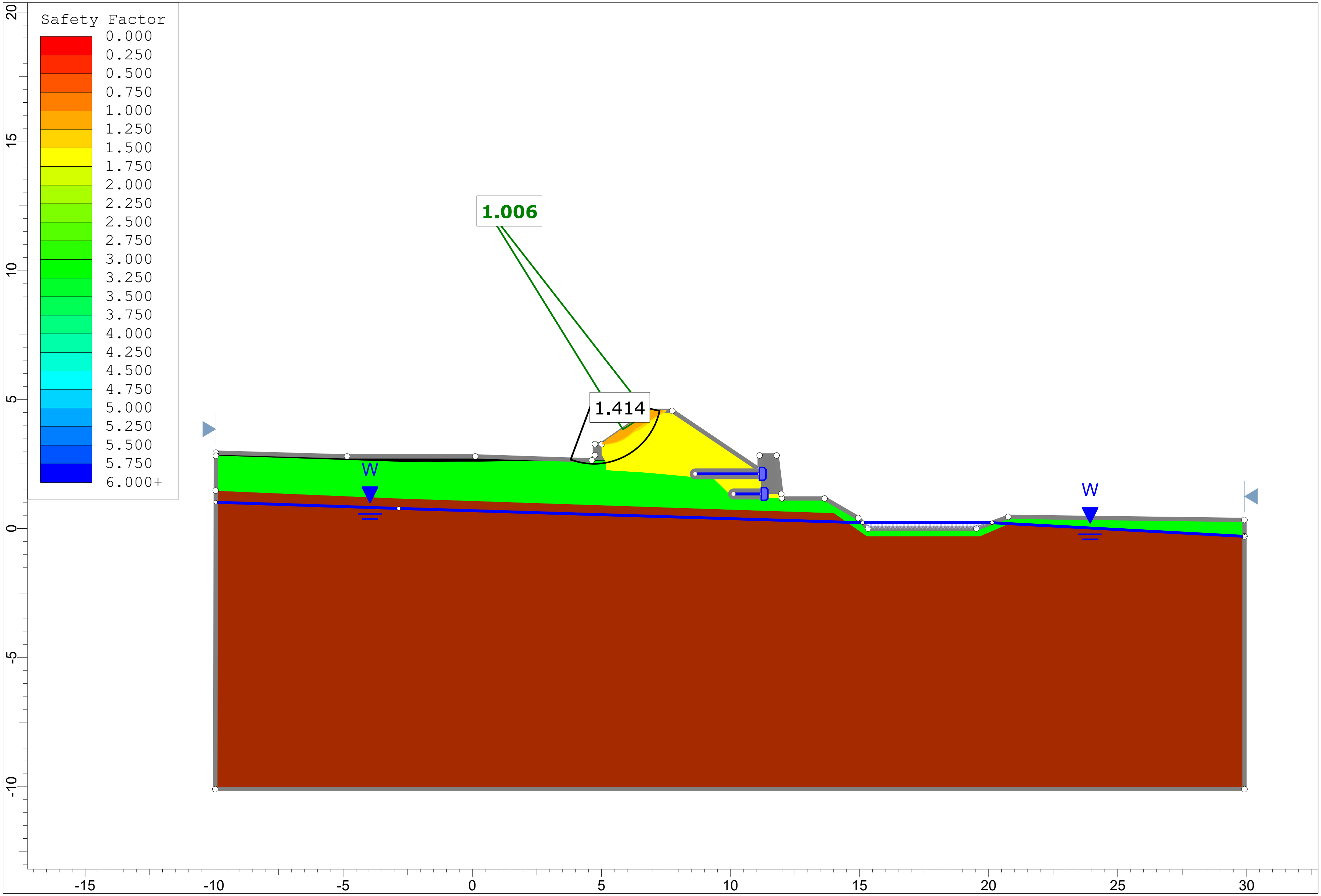
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.507
0.553
W
W
20
15
10
5
0
-5
-10
-15
-10
-5
0
5
10
15
20
25
30



Safety Factor
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0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
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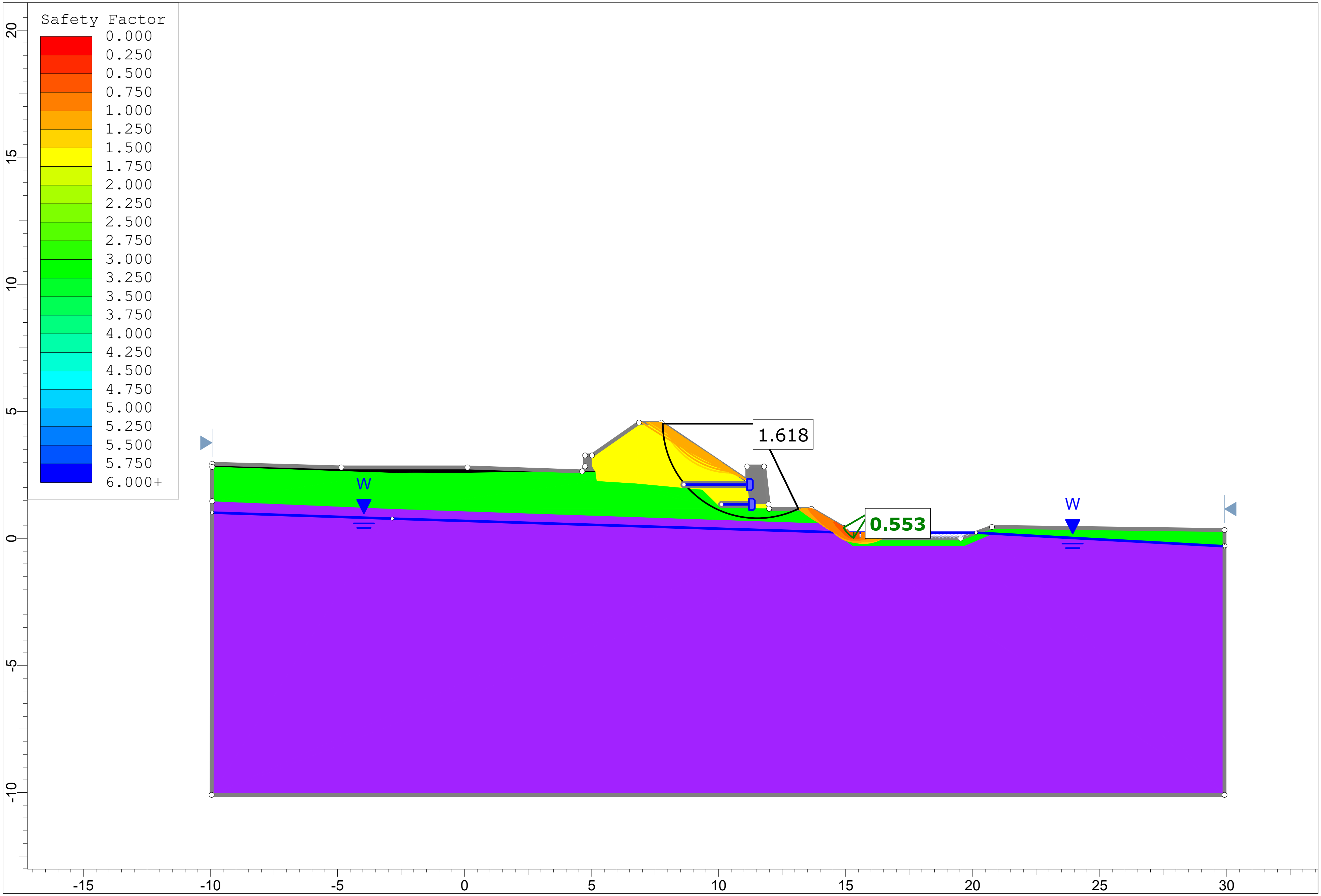
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.006
1.414
W
W
20
15
10
5
0
-5
-10
-15
-10
-5
0
5
10
15
20
25
30



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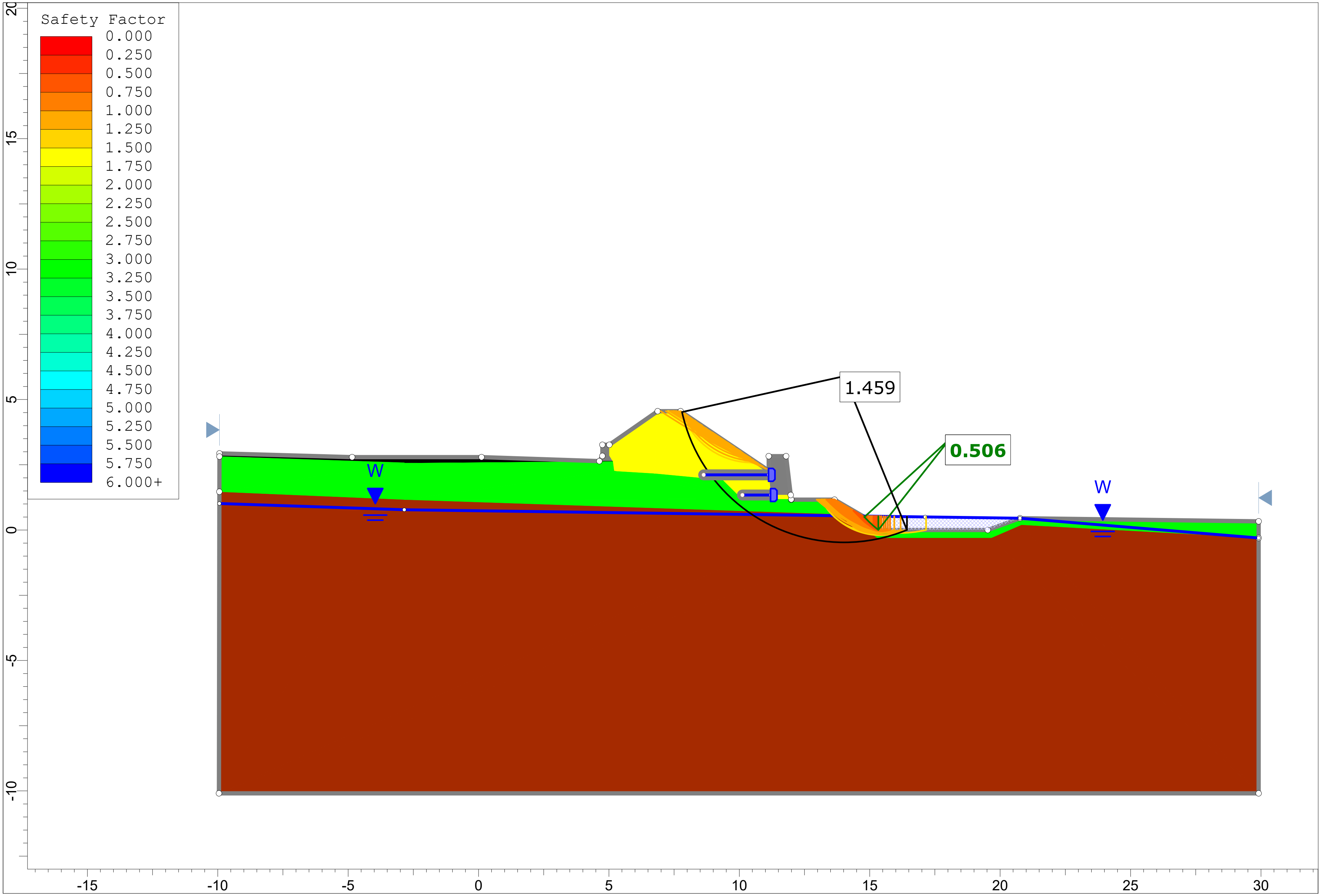
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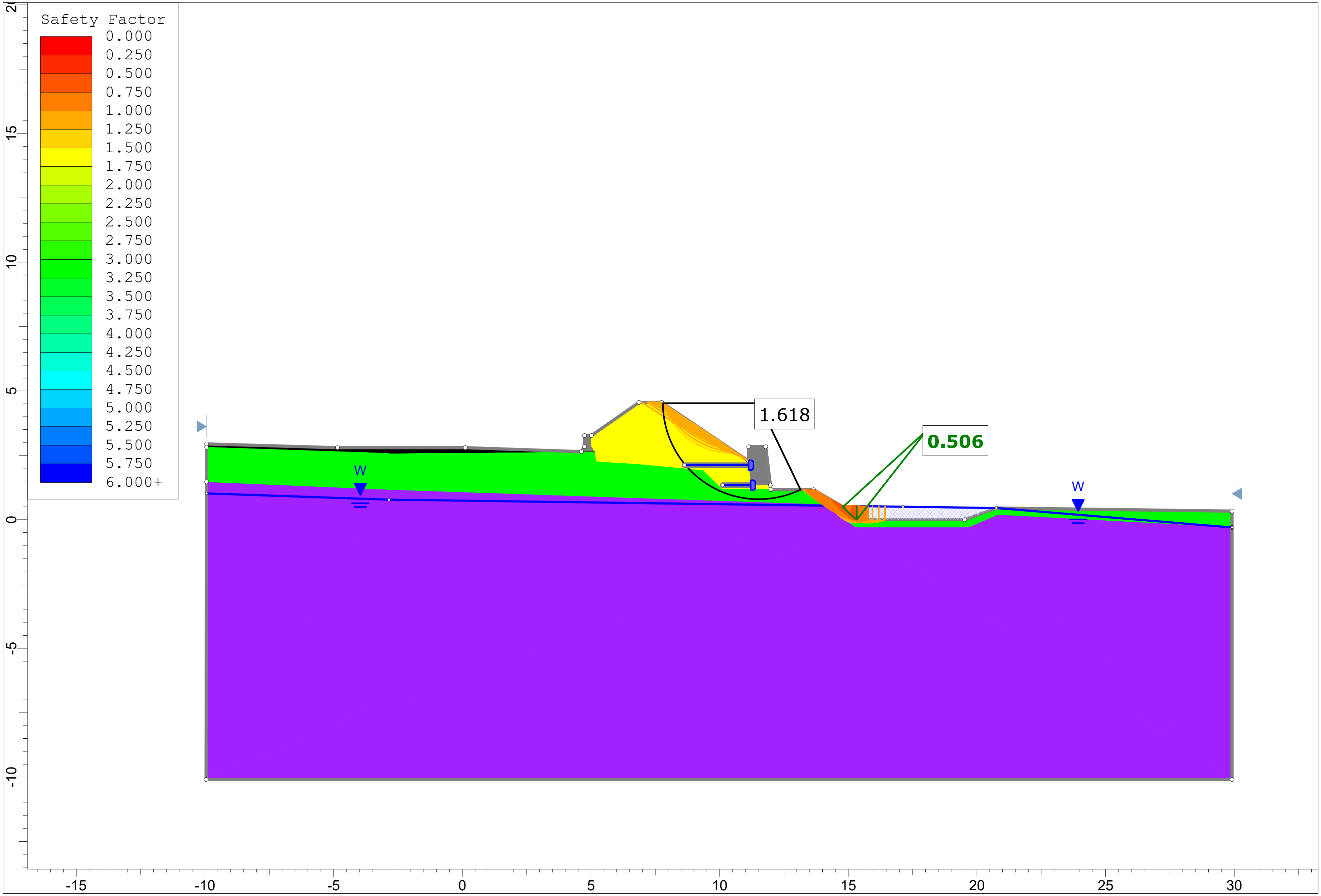
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.459
0.506
W
W
20
15
10
5
0
-5
-10
-15
-10
-5
0
5
10
15
20
25
30



Safety Factor
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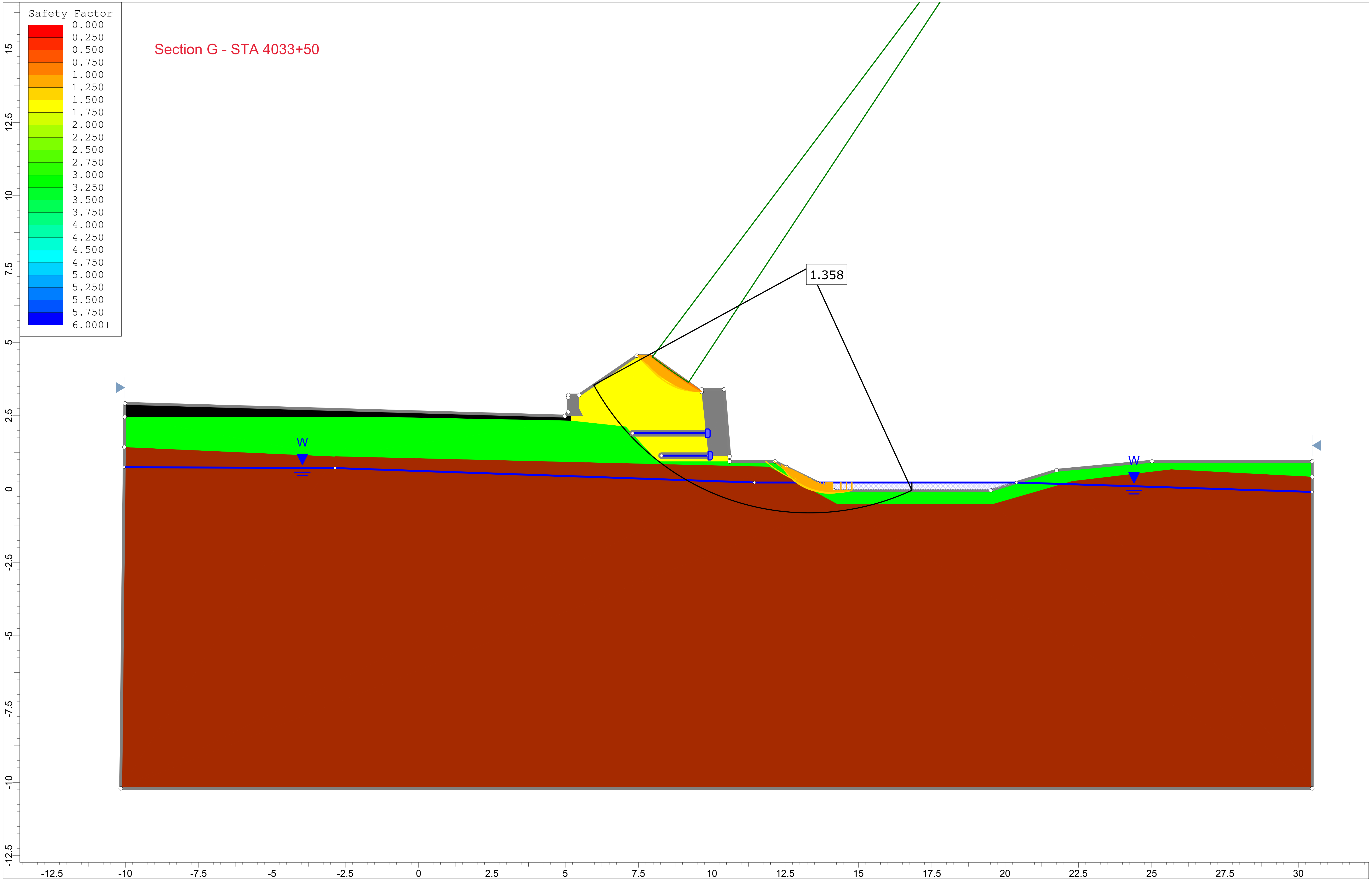
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.618
0.506
W
W
-15
-10
-5
0
5
10
15
20
25
30



Safety Factor
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1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Section G - STA 4033+50
1.358
W
W
15
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
-12.5
-12.5
-10
-7.5
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2.5
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22.5
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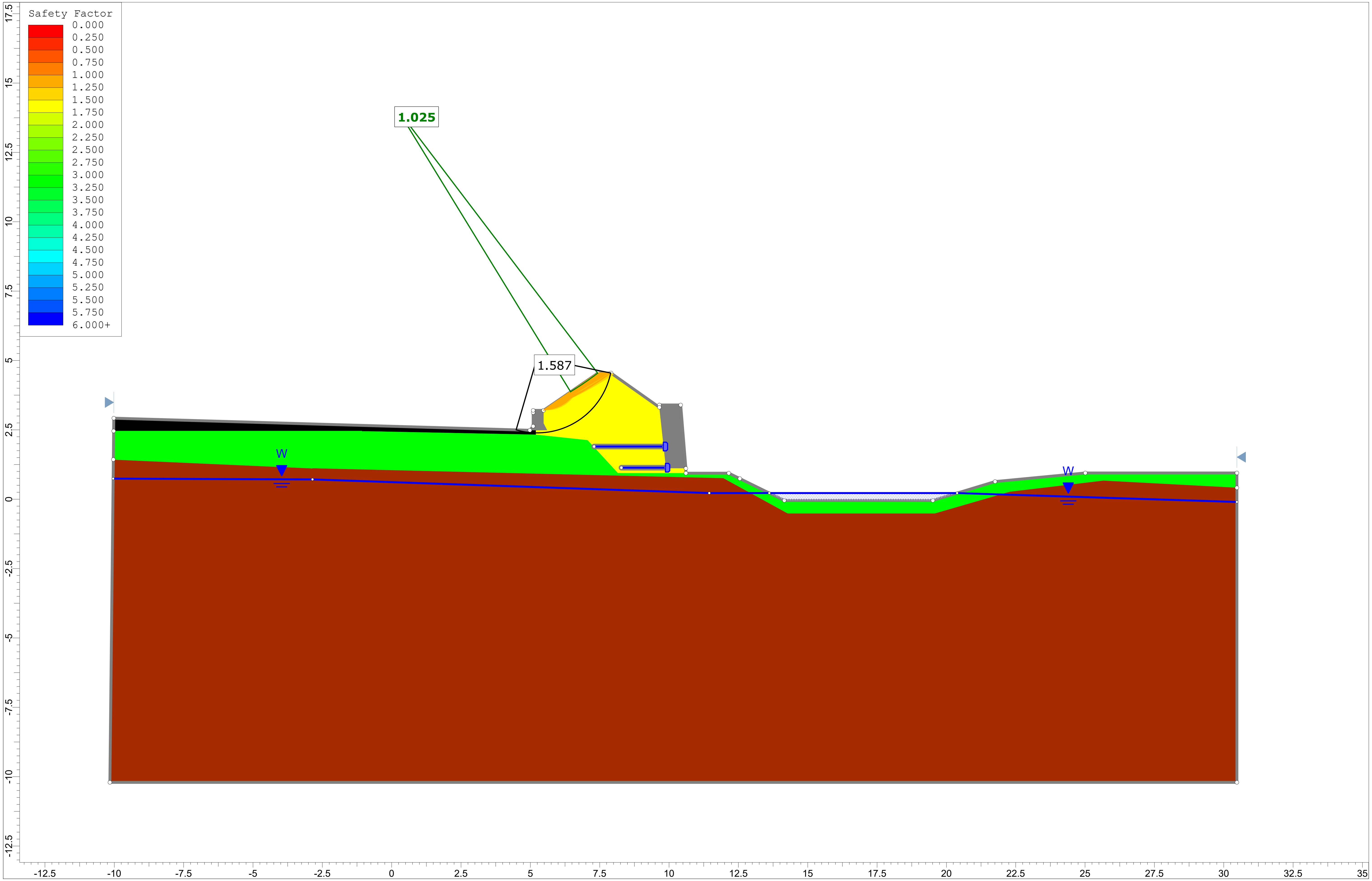
27.5
30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1.250
1.500
1.750
2.000
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2.500
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3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.025
1.587
W
W
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
-12.5
-12.5
-10
-7.5
-5
-2.5
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12.5
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17.5
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22.5
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27.5
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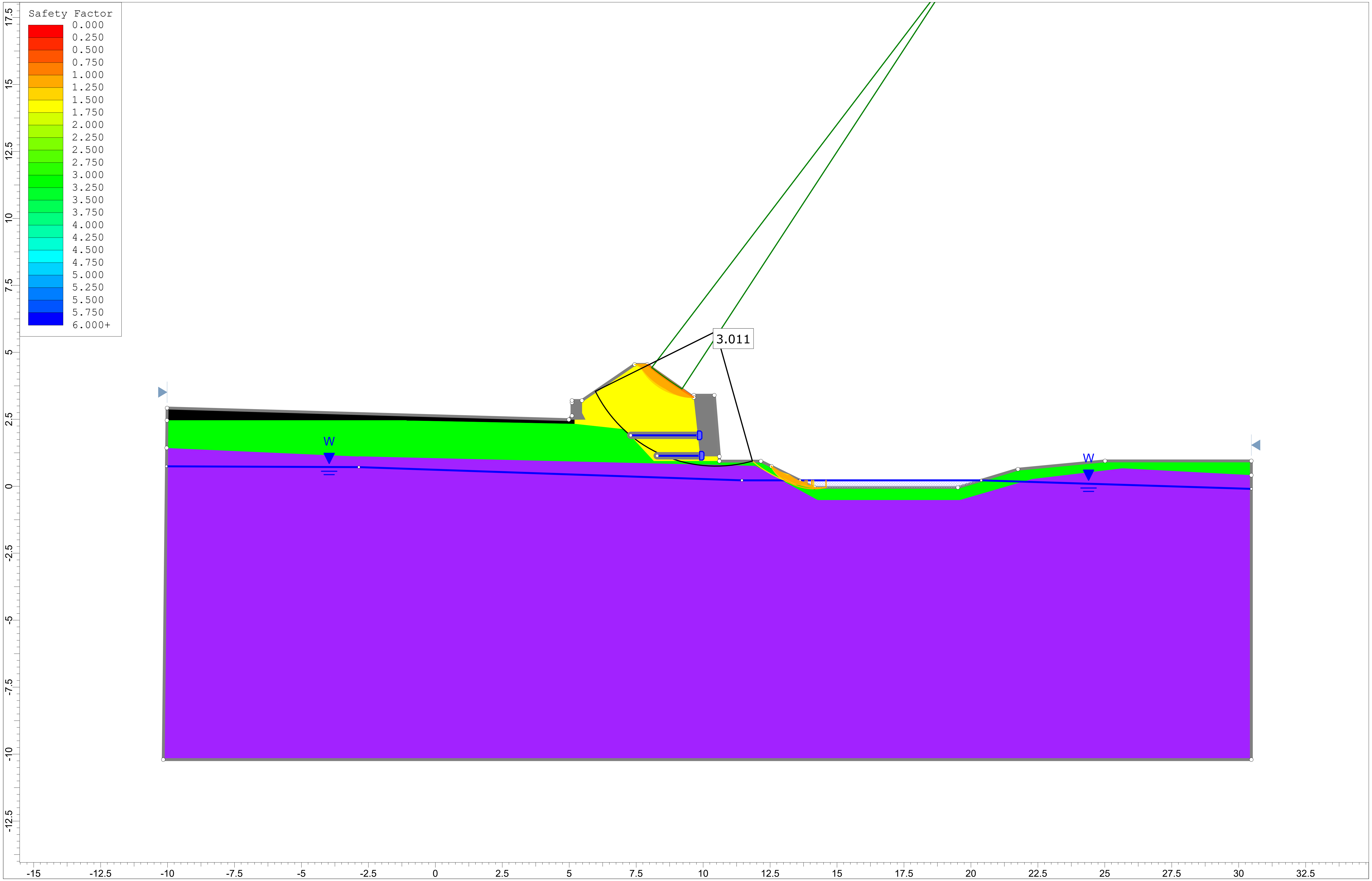
32.5
35



Safety Factor
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0.750
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1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
3.011
W
W
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
-12.5
-15
-12.5
-10
-7.5
-5
-2.5
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20
22.5
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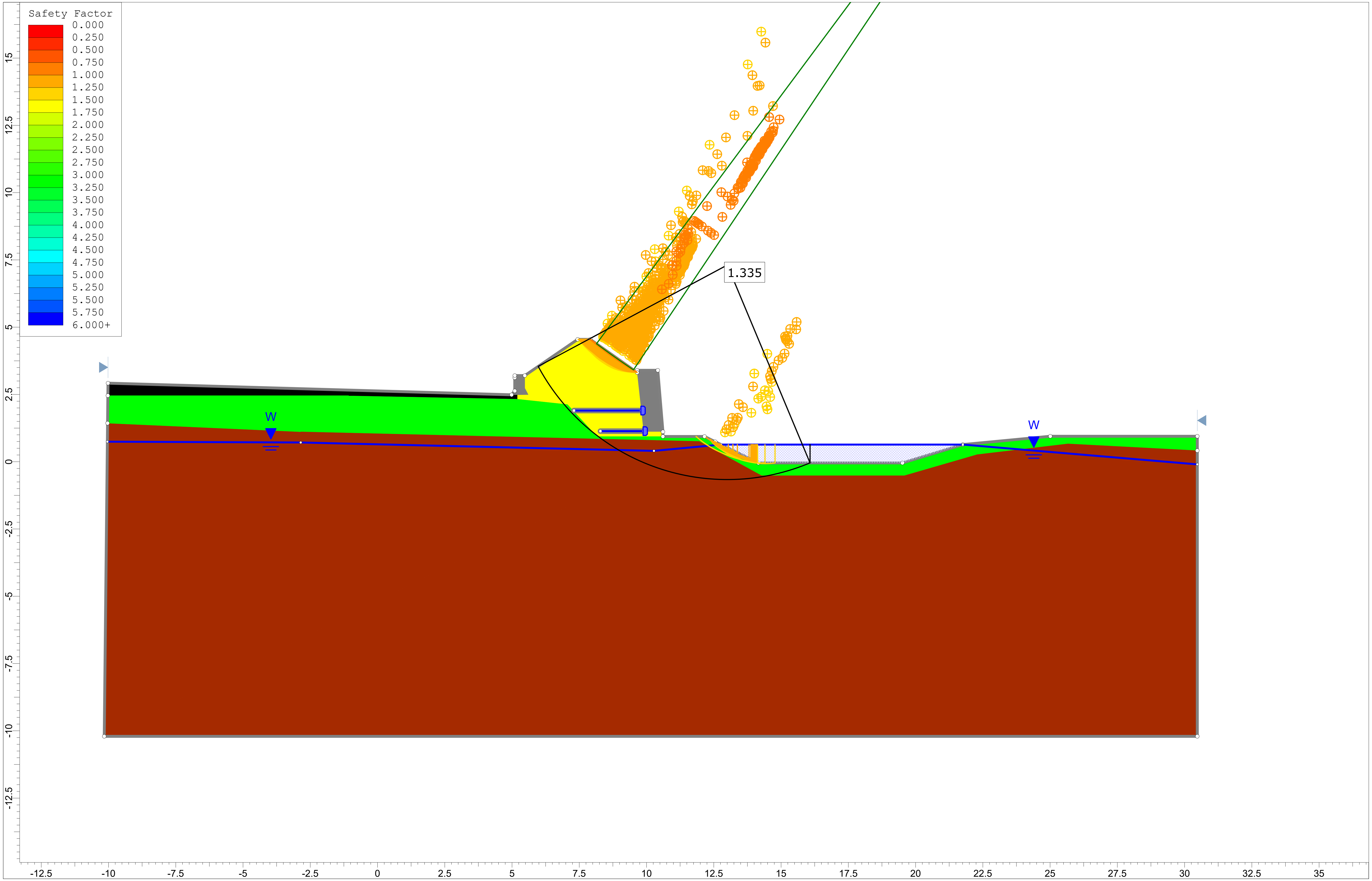
27.5
30
32.5



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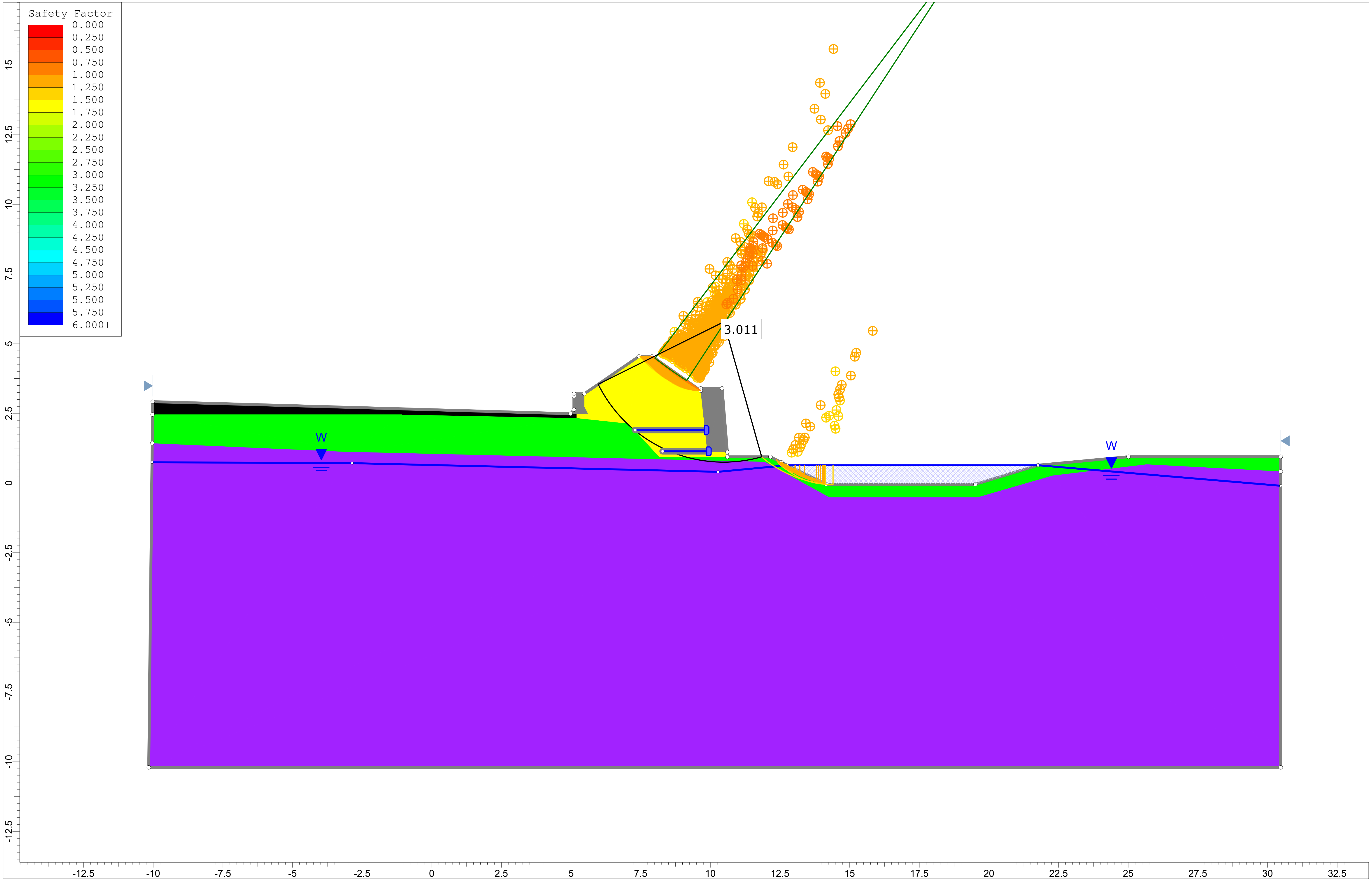

Safety Factor
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0.750
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1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
3.011
W
W
15
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
-12.5
-12.5
-10
-7.5
-5
-2.5
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7.5
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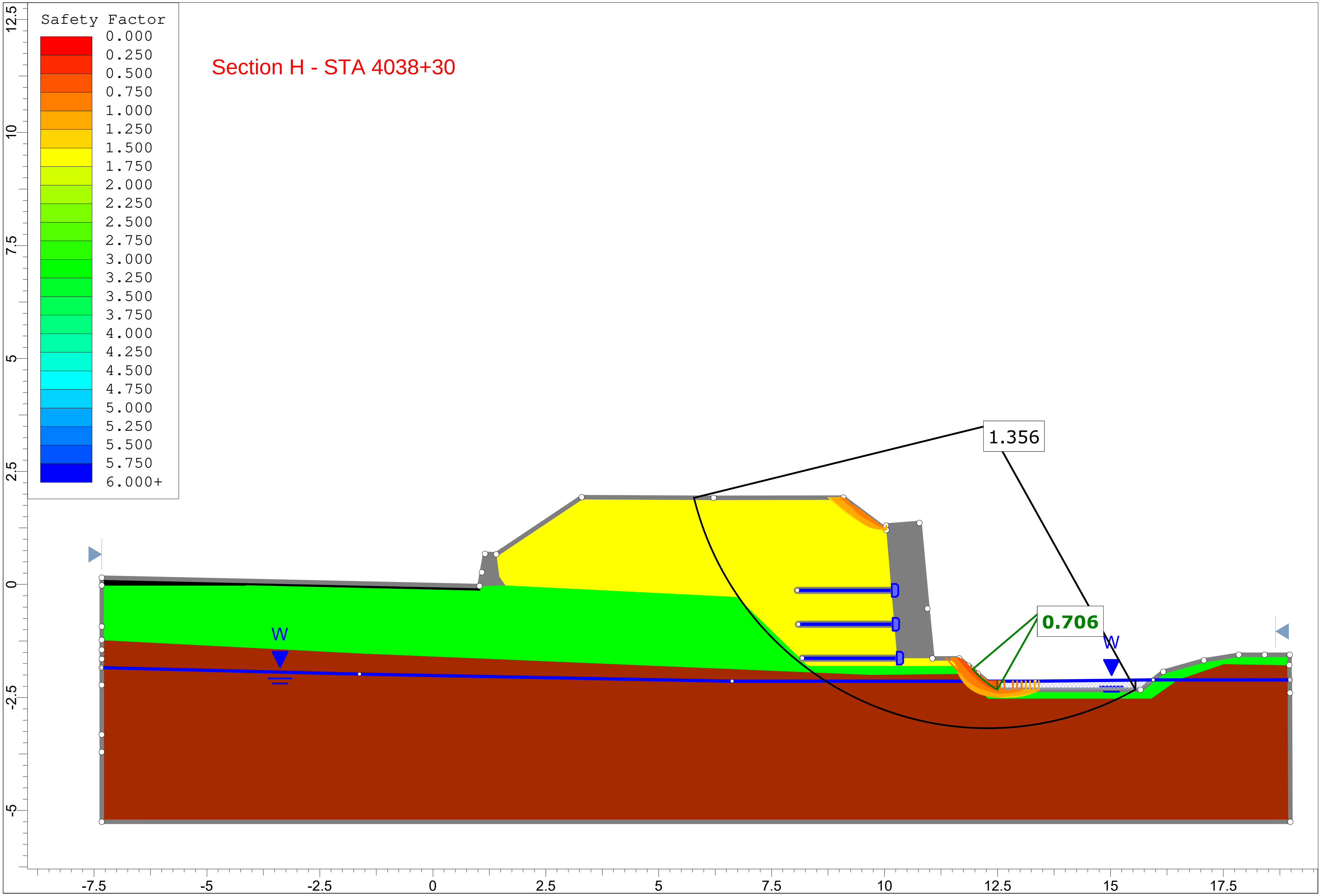
12.5
15
17.5
20
22.5
25
27.5
30
32.5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0.500
0.750
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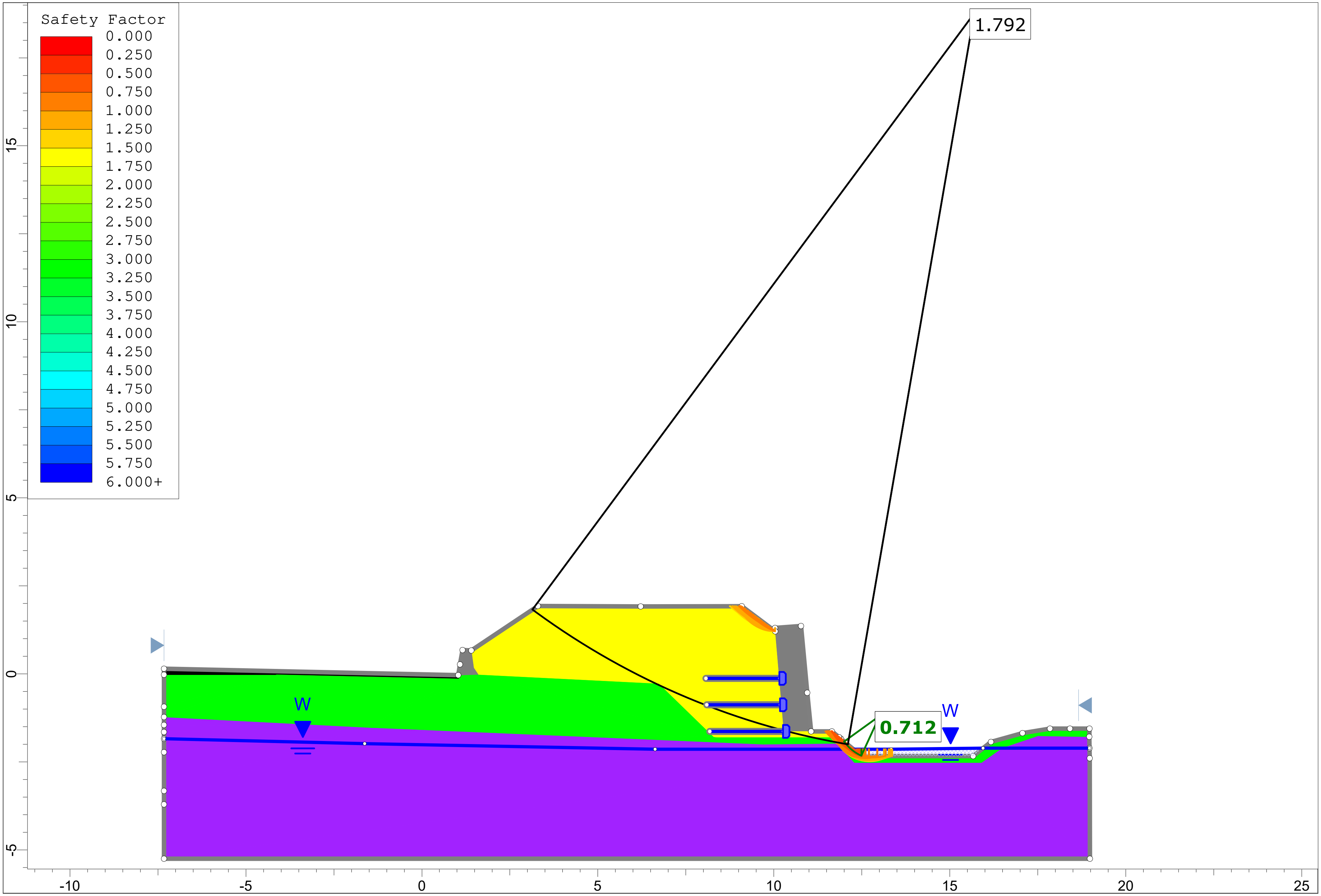
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Section H - STA 4038+30
1.356
0.706
W
W
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5



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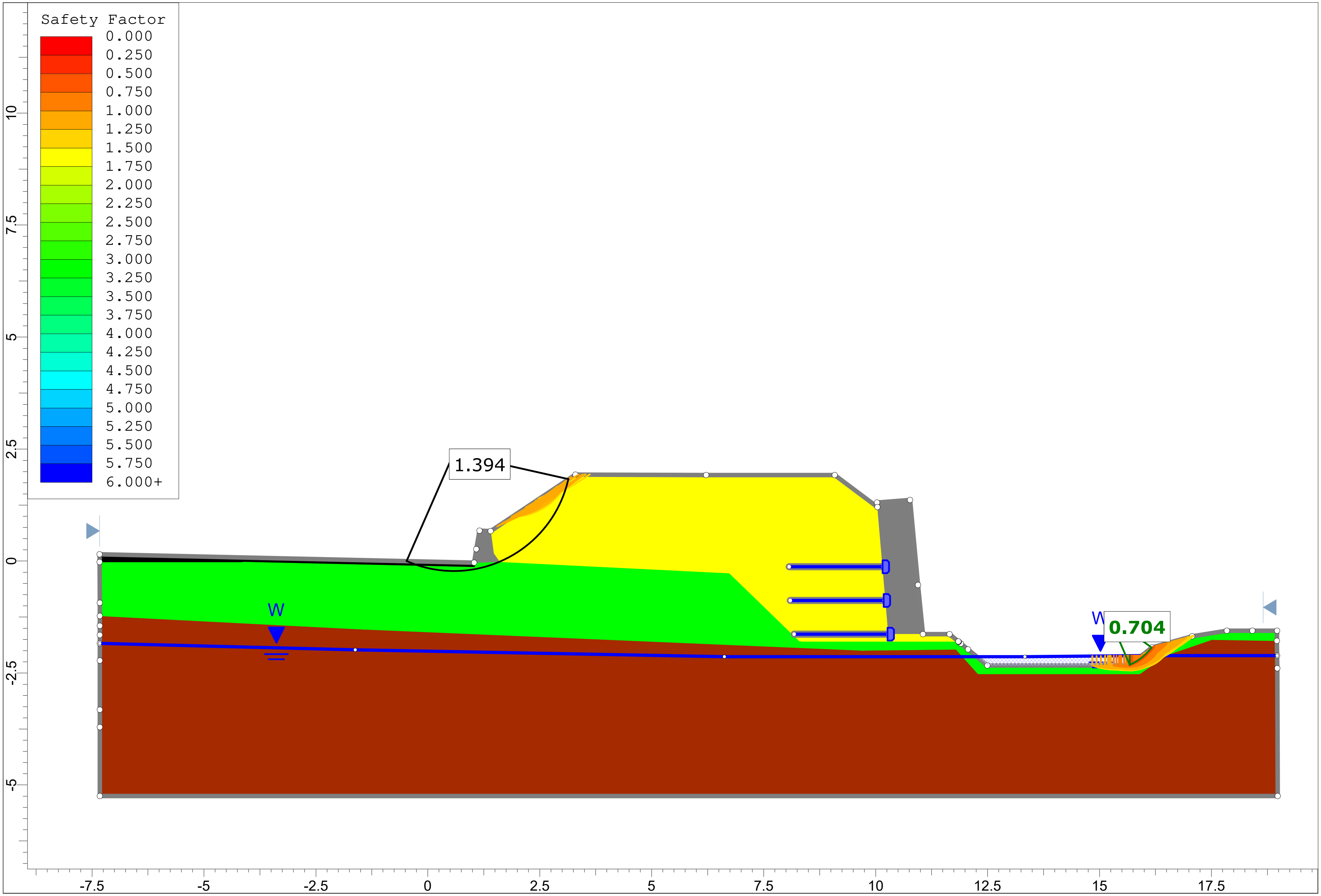
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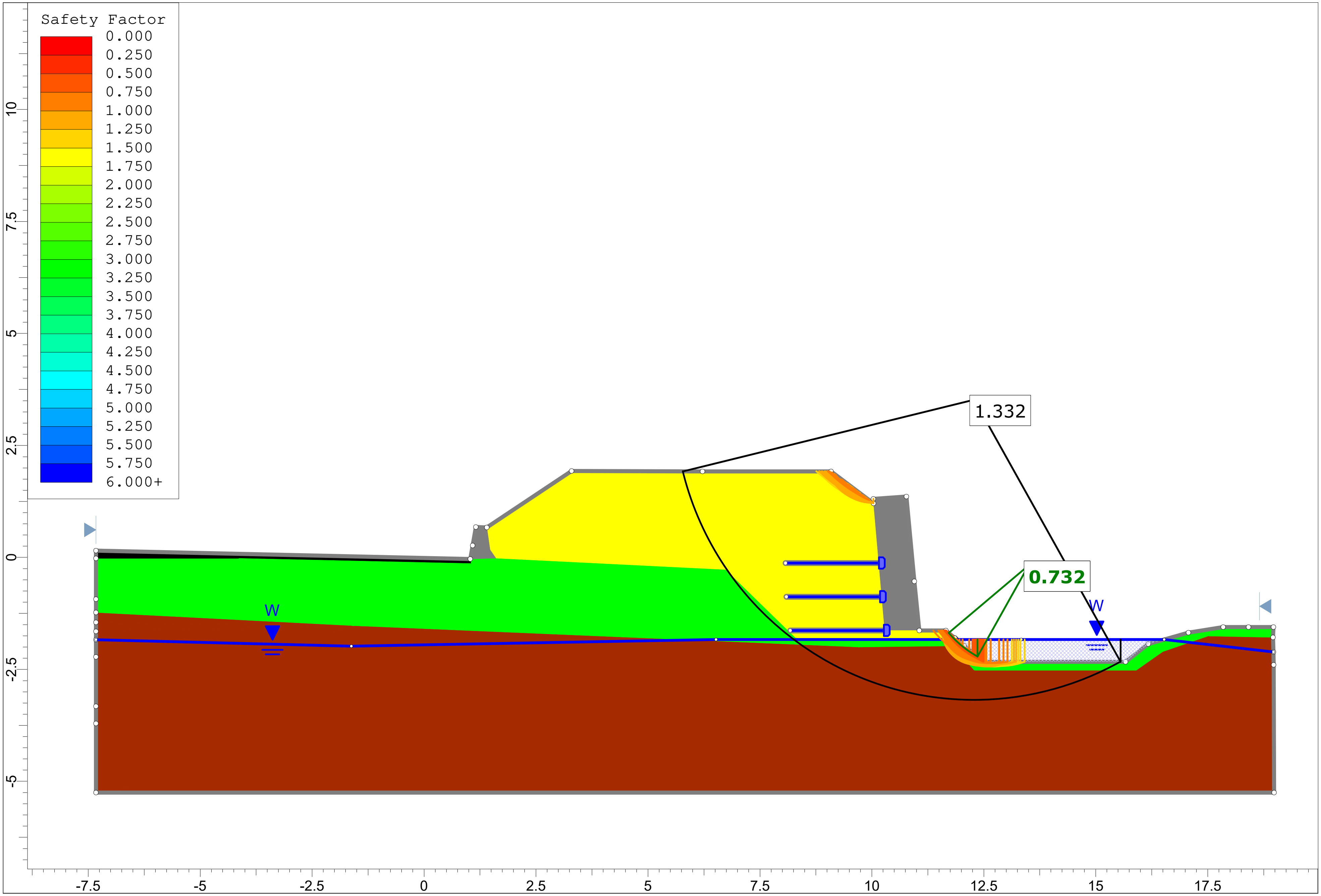
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.394
0.704
W
W
10
7.5
5
2.5
0
-2.5
-5
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5


Safety Factor
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0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
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3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.332
0.732
W
W
10
7.5
5
2.5
0
-2.5
-5
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
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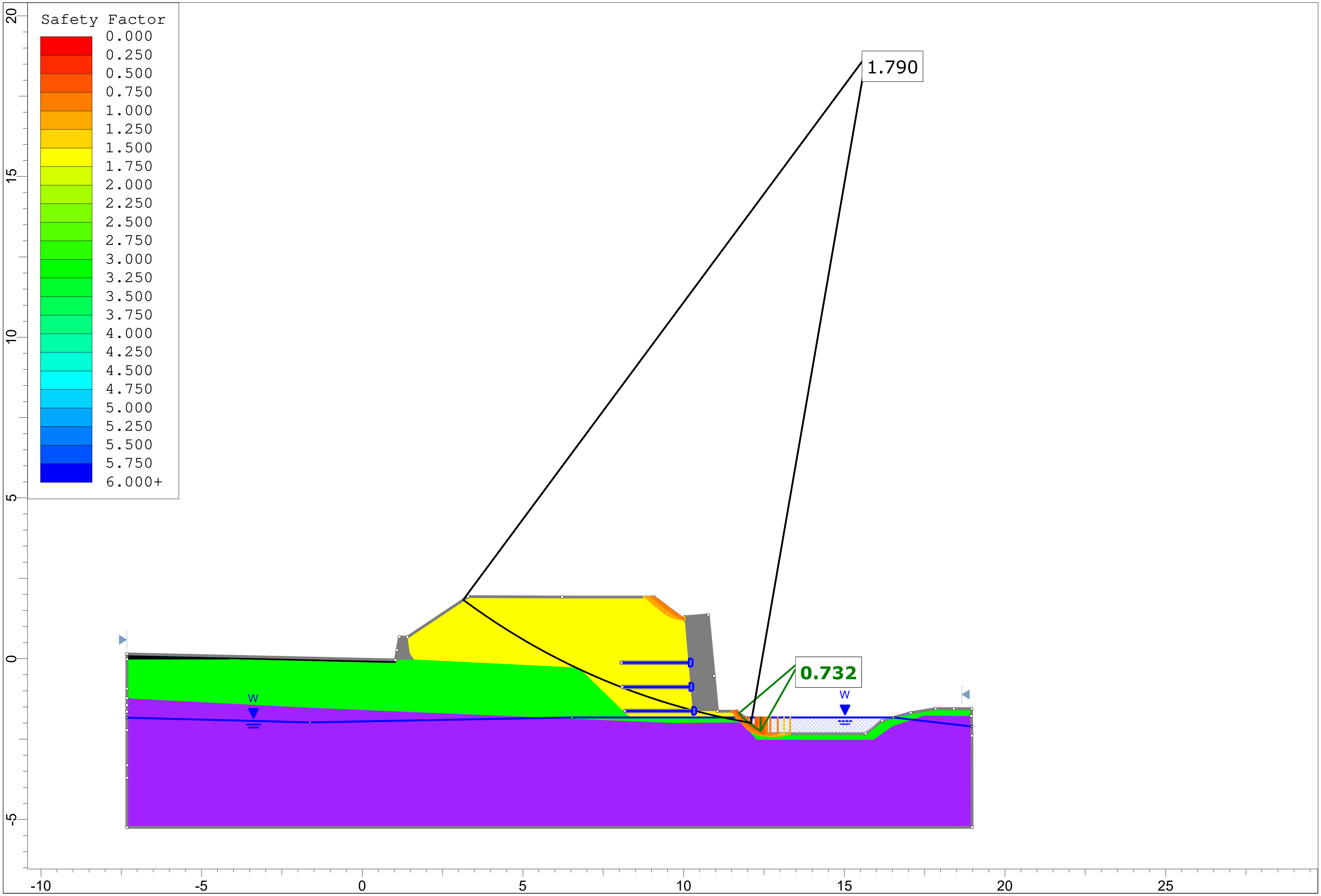
17.5



Safety Factor
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1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.790
0.732
W
W
20
15
10
5
0
-5
-10
-5
0
5
10
15
20
25