APPENDIX E – GEOTECHNICAL REPORT

Archibald & Watt Street Renewal – Geotechnical Report

Geotechnical Investigation and Design Review

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Sign-off Sheet

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1.0 INTRODUCTION

The City of Winnipeg has retained Stantec to perform a pavement coring investigation, geotechnical site investigation, provide a slope stability review for the construction of a new sidewalk and retaining wall, and provide soil strength parameters for the structural design of the proposed sidewalk and retaining wall at the Archibald Street Underpass.

The work that has been performed as part of this review has included the following:

- A pavement coring investigation consisting of 12 pavement cores and sampling to identify the existing site pavement conditions.
- A testhole drilling program consisting of 3 testholes, soil sampling, and laboratory testing to identify the existing subsurface conditions.
- A slope stability analysis for the proposed sidewalk and retaining wall.
- The preparation of a summary report (this report) presenting the existing site conditions and providing soil strength parameters in support of the structural design of the proposed sidewalk and retaining wall.

2.0 EXISTING CONDITIONS AND PROPOSED CONSTRUCTION

The Archibald Street underpass is located along Archibald Street, and consists of a roadway underpass beneath the Canadian Pacific (CP) rail lines. The length of the underpass is approximately 220 m, and is approximately 5 m below surrounding grades at its deepest point.

The Archibald Street Underpass has an existing geometry that includes east/west embankment side slopes of approximately 3H:1V on the north and south approaches of the underpass, embankment side slopes of approximately 2H:1V under the rail bridge structure, sidewalk widths of approximately 1.8 m and a retaining wall adjacent to the roadway with a maximum height of approximately 1.8 m. The existing site geometry is shown in plan on Drawing C-105 and in section on Drawings C-106 to C-110 in **Appendix B**.

The railway bridge over the underpass is founded on hexagonal precast concrete piles. The existing railway structure foundation details are shown on Drawing 4102-06 in **Appendix B**.

The proposed construction work to be completed for the renewal of the Archibald Street Underpass includes the removal and replacement of the existing face of the retaining wall adjacent to the roadway on both sides of the road, widening the sidewalk to 3.2 m on both sides of the road, and the addition of an active transportation (AT) path connection approximately 25 m northeast of the structure. The sidewalk north of the structure will include the construction of a switchback on the side slope. For the sidewalk widening, the native soil material upslope of the sidewalk has been proposed to be excavated at a temporary side slope of 1H:1V from the elevation of the sidewalk to existing grade.

3.0 INVESTIGATION PROGRAM

The investigation program for this project consisted of a pavement coring program, detailed drilling and sampling program and a laboratory testing program.

3.1 CORING, DRILLING AND SAMPLING PROGRAM

The geotechnical coring, drilling and sampling program was performed on February 22, 2016 with drilling services provided by Paddock Drilling Ltd. and continuous Stantec personnel supervision. The drilling was performed using a truck mounted Canterra CT-250 drill rig. A total of ten pavement cores and two testholes (TH01 and TH02) were completed on Archibald Street and Watt Street at the locations shown on Drawings C-101 to C-104 in **Appendix B**. Photos of the pavement structure are shown in **Appendix C**. One testhole (TH03) was completed on the upper bank southeast of the underpass structure with the location shown on Drawing C-105 in **Appendix B**. Representative cross sections of the underpass are included on Drawings C-106 to C-110 in **Appendix B**.

The drilling program consisted of advancing 150 mm diameter solid stem augers through the native overburden materials down to a depth of 2.1 m in testholes TH01 and TH02 and to power auger refusal in testhole TH03. Overburden soil samples were retrieved from the auger flights at 0.75 m to 1.5 m intervals. A total of six (6) undisturbed Shelby tube samples were also collected at various depths from testhole TH03. Standard Penetration Tests (SPT) were completed using a 35 mm inside diameter split spoon to collect samples and “N” values within the underlying till in testhole TH03. All samples were visually inspected in the field for material types and transferred to our Winnipeg laboratory for further inspection and testing. A description of the soil stratigraphy is as given within Sections 4 and 5 of this report as well as the detailed testhole logs enclosed in **Appendix D**.

To monitor the long term groundwater level conditions at the site, a vibrating wire piezometer was installed within testhole TH03. The vibrating wire piezometer was installed within the clay layer at approximate elevation 222 m. The results of the monitoring for this piezometer are shown on Figure F1 in **Appendix F**.

3.2 LABORATORY TESTING

A laboratory testing program was performed on select soil samples from the drilling program to determine the relevant engineering properties of the subsurface materials relative to the pavement subsurface and the slope stability assessment. Diagnostic testing included moisture contents on all collected soil samples, field torvanes on clay and silty clay samples, particle size analyses, Atterberg limits, one unit weight test, and one direct shear test. The results of the laboratory testing are shown on the testhole logs in **Appendix D** and on the laboratory testing results provided in **Appendix E**.

4.0 ARCHIBALD STREET INVESTIGATION RESULTS

A total of ten pavement cores and two testholes (TH01 and TH02) were completed on Archibald Street and Watt Street at the locations shown on Drawings C-101 to C-104 in **Appendix B**. The ten pavement cores were completed to investigate the pavement structure on Archibald Street and Watt Street with photographs of each core shown in **Appendix C**. The overall stratigraphic conditions of the two testholes (TH01 and TH02) drilled on the center northbound lane on Archibald Street have been based upon the investigation results obtained during the drilling, sampling and laboratory investigation programs. The pertinent results from this investigation are as outlined below.

4.1 STRATIGRAPHY

The stratigraphy of testhole TH01 at the site consisted of surficial asphalt pavement, overlying concrete, overlying crushed limestone road base. The road structure (asphalt, concrete, road base) was underlain by layers of fat clay and silt until the termination depth of the testhole. The stratigraphy of testhole TH02 at the site consisted of surficial asphalt pavement, overlying concrete, overlying crushed limestone road base. The road structure was underlain by a layer of silty clay, encountered to the termination depth of the testhole. A description of the soil stratigraphy is as given below, with detailed testhole logs and the symbols and terms provided in **Appendix D**.

4.1.1 Asphalt

A surface layer of approximately 100 mm thick asphalt was observed in both testholes. The asphalt is shown in Photos 1 (TH01) and 2 (TH02) in **Appendix C**. The asphalt layer observed in the pavement cores ranged in thickness from 0 to 140 mm (approximate average of 80 mm). The asphalt from the pavement cores is shown in Photos 3 to 12 in **Appendix C**.

4.1.2 Concrete

A layer of concrete was encountered underlying the asphalt in both testholes. The concrete was approximately 200 mm thick and is shown in Photos 1 (TH01) and 2 (TH02) in **Appendix C**. The concrete layer encountered in the pavement cores ranged in thickness from 190 to 270 mm (approximate average of 240 mm). The concrete from the pavement cores is shown in Photos 3 to 12 in **Appendix C**.

4.1.3 Road Base

A layer of road base was encountered underlying the concrete in both testholes. The road base was comprised of crushed limestone and was approximately 100 mm thick in testhole TH01 and

1.4 m thick in testhole TH02. The moisture content of the road base ranged from 3% to 12% (overall average of approximately 8%). The road base material had a maximum aggregate size of 25 mm.

4.1.4 Fat Clay

A layer of fat clay was encountered underlying the road base in testhole TH01. The clay was black to grey in colour, moist, fat (i.e. of high plasticity) and contained trace silt. The moisture content of the clay ranged from 30% to 38% (overall average of approximately 35%), and generally decreased with depth. From the particle size and Atterberg limits testing, the activity of this layer was 0.69, classifying the clay mineralogy as kaolinite to illite.

4.1.5 Silty Clay

A layer of silty clay was encountered underlying the road base in testhole TH02. The silty clay was grey in colour, moist, and lean (i.e. of low plasticity). The moisture content of the silty clay ranged from 31% to 43% (overall average of approximately 37%), and generally increased with depth.

4.1.6 Silt

A layer of silt was encountered underlying the fat clay in testhole TH01. The silt was tan in colour, soft, and moist. The moisture content of the clay ranged from 22% to 24% (overall average of approximately 23%), and generally decreased with depth.

4.2 LABORATORY TEST RESULTS

Moisture content tests were conducted on soil samples recovered from the testholes with the moisture content test results shown on the testhole logs provided in **Appendix D**. One soil sample from testhole TH01 was also tested for particle size analysis (ASTM D422) and Atterberg limits (ASTM D4318). A summary of the particle size analysis performed is shown below in **Table 1** and the Atterberg limits are shown in **Table 2**. Laboratory summary sheets for the particle size analysis and Atterberg limits are included in **Appendix E.1**.

Table 1 - Archibald Street Particle Size Analysis Results

Testhole Number	Sample Depth (m)	Soil Type	Particle Size				Activity
			Gravel (%) 75 to 4.75 mm	Sand (%) <4.75 to 0.075 mm	Silt (%) <0.075 to 0.002 mm	Clay (%) <0.002 mm	
TH01	0.9	Clay	0.0	2.2	25.8	72.0	0.69

Table 2 - Archibald Street Atterberg Limits Results

Testhole Number	Sample Depth (m)	Soil Type	Liquid Limit	Plastic Limit	Plasticity Index
TH01	0.9	Clay	77	27	50

4.3 GROUNDWATER AND SLOUGHING CONDITIONS

No groundwater seepage or sloughing conditions were observed during or upon completion of drilling of testholes TH01 and TH02.

5.0 ARCHIBALD UNDERPASS INVESIGATION RESULTS

The overall stratigraphic conditions of the testhole (TH03) drilled on the upper bank southeast of the Archibald Underpass have been based upon the investigation results obtained during the field and laboratory investigation programs. The pertinent results from this investigation are as outlined below.

5.1 SITE GEOMETRY

The existing side slope geometry has been based on the topographic survey that was completed by Stantec in February 2016. From the survey information, five cross sections have been prepared to represent the geometry of the underpass. The cross sections are shown in plan on Drawing C-105 in and in section on Drawings C-106 to C-110 in **Appendix B**. The Archibald Street Underpass has an existing geometry that includes east/west embankment side slopes of approximately 3H:1V on the north and south approaches of the underpass, embankment side slopes of approximately 2H:1V under the rail bridge structure, sidewalk widths of approximately 1.8 m and a retaining wall adjacent to the roadway with a maximum height of approximately 1.8 m.

5.2 STRATIGRAPHY

The stratigraphy of testhole TH03 at the site consisted of a surface layer of approximately 0.5 m of topsoil, overlying approximately 1.2 m of clay fill, overlying approximately 0.1 m of sand fill, overlying approximately 14.6 m of fat clay, overlying silt till. A description of the soil stratigraphy is as given below, with the detailed testhole log located in **Appendix D**.

5.2.1 Topsoil

A surface layer of approximately 0.5 m thick topsoil was observed in the testhole. The topsoil was black in colour containing some organics. The moisture content of the topsoil was 21%.

5.2.2 Clay Fill

A 1.2 m thick layer of clay fill was encountered underlying the topsoil in the testhole. The clay fill was brown in colour containing some silt, fine to coarse sand. From the field torvane testing completed, the undrained shear strength of the clay fill ranged from 112 kPa to 121 kPa (approximate average of 117 kPa), classifying the material as very stiff in consistency. The moisture content of the clay fill ranged from 32% to 34% (overall average of approximately 33%), and generally decreased with depth.

5.2.3 Sand Fill

A 0.1 m thick layer of sand fill was encountered underlying the clay fill in the testhole. The sand fill was tan in colour, loose, containing some fine to coarse gravel. The moisture content of the sand was 4%.

5.2.4 Fat Clay

A 14.6 m thick layer of fat clay was encountered underlying the sand in the testhole. The clay was brown to grey in colour, moist, and fat (i.e. of high plasticity). From the field torvane testing completed, the undrained shear strength of the clay ranged from 20 kPa to 65 kPa (approximate average of 39 kPa), classifying the material as stiff in consistency becoming soft with depth. The moisture content of the clay ranged from 35% to 62% (overall average of approximately 51%), and generally increased with depth. From the particle size and Atterberg limits testing, the activity of this layer ranged from 0.70 to 0.95, classifying the clay mineralogy as kaolinite to illite.

5.2.5 Silt Till

Silt till was encountered below the fat clay in the testhole. The silt till was tan in colour, compact and becoming very dense with depth, moist, non-plastic, and contained some sand. 1.2 m of silt till was encountered prior to auger refusal at elevation 213.5 m. Standard Penetration Tests (SPT) completed within the silt till show an uncorrected SPT "N" value of 16 blows per 300 mm where complete SPT testing could be performed (upper portion of deposit). The SPT testing near the bottom of the testhole showed 50 blows for less than 300 mm of penetration, and this has been taken as SPT "refusal". The moisture content in the silt till ranged from 10% to 14% (overall average of approximately 17%).

5.3 LABORATORY TEST RESULTS

Moisture content tests were conducted on soil samples recovered from the testhole with the moisture content test results shown on the testhole logs provided in **Appendix D**. Select representative soil samples were also tested for particle size analysis (ASTM D422), Atterberg limits (ASTM D4318), unit weight (ASTM D7263), and direct shear (ASTM D3080). A summary of the particle size analyses performed is shown in **Table 3**, the Atterberg limits are shown in **Table 4**, the unit weight is shown in **Table 5** and the direct shear test results are shown in **Table 6**. Laboratory summary sheets for the particle size analysis, Atterberg limits, unit weight and the direct shear test are included in **Appendix E.2**.

Table 3 - Archibald Underpass Particle Size Analysis Results

Testhole Number	Sample Depth (m)	Soil Type	Particle Size				Activity
			Gravel (%) 75 to 4.75 mm	Sand (%) <4.75 to 0.075 mm	Silt (%) <0.075 to 0.002 mm	Clay (%) <0.002 mm	
TH03	0.8	Clay Fill	0.0	2.3	27.0	70.7	0.75
TH03	3.0	Clay	0.0	0.4	12.0	87.6	0.96
TH03	9.1	Clay	0.3	7.7	27.9	64.1	0.70

Table 4 - Archibald Underpass Atterberg Limits Results

Testhole Number	Sample Depth (m)	Soil Type	Liquid Limit	Plastic Limit	Plasticity Index
TH03	0.8	Clay Fill	80	27	53
TH03	3.0	Clay	115	31	84
TH03	9.1	Clay	62	17	45

Table 5 - Archibald Underpass Unit Weight Test Results

Testhole Number	Sample Depth (m)	Soil Type	Bulk Density (kN/m^3)
TH03	3.0	Clay	16.6

Table 6 - Direct Shear Test Results

Testhole Number	Sample Depth (m)	Soil Type	Effective Shear Strength	Effective Friction Angle	Effective Cohesion (kPa)
TH03	9.1	Clay	Peak	15°	5
TH03	9.1	Clay	Residual	10°	2

5.4 GROUNDWATER AND SLOUGHING CONDITIONS

Moderate groundwater seepage was observed in testhole TH03 during the drilling within the silt till at a depth of 16.5 m below ground surface. The groundwater level was observed at a depth of 9.8 m below ground surface upon completion of the drilling. No sloughing conditions were observed during or upon completion of drilling of testhole TH03.

5.5 VIBRATING WIRE PIEZOMETER – TH03

A vibrating wire piezometer was installed within testhole TH03 upon completion of drilling on February 22, 2016. The vibrating wire piezometer was installed within the native clay layer with a tip elevation 9.1 m below ground surface at elevation 222.0 m. The measured groundwater level on February 22, 2016 was found to be at elevation 233.7 m. This elevation corresponds to 2.6 m above existing ground surface, and it is likely that the instrument had yet to stabilize. The groundwater level was monitored on February 24, 2016 at elevation 226.7 m, which represents a groundwater level at 4.4 m below existing grade. The groundwater level was last monitored on April 15, 2016 at elevation 227.1 m, which represents a groundwater level at 4.0 m below existing grade. The monitored groundwater level within testhole TH03 has increased since the installation of the piezometer. The results of the monitoring for this piezometer are shown on Figure F1 in **Appendix F**.

6.0 SLOPE STABILITY REVIEW

The methodology and results for the detailed slope stability review of the underpass side slopes are as outlined below.

6.1 SLOPE STABILITY METHODOLOGY

A slope stability analysis for the underpass side slopes at the site was undertaken with the assistance of the computer model Slope/W, developed by GeoSlope International Inc. of Calgary, Alberta. For the stability analysis, the Morgenstern-Price generalized limit equilibrium solution with constant interslice force inclination has been used. The Morgenstern-Price method simultaneously solves for force and moment equilibrium, and is considered to be the current industry state of practice. The computer model investigates a large number of potential failure surfaces and depending on the method of analysis used can present the results in the form of contours of computed Factor of Safety (FS) against sliding.

Stability of a slope is typically generalized as a ratio of the forces that resist failure divided by the forces that drive failure. This unitless fraction is called a Factor of Safety. Factors of Safety that are unity (1.0) or less indicate that driving forces exceed resisting forces and from a geotechnical engineering perspective the slope has failed or is highly unstable. Due to the natural variability of soils and the conditions that can affect the driving and resisting forces unpredictably, the geotechnical engineering industry typically requires a minimum FS of 1.5 for long term steady state scenarios and 1.3 for short term transient (construction) scenarios.

The slope stability analysis has generally consisted of evaluating the existing site conditions and the impact to the overall stability of the underpass side slope during the construction of the retaining wall and sidewalk, and the final site conditions at the underpass structure, north of the underpass structure and south of the underpass structure. The slope stability review assumed a "normal" groundwater level at elevation 227.0 m, and a "critical" groundwater level at elevation 230.0 m.

The slope stability analysis cross sections at the underpass structure are representative of a length of approximately 45 m, and includes taking the weighted average factor of safety for three cross sections (i.e. Cross Section 1+264.62 adjacent to the structure on the north side 11 m representative length, Cross Section 1+247.60 in the middle of the structure 25 m representative length, and Cross Section 1+235.00 adjacent to the structure on the south side 9 m representative length). This weighted average approach is to account for the different foundation elements of the structure at various cross section locations to approximate the three dimensional average of this 45 m zone.

The slope stability analysis performed at the underpass structure shown on Cross Section 1+247.60 has included a train loading at the top of the side slope using the American Railway Engineering and Maintenance-of-Way Association (AREMA) Cooper E90 loading.

6.2 SOIL SHEAR STRENGTH PARAMETERS

The native soil shear strength parameters are critical to any slope stability assessment, as the established factor of safety for a given slip surface is a function of the available shear resistance along the slip surface.

For all slope stability analysis performed, the effective shear strength parameters outlined on **Table 7** below for the various in-situ and fill soils have been used. The shear strength parameters for the in-situ soils are considered to be conservative estimates for post-peak effective strengths. Based on our experience with lacustrine clay soils in Winnipeg, the peak effective strength results from the direct shear testing were lower than typical values and therefore were not used for the analysis. The concrete piles for the bridge abutment and piers have been included in the slope stability analysis performed at the Archibald Street Underpass shown on Cross Section 1+247.60.

Table 7 - Summary of Effective Shear Strength Parameters

Material	Unit Weight (kN/m^3)	Effective Friction Angle	Effective Cohesion (kPa)
Native Clay	18	20°	5
Silt Till	18	30°	0
Concrete	23.5	50°	500

6.3 EXISTING CONDITIONS SLOPE STABILITY RESULTS

The slope stability results for the existing conditions at the underpass structure, north of the underpass structure and south of the underpass structure are outlined in the following sections.

6.3.1 At Underpass Structure Results

The three cross sections analyzed for the existing conditions at the underpass structure using the weighted average approach are shown in plan on Drawing C-105 and section on Drawings C-107 to C-109 in **Appendix B**. The slope stability results for the existing conditions at the underpass structure are outlined in **Table 8** below and are shown in **Appendix G.1**.

Table 8 - Existing Conditions Slope Stability Results at Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety	Representative Length (m)	Weighted Average Factor of Safety
1+235.00	G1	Overall	227.0	1.63	9	1.75
1+247.60	G2	Overall	227.0	1.87	25	
1+264.62	G3	Overall	227.0	1.59	11	
1+235.00	G4	Overall	230.0	1.37	9	1.60
1+247.60	G5	Overall	230.0	1.80	25	
1+264.62	G6	Overall	230.0	1.35	11	
1+235.00	G7	Top of Slope to Sidewalk	227.0	2.03	9	1.59
1+247.60	G8	Top of Slope to Sidewalk	227.0	1.28	25	
1+264.62	G9	Top of Slope to Sidewalk	227.0	1.95	11	
1+235.00	G10	Top of Slope to Sidewalk	230.0	1.87	9	1.51
1+247.60	G11	Top of Slope to Sidewalk	230.0	1.23	25	
1+264.62	G12	Top of Slope to Sidewalk	230.0	1.84	11	
1+235.00	G13	Sidewalk to Road	227.0	2.03	N/A	N/A
1+247.60	G14	Sidewalk to Road	227.0	6.18	N/A	
1+264.62	G15	Sidewalk to Road	227.0	1.93	N/A	
1+235.00	G16	Sidewalk to Road	230.0	1.81	N/A	N/A
1+247.60	G17	Sidewalk to Road	230.0	5.93	N/A	
1+264.62	G18	Sidewalk to Road	230.0	1.68	N/A	

6.3.2 North of Underpass Structure

The cross section analyzed for the existing conditions north of the underpass structure (Cross Section 1+275.00) is shown in plan on Drawing C-105 and section on Drawing C-110 in **Appendix B**. The slope stability results for the existing conditions north of the underpass structure are outlined in **Table 9** below and are shown in **Appendix G.2**.

Table 9 - Existing Conditions Slope Stability Results North of Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety
1+275.00	G19	Overall	227.0	1.80
1+275.00	G20	Overall	230.0	1.47
1+275.00	G21	Top of Slope to Sidewalk	227.0	2.11
1+275.00	G22	Top of Slope to Sidewalk	230.0	1.89
1+275.00	G23	Sidewalk to Road	227.0	2.26
1+275.00	G24	Sidewalk to Road	230.0	1.93

6.3.3 South of Underpass Structure

The cross section analyzed for the existing conditions south of the underpass structure (Cross Section 1+215.00) is shown in plan on Drawing C-105 and section on Drawing C-106 in **Appendix B**. The slope stability results for the existing conditions south of the underpass structure are outlined in **Table 10** below and are shown in **Appendix G.3**.

Table 10 - Existing Conditions Slope Stability Results South of Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety
1+215.00	G25	Overall	227.0	1.83
1+215.00	G26	Overall	230.0	1.48
1+215.00	G27	Top of Slope to Sidewalk	227.0	2.14
1+215.00	G28	Top of Slope to Sidewalk	230.0	1.89
1+215.00	G29	Sidewalk to Road	227.0	2.26
1+215.00	G30	Sidewalk to Road	230.0	1.97

6.4 CONSTRUCTION CONDITIONS SLOPE STABILITY RESULTS

The proposed construction work to be completed includes the removal and replacement of the existing face of the retaining wall adjacent to the roadway on both sides of the road, widening the sidewalk to 3.2 m on both sides of the road, and the addition of an active transportation (AT) path connection approximately 25 m northeast of the structure. The sidewalk north of the structure will include the construction of a switchback on the side slope. During construction the native soil material upslope of the sidewalk has been proposed to be excavated at a temporary side slope of 1H:1V from the elevation of the sidewalk to existing grade. The slope stability results for the construction conditions at the underpass structure, north of the underpass structure and south of the underpass structure are outlined in the following sections.

6.4.1 At Underpass Structure Results

The three cross sections analyzed for the construction conditions at the underpass structure using the weighted average approach are shown in plan on Drawing C-105 and section on Drawings C-107 to C-109 in **Appendix B**. The slope stability results for the construction conditions at the underpass structure are outlined in **Table 11** below and are shown in **Appendix H.1**.

Table 11 - Construction Conditions Slope Stability Results at Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety	Representative Length (m)	Weighted Average Factor of Safety
1+235.00	H1	Overall	227.0	1.57	9	1.72
1+247.60	H2	Overall	227.0	1.86	25	
1+264.62	H3	Overall	227.0	1.51	11	
1+235.00	H4	Overall	230.0	1.29	9	1.55
1+247.60	H5	Overall	230.0	1.77	25	
1+264.62	H6	Overall	230.0	1.26	11	
1+235.00	H7	Top of Slope to Sidewalk	227.0	1.52	9	1.36
1+247.60	H8	Top of Slope to Sidewalk	227.0	1.25	25	
1+264.62	H9	Top of Slope to Sidewalk	227.0	1.47	11	
1+235.00	H10	Top of Slope to Sidewalk	230.0	1.43	9	1.30
1+247.60	H11	Top of Slope to Sidewalk	230.0	1.20	25	
1+264.62	H12	Top of Slope to Sidewalk	230.0	1.41	11	
1+235.00	H13	Sidewalk to Road	227.0	2.84	N/A	N/A
1+247.60	H14	Sidewalk to Road	227.0	8.13	N/A	
1+264.62	H15	Sidewalk to Road	227.0	2.82	N/A	
1+235.00	H16	Sidewalk to Road	230.0	2.51	N/A	N/A
1+247.60	H17	Sidewalk to Road	230.0	7.81	N/A	
1+264.62	H18	Sidewalk to Road	230.0	2.39	N/A	

6.4.2 North of Underpass Structure

The cross section analyzed for the construction conditions north of the underpass structure (Cross Section 1+275.00) is shown in plan on Drawing C-105 and section on Drawing C-110 in

Appendix B. The slope stability results for the construction conditions north of the underpass structure are outlined in **Table 12** below and are shown in **Appendix H.2**.

Table 12 - Construction Conditions Slope Stability Results North of Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety
1+275.00	H19	Overall	227.0	1.71
1+275.00	H20	Overall	230.0	1.38
1+275.00	H21	Top of Slope to Sidewalk	227.0	1.39
1+275.00	H22	Top of Slope to Sidewalk	230.0	1.34
1+275.00	H23	Sidewalk to Road	227.0	3.94
1+275.00	H24	Sidewalk to Road	230.0	3.32

6.4.3 South of Underpass Structure

The cross section analyzed for the construction conditions south of the underpass structure (Cross Section 1+215.00) is shown in plan on Drawing C-105 and section on Drawing C-106 in **Appendix B**. The slope stability results for the construction conditions south of the underpass structure are outlined in **Table 13** below and are shown in **Appendix H.3**.

Table 13 - Construction Conditions Slope Stability Results South of Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety
1+215.00	H25	Overall	227.0	1.74
1+215.00	H26	Overall	230.0	1.40
1+215.00	H27	Top of Slope to Sidewalk	227.0	1.41
1+215.00	H28	Top of Slope to Sidewalk	230.0	1.37
1+215.00	H29	Sidewalk to Road	227.0	3.96
1+215.00	H30	Sidewalk to Road	230.0	3.56

6.5 FINAL CONDITIONS SLOPE STABILITY RESULTS

The proposed final design includes a 3.2 m wide sidewalk on both sides of the road, an AT path connection approximately 25 m northeast of the bridge structure, and a switchback on the side slope north of the bridge structure. The slope stability results for the final conditions at the underpass structure, north of the underpass structure and south of the underpass structure are outlined in the following sections.

6.5.1 At Underpass Structure Results

The three cross sections analyzed for the existing conditions at the underpass structure using the weighted average approach are shown in plan on Drawing C-105 and section on Drawings C-107 to C-109 in **Appendix B**. The slope stability results for the final conditions at the underpass structure are outlined in **Table 14** below and are shown in **Appendix I.1**.

Table 14 - Final Conditions Slope Stability Results at Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety	Representative Length (m)	Weighted Average Factor of Safety
1+235.00	H1	Overall	227.0	1.62	9	1.75
1+247.60	H2	Overall	227.0	1.87	25	
1+264.62	H3	Overall	227.0	1.57	11	
1+235.00	H4	Overall	230.0	1.36	9	1.59
1+247.60	H5	Overall	230.0	1.78	25	
1+264.62	H6	Overall	230.0	1.33	11	
1+235.00	H7	Top of Slope to Sidewalk	227.0	1.91	9	1.54
1+247.60	H8	Top of Slope to Sidewalk	227.0	1.28	25	
1+264.62	H9	Top of Slope to Sidewalk	227.0	1.82	11	
1+235.00	H10	Top of Slope to Sidewalk	230.0	1.78	9	1.46
1+247.60	H11	Top of Slope to Sidewalk	230.0	1.23	25	
1+264.62	H12	Top of Slope to Sidewalk	230.0	1.73	11	
1+235.00	H13	Sidewalk to Road	227.0	2.15	N/A	N/A
1+247.60	H14	Sidewalk to Road	227.0	6.19	N/A	
1+264.62	H15	Sidewalk to Road	227.0	2.01	N/A	
1+235.00	H16	Sidewalk to Road	230.0	1.86	N/A	N/A
1+247.60	H17	Sidewalk to Road	230.0	5.96	N/A	
1+264.62	H18	Sidewalk to Road	230.0	1.75	N/A	

6.5.2 North of Underpass Structure

The cross section analyzed for the final conditions north of the underpass structure (Cross Section 1+275.00) is shown in plan on Drawing C-105 and section on Drawing C-110 in **Appendix B**. The slope stability results for the final conditions north of the underpass structure are outlined in **Table 15** below and are shown in **Appendix I.2**.

Table 15 - Final Conditions Slope Stability Results North of Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety
1+275.00	H19	Overall	227.0	1.77
1+275.00	H20	Overall	230.0	1.41
1+275.00	H21	Top of Slope to Sidewalk	227.0	1.87
1+275.00	H22	Top of Slope to Sidewalk	230.0	1.66
1+275.00	H23	Sidewalk to Road	227.0	2.35
1+275.00	H24	Sidewalk to Road	230.0	1.97

6.5.3 South of Underpass Structure

The cross section analyzed for the final conditions south of the underpass structure (Cross Section 1+215.00) is shown in plan on Drawing C-105 and section on Drawing C-106 in **Appendix B**. The slope stability results for the final conditions south of the underpass structure are outlined in **Table 16** below and are shown in **Appendix I.3**.

Table 16 - Final Conditions Slope Stability Results South of Underpass Structure

Cross Section	Figure Number	Slip Surface	GWL (m)	Factor of Safety
1+215.00	H25	Overall	227.0	1.80
1+215.00	H26	Overall	230.0	1.45
1+215.00	H27	Top of Slope to Sidewalk	227.0	1.91
1+215.00	H28	Top of Slope to Sidewalk	230.0	1.72
1+215.00	H29	Sidewalk to Road	227.0	2.40
1+215.00	H30	Sidewalk to Road	230.0	2.11

6.6 SLOPE STABILITY DISCUSSION

Based on the slope stability results for the proposed construction work of replacing the existing face of the retaining wall and the construction of the proposed sidewalk, the overall factors of safety decrease slightly from the existing conditions results however all estimated factors of safety meet the required factor of safety of 1.3 for short term transient (construction) scenarios.

Based on the slope stability results for the final conditions, the overall factors of safety decrease slightly from the existing conditions results however all the factors of safety meet the required factors of safety of 1.5 for long term steady state scenarios and 1.3 for short term transient scenarios.

Based on our professional opinion, no slope stability improvement techniques would be required for the underpass side slopes during construction or for the final conditions. Since both sides of the underpass are similar in existing, construction and final geometry, the results of the slope stability analysis completed for the eastern side slope can be used for the western side slope.

7.0 LATERAL EARTH PRESSURES

Any below grade walls for the proposed retaining wall and new sidewalk should be designed to resist lateral earth pressures based upon the following formula.

$$P = K_x (\gamma D + q)$$

Where,

P = lateral earth pressure at depth, D. (kPa)
K_x = applicable earth pressure coefficient.
γ = bulk soil unit weight (kN/m^3).
q = live load surcharge within distance D. (kPa)

The above expression assumes the subsurface walls will be drained and there will be no buildup of hydrostatic pressure on the walls. A 0.3 m (minimum) wide layer of free-draining granular material or an approved drainage layer product must be provided adjacent to the below grade walls and a subsurface drainage system must be provided at the base of the walls to prevent the buildup of hydrostatic pressure. Well-graded granular fill is not recommended as a drainage layer due to the reduced flow rates with this type of material. Excessive compaction should be avoided adjacent to the wall to prevent potential damage to the structure.

If a drainage layer is not provided adjacent to subsurface walls, the full hydrostatic pressure should be added to the above lateral earth pressure and applied over the buried depth of the subsurface wall.

The applicable active coefficient of lateral earth pressure for a slope of 3H:1V for the clay soil is provided below on **Table 17**. The recommended drainage layer is too thin (0.3 m) to be used as the dominant lateral earth pressure material.

Table 17 - Active Earth Pressure Coefficient for 3H:1V Side Slope

Material	Effective Friction Angle	Unit Weight (kN/m^3)	Active Earth Pressure Coefficient, K_a
Clay	20°	18	0.72

The active earth pressure coefficient may be used for subsurface walls that would be subject to lateral rotation.

8.0 PROJECT SUMMARY

The City of Winnipeg retained Stantec to perform a pavement coring investigation, geotechnical site investigation, provide a slope stability review for the construction of a new sidewalk and retaining wall, and provide soil strength parameters for the structural design of the proposed sidewalk and retaining wall at the Archibald Street Underpass.

The geotechnical drilling and sampling program was performed on February 22, 2016 with services provided by Paddock Drilling Ltd. and continuous Stantec supervision. The drilling was performed using a truck mounted Canterra CT-250 drill rig. A total of ten pavement cores and two testholes (TH01 and TH02) were completed on Archibald Street and Watt Street. The ten pavement cores had an average thickness of asphalt of approximately 80 mm and an average thickness of concrete of approximately 240 mm. The stratigraphy of testhole TH01 at the site consisted of a surficial layer of asphalt pavement, overlying concrete, crushed limestone road base, fat clay and silt. The stratigraphy of testhole TH02 at the site consisted of a surficial layer of asphalt pavement, overlying concrete, crushed limestone road base, and silty clay. One testhole (TH03) was completed on the upper bank southeast of the underpass structure. The stratigraphy of testhole TH03 at the site consisted of a surficial layer of topsoil, overlying clay fill, sand fill, fat clay, and silt till.

Based on this review, the overall factors of safety decrease slightly from the existing conditions results during and following construction however all the factors of safety meet the required factors of safety of 1.5 for long term steady state scenarios and 1.3 for short term transient scenarios. Based on our professional opinion, no slope stability improvement techniques would be required for the underpass side slopes during construction or for the final conditions. Since both sides of the underpass are similar in existing, construction and final geometry, the results of the slope stability analysis completed for the eastern side slope can be used for the western side slope.

9.0 CLOSURE

This report has been prepared for the sole benefit of the City of Winnipeg and its agents, and may not be used by any third party without the express written consent of Stantec Consulting Ltd. Any use, which a third party makes of this report, is the responsibility of such third party. Use of this report is subject to the Statement of General Conditions provided in **Appendix A**. It is the responsibility of the City of Winnipeg who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec Consulting Ltd. should any of these not be satisfied. The Statement of General Conditions addresses the following:

- Use of the report
- Basis of the report
- Standard of care
- Interpretation of site conditions
- Varying or unexpected site conditions
- Planning, design or construction

We trust the above information meets with your present requirements. Should you have any questions or require further information, please contact us. This report has been prepared by Justin Saj B.Sc., E.I.T. and reviewed by Thomas Crilly M.Sc., P.Eng.

We appreciate the opportunity to assist you in this project.

Appendix A
STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec's present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec will not be responsible to any party for damages incurred as a result of failing to notify Stantec that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec, sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc.), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec cannot be responsible for site work carried out without being present.

Appendix B
DRAWINGS

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Legend
- TESTHOLE
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Title
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Project No. 113706881

Scale 1:750 (0 7.5 22.5)

Drawing No. C-101

Sheet 1 of 10

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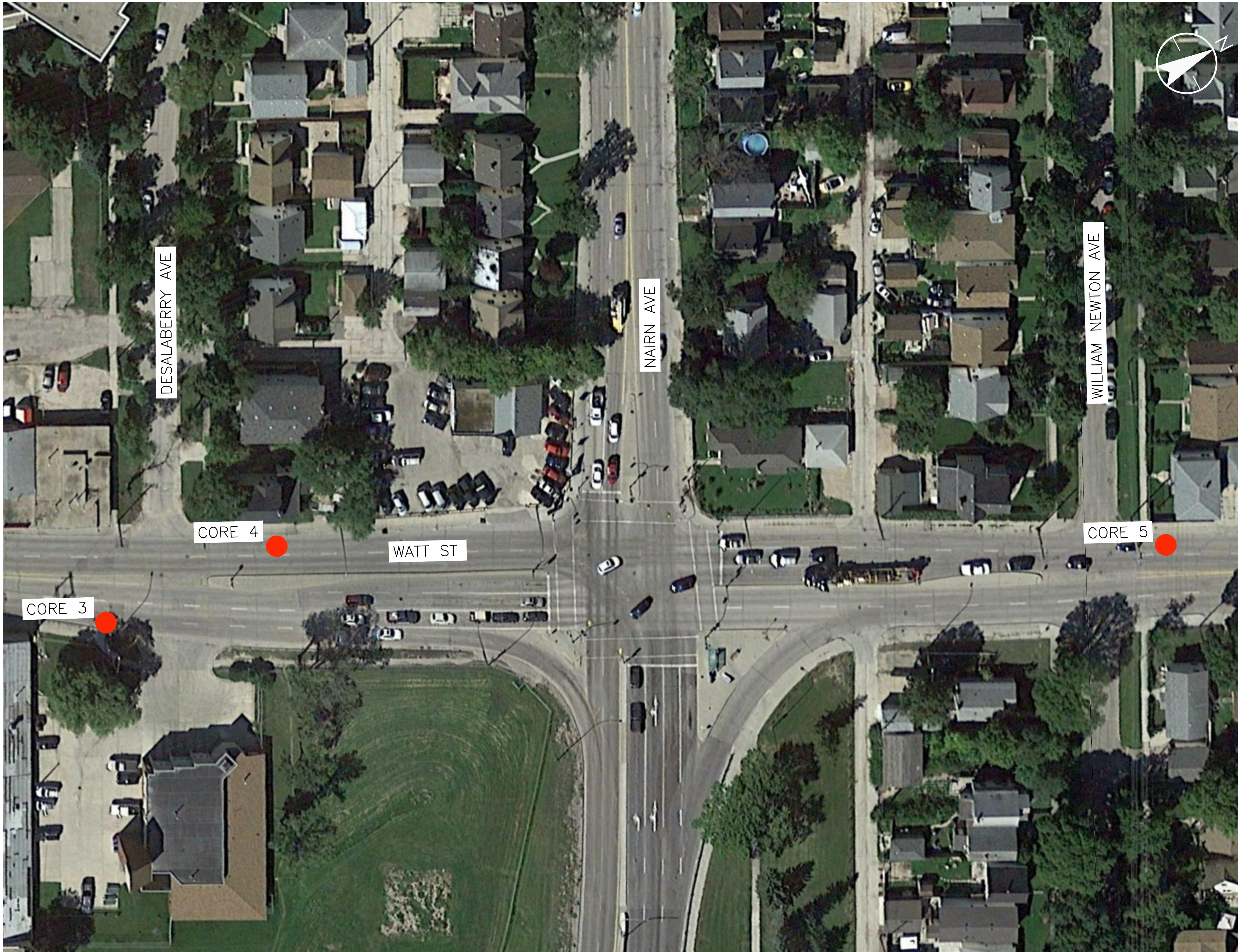

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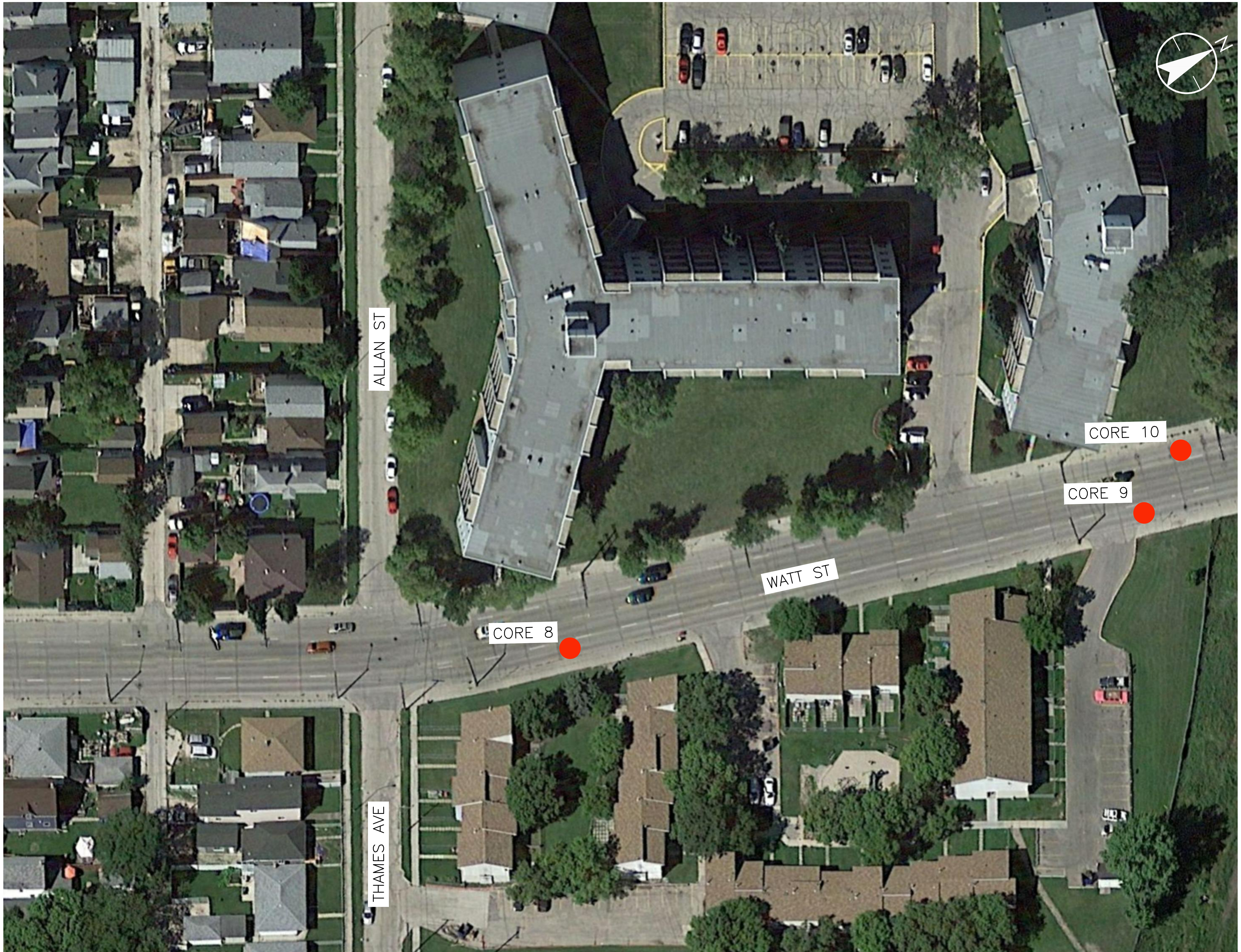

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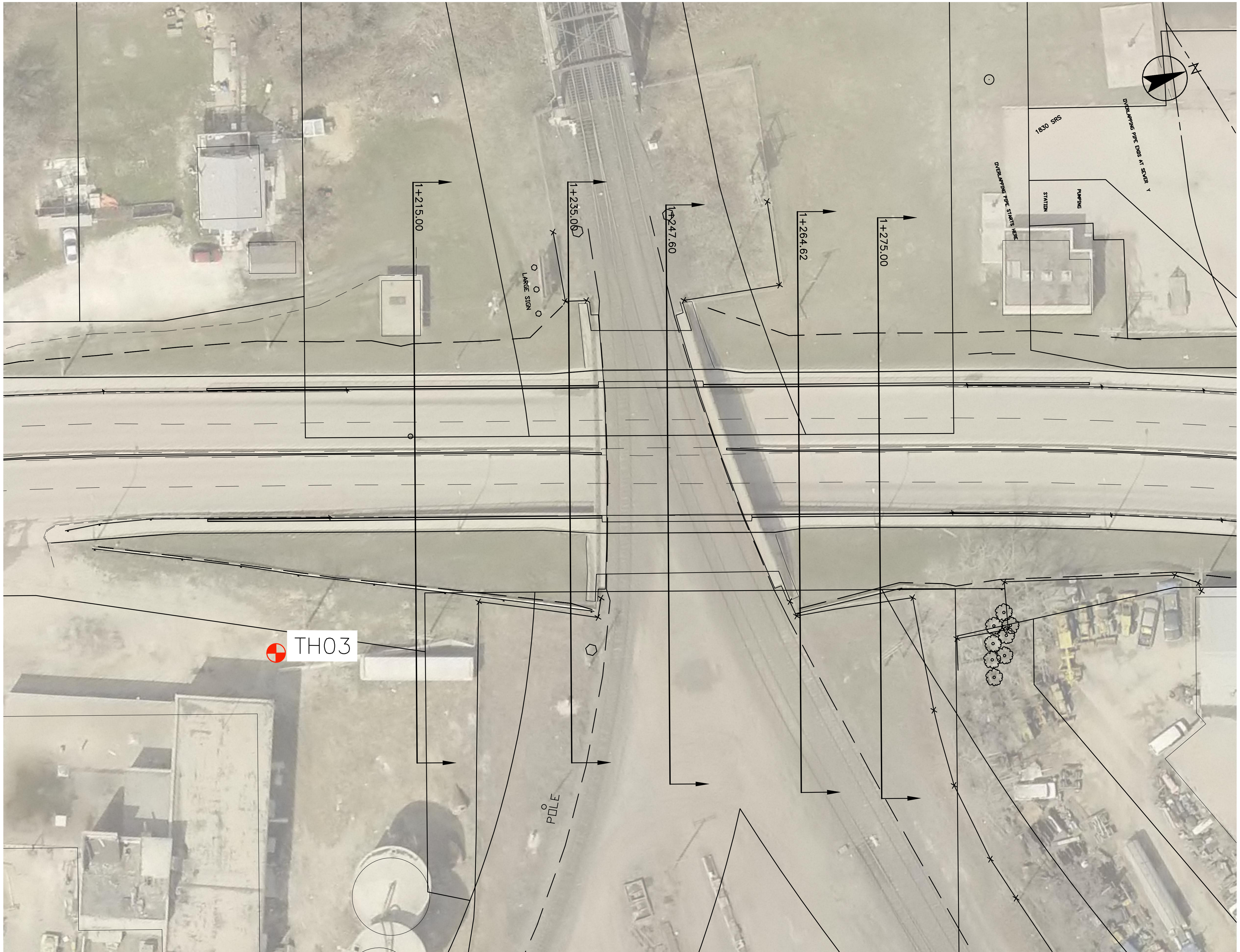

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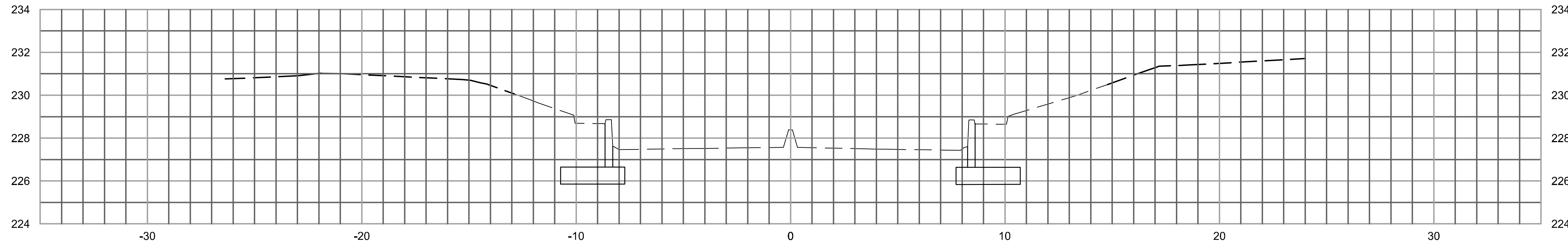

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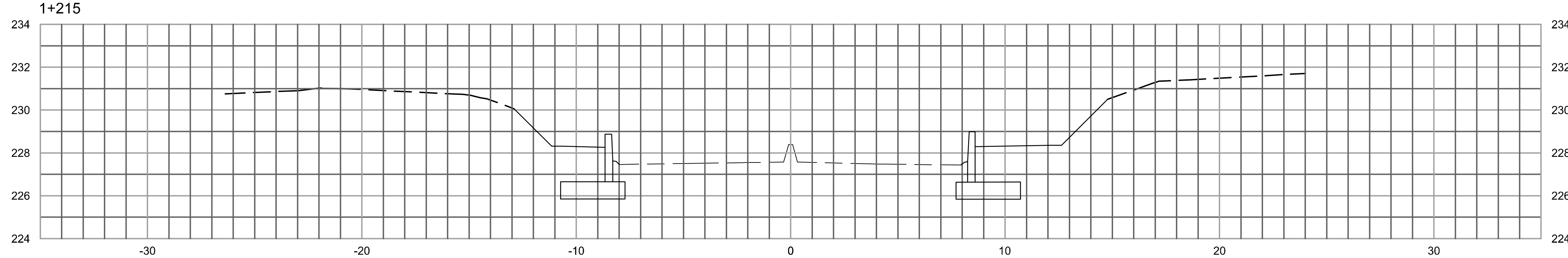

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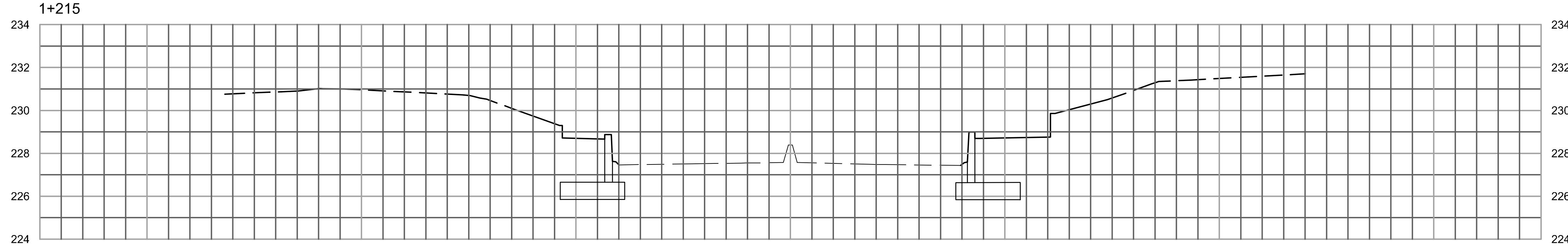

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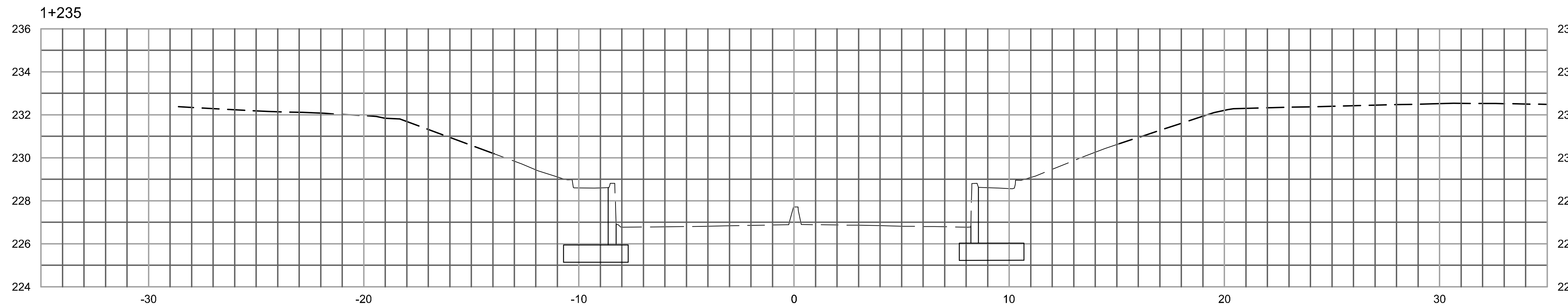

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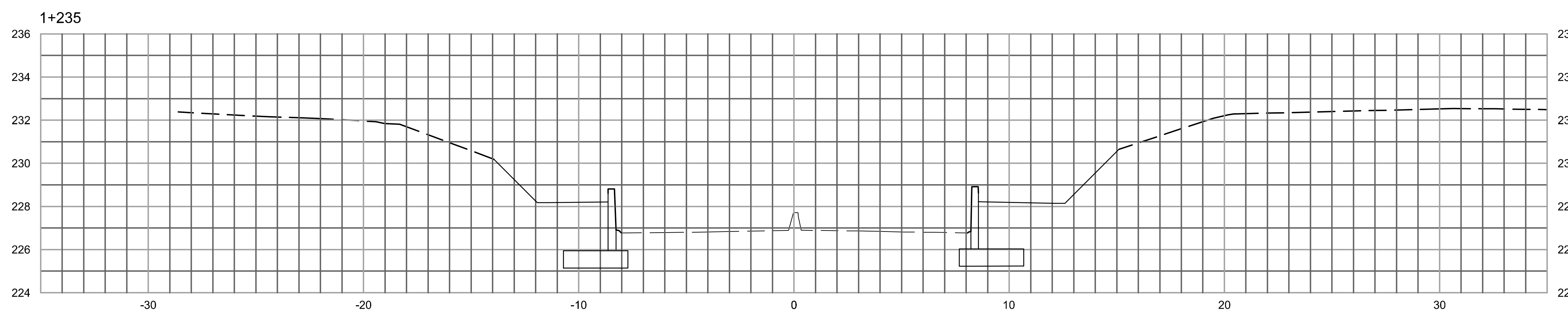

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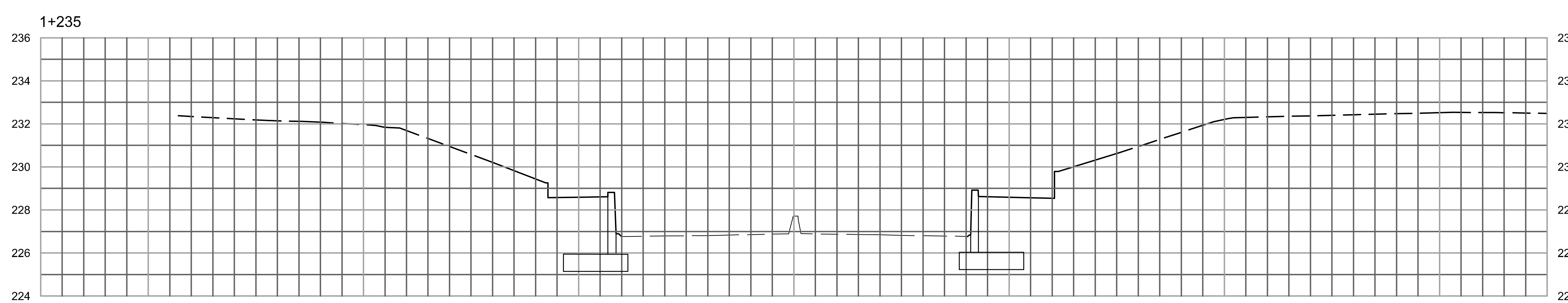

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Drawing No. C-107

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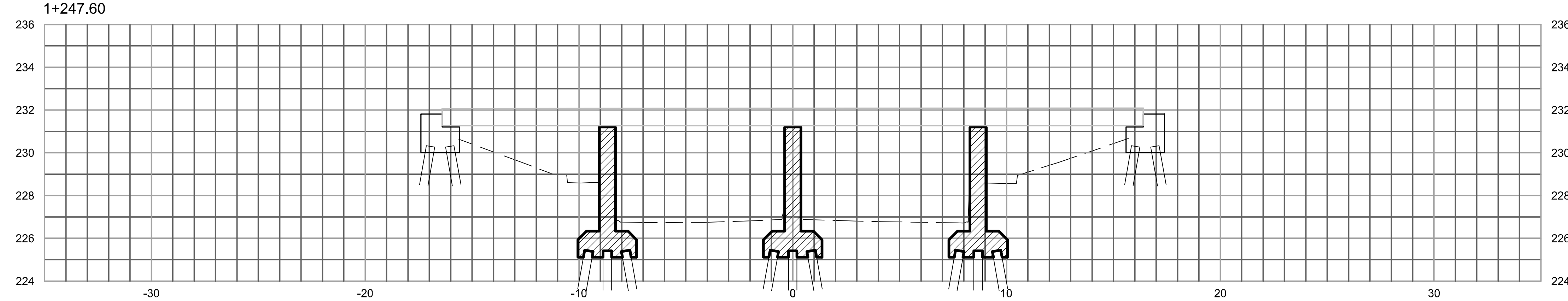

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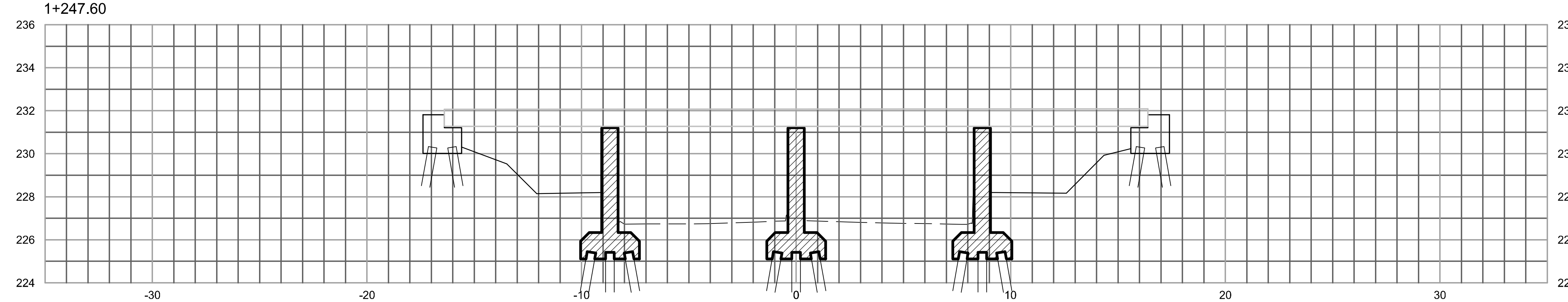

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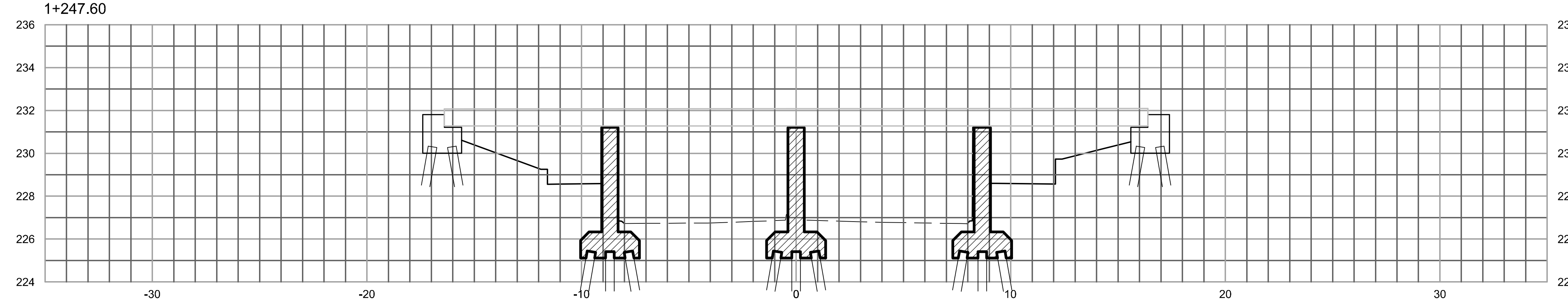

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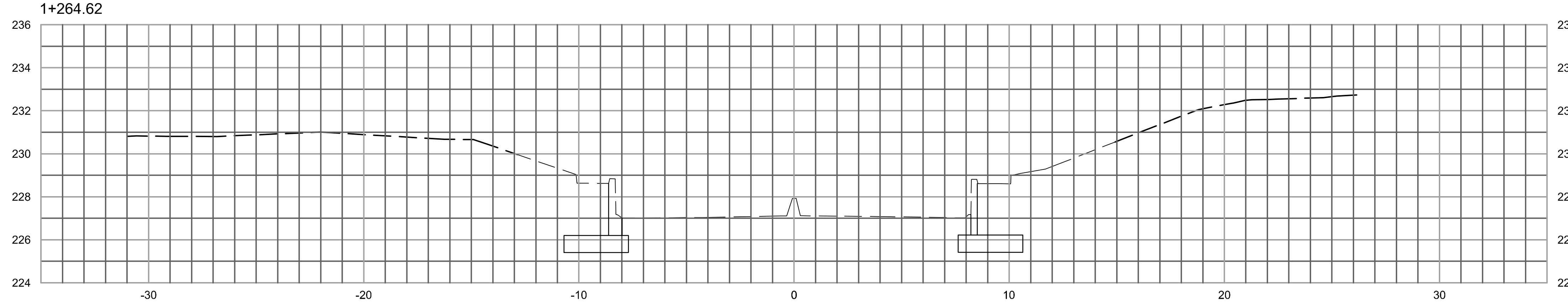

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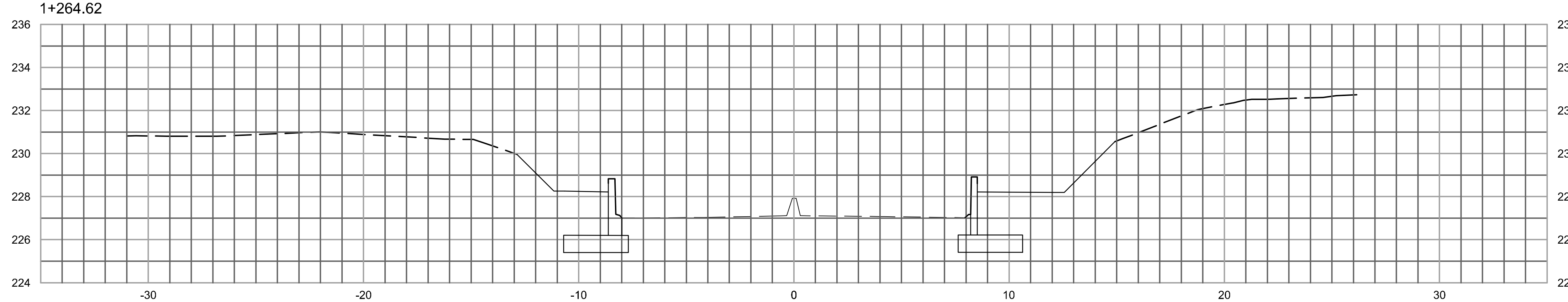

FINAL CONDITIONS

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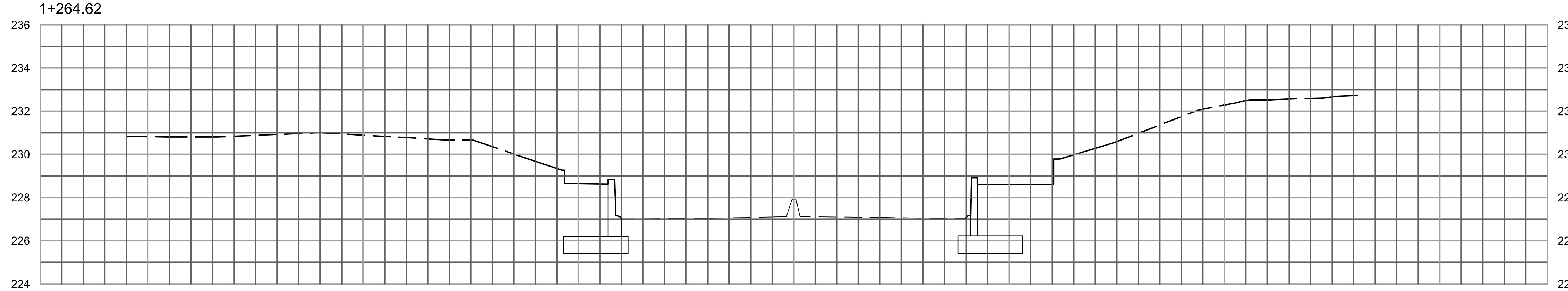

ORIGINAL SHEET - ISO 11x17 - v14.06

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Stantec Consulting Ltd.
Suite 500, 311 Portage Avenue
Winnipeg MB Canada R3B 2B9
Tel. 204.489.5900 Fax. 204.453.9012
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Legend

Notes

Revision	By	Appd.	YY.MM.DD
5			
4			
3			
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D			
C			
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File Name: 06881_c-106	Dwn.	Chkd.	Dsgn.	YY.MM.DD
				16.06.15

Permit-Seal

Client/Project

CITY OF WINNIPEG

2016 REGIONAL STREET RENEWAL PROGRAM
ARCHIBALD STREET MILL AND FILL AND REHABILITATION

WINNIPEG, MB

Title

CROSS SECTION 1 + 264.62
EXISTING, CONSTRUCTION AND
FINAL CONDITIONS

Project No. 113706881

Scale 1:1000 (0 10 30)

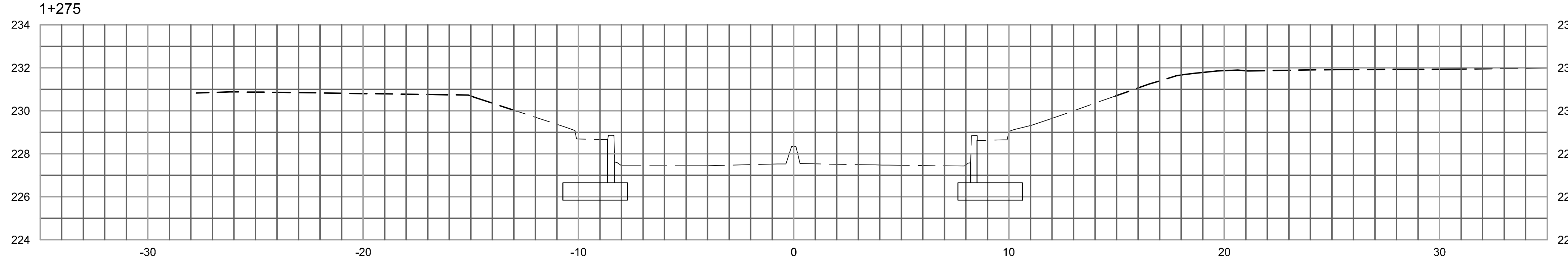
Drawing No. C-109

Sheet 9 of 10

Revision 0

EXISTING CONDITIONS

1+275



CONSTRUCTION CONDITIONS

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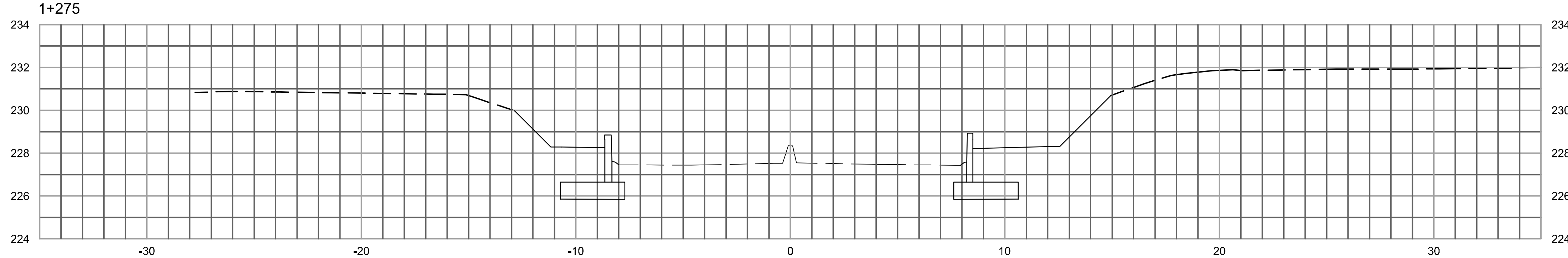
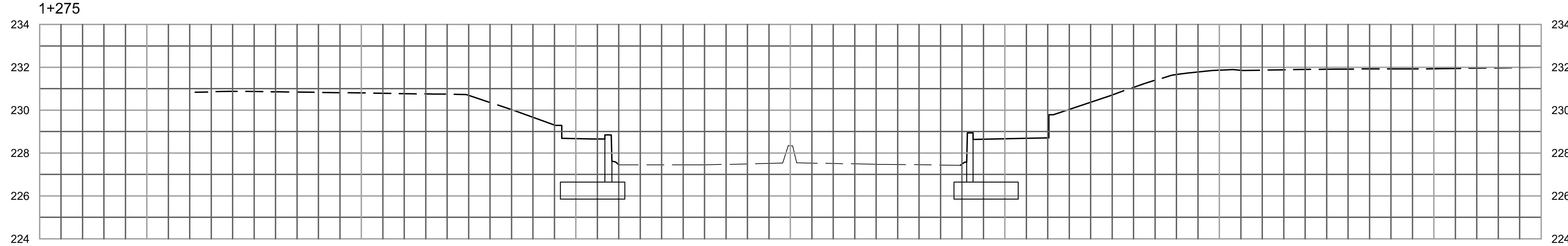


FINAL CONDITIONS

1+275



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2016/06/15 3:18 PM By: Bun, Sothea

ORIGINAL SHEET - ISO 11x17 - v14.06

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Notes

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File Name: 06881_c-106 — Dwn. Chkd. Dsgn. YY.MM.DD 16.06.15

Permit-Seal

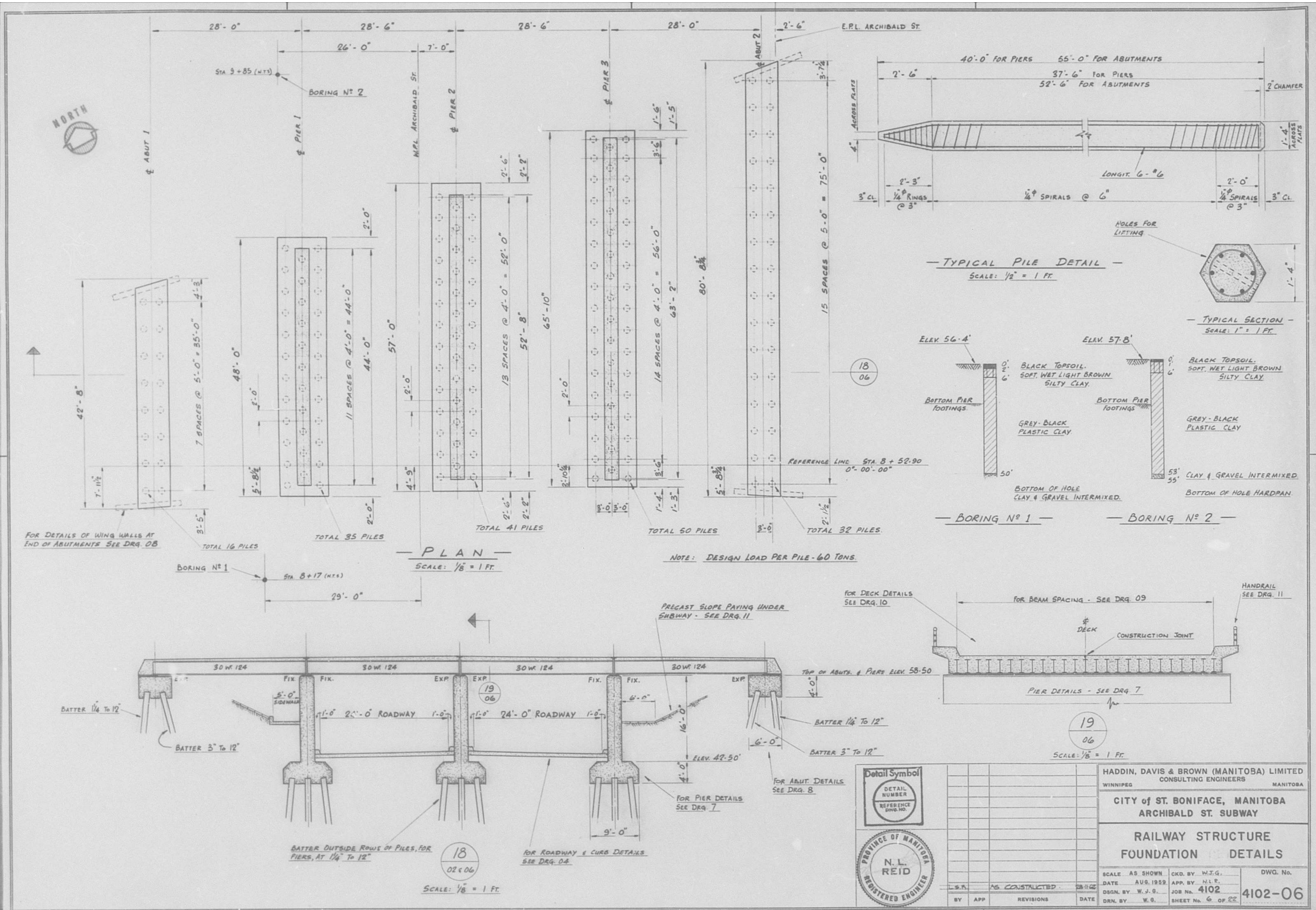
Client/Project
CITY OF WINNIPEG

2016 REGIONAL STREET RENEWAL PROGRAM
ARCHIBALD STREET MILL AND FILL AND REHABILITATION
WINNIPEG, MB

Title
CROSS SECTION 1 + 275
EXISTING, CONSTRUCTION AND
FINAL CONDITIONS

Project No.	Scale
113706881	1:1000 (0 10 30)

Drawing No.	Sheet	Revision
C-110	10 of 10	0



PLAN
SCALE: 1/8" = 1 FT.
NORTH
℄ ABUT 1
℄ PIER 1
W.P.L. ARCHIBALD ST.
℄ PIER 2
℄ PIER 3
℄ ABUT 2
E.P.L. ARCHIBALD ST.
28'-0"
28'-6"
28'-6"
28'-0"
26'-0"
7'-0"
2'-6"
STA 9 + 85 (N.T.S.)
BORING Nº 2
STA 8+17 (N.T.S.)
BORING Nº 1
29'-0"
7 SPACES @ 5'-0" = 35'-0"
11 SPACES @ 4'-0" = 44'-0"
13 SPACES @ 4'-0" = 52'-0"
14 SPACES @ 4'-0" = 56'-0"
15 SPACES @ 5'-0" = 75'-0"
42'-8"
48'-0"
57'-0"
65'-10"
80'-8¾"
44'-0"
52'-8"
63'-2"
REFERENCE LINE STA. 8 + 52.90
0°-00'-00"
FOR DETAILS OF WING WALLS AT END OF ABUTMENTS SEE DRG. 08
TOTAL 16 PILES
TOTAL 35 PILES
TOTAL 41 PILES
TOTAL 50 PILES
TOTAL 32 PILES.
NOTE: DESIGN LOAD PER PILE - 60 TONS.
18
06
40'-0" FOR PIERS 55'-0" FOR ABUTMENTS
2'-6"
37'-6" FOR PIERS
52'-6" FOR ABUTMENTS
2" CHAMFER
ACROSS FLATS
1'-4" ACROSS FLATS
LONGIT. 6 - #6
3" CL.
2'-3"
¼"φ RINGS @ 3"
¼"φ SPIRALS @ 6"
2'-0"
¼"φ SPIRALS @ 3"
— TYPICAL PILE DETAIL —
SCALE: ½" = 1 FT.
HOLES FOR LIFTING
1'-4"
— TYPICAL SECTION —
SCALE: 1" = 1 FT.
ELEV. 56.4'
BLACK TOPSOIL.
SOFT, WET LIGHT BROWN SILTY CLAY.
BOTTOM PIER FOOTINGS
GREY-BLACK PLASTIC CLAY
BOTTOM OF HOLE CLAY & GRAVEL INTERMIXED.
— BORING Nº 1 —
ELEV. 57.8'
BLACK TOPSOIL.
SOFT, WET LIGHT BROWN SILTY CLAY
BOTTOM PIER FOOTINGS
GREY-BLACK PLASTIC CLAY
CLAY & GRAVEL INTERMIXED
BOTTOM OF HOLE HARDPAN.
— BORING Nº 2 —
PRECAST SLOPE PAVING UNDER SUBWAY - SEE DRG. 11
30 W. 124
EXP.
FIX.
TOP OF ABUTS. & PIERS ELEV. 58.50
BATTER 1¼ TO 12"
BATTER 3" TO 12"
5'-0" SIDEWALK
24'-0" ROADWAY
16'-0"
ELEV. 42.50'
6'-0"
9'-0"
FOR ABUT. DETAILS SEE DRG. 8
FOR PIER DETAILS SEE DRG. 7
BATTER OUTSIDE ROWS OF PILES, FOR PIERS, AT 1¼" TO 12"
FOR ROADWAY & CURB DETAILS SEE DRG. 04
18
02 & 06
SCALE: 1/8" = 1 FT.
FOR DECK DETAILS SEE DRG. 10
FOR BEAM SPACING - SEE DRG 09
HANDRAIL SEE DRG. 11
℄ DECK
CONSTRUCTION JOINT
PIER DETAILS - SEE DRG 7
19
06
SCALE: 1/8" = 1 FT.
Detail Symbol
DETAIL NUMBER
REFERENCE DWG. NO.
PROVINCE OF MANITOBA
N.L. REID
REGISTERED ENGINEER
L.S.R.
AS CONSTRUCTED
BY
APP
REVISIONS
DATE
HADDIN, DAVIS & BROWN (MANITOBA) LIMITED
CONSULTING ENGINEERS
WINNIPEG
MANITOBA
CITY of ST. BONIFACE, MANITOBA
ARCHIBALD ST. SUBWAY
RAILWAY STRUCTURE
FOUNDATION DETAILS
SCALE AS SHOWN
DATE AUG. 1959
DSGN. BY W. J. G.
DRN. BY W. G.
CKD. BY W.J.G.
APP. BY N.L.R.
JOB No. 4102
SHEET No. 6 OF 22
DWG. No.
4102-06

Appendix C
PAVEMENT CORE PHOTOS

Photo 1 – Core TH01

Photo 2 – Core TH02

Photo 3 – Core 1

Photo 4 – Core 2

Photo 5 – Core 3

Photo 6 – Core 4

Photo 7 – Core 5

Photo 8 – Core 6

Photo 9 – Core 7

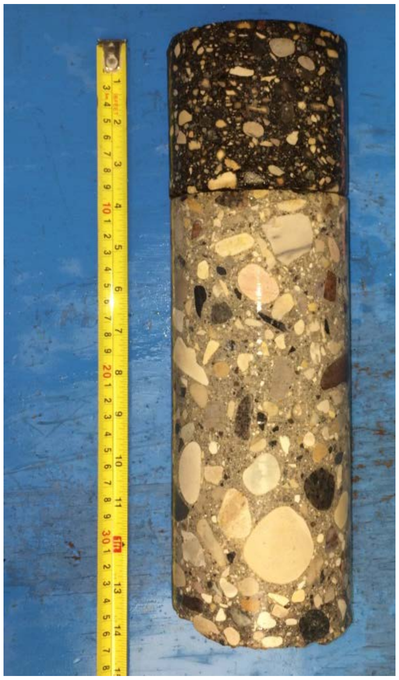


Photo 10 – Core 8

Photo 11 – Core 9

Photo 12 – Core 10

Appendix D
TESTHOLE LOGS

Stantec

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta-morphic Bedrock	Sedi-mentary Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

▼ measured in standpipe, piezometer, or well

▽ inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_U	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

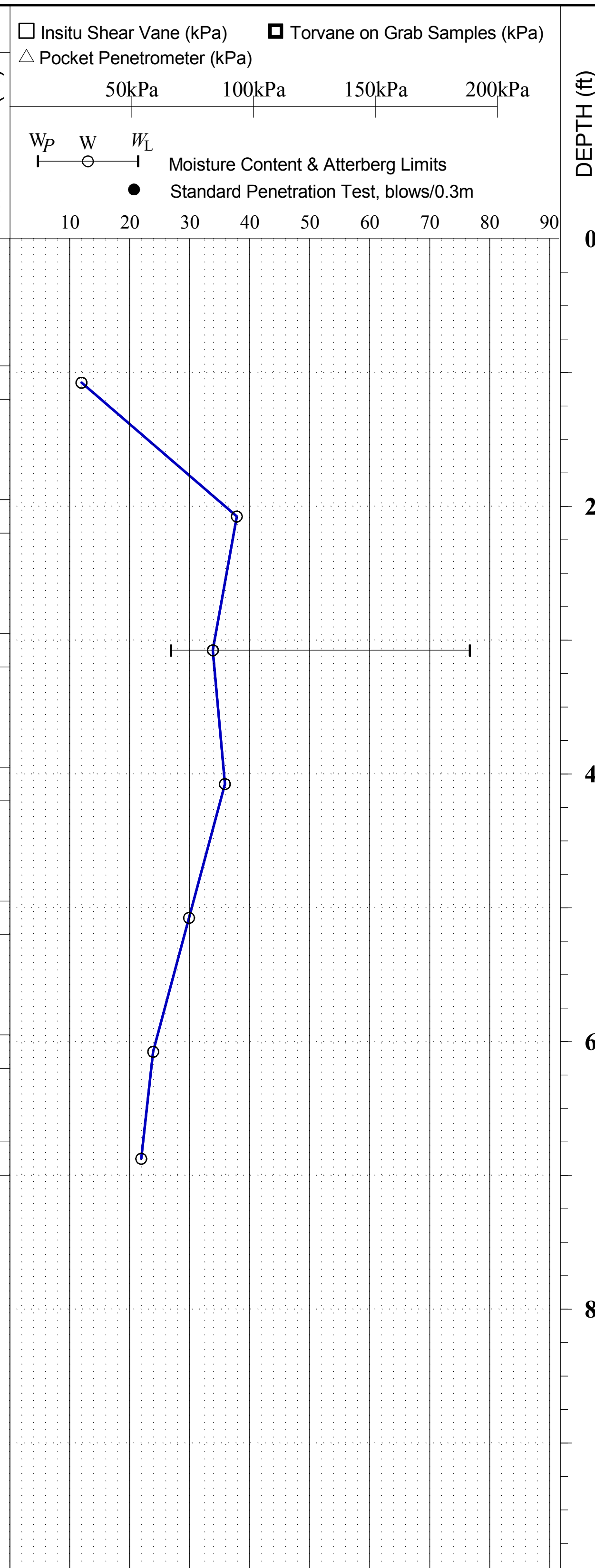
	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

TH01 TESTHOLE RECORD

CLIENT	City of Winnipeg	PROJECT No.	113706881
PROJECT	Archibald & Watt Street Renewal	DATUM	NAD83
NORTHING	5529319		
LOCATION	Winnipeg, MB	ELEVATION	230.7 m
EASTING	635948		
DRILLING DATE	February 22, 2016	DRILLING CO.	Paddock Drilling Ltd.
DRILLING METHOD	150 mm SSA		

DEPTH (m)	SOIL TYPE	SOIL DESCRIPTION	SAMPLE TYPE	MOISTURE CONTENT (%)
0	AS	ASPHALT		
	CO	CONCRETE		
	GW	BASE: crushed limestone max aggregate size 25 mm	GS	12
	CH	Black stiff fat CLAY (CH)		
			GS	38
1		Particle Size Analysis at 0.9 m - Gravel 0.0%, Sand 2.2%, Silt 25.8%, Clay 72.0% - grey below 0.9 m	GS	34
			GS	36
		- trace silt below 1.4 m		
			GS	30
	ML	Tan soft SILT (ML)		
			GS	24
2			GS	22

• The soil was frozen to a depth of 0.8 m.
• No groundwater seepage or soil sloughing was observed during or upon completion of drilling.
• Testhole terminated at a depth of 2.1 m.



Sample Type: GS - Grab Sample SPT - Standard Penetration Test ST - Shelby Tube PT - Piston Tube VT - Shear Vane Test

Piezometer Backfill Type: Bentonite, Drill Cuttings, Sand, Slough

Logged by: Sothea Bun
Reviewed by: German Leal

Stantec

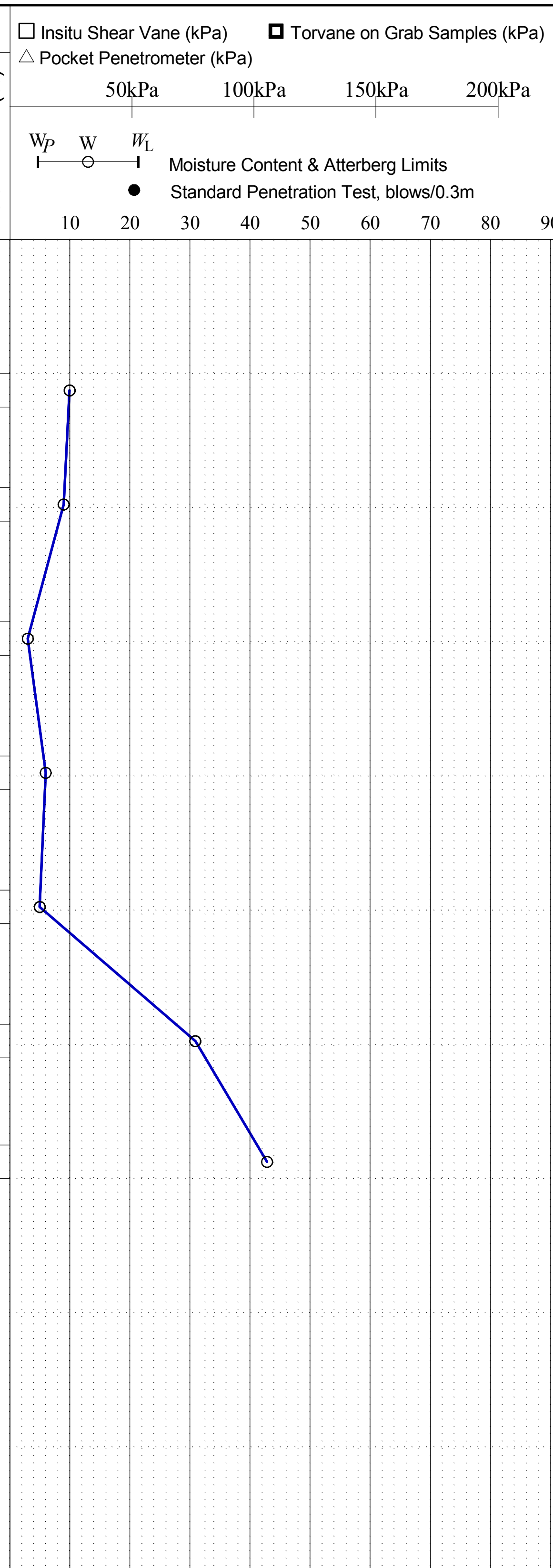
TH02 TESTHOLE RECORD

CLIENT: City of Winnipeg
PROJECT No.: 113706881
PROJECT: Archibald & Watt Street Renewal
DATUM: NAD83
NORTHING: 5529374
LOCATION: Winnipeg, MB
ELEVATION: 230.6 m
EASTING: 635963
DRILLING DATE: February 22, 2016
DRILLING CO.: Paddock Drilling Ltd.
DRILLING METHOD: 150 mm SSA

DEPTH (m)	SOIL TYPE	SOIL DESCRIPTION
0	AS	ASPHALT
	CO	CONCRETE
	GW	BASE: crushed limestone max aggregate size 25 mm
	CL ML	Grey firm SILTY CLAY (CL-ML)

• No groundwater seepage or soil sloughing was observed during or upon completion of drilling.
• Testhole terminated at a depth of 2.1 m.

SAMPLE TYPE	MOISTURE CONTENT (%)
GS	10
GS	9
GS	3
GS	6
GS	5
GS	31
GS	43



Depth (m): 0, 1, 2, 3 — Depth (ft): 0, 2, 4, 6, 8, 10

Sample Type: GS - Grab Sample, SPT - Standard Penetration Test, ST - Shelby Tube, PT - Piston Tube, VT - Shear Vane Test

Piezometer Backfill Type: Bentonite, Drill Cuttings, Sand, Slough

Logged by: Sothea Bun
Reviewed by: German Leal

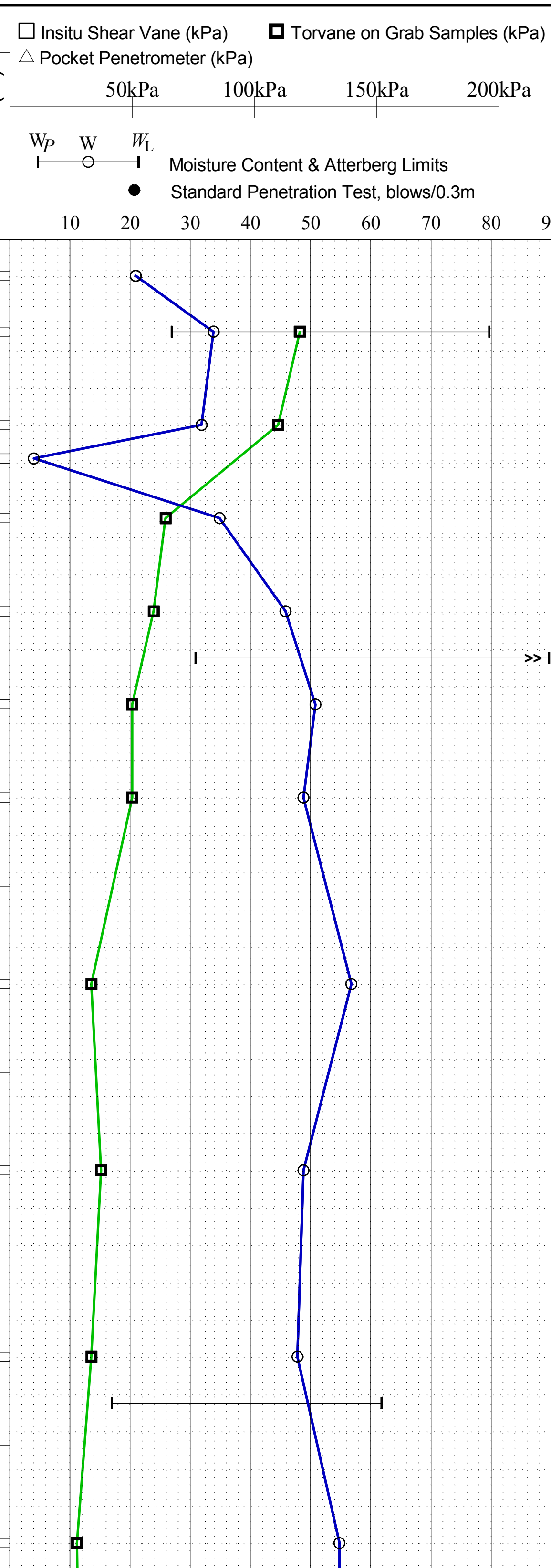
Stantec

TH03 TESTHOLE RECORD

CLIENT	City of Winnipeg	PROJECT No.	113706881
PROJECT	Archibald & Watt Street Renewal	DATUM NAD83	NORTHING 5529466
LOCATION	Winnipeg, MB	ELEVATION 231.1 m	EASTING 636005
DRILLING DATE	February 22, 2016	DRILLING CO. Paddock Drilling Ltd.	DRILLING METHOD 150 mm SSA

SOIL TYPE	SOIL DESCRIPTION
TP	TOPSOIL: black, some organics
FL	FILL: very stiff brown clay some silt, fine to coarse sand Particle Size Analysis at 0.8 m - Gravel 0.0%, Sand 2.3%, Silt 27.0%, Clay 70.7%
SP	FILL: Loose tan sand some fine to coarse gravel
CH	Stiff brown fat CLAY (CH) Particle Size Analysis at 3.0 m - Gravel 0.0%, Sand 0.4%, Silt 12.0%, Clay 87.6% - firm below 6.1 m - grey below 8.7 m Particle Size Analysis at 9.1 m - Gravel 0.3%, Sand 7.7%, Silt 27.9%, Clay 64.1%

SAMPLES TYPE	NUMBER	MOISTURE CONTENT (%)
GS		21
GS		34
GS		32
GS		4
GS		35
GS		46
ST		
GS		51
GS		49
ST		
GS		57
ST		
GS		49
GS		48
ST		
GS		55



DEPTH (m): 0–10; DEPTH (ft): 0–36

Sample Type: GS - Grab Sample, SPT - Standard Penetration Test, ST - Shelby Tube, PT - Piston Tube, VT - Shear Vane Test

Piezometer Backfill Type: Bentonite, Drill Cuttings, Sand, Slough

Logged by: Sothea Bun

Reviewed by: German Leal

Stantec

TH03 TESTHOLE RECORD

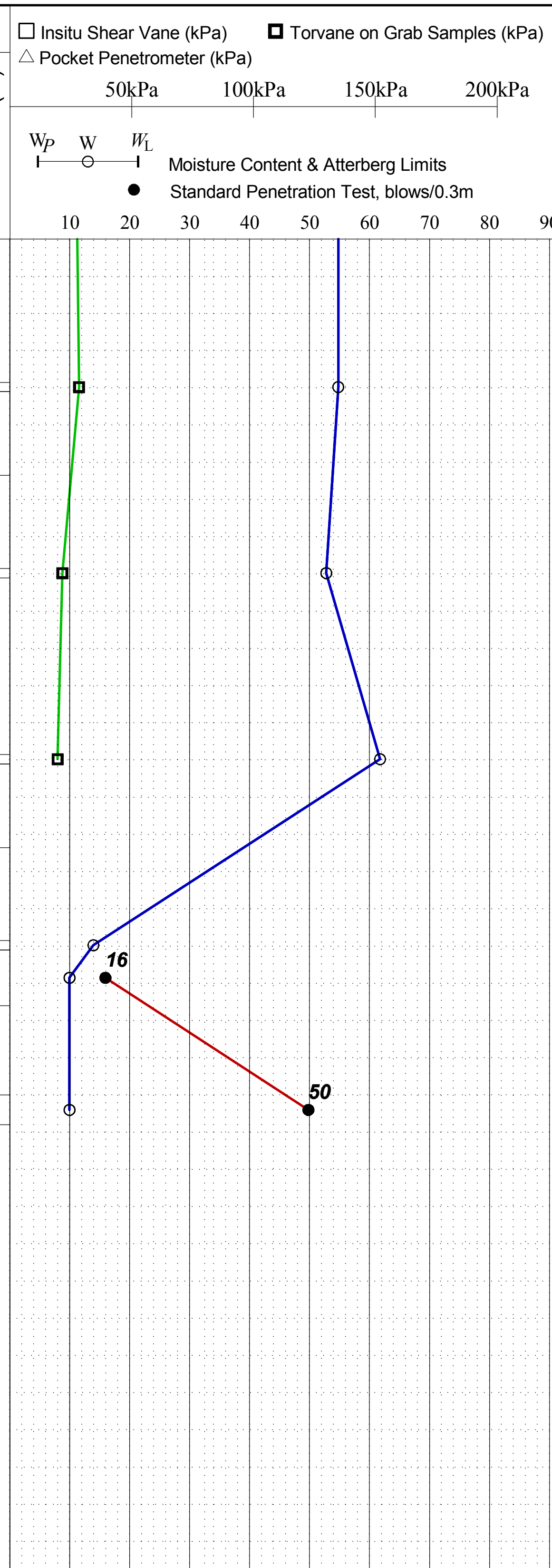
cont'd

CLIENT City of Winnipeg | PROJECT No. 113706881
PROJECT Archibald & Watt Street Renewal | DATUM NAD83 | NORTHING 5529466
LOCATION Winnipeg, MB | ELEVATION 231.1 m | EASTING 636005
DRILLING DATE February 22, 2016 | DRILLING CO. Paddock Drilling Ltd. | DRILLING METHOD 150 mm SSA

DEPTH (m)	SOIL TYPE	SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	MOISTURE CONTENT (%)	DEPTH (ft)
11						36
12			GS		55	38, 40
			ST			42
13		- soft below 13.7 m	GS		53	44
14						46, 48
15		- trace till inclusions below 14.9 m	GS		62	50
16			ST			52, 54
	TL	Compact tan silt (ML) TILL				
17	TL	- some sand below 16.8 m	GS		14	56
	TL		SS		10	58
18	TL	- very dense below 18.0 m	SS		10	60

- Moderate groundwater seepage was observed at a depth of 16.5 m.
- Groundwater level was observed at a depth of 9.8 m upon completion of drilling.
- No soil sloughing was observed during or upon completion of drilling.
- Auger refusal at a depth of 18.1 m on dense till.
- Vibrating wire piezometer installed, with tip at a depth of 9.1 m.

Depth (m): 19, 20, 21 — Depth (ft): 62, 64, 66, 68, 70, 72



Sample Type: GS - Grab Sample SPT - Standard Penetration Test
ST - Shelby Tube PT - Piston Tube VT - Shear Vane Test

Piezometer Backfill Type: Bentonite, Drill Cuttings, Sand, Slough

Logged by: Sothea Bun
Reviewed by: German Leal

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Appendix E
LABORATORY TESTING RESULTS

E.1 ARCHIBALD STREET RESULTS

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

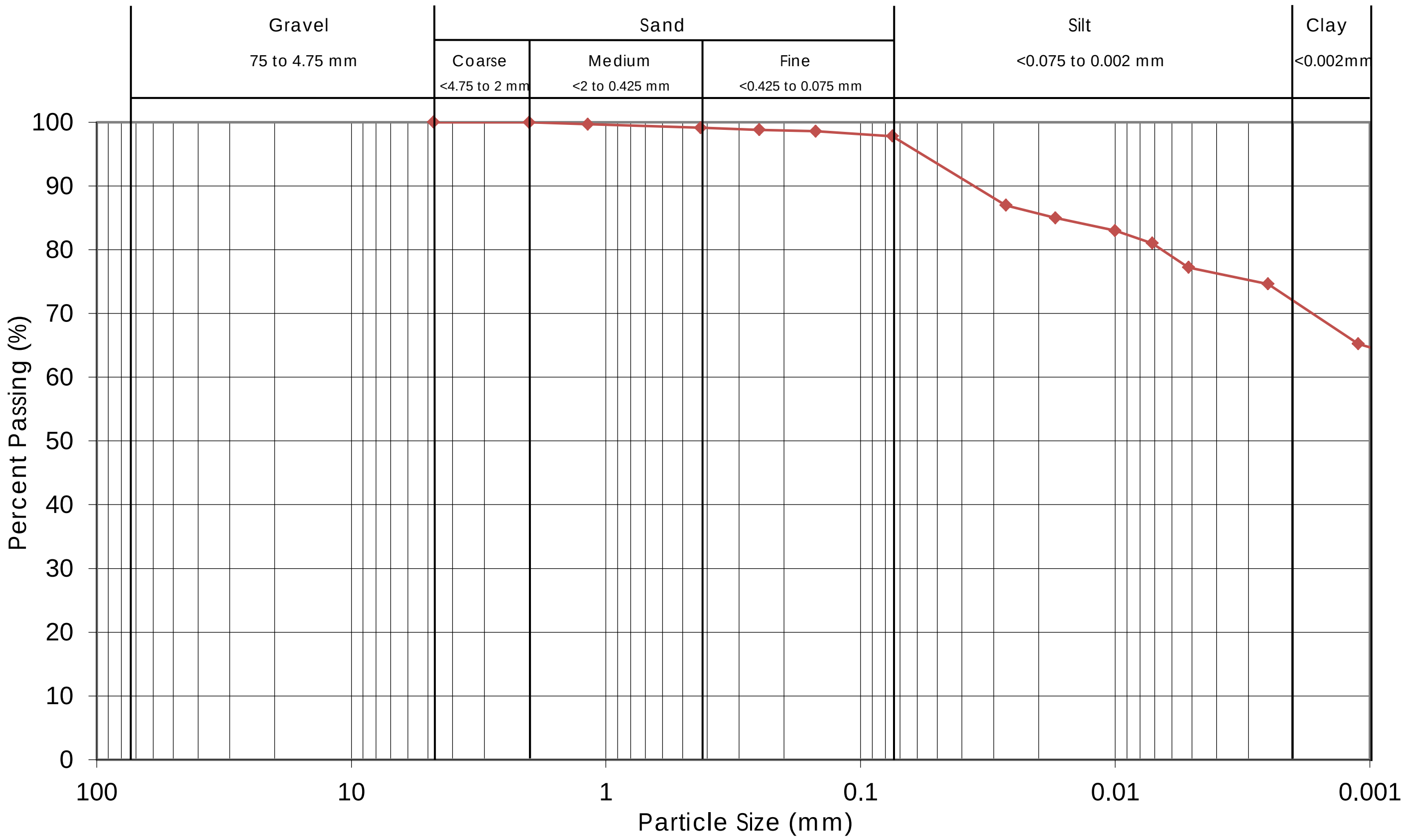
PARTICLE SIZE ANALYSIS
ASTM D422

The City of Winnipeg Corporate Finance Department Materials Management Division
185 King Street, Main Floor
Winnipeg, Manitoba
R3B 1J1

Project No.: 113706881
Project Name: Archibald and Watt Street Renewal

Date Samples Received: February 22, 2016
Tested By: Larry Presado, C.Tech.

Material Type: Clay



Symbol	Sample ID	Gravel, % 75 to 4.75 mm	Sand, % Coarse <4.75 to 2.0 mm	Sand, % Medium <2.0 to 0.425 mm	Sand, % Fine <0.425 to 0.075 mm	Silt, % <0.075 to 0.002 mm	Clay, % <0.002 mm	Colloids, % < 0.001 mm
◆	TH1 - 0.9 m	0.0	0.0	0.9	1.3	25.8	72.0	64.7

NT*: Sample not tested for colloids.

Reviewed By: Justin Saj, B.Sc., EIT
Date Reviewed: March 5, 2016

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS
ASTM D4318

The City of Winnipeg Corporate Finance
Department Materials Management Division
185 King Street, Main Floor
Winnipeg, Manitoba
R3B 1J1

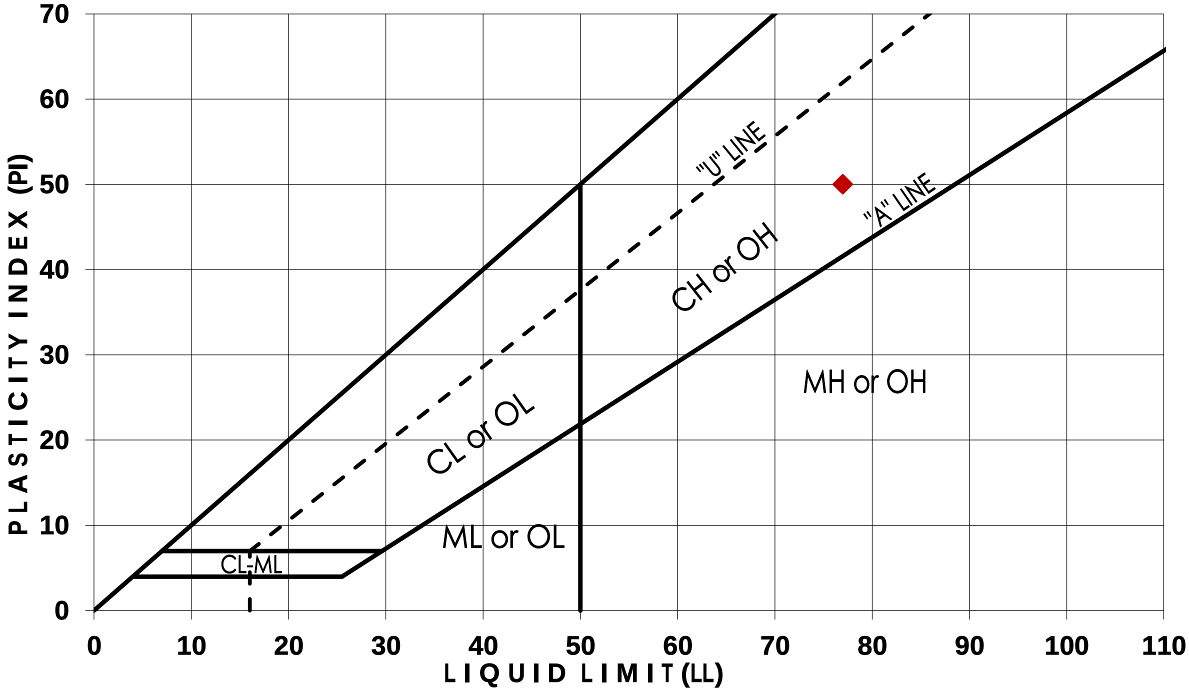
Project No.: 113706881
Project Name: Archibald and Watt Street Renewal

Date Samples Received: February 22, 2016
Tested By: Larry Presado, C.Tech.

Material Type: Clay

Symbol	Testhole No.	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	USCS
◆	TH1	0.9	77	27	50	CH

Plasticity Chart



Reviewed By: Justin Saj, B.Sc., EIT
Date Reviewed: March 5, 2016

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of the test results is provided only on written request. The data presented above is for the sole use of the client stipulated above. Stantec is not responsible, nor can be held liable, for the use of this report by any other party, with or without the knowledge of Stantec.

E.2 ARCHIBALD UNDERPASS RESULTS

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

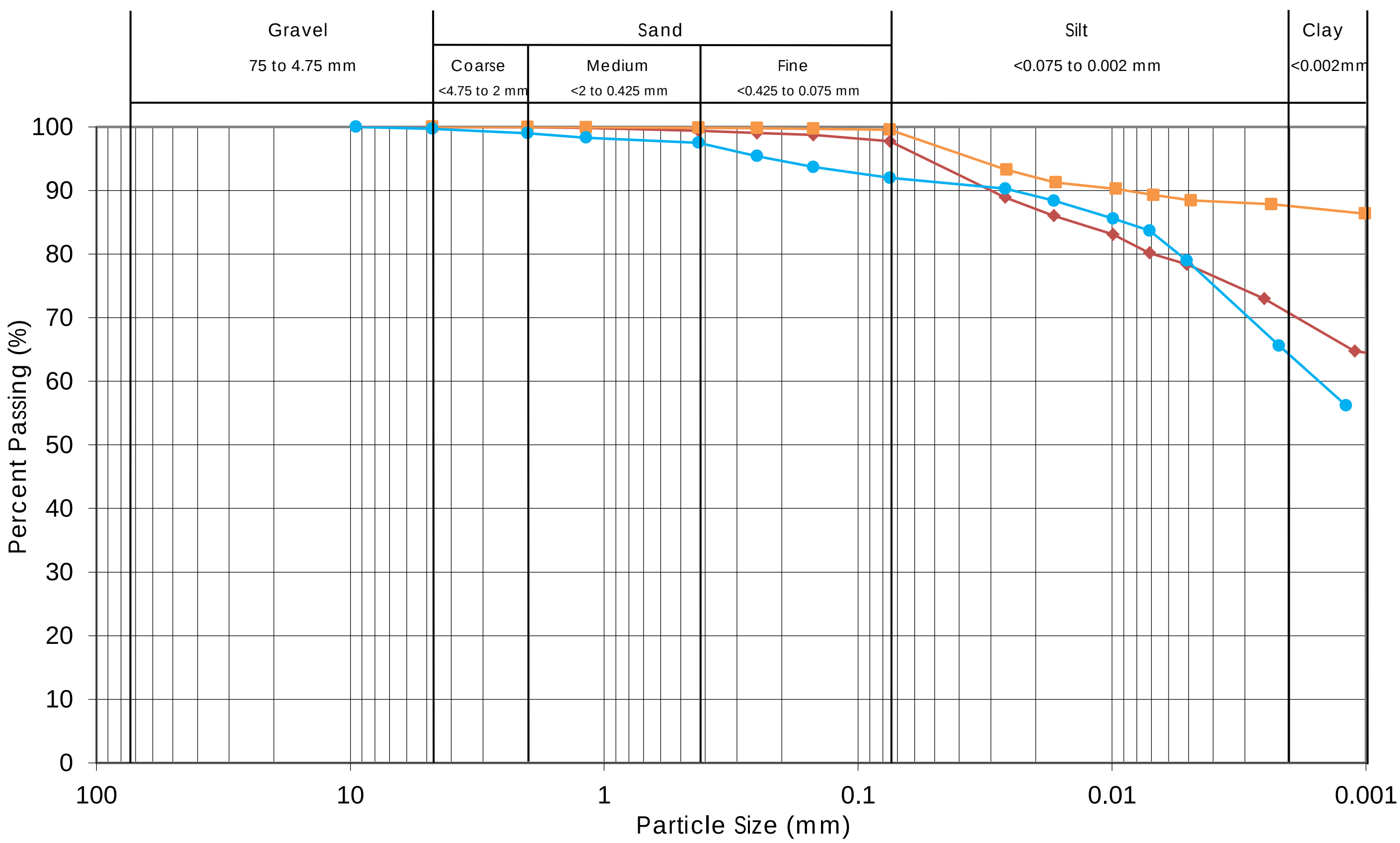
PARTICLE SIZE ANALYSIS
ASTM D422

The City of Winnipeg Corporate Finance
Department Materials Management Division
185 King Street, Main Floor
Winnipeg, Manitoba
R3B 1J1

Project No.: 113706881
Project Name: Archibald and Watt Street Renewal

Date Samples Received: February 22, 2016
Tested By: Larry Presado, C.Tech.

Material Type: Clay



Symbol	Sample ID	Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.002 mm	Clay, % <0.002 mm	Colloids, % < 0.001 mm
			Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
◆	TH3 - 0.8 m	0.0	0.0	0.6	1.7	27.0	70.7	64.5
■	TH3 - 3.0 m	0.0	0.0	0.1	0.3	12.0	87.6	86.4
●	TH3 - 9.1 m	0.3	0.7	1.5	5.5	27.9	64.1	NT*

NT*: Sample not tested for colloids.

Reviewed By: Justin Saj, B.Sc., EIT
Date Reviewed: March 5, 2016

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS

ASTM D4318

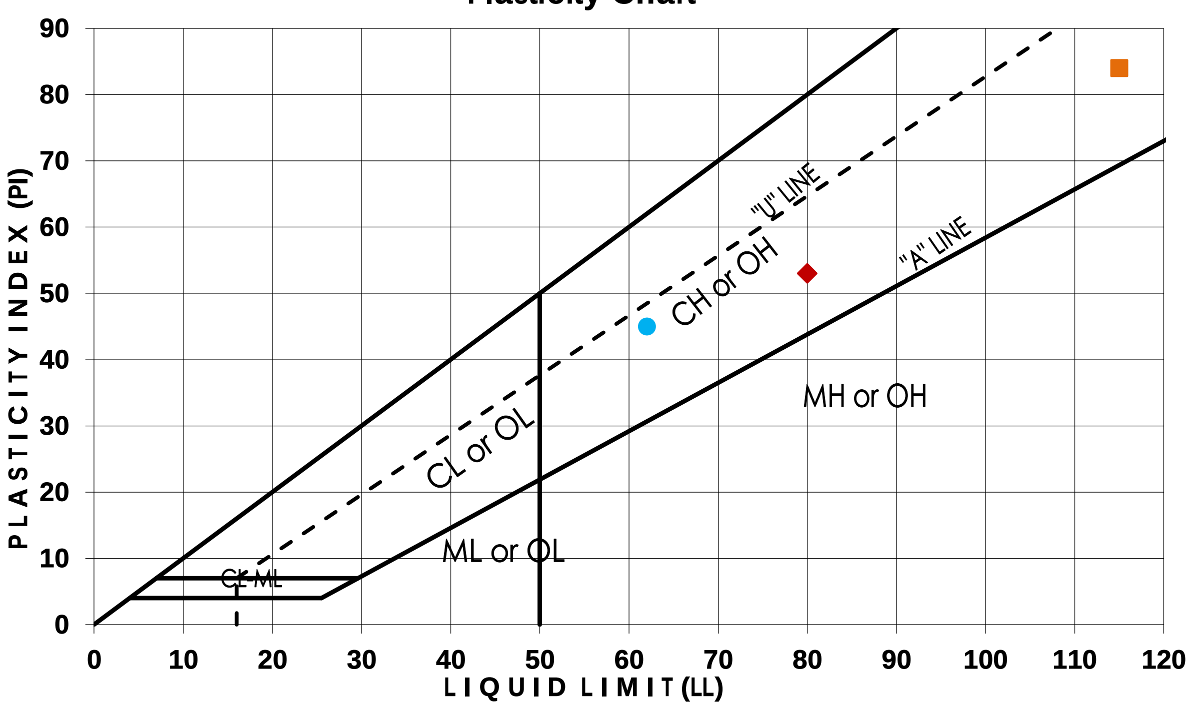
The City of Winnipeg Corporate Finance
Department Materials Management Division
185 King Street, Main Floor
Winnipeg, Manitoba
R3B 1J1

Project No.: 113706881
Project Name: Archibald and Watt Street Renewal

Date Samples Received: February 22, 2016
Material Type: Clay
Tested By: Larry Presado, C.Tech.

Symbol	Testhole No.	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	USCS
◆	TH3	0.9	80	27	53	CH
■	TH3	3.0	115	31	84	CH
●	TH3	9.1	62	17	45	CH

Plasticity Chart



Reviewed By: Justin Saj, B.Sc., EIT
Date Reviewed: March 5, 2016

DETERMINATION OF IN-SITU UNIT WEIGHT OF SOIL

Stantec

Test Method: Laboratory Determination of Density (Unit Weight) of Soil Specimens (ASTM D7263)

Client: City of Winnipeg
Project: Archibald & Watt Street Renewal
Project No.: 113706881
Sampling Method: shelby tube

Sample No.: 7244
Field I. D. : TH3 @ 3.0 m
Date: 25-Feb-16
Technologist: Larry Presado

Sample Description: clay, light brown, firm to stiff, moist, high plasticity, trace silt, trace sand
(Indicate soil type, colour, moisture, consistency, plasticity or grain size, any inclusions)

A - MEASUREMENTS

	Diameter (mm)		Height (mm)
Trial 1	72.77	Trial 1	161.44
Trial 2	72.8	Trial 2	161.32
Trial 3	72.94	Trial 3	161.57
Mean	234.28	Mean	161.44

Volume of Sample, v = 672.68 cm^3

Weight of sample (wet): W = 1136.92 g

Bulk density (wet): D = W/v 16.563 kN/m^3

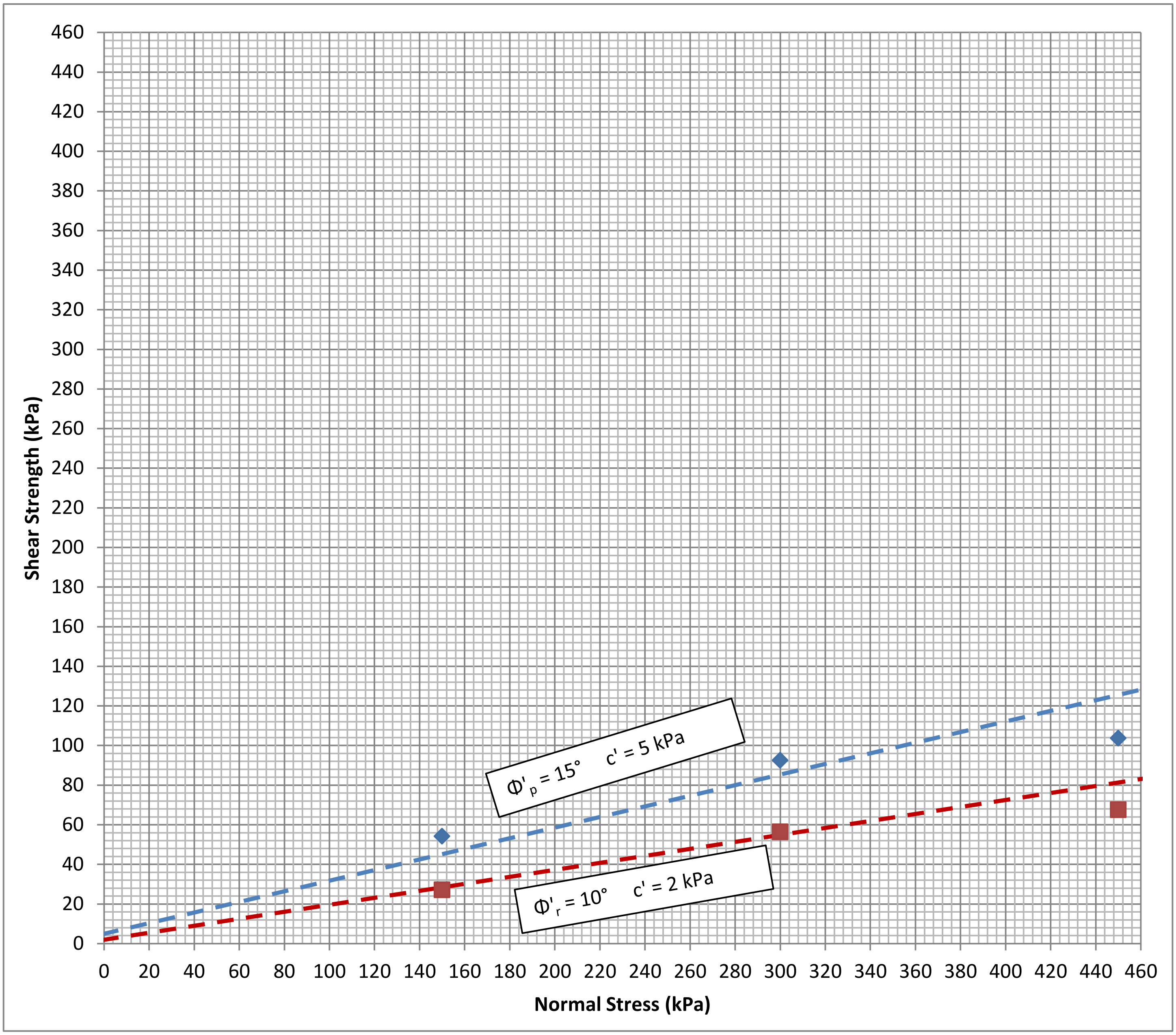
B - MOISTURE CONTENT

	Top (gr)	Bottom (gr)
Tare #	298	295
Tare weight:	20.07	20.88
Weight of Tare + wet sample:	66.81	77.13
Weight Tare + dry sample:	49.97	56.79
Water weight:	16.84	20.34
Weight of dry sample:	29.9	35.91
% water:	56.3	56.6

DIRECT SHEAR TEST RESULTS

ASTM D3080

Archibald Street Underpass - TH3 at 9.1 m



Date	Testhole	Depth	MC	Atterberg Limits			Grain Size Distribution			
				LL	PL	PI	Gravel	Sand	Silt	Clay
25-Mar-16	TH3	9.1 m	44.0%	62	17	45	0.3%	7.7%	27.9%	64.1%

NOTES

MC - Moisture Content
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index

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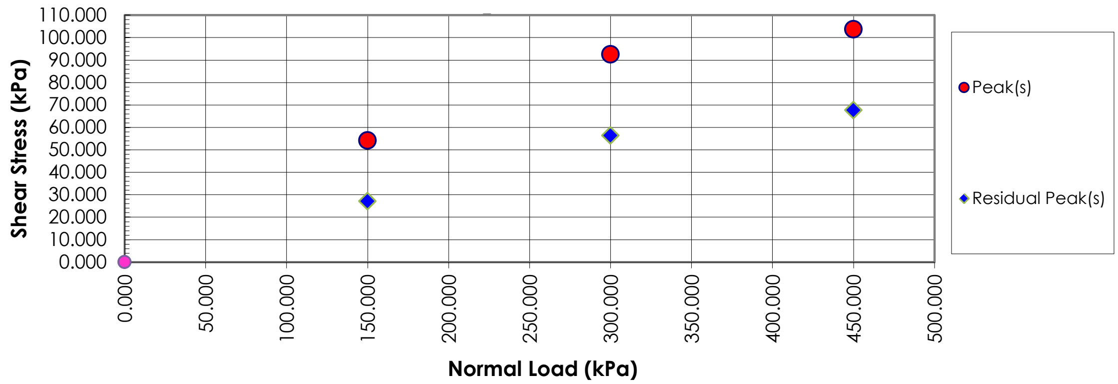
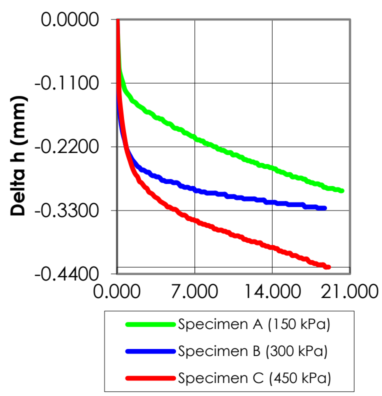
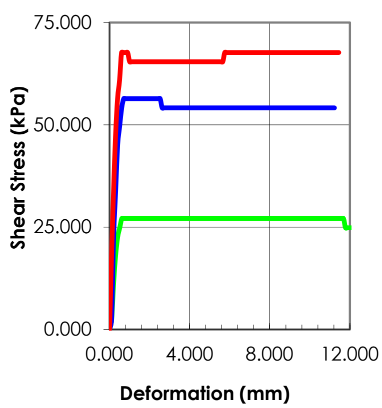
Direct Shear Test

Stantec







	Specimen			
Initial	**A**	**B**	**C**	**D**
Moisture (%)	49.83	49.75	50.27	
Density (g/cm3)	1.134	1.173	1.135	
Void Ratio	1.426	1.344	1.423	
Saturation (%)	96.13	100.00	97.17	
Diameter (mm)	60.000	60.000	60.000	
Height (mm)	25.400	25.400	25.400	

Final	A	B	C	D
Moisture (%)	49.56	39.54	42.78	
Density (g/cm3)	1.100	1.227	1.131	
Void Ratio	1.499	1.241	1.431	
Saturation (%)	95.38	97.04	100.00	
Diameter (mm)	60.000	60.000	60.000	
Height (mm)	24.688	24.040	22.514	
Normal Stress (kPa)	150.0	300.0	450.0	
Peak Stress (kPa)	54.1	92.5	103.7	
Residual Stress (kPa)	27.1	56.4	67.6	
Strain (%)	20.290	18.720	19.083	
Rate (mm/min)	0.008	0.008	0.008	

Project Date	
Date	25-Mar-16

Project:	Archibald & Watt Street Renewal
Location:	
Project Number:	113706880
Boring Number	
Sample Number:	TH03 @ 30' (9.1m)
Depth:	9.1m
Sample Type:	Undisturbed
Description:	Clay
Test Type:	Direct Shear
Remarks:	

Checked By: C.Lamoureux

Date: 25-Mar-16

Tested By: C.Oost

Stantec Consulting Ltd.

Direct Shear Test

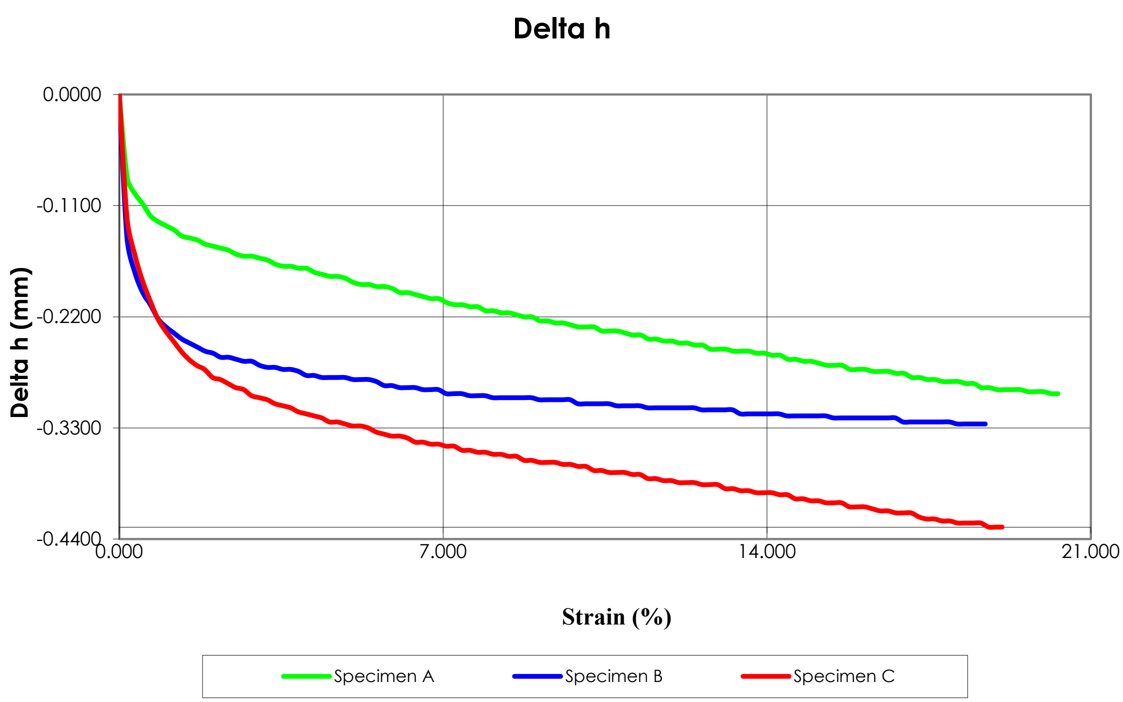
Stantec

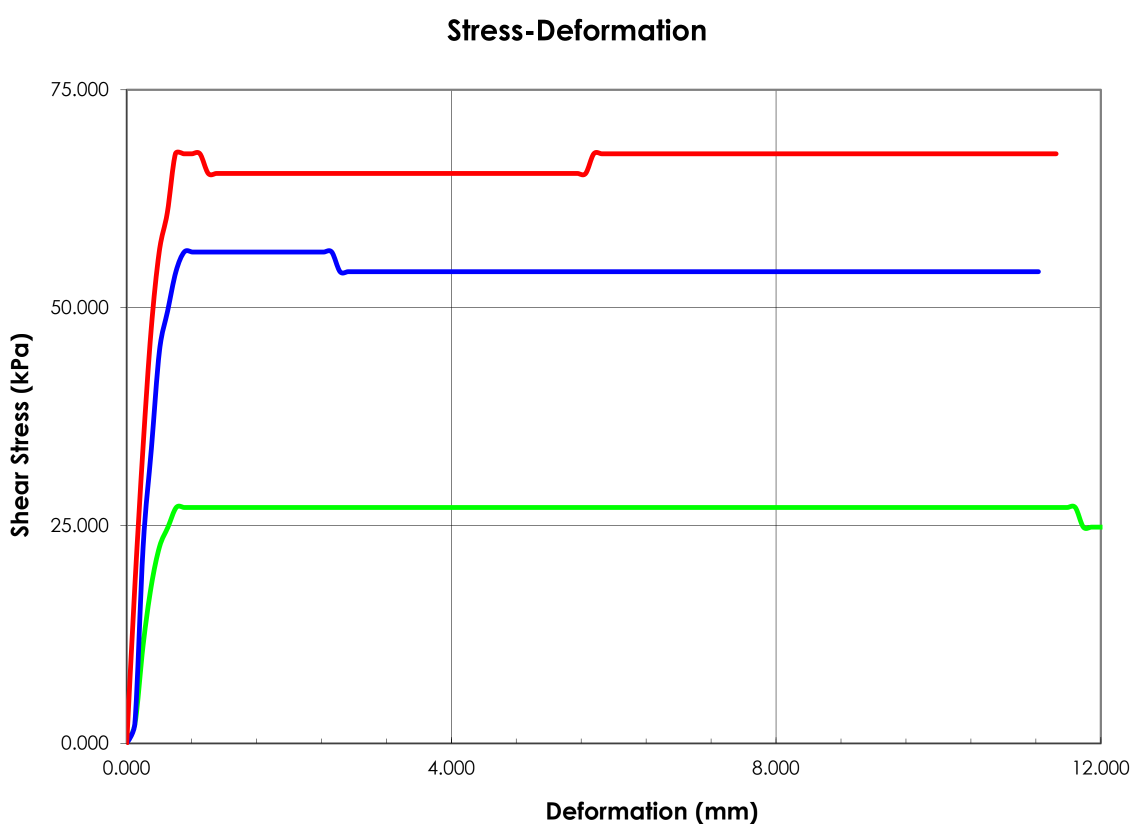
Checked By

Date

Date

Tested By





lab_11376880_dsh_th03-30ft.HSD

Stantec Consulting Ltd.

Direct Shear Test

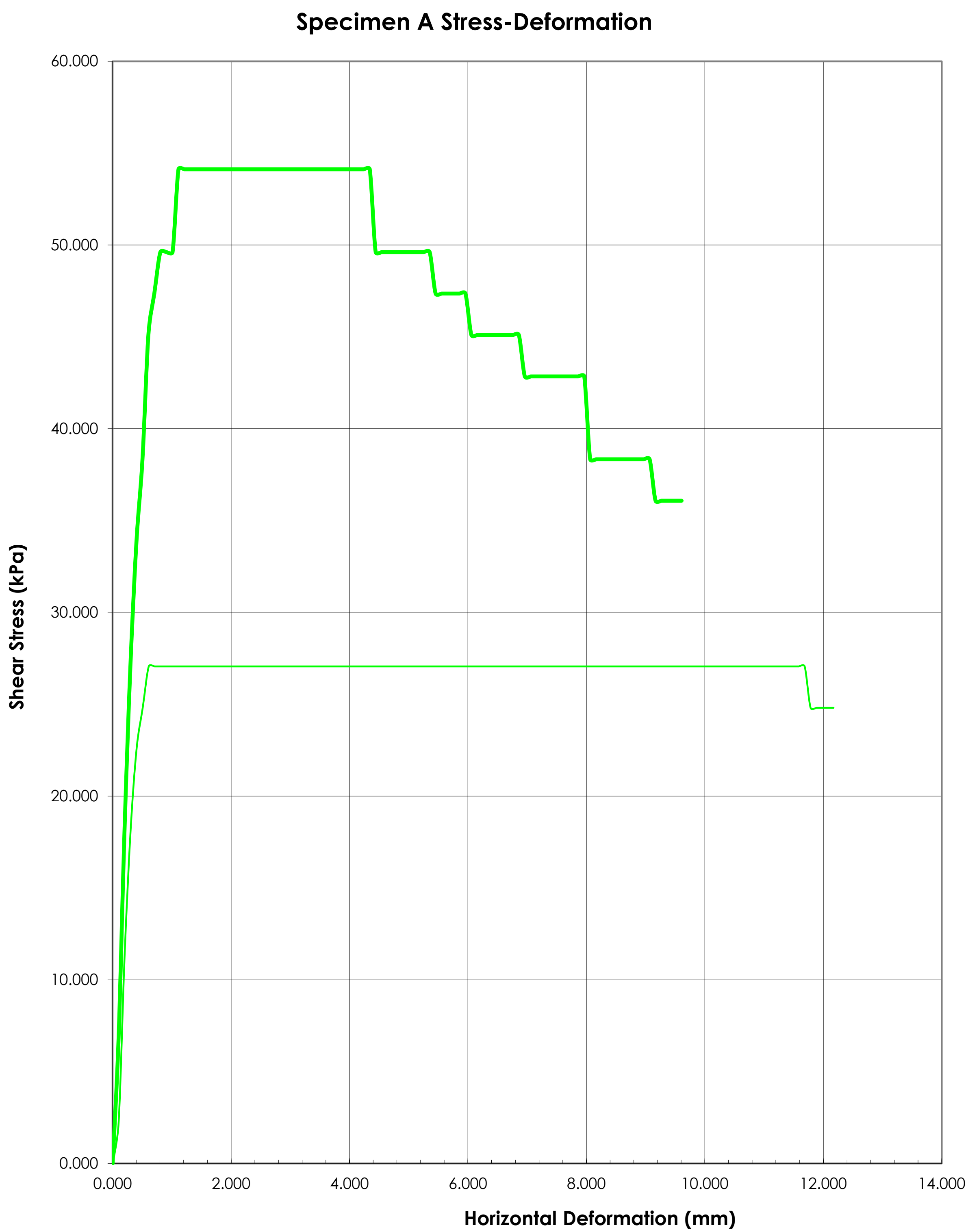
Stantec

Checked By

Date

Date

Tested By



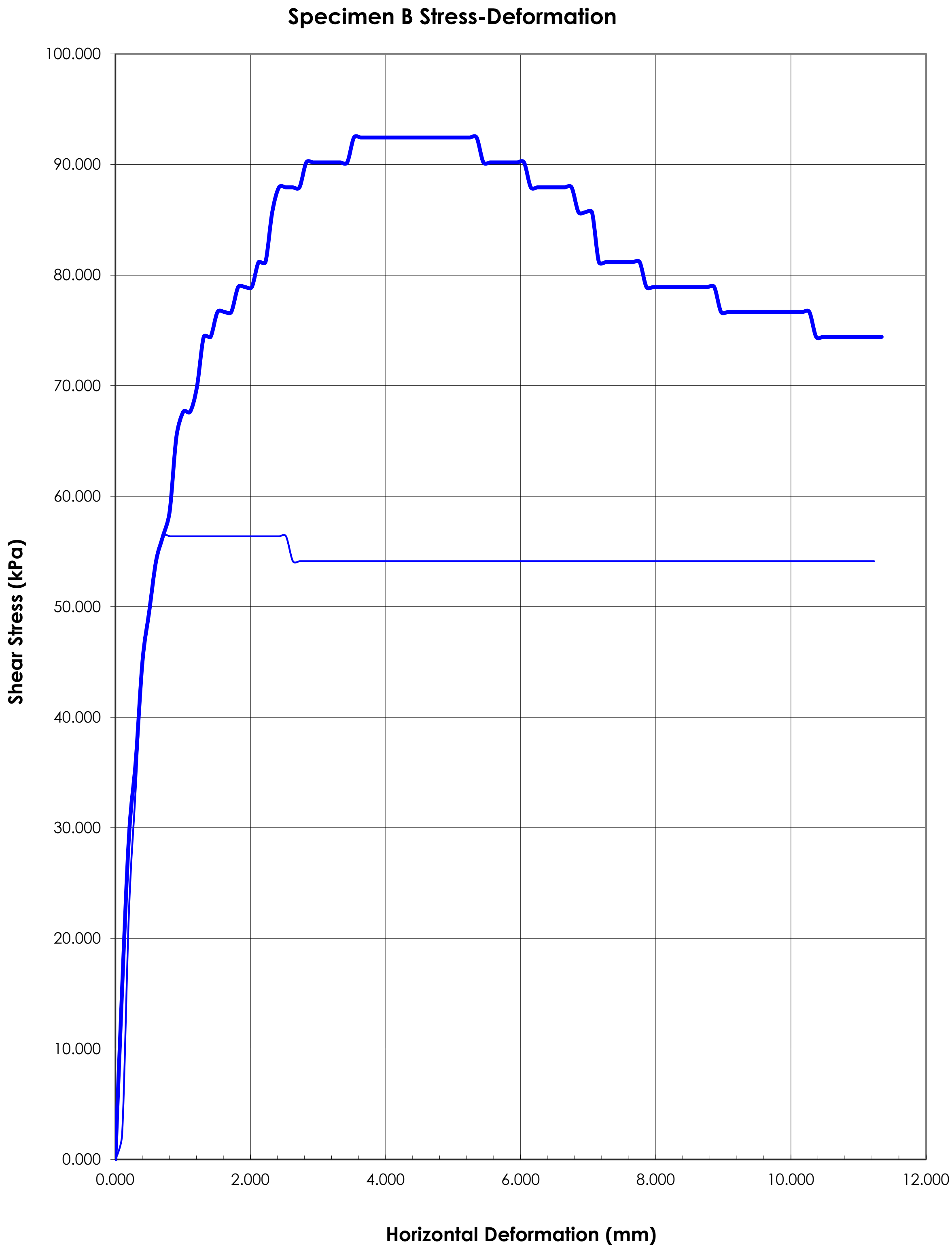
lab_11376880_dsh_th03-30ft.HSD

Stantec Consulting Ltd.

Direct Shear Test

Stantec

Checked By
Date
Date
Tested By



lab_11376880_dsh_th03-30ft.HSD

Stantec Consulting Ltd.
Direct Shear Test

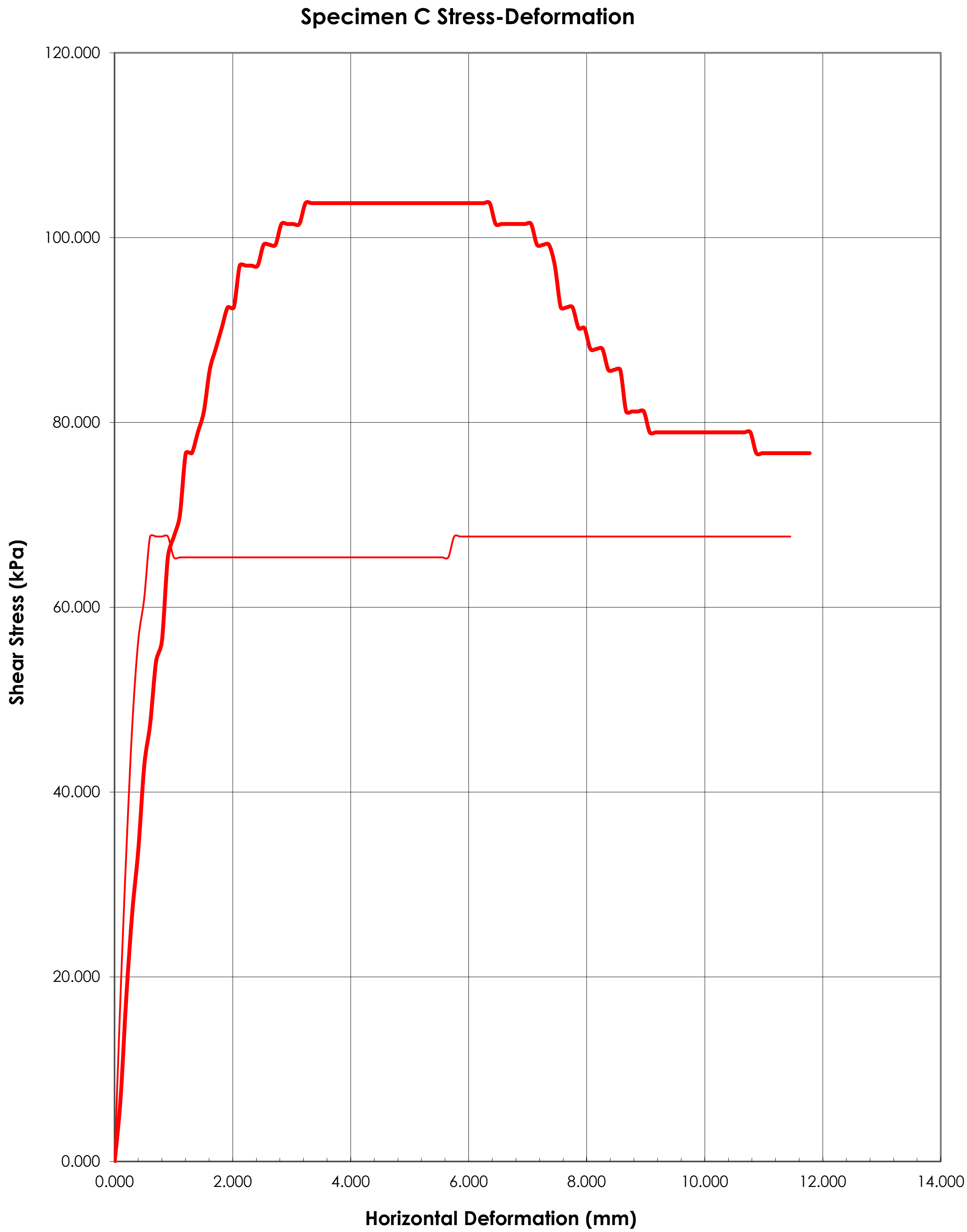
Stantec

Checked By

Date

Date

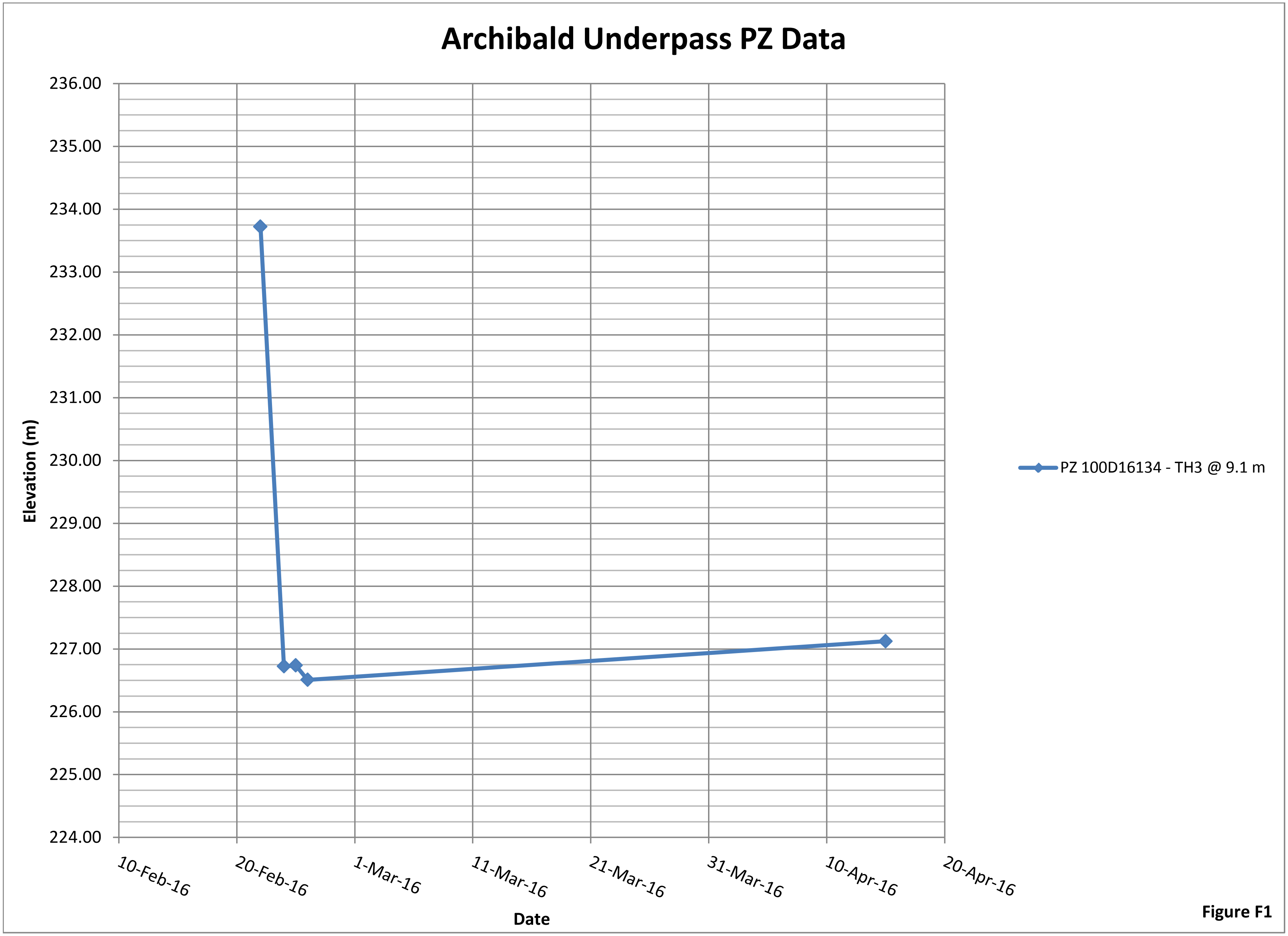
Tested By



lab_11376880_dsh_th03-30ft.HSD

Appendix F
VIBRATING WIRE PIEZOMETER DATA

Stantec



Archibald Underpass PZ Data
Elevation (m)
236.00
235.00
234.00
233.00
232.00
231.00
230.00
229.00
228.00
227.00
226.00
225.00
224.00
10-Feb-16
20-Feb-16
1-Mar-16
11-Mar-16
21-Mar-16
31-Mar-16
10-Apr-16
20-Apr-16
Date
PZ 100D16134 - TH3 @ 9.1 m
Figure F1

Appendix G
EXISTING CONDITIONS SLOPE STABILITY RESULTS

Stantec

G.1 AT UNDERPASS STRUCTURE

Station 1+235.00 - Existing Conditions Immediately South of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

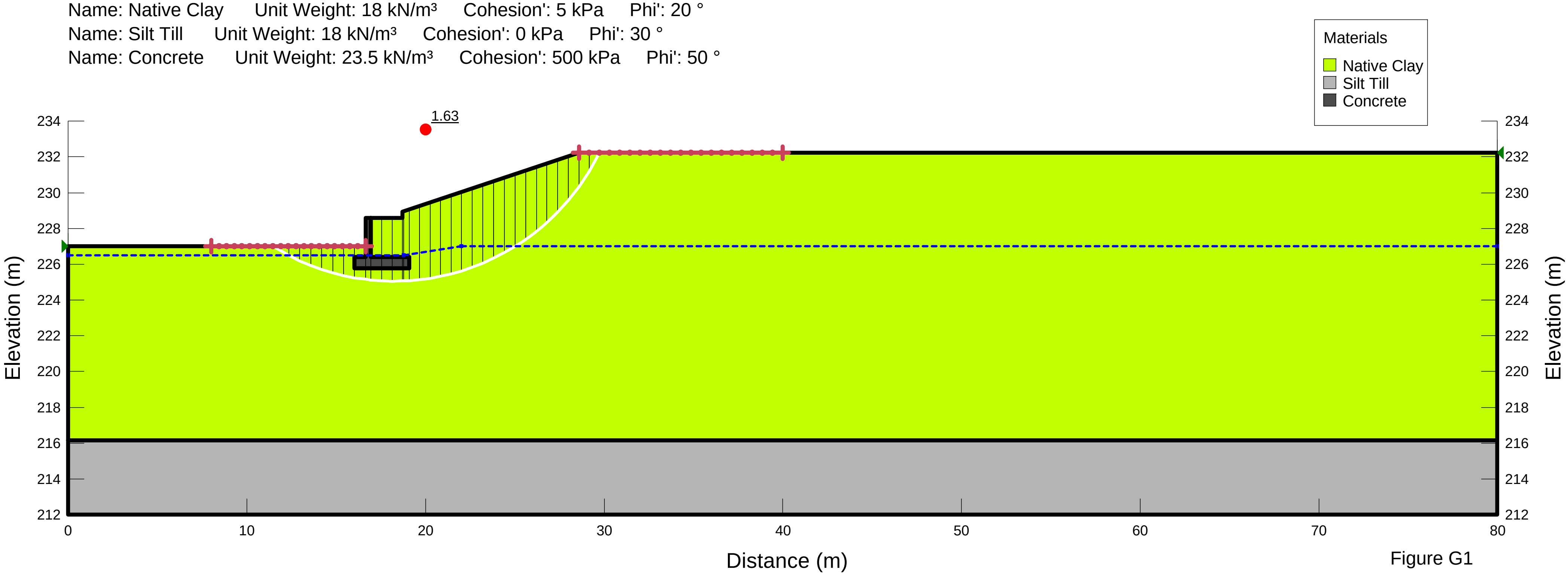
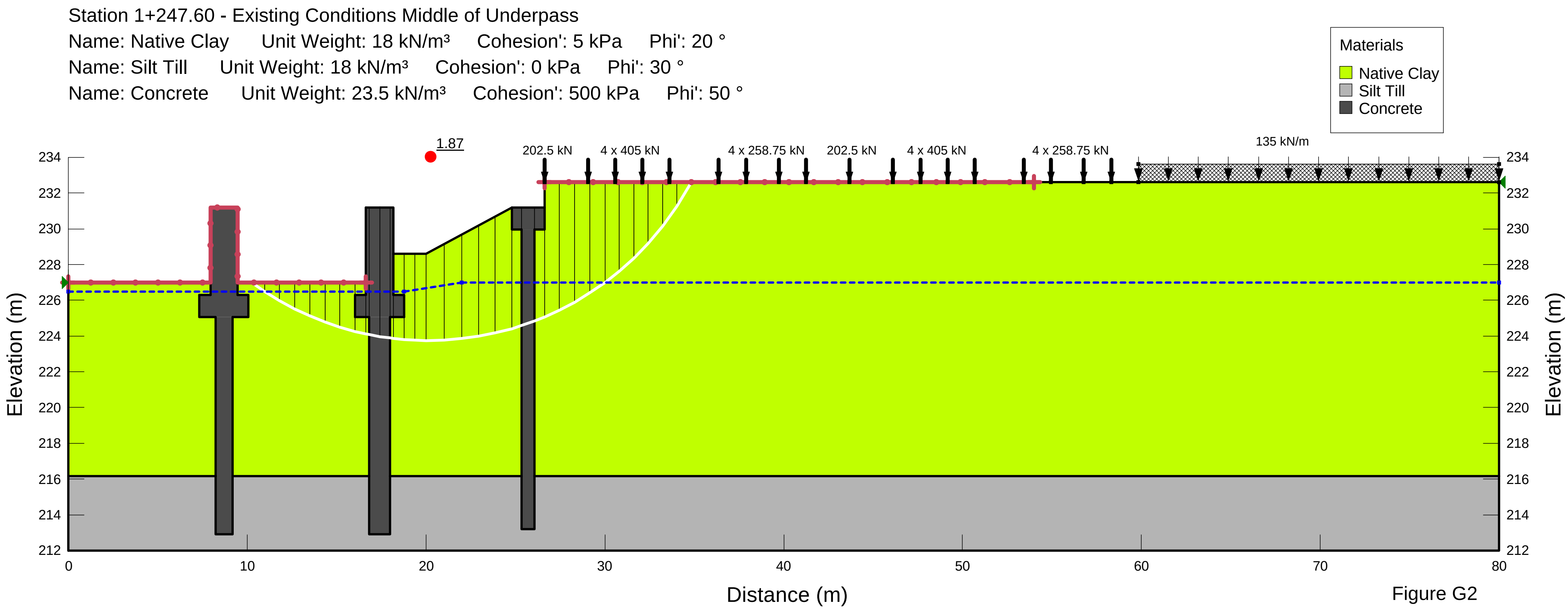
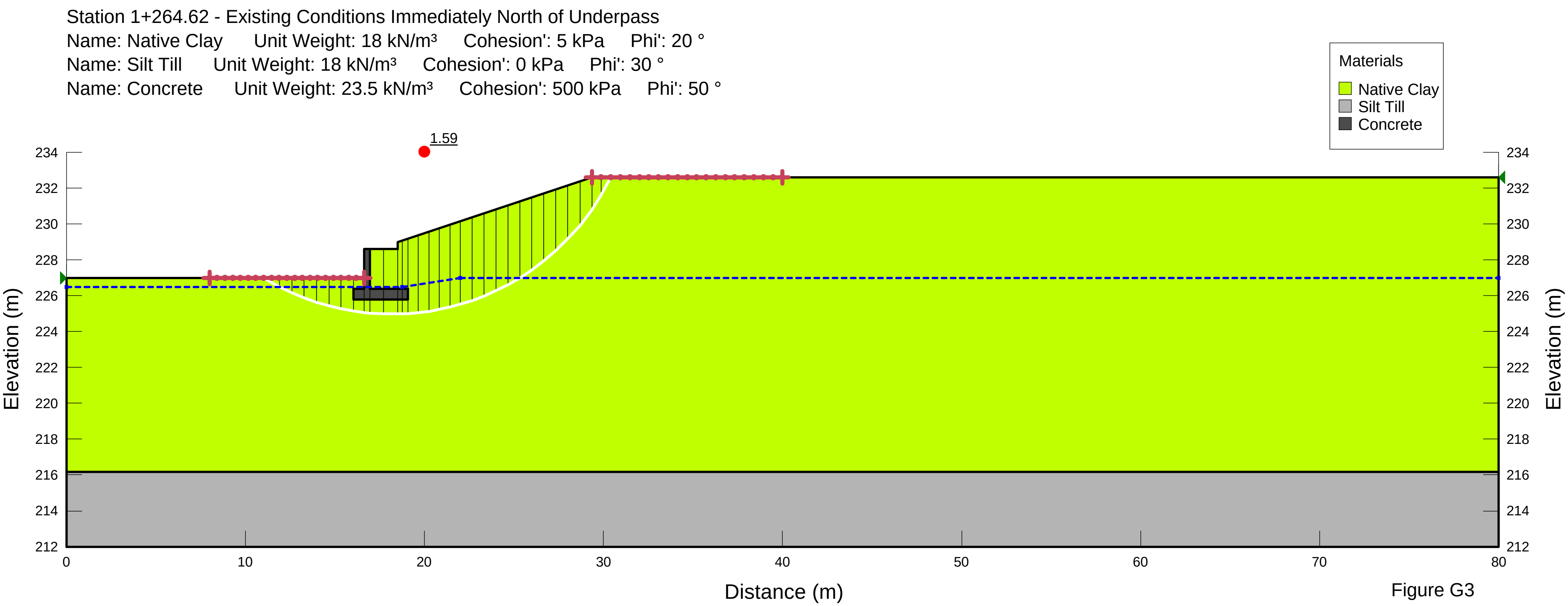


Figure G1


Station 1+247.60 - Existing Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.87
202.5 kN
4 x 405 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80
Figure G2



Station 1+264.62 - Existing Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.59
Elevation (m)
Distance (m)

Figure G3

Station 1+235.00 - Existing Conditions Immediately South of Underpass

Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °

Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °

Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

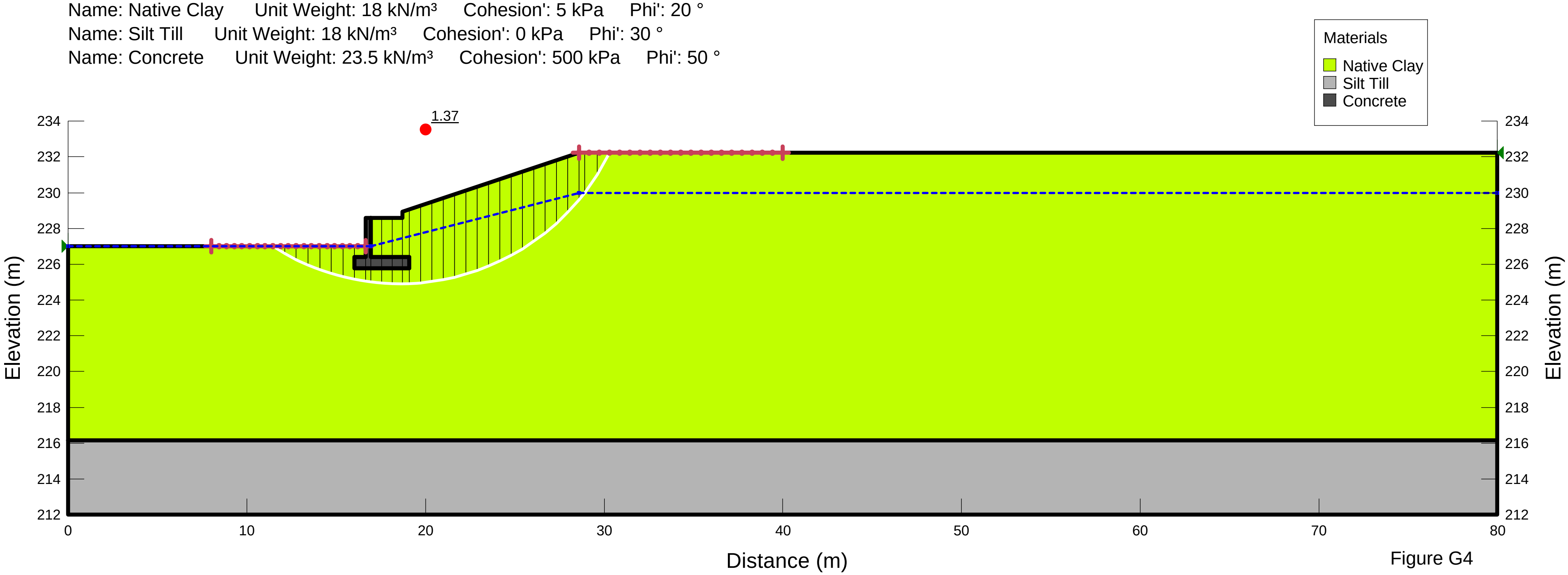


Figure G4

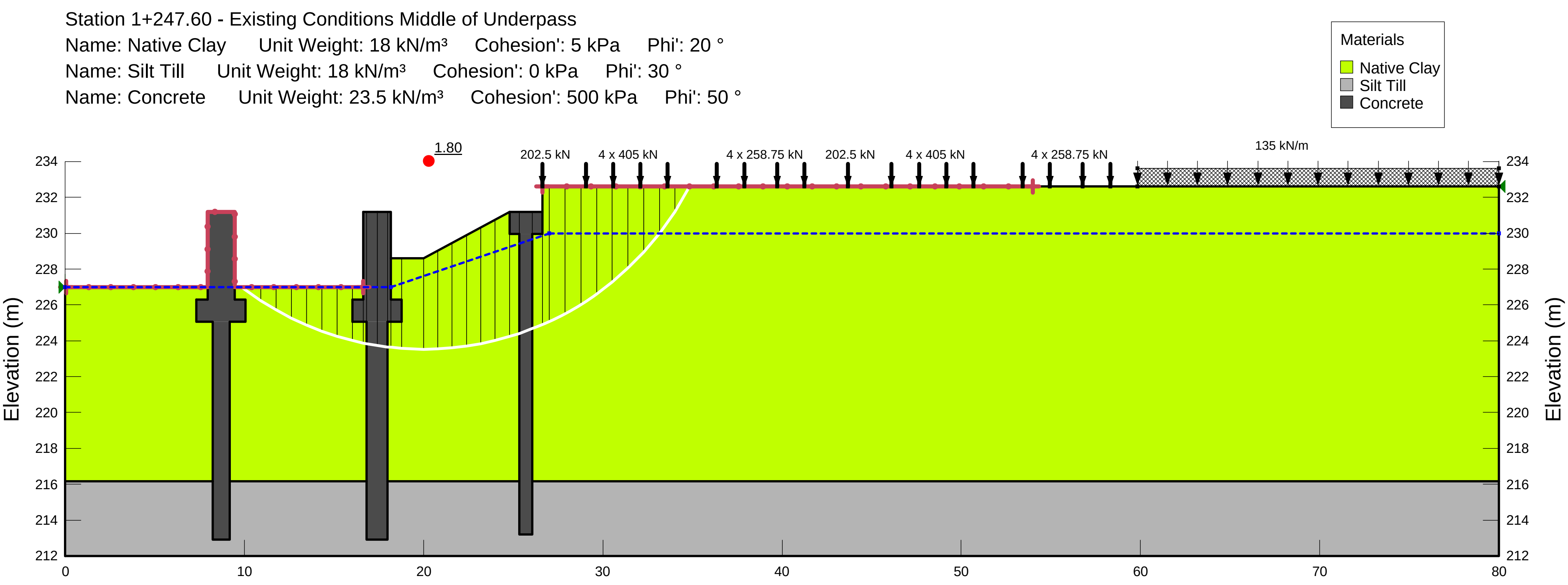

Station 1+247.60 - Existing Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.80
202.5 kN
4 x 405 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
Elevation (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80
Distance (m)

Figure G5

Station 1+264.62 - Existing Conditions Immediately North of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

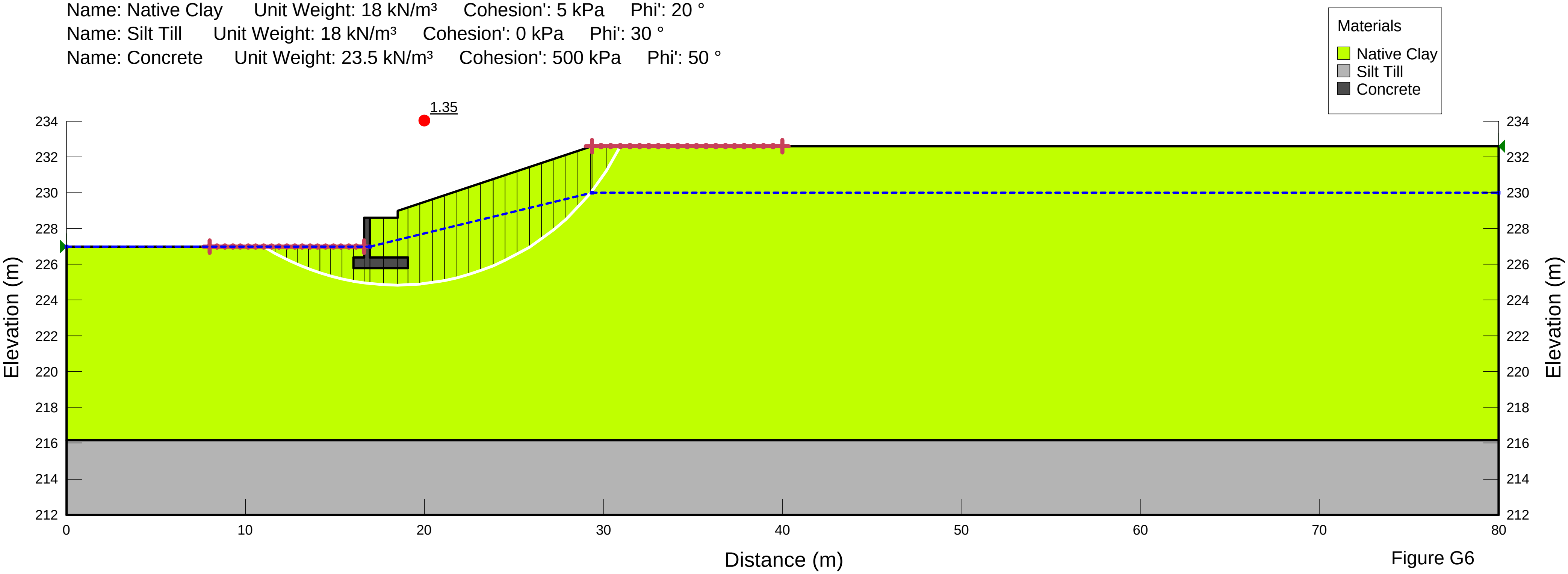


Figure G6

Station 1+235.00 - Existing Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

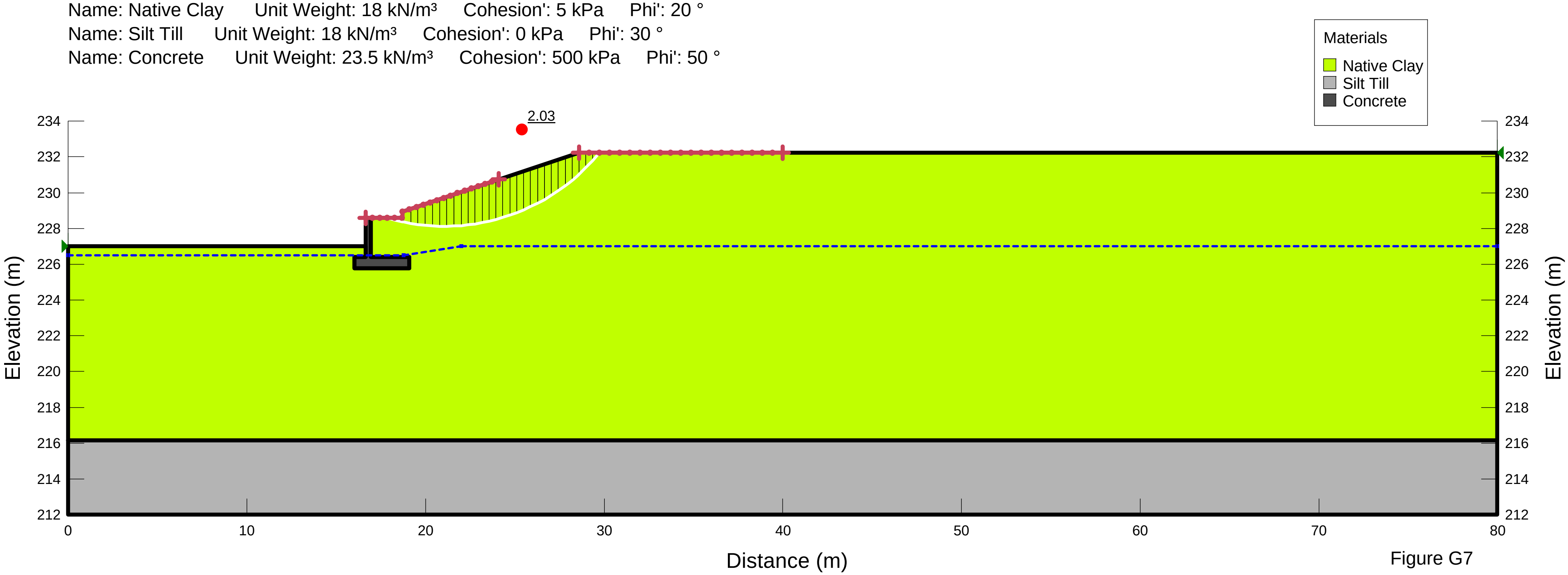


Figure G7

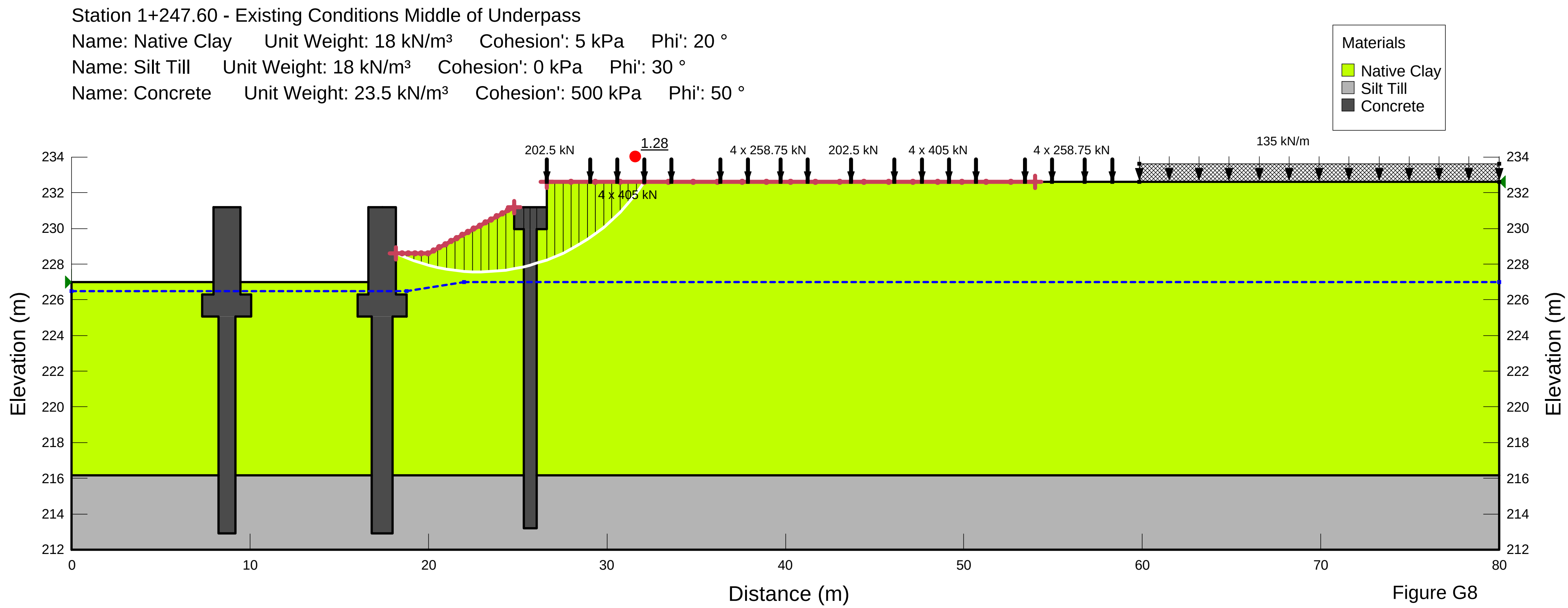
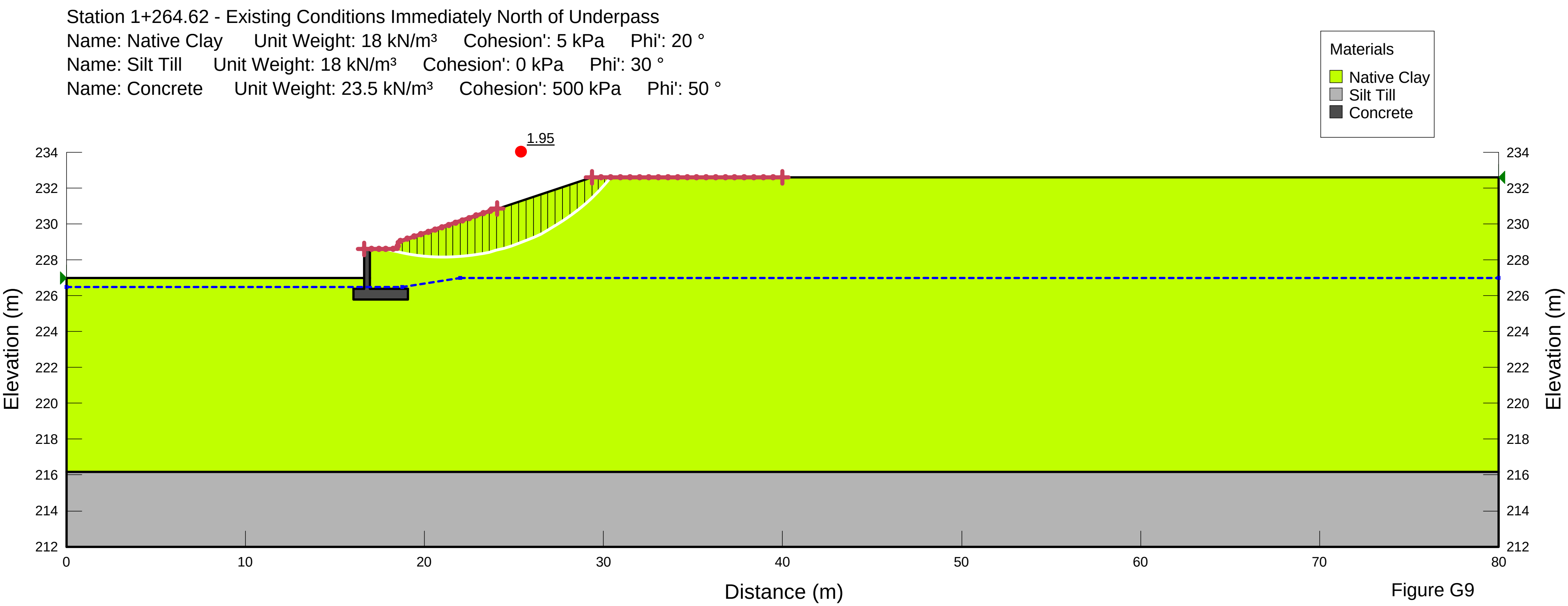

Station 1+247.60 - Existing Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.28
202.5 kN
4 x 405 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
Elevation (m)
Distance (m)

Figure G8



Station 1+264.62 - Existing Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.95
Elevation (m)
Distance (m)
0
10
20
30
40
50
60
70
80
212
214
216
218
220
222
224
226
228
230
232
234

Figure G9

Station 1+235.00 - Existing Conditions Immediately South of Underpass

Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °

Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °

Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

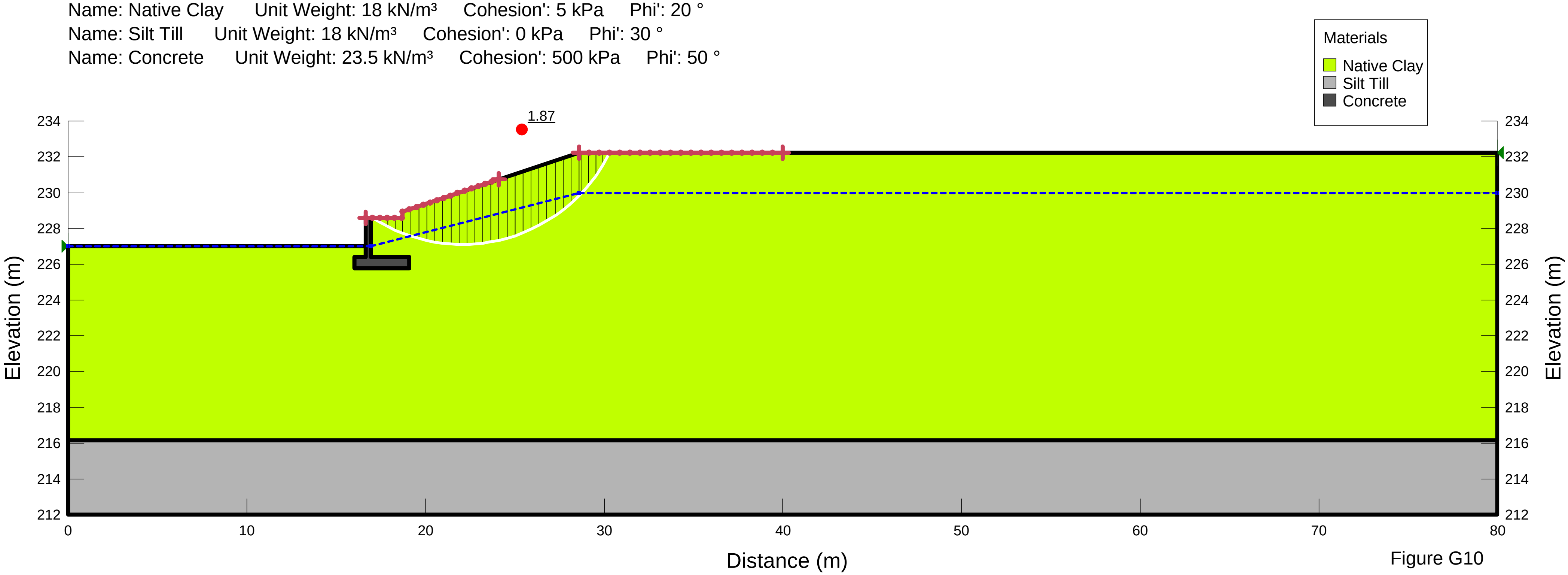
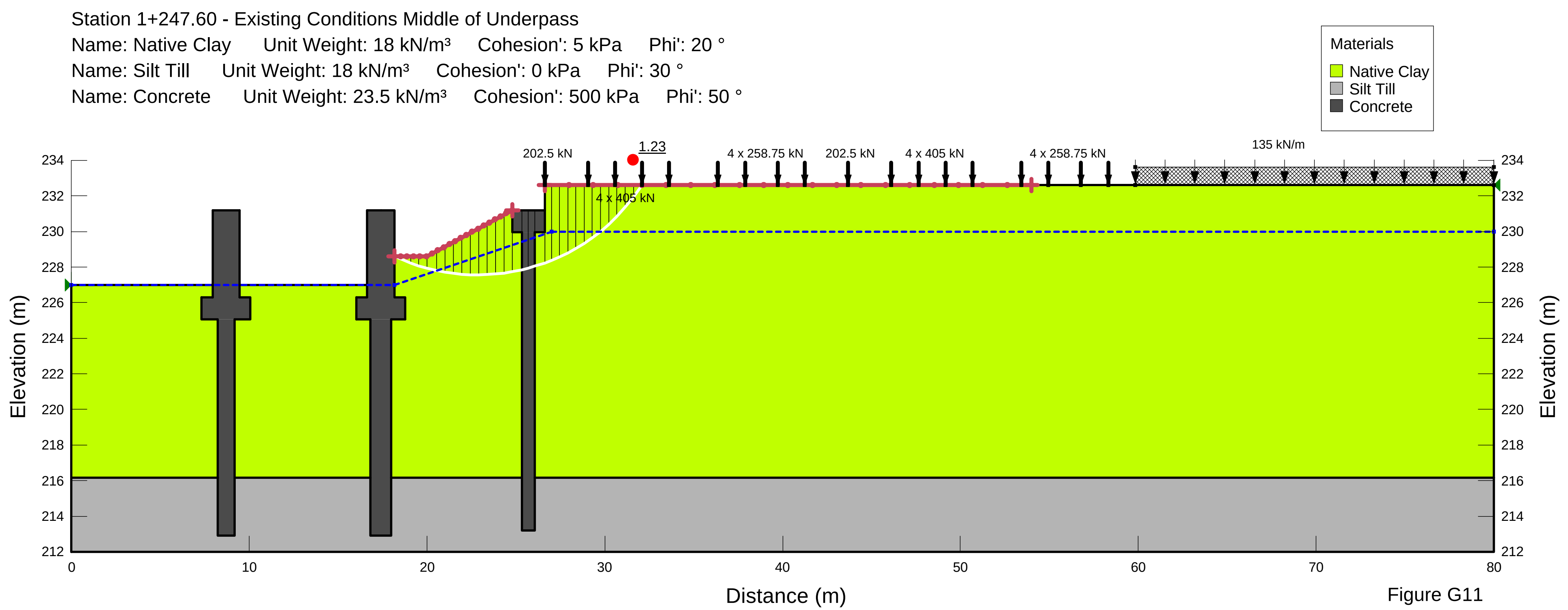


Figure G10



Station 1+247.60 - Existing Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
202.5 kN
1.23
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
4 x 405 kN
Elevation (m)
Distance (m)

Figure G11

Station 1+264.62 - Existing Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

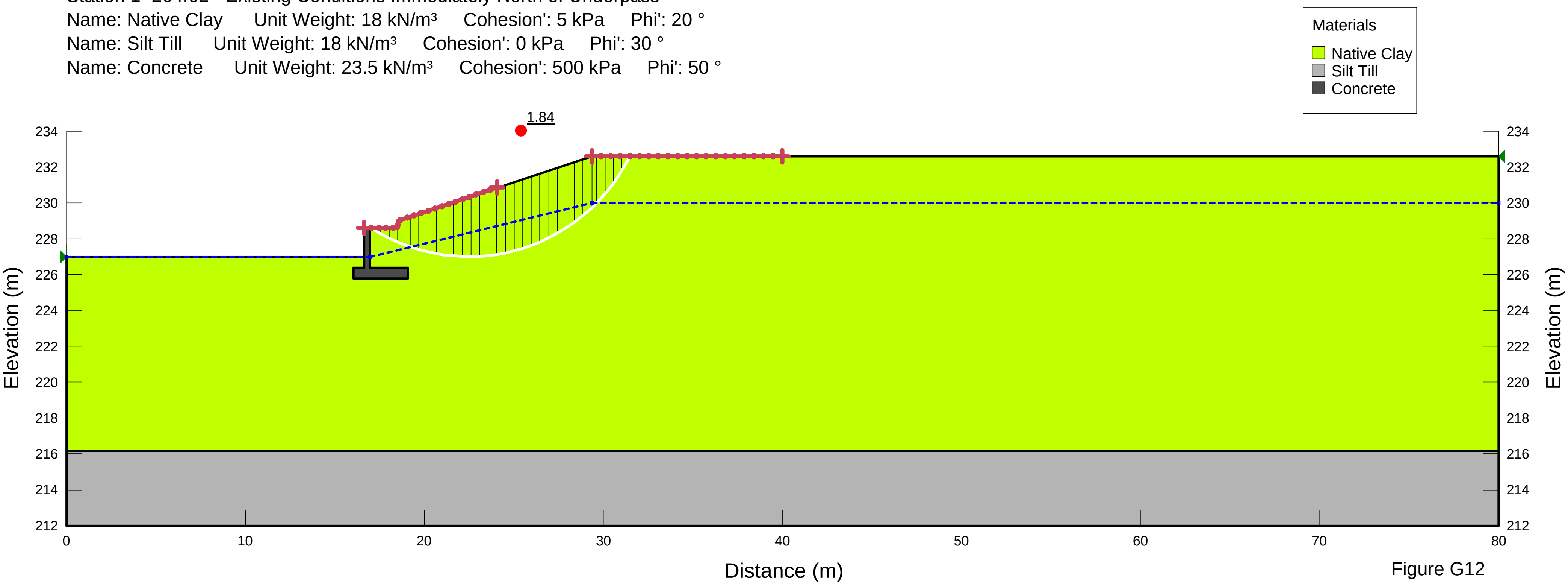


Figure G12

Station 1+235.00 - Existing Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

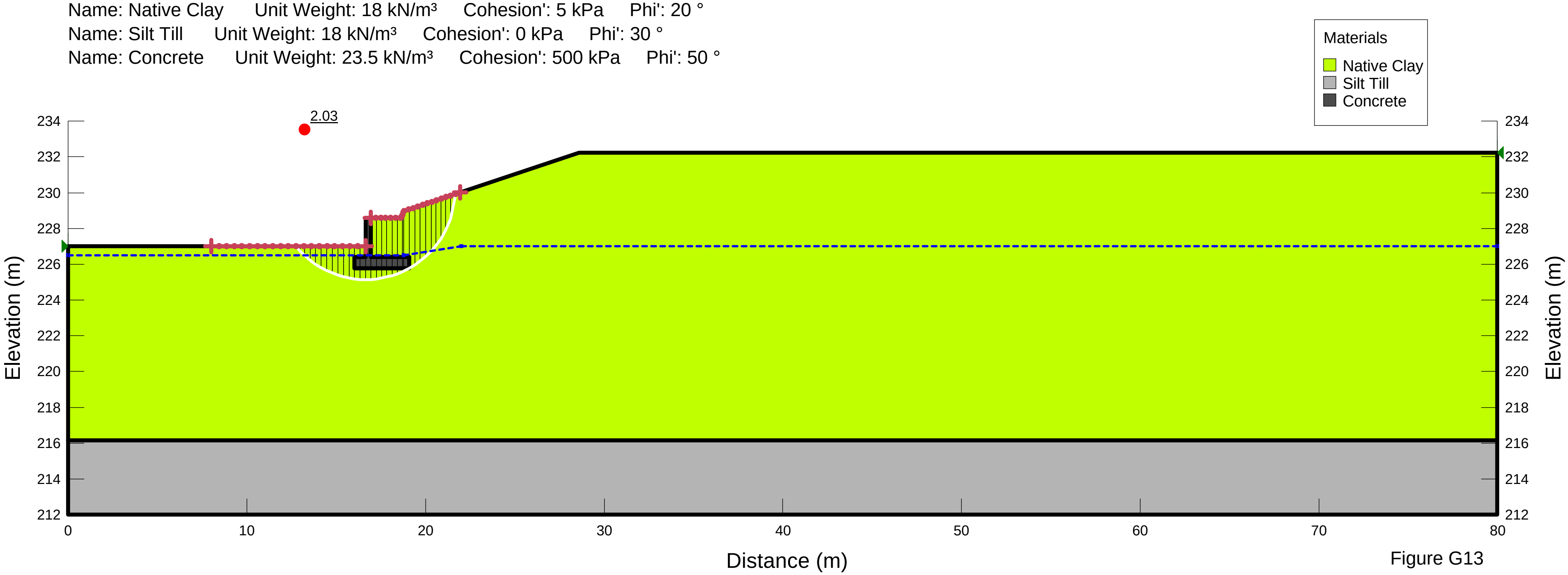
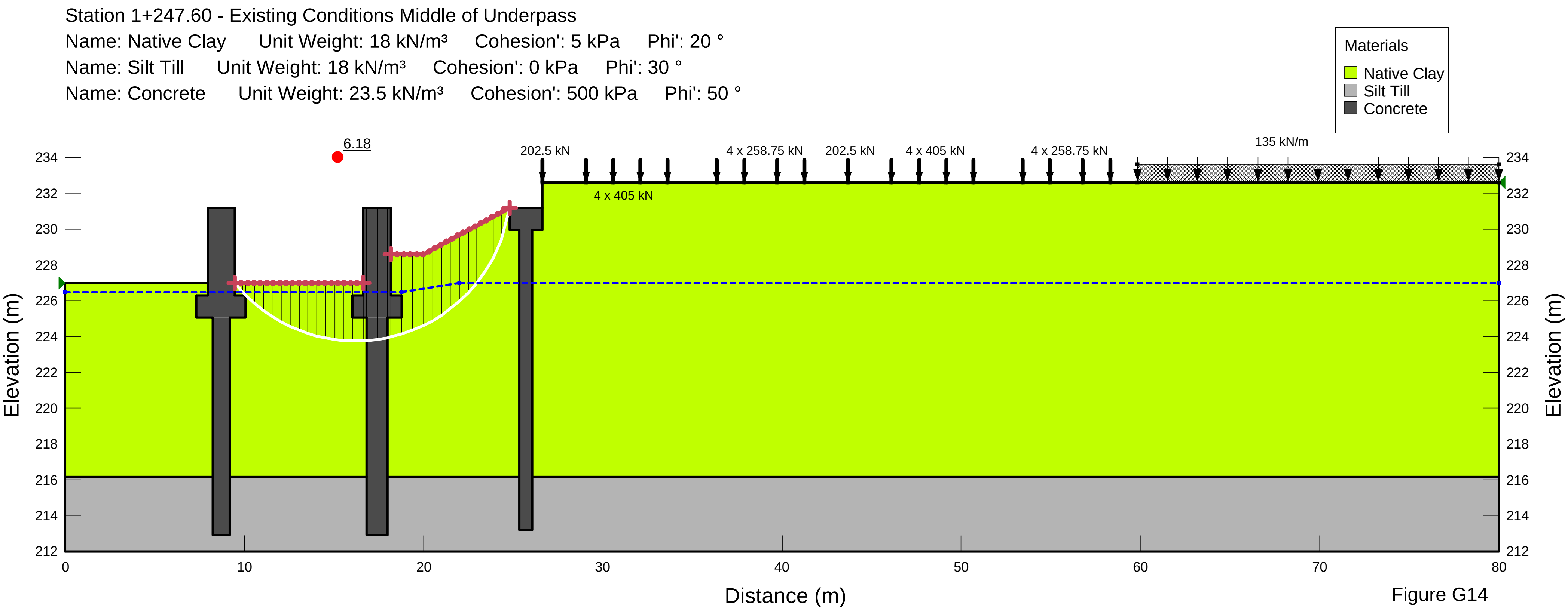


Figure G13


Station 1+247.60 - Existing Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
6.18
202.5 kN
4 x 405 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80
Figure G14

Station 1+264.62 - Existing Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

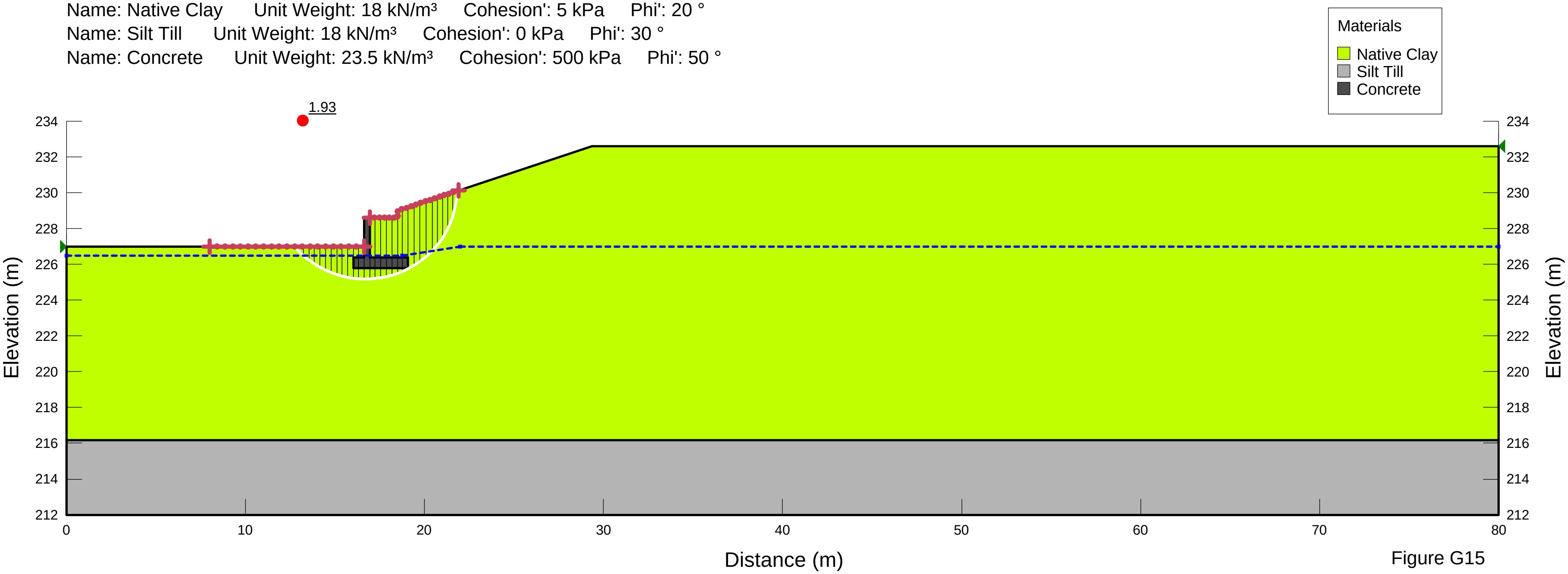


Figure G15

Station 1+235.00 - Existing Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

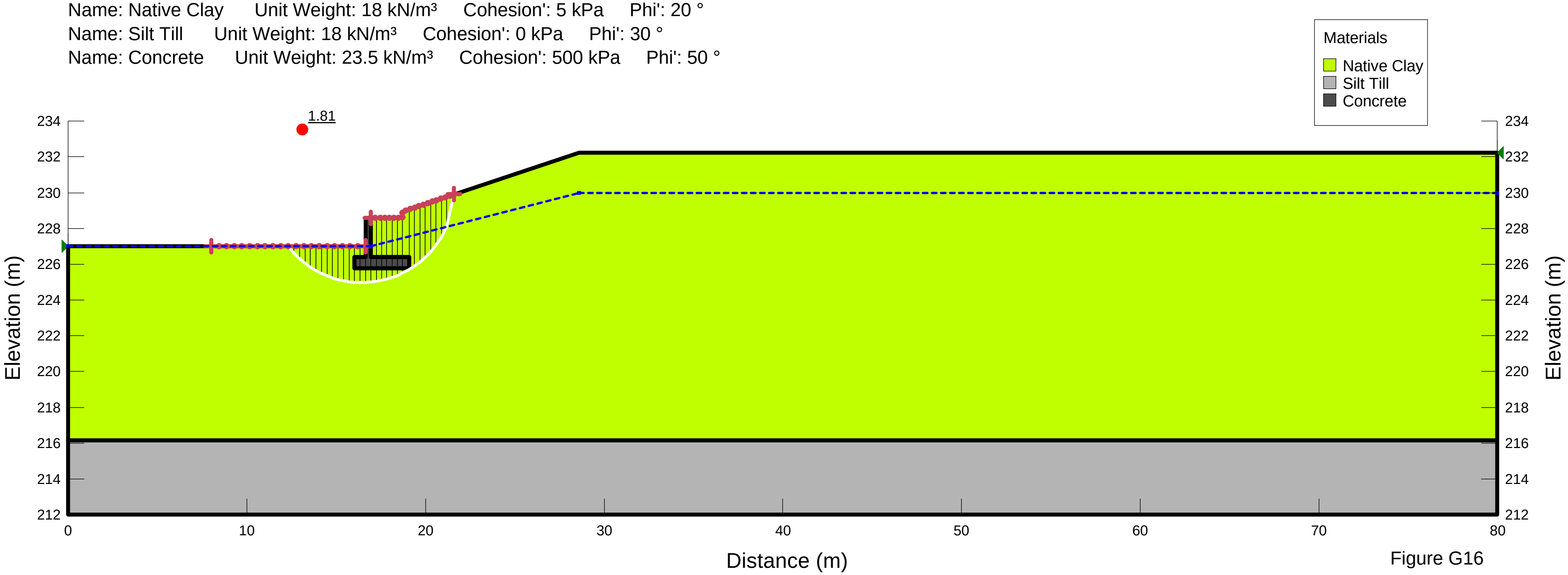
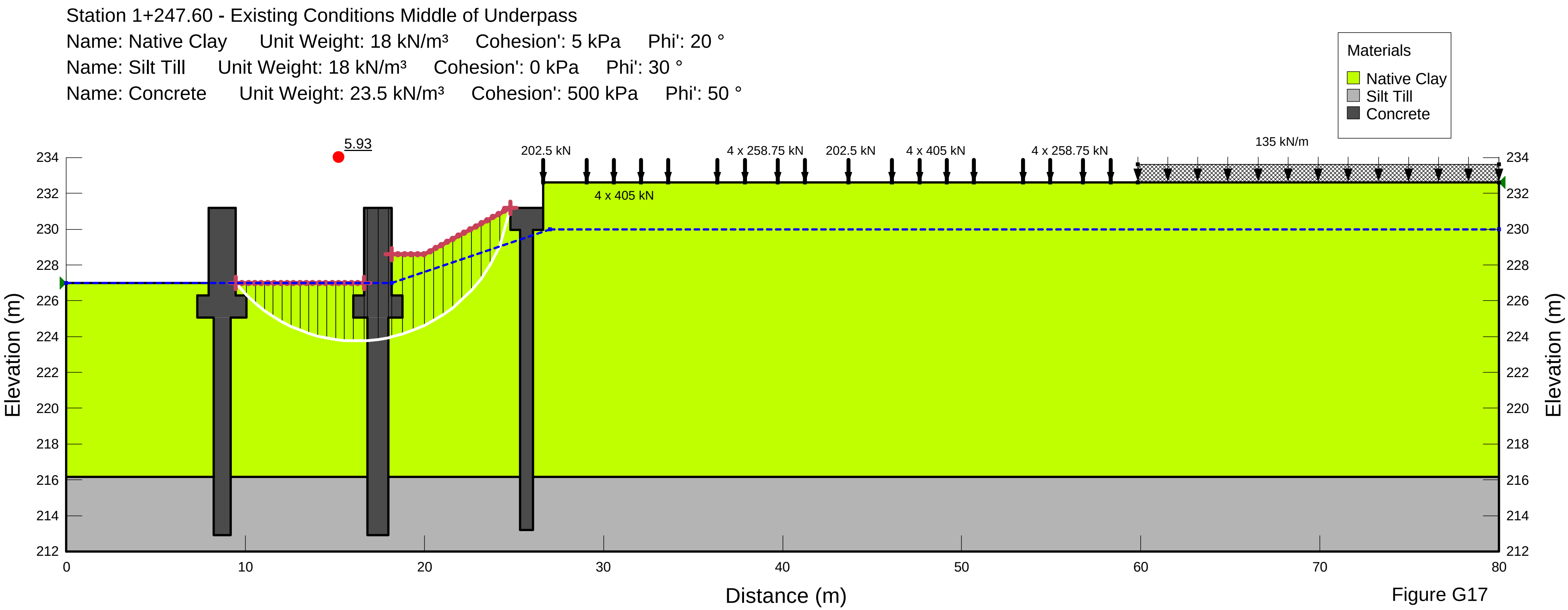
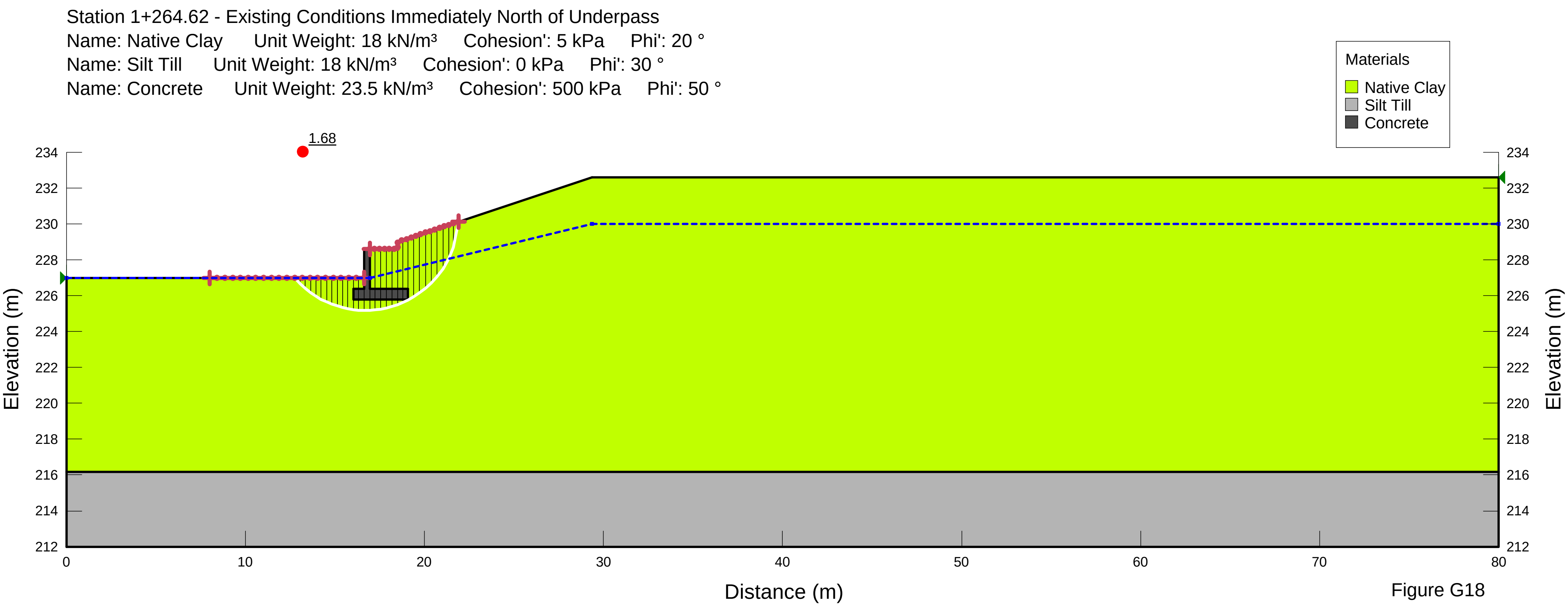


Figure G16

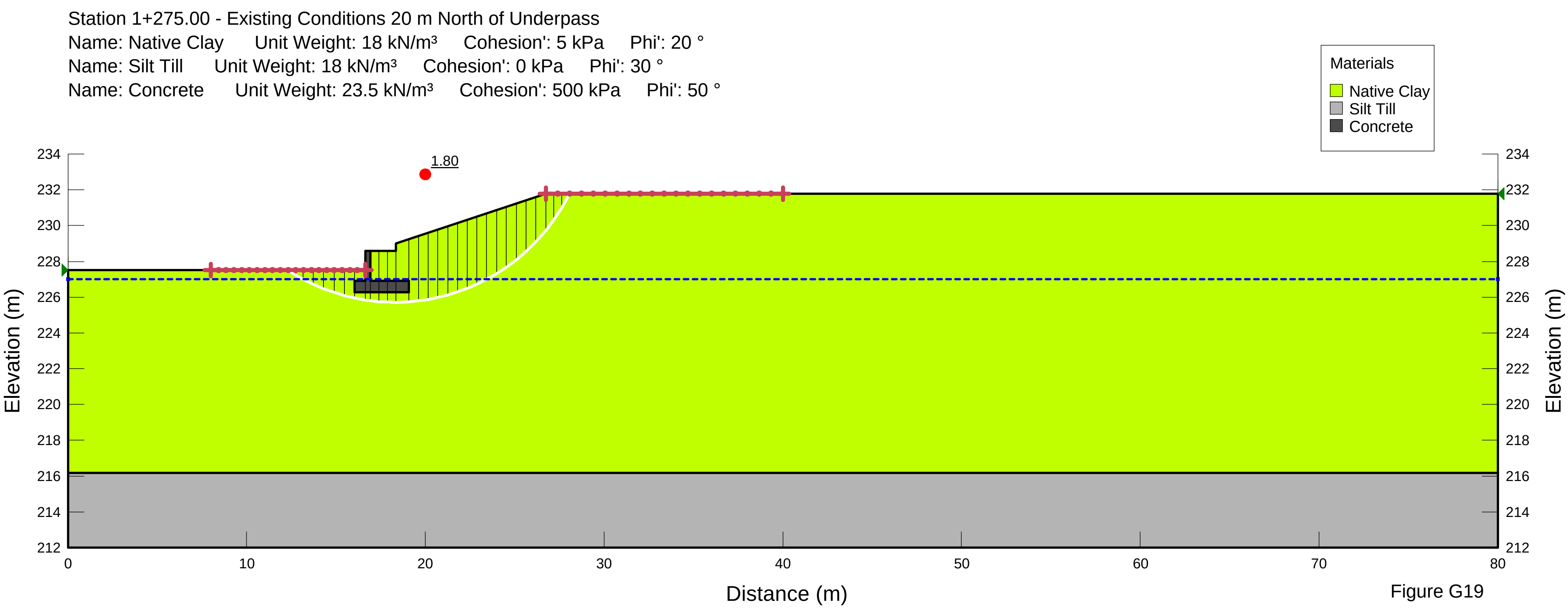


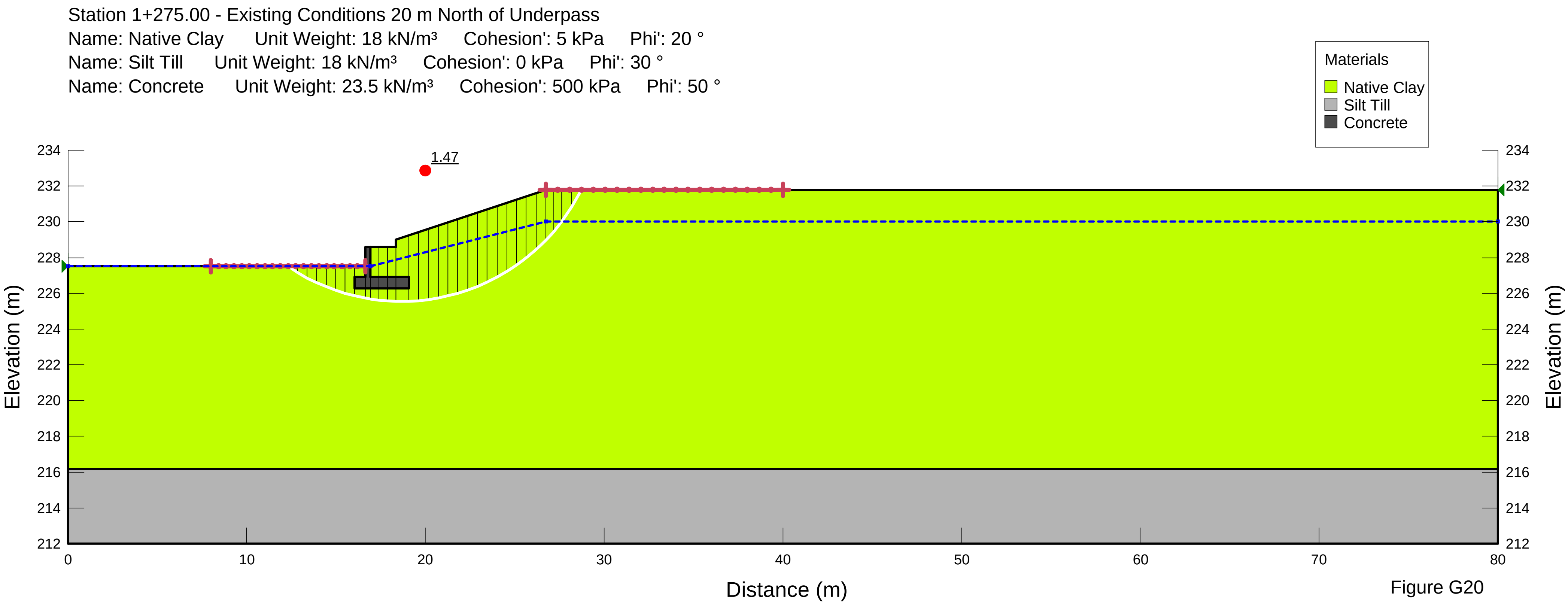
Station 1+247.60 - Existing Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
5.93
202.5 kN
4 x 405 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
Elevation (m)
Distance (m)

Figure G17


Station 1+264.62 - Existing Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.68
Elevation (m)
Distance (m)
212
214
216
218
220
222
224
226
228
230
232
234
0
10
20
30
40
50
60
70
80
Figure G18

G.2 NORTH OF UNDERPASS STRUCTURE


Station 1+275.00 - Existing Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.80
234
232
230
228
226
224
222
220
218
216
214
212
Elevation (m)
0
10
20
30
40
50
60
70
80
Distance (m)
Figure G19



Station 1+275.00 - Existing Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.47
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure G20

Station 1+275.00 - Existing Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

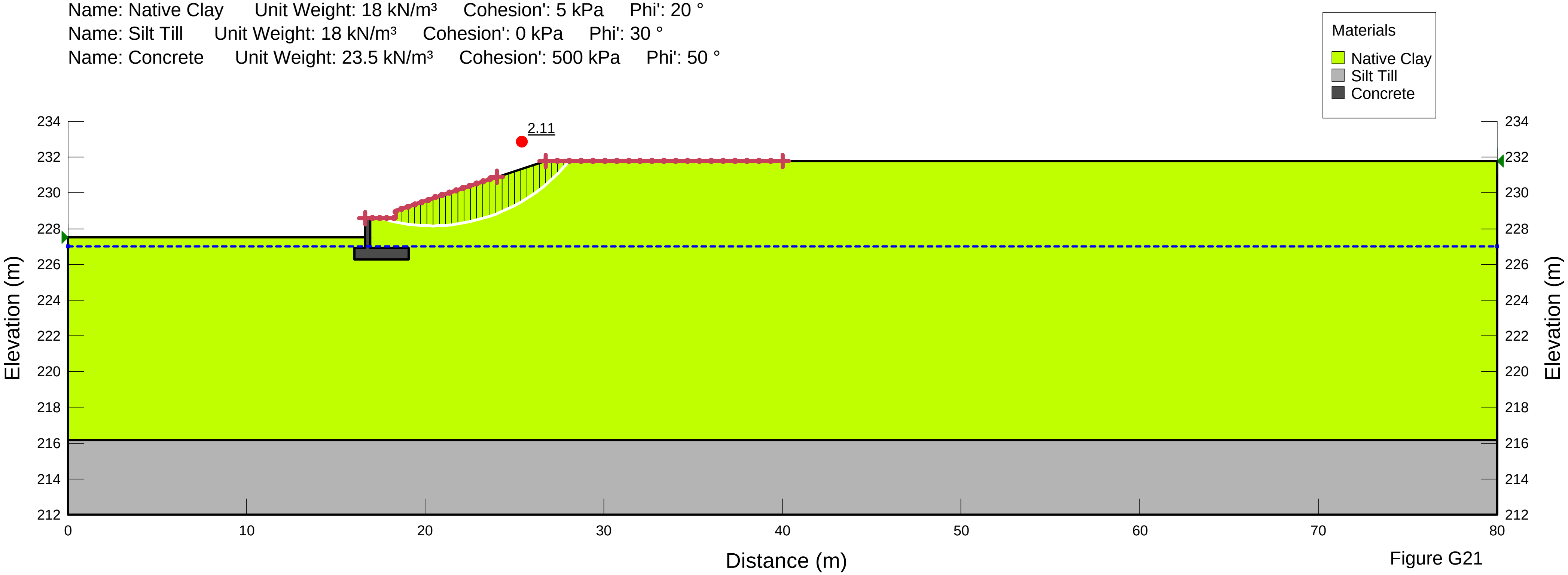


Figure G21

Station 1+275.00 - Existing Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

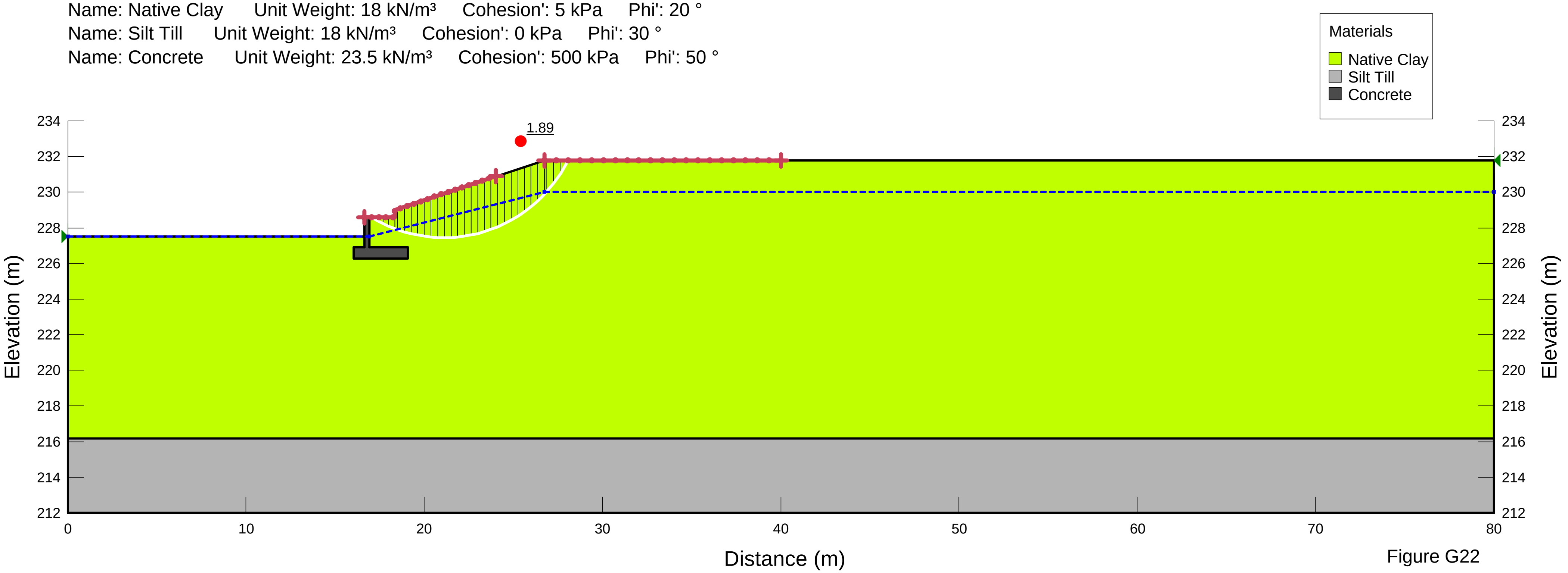
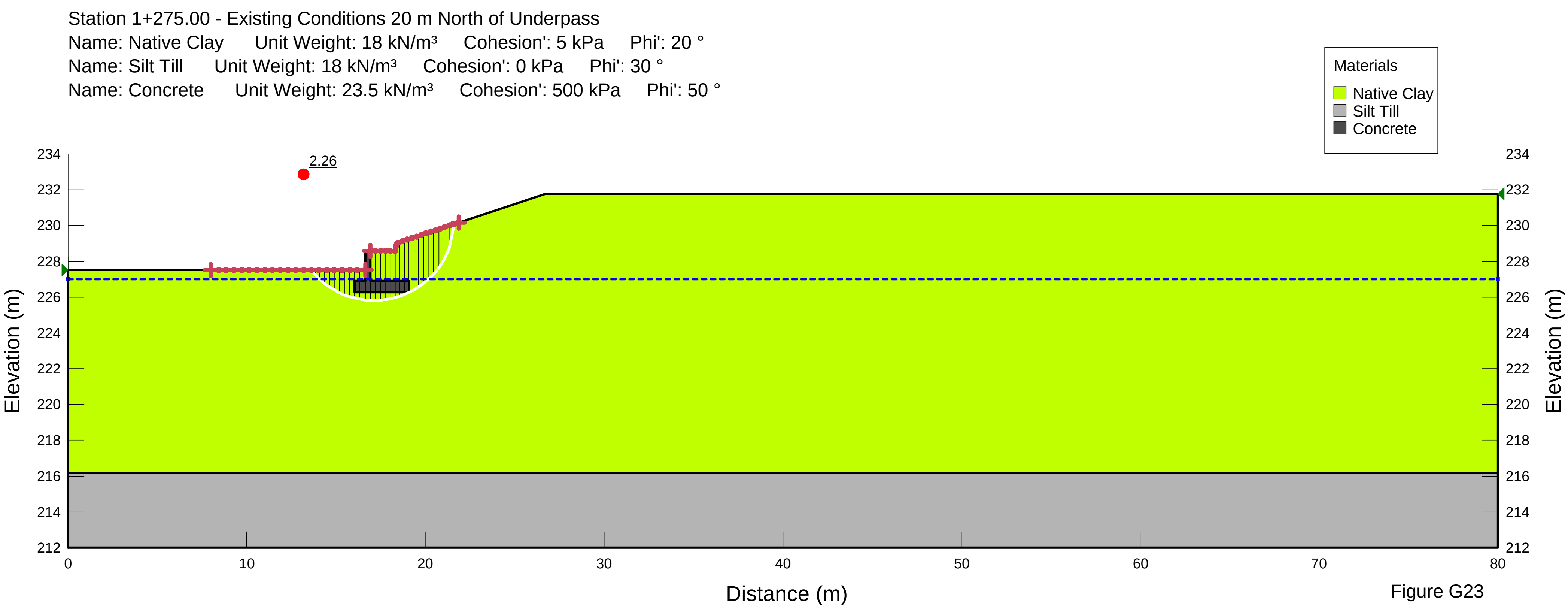


Figure G22



Station 1+275.00 - Existing Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
2.26
Elevation (m)
Distance (m)

Figure G23

Station 1+275.00 - Existing Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

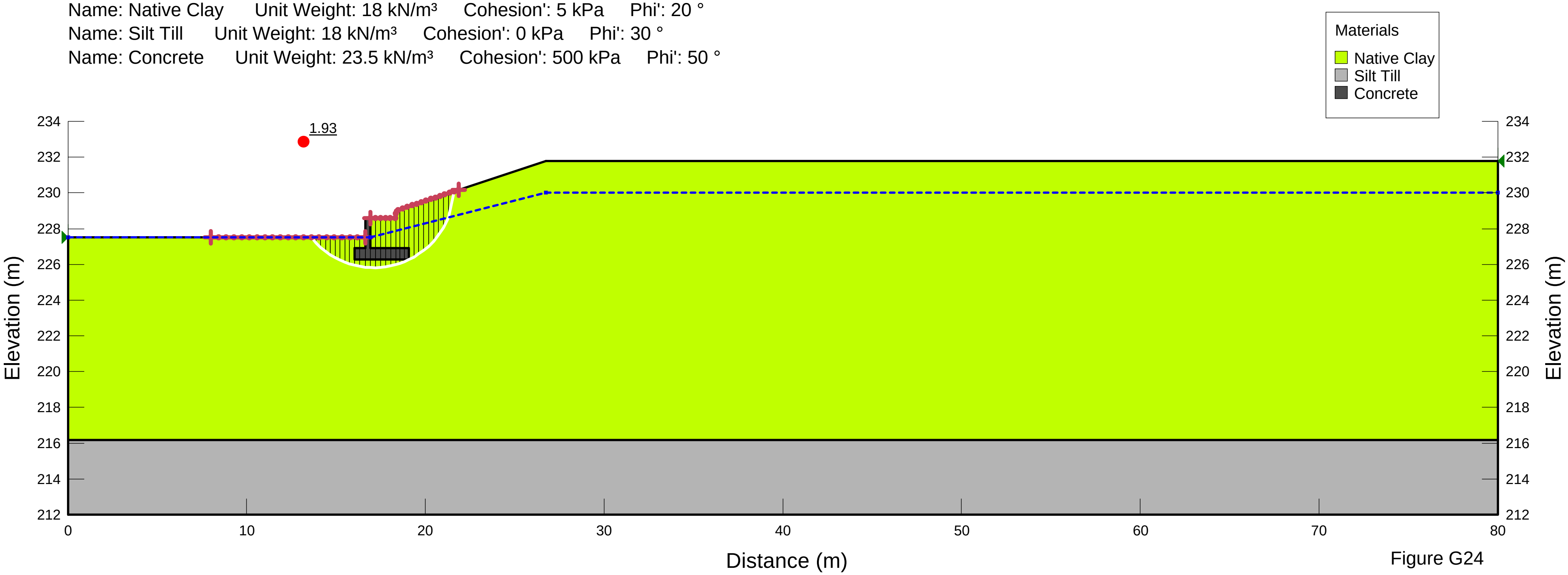


Figure G24

G.3 SOUTH OF UNDERPASS STRUCTURE

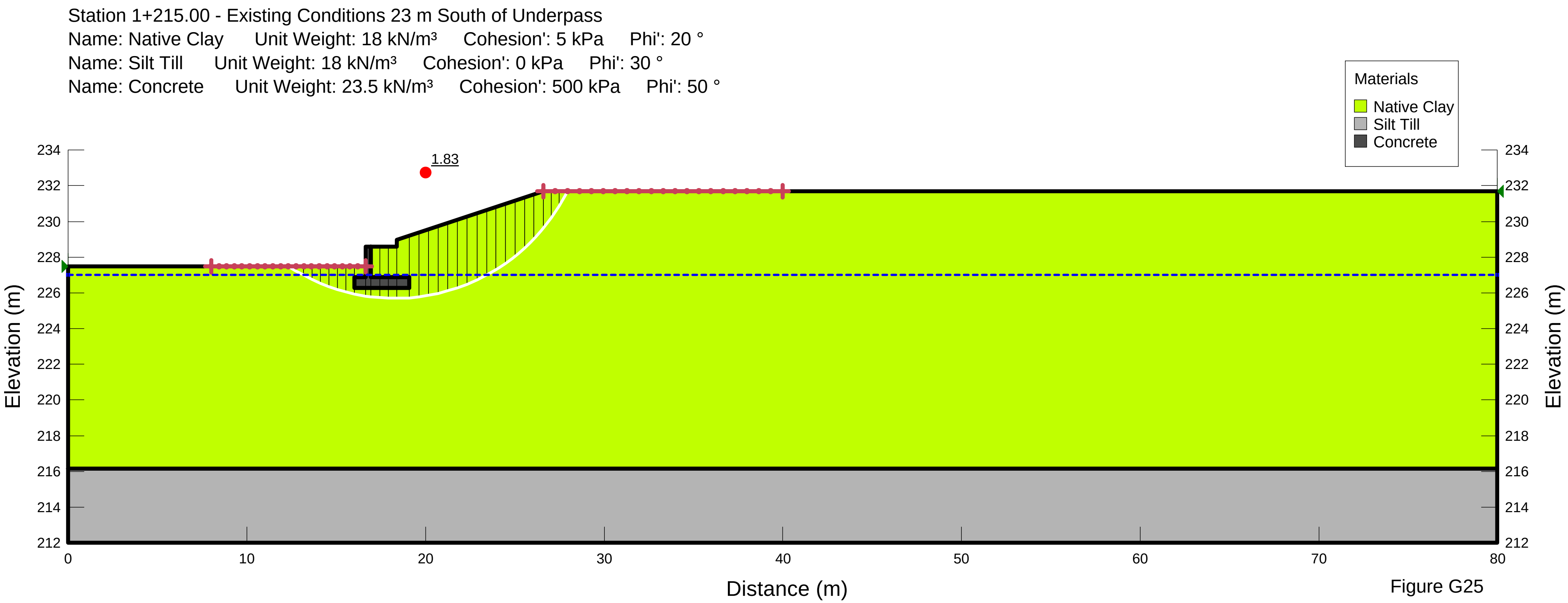

Station 1+215.00 - Existing Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.83
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure G25

Station 1+215.00 - Existing Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

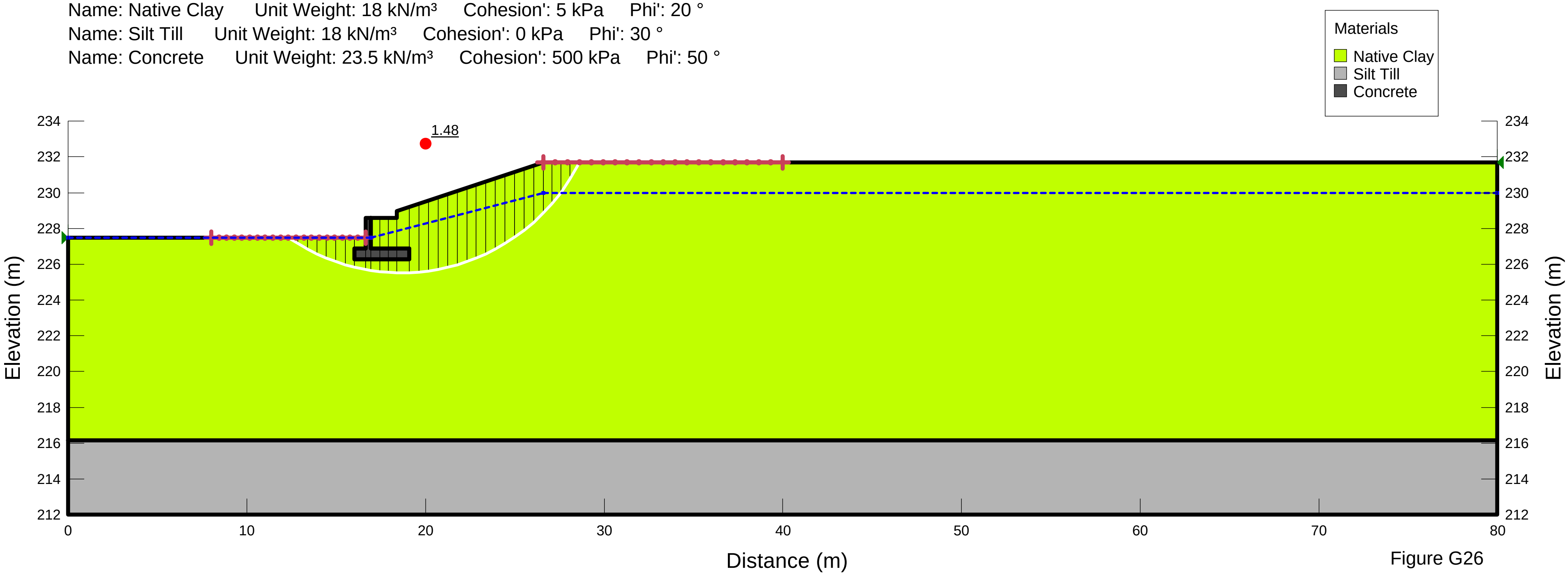


Figure G26

Station 1+215.00 - Existing Conditions 23 m South of Underpass
Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °
Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

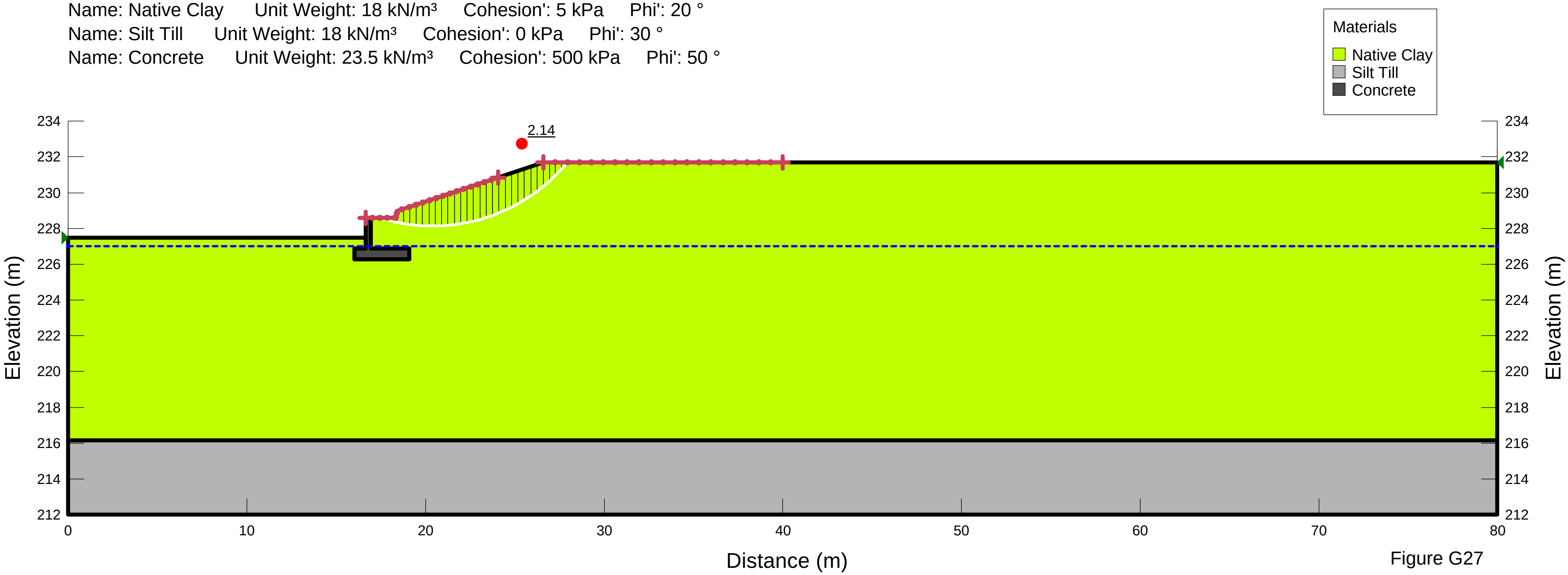


Figure G27

Station 1+215.00 - Existing Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

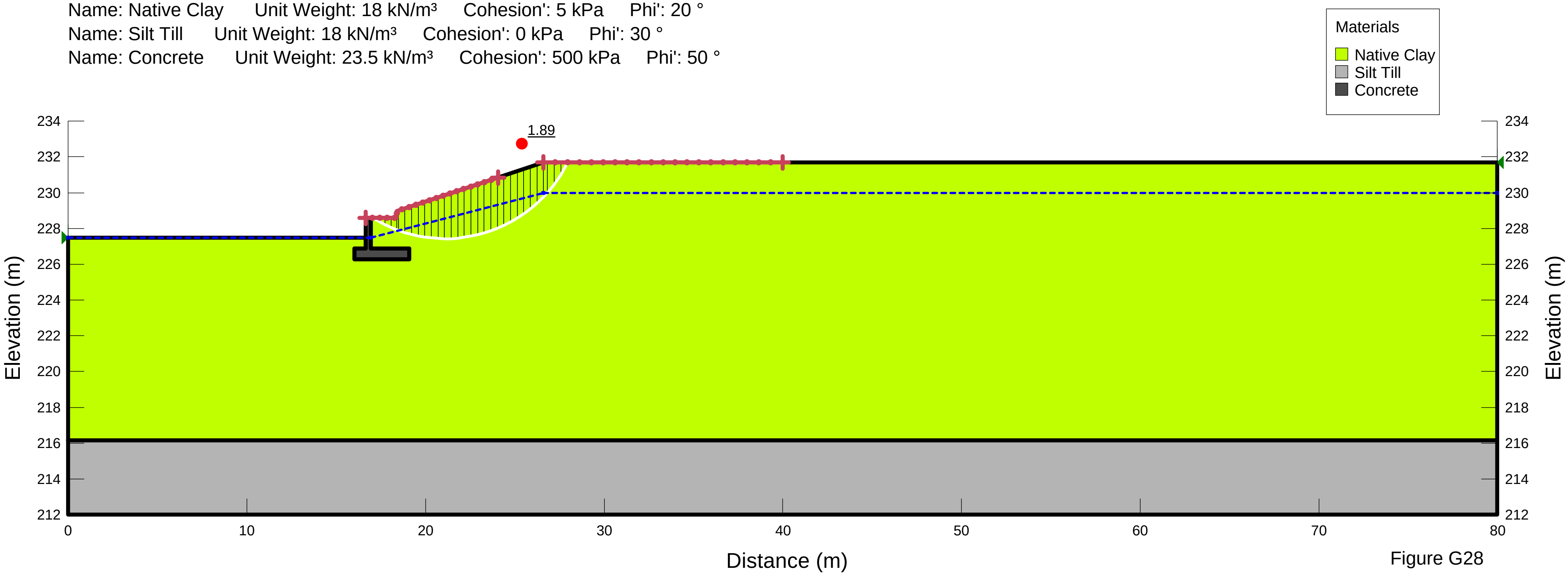


Figure G28

Station 1+215.00 - Existing Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

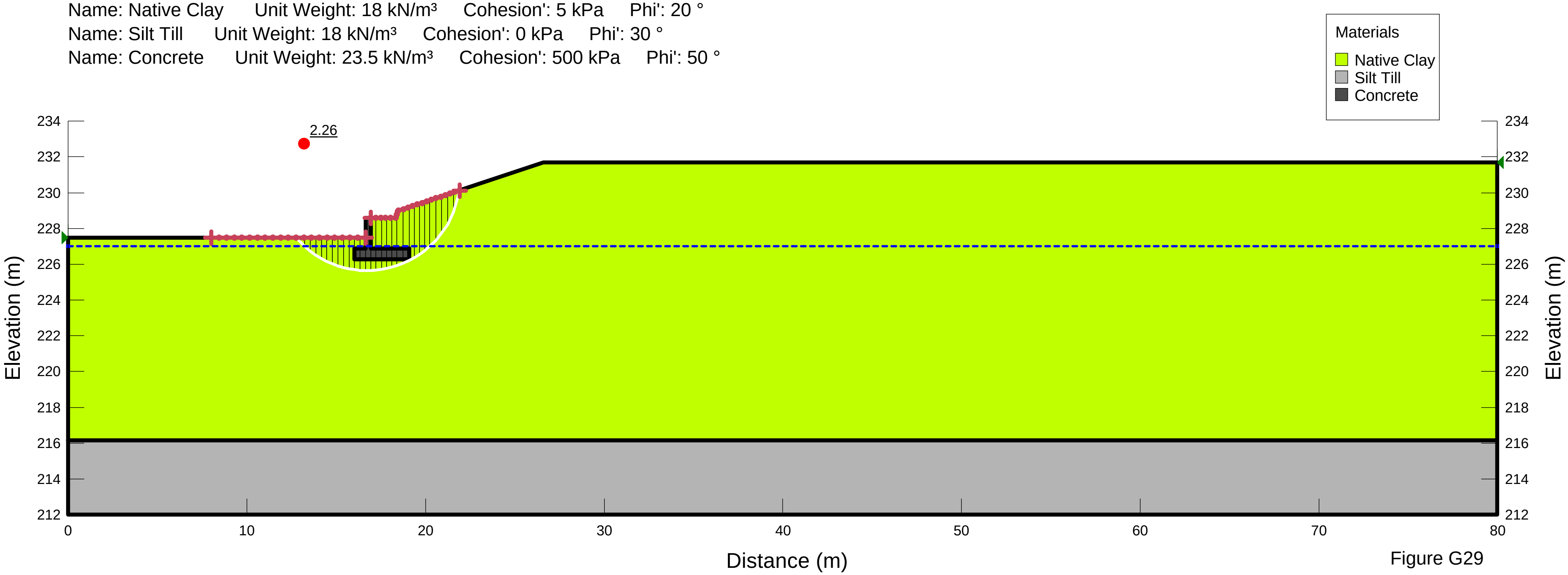


Figure G29

Station 1+215.00 - Existing Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

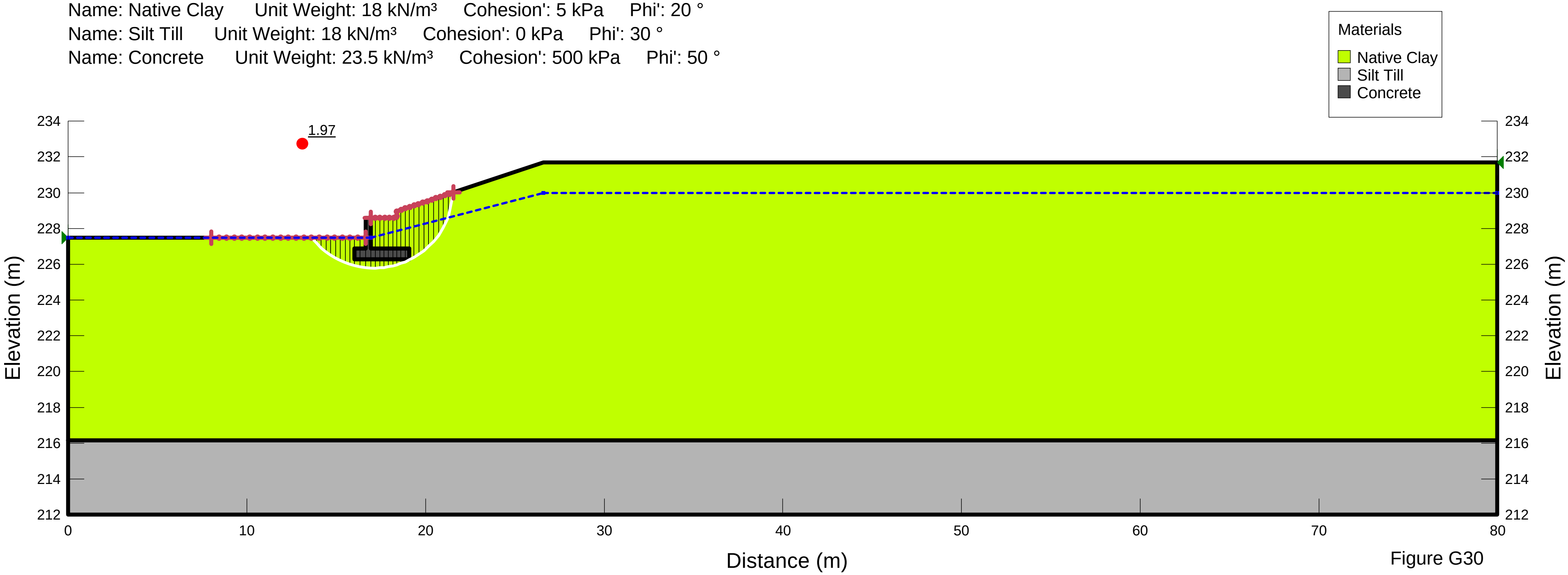


Figure G30

Appendix H
CONSTRUCTION CONDITIONS SLOPE STABILITY RESULTS

H.1 AT UNDERPASS STRUCTURE

Station 1+235.00 - Construction Conditions Immediately South of Underpass
Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °
Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

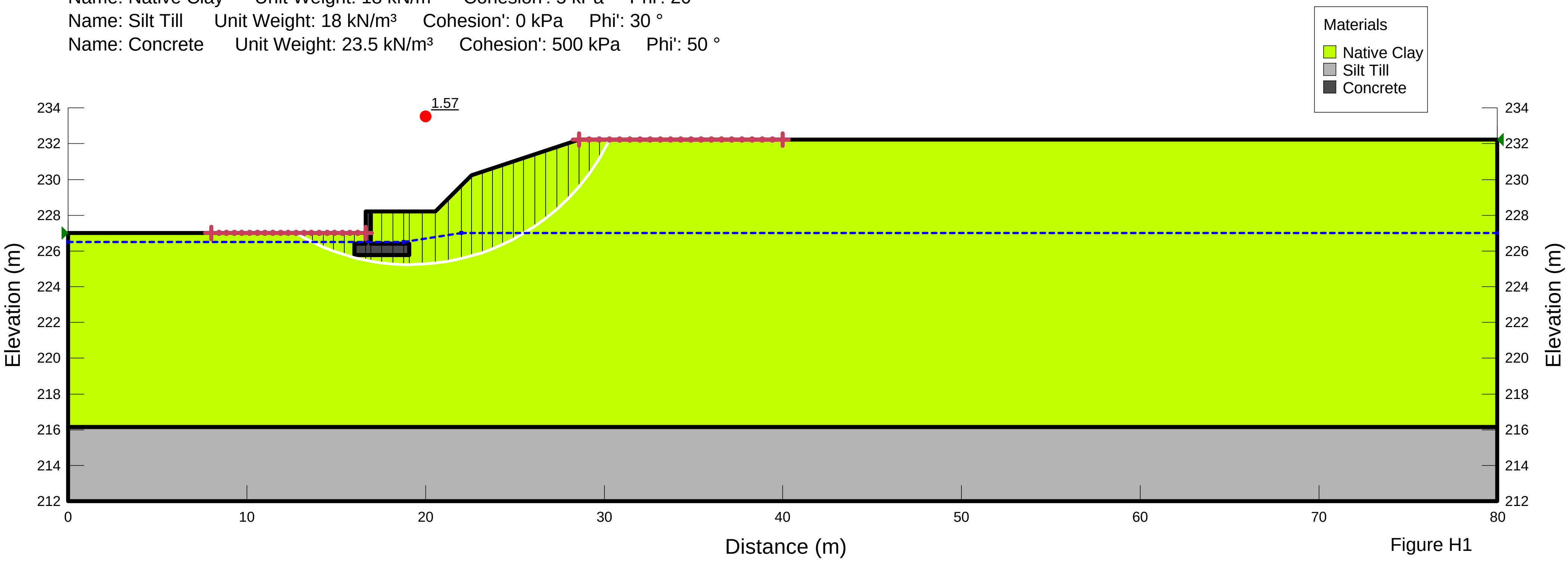


Figure H1

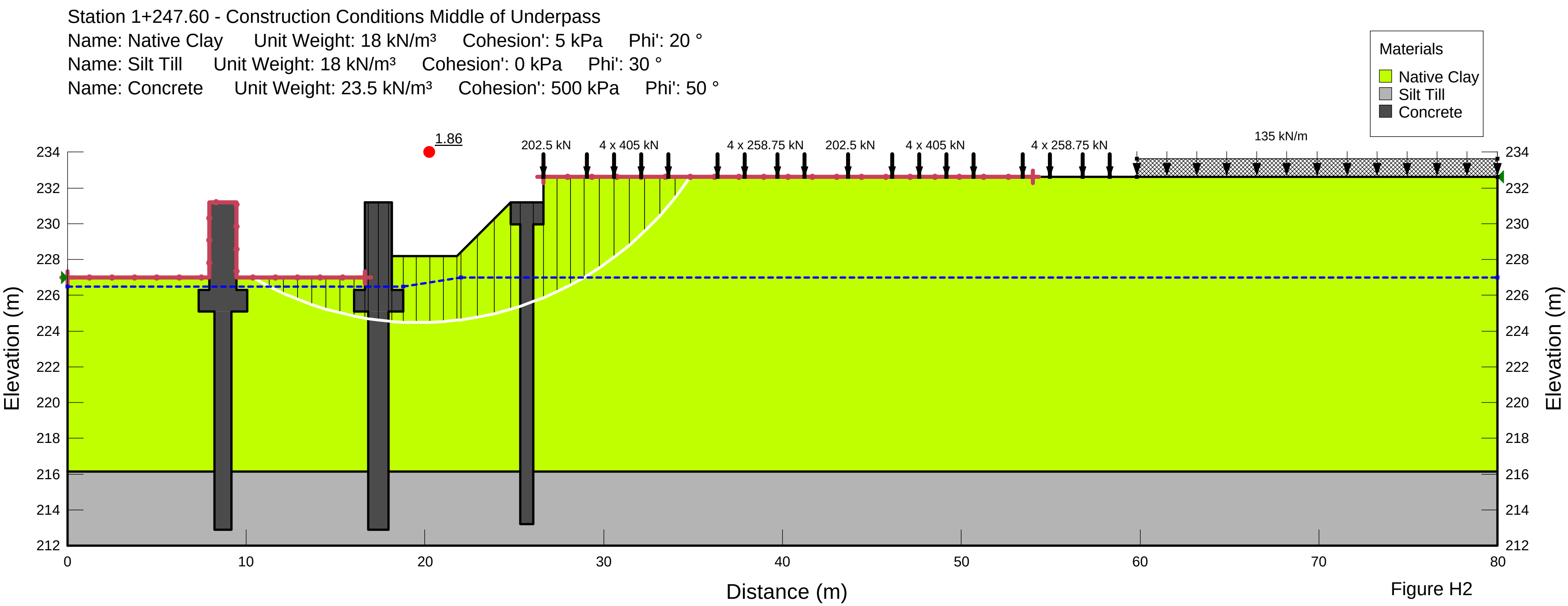

Station 1+247.60 - Construction Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.86
202.5 kN
4 x 405 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
Elevation (m)
Distance (m)
212
214
216
218
220
222
224
226
228
230
232
234
0
10
20
30
40
50
60
70
80

Figure H2

Station 1+264.62 - Construction Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

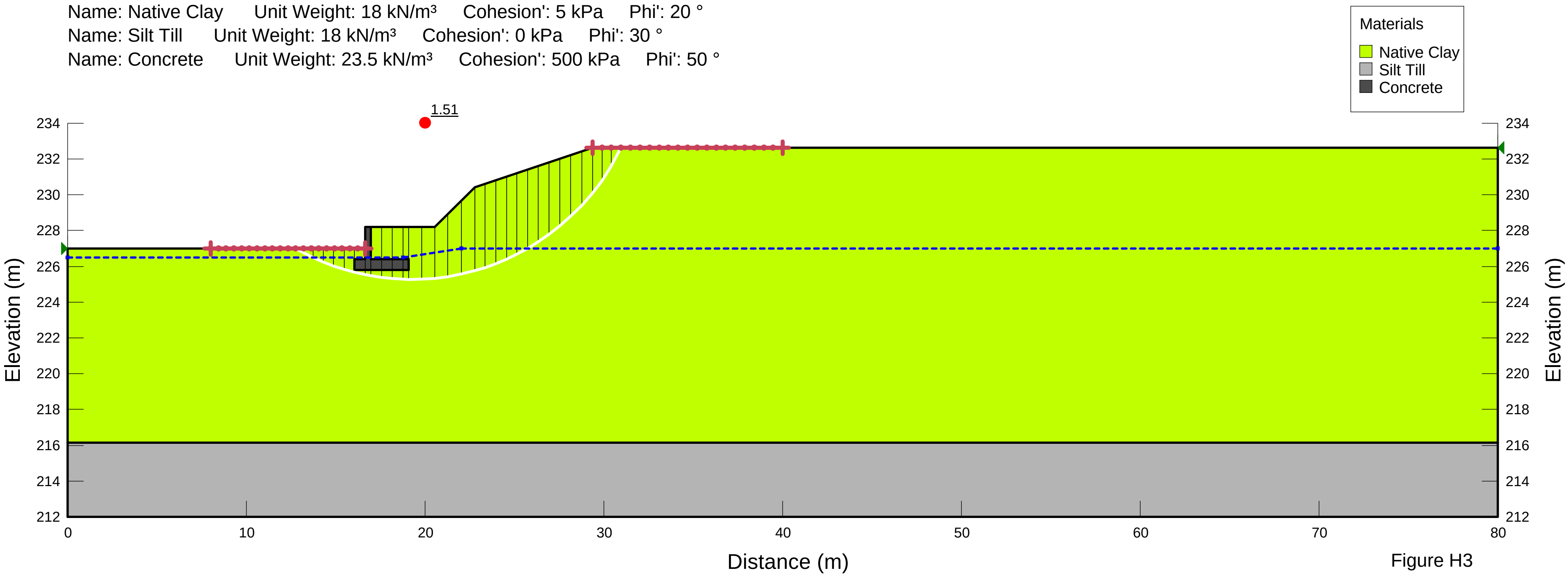


Figure H3

Station 1+235.00 - Construction Conditions Immediately South of Underpass
Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °
Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

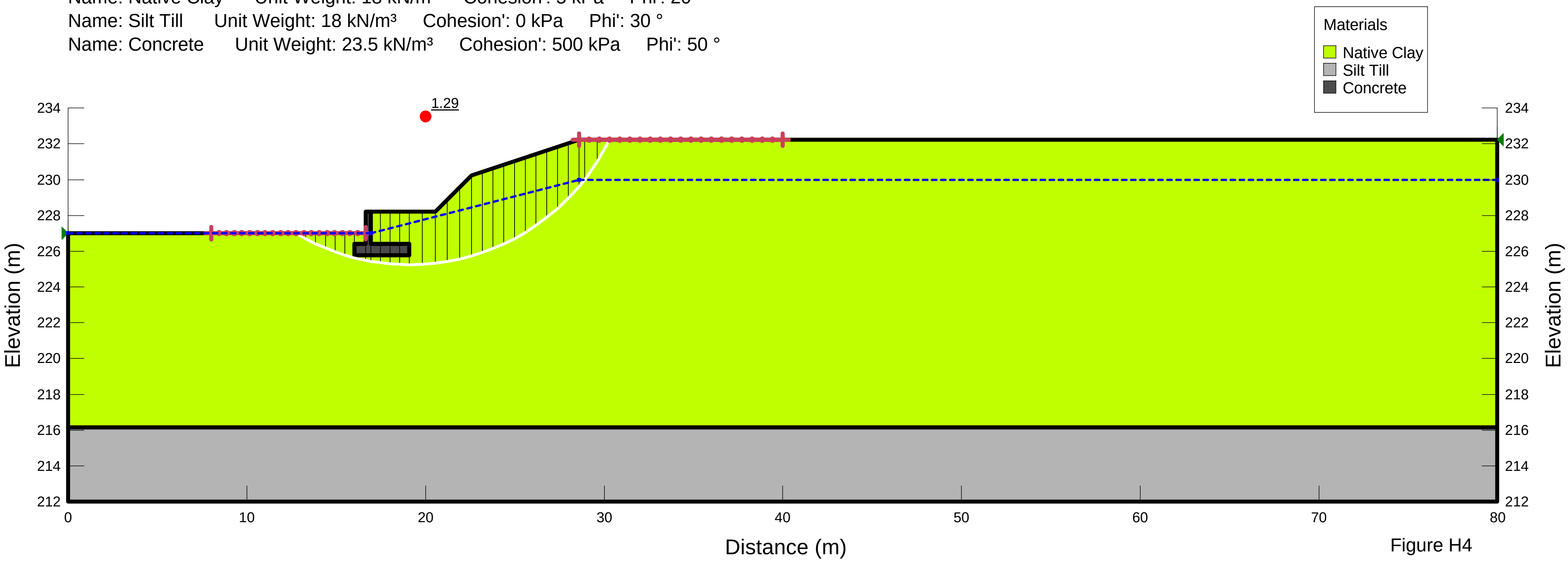


Figure H4

Station 1+247.60 - Construction Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

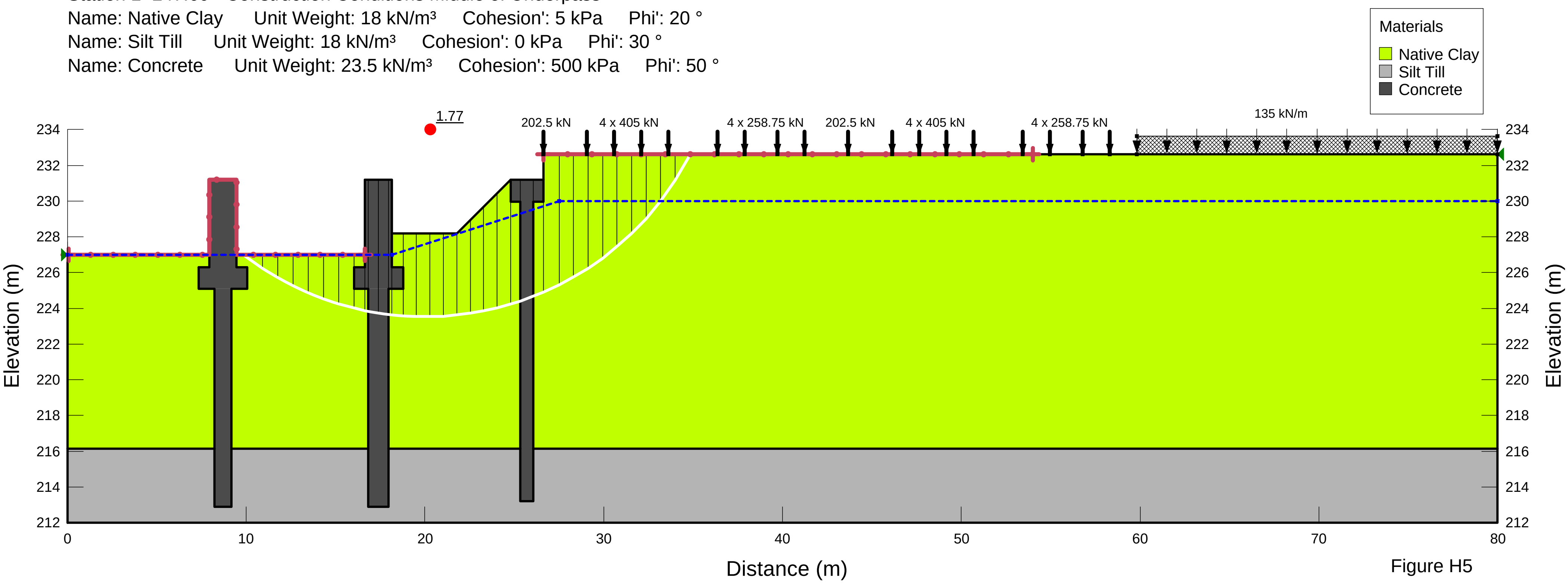


Figure H5

Station 1+264.62 - Construction Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

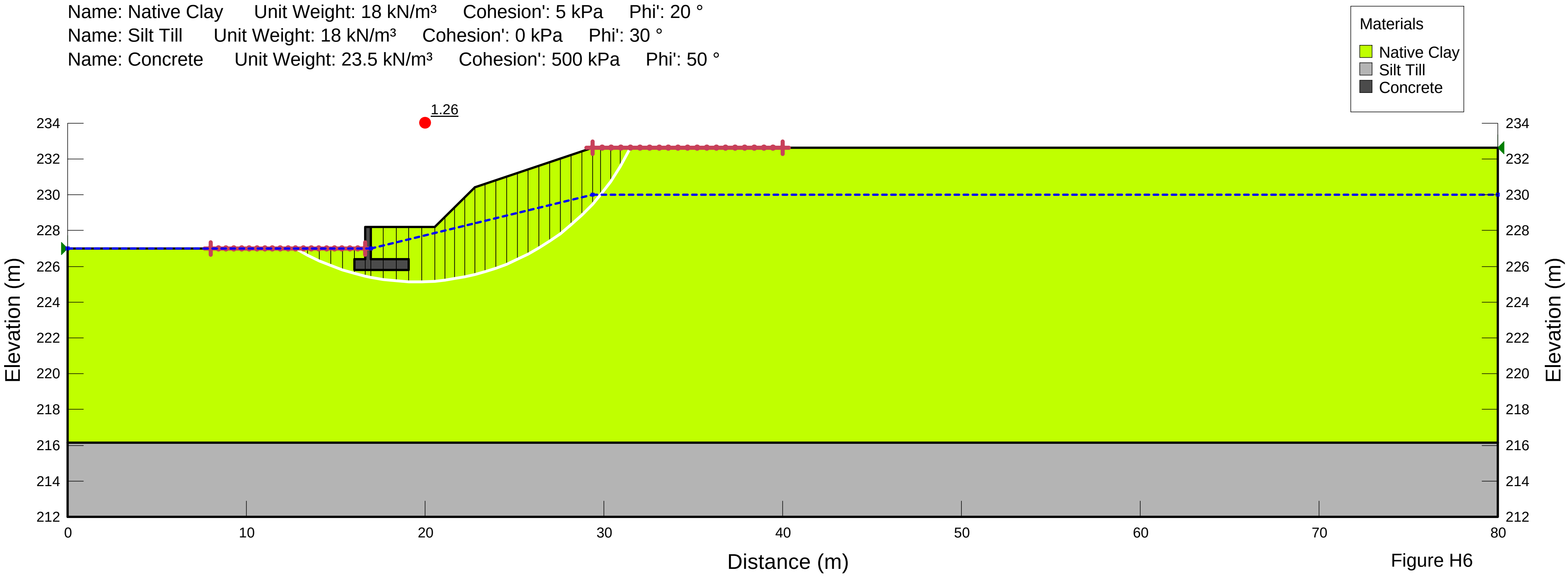
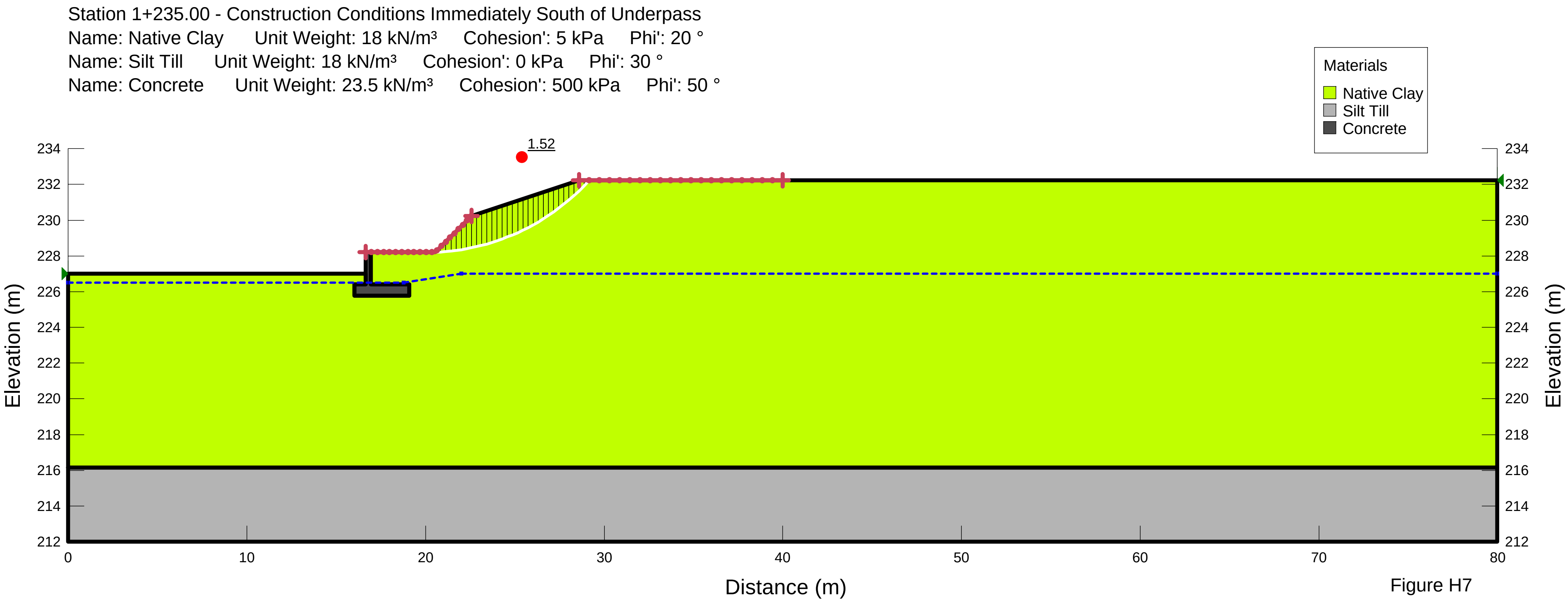


Figure H6



Station 1+235.00 - Construction Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.52
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure H7

Station 1+247.60 - Construction Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

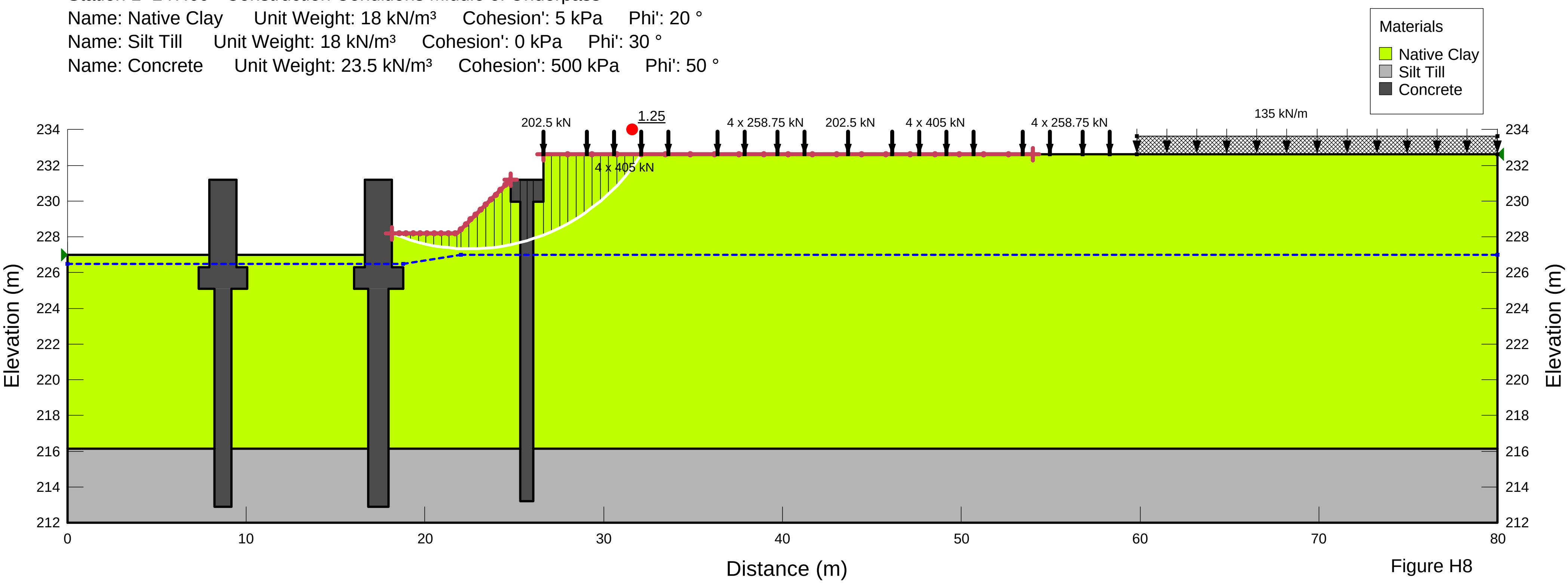


Figure H8

Station 1+264.62 - Construction Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

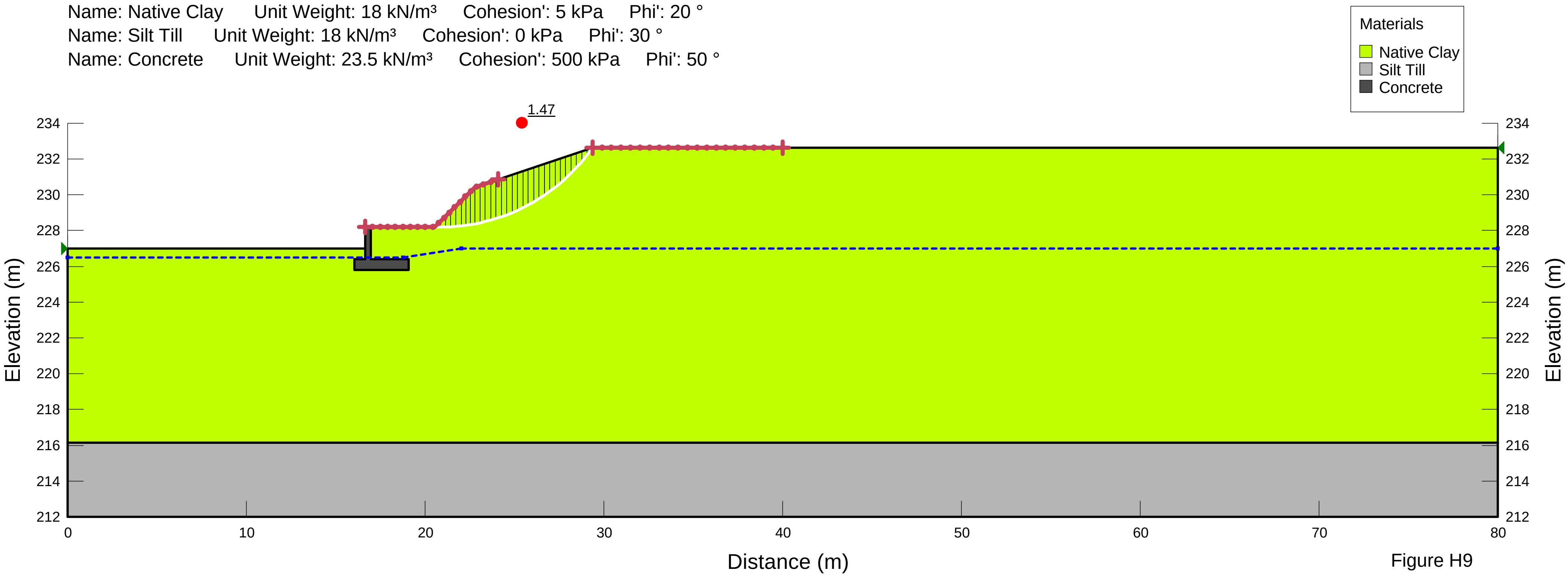


Figure H9

Station 1+235.00 - Construction Conditions Immediately South of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

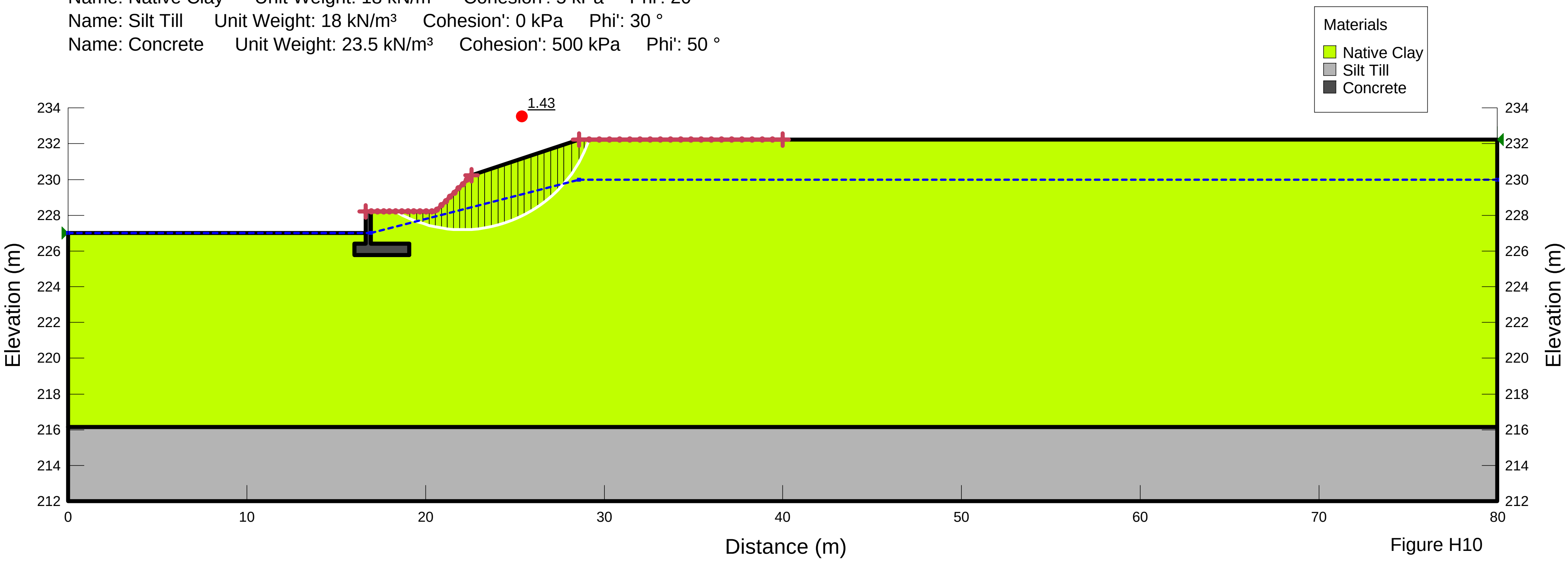


Figure H10

Station 1+247.60 - Construction Conditions Middle of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

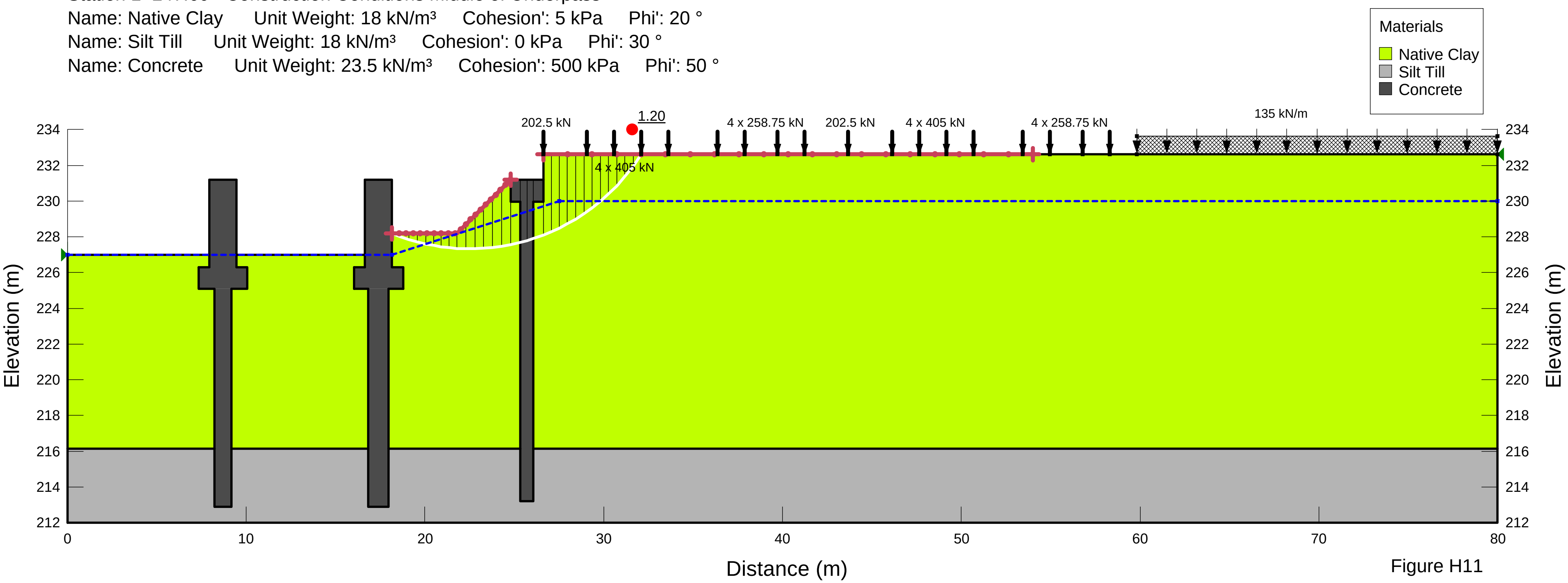
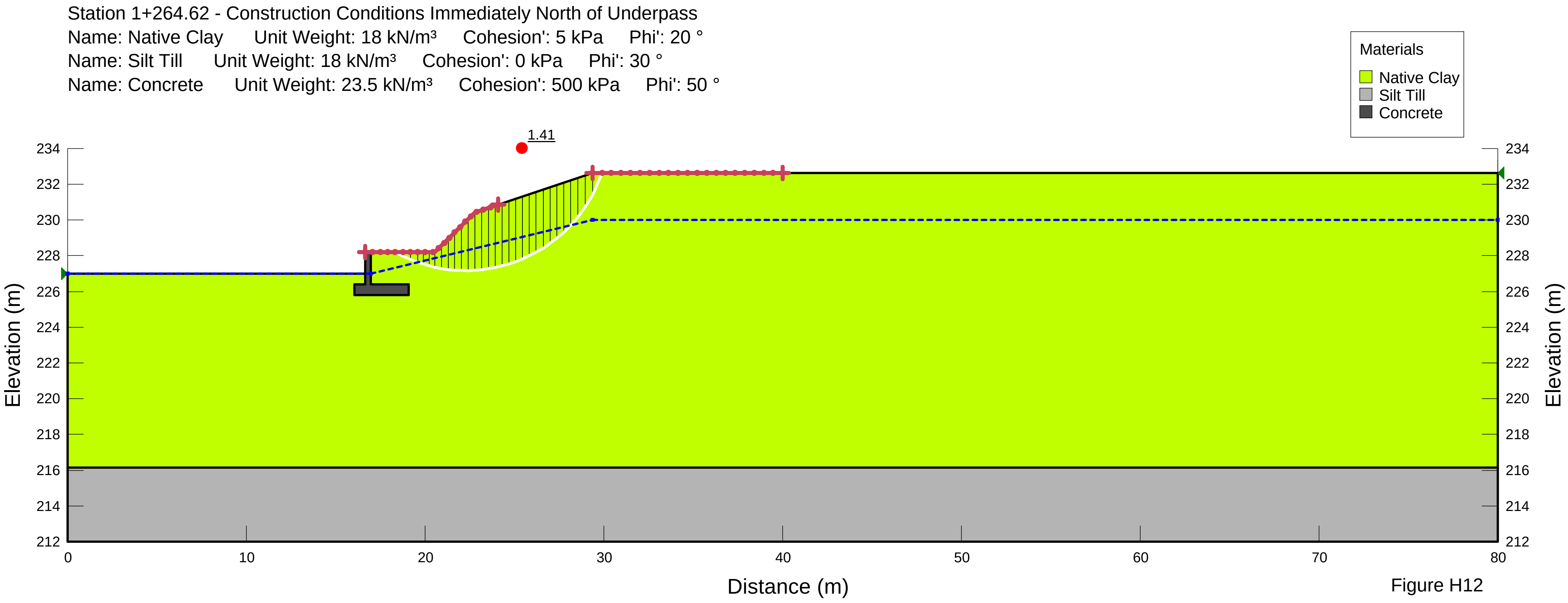


Figure H11



Station 1+264.62 - Construction Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.41
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure H12

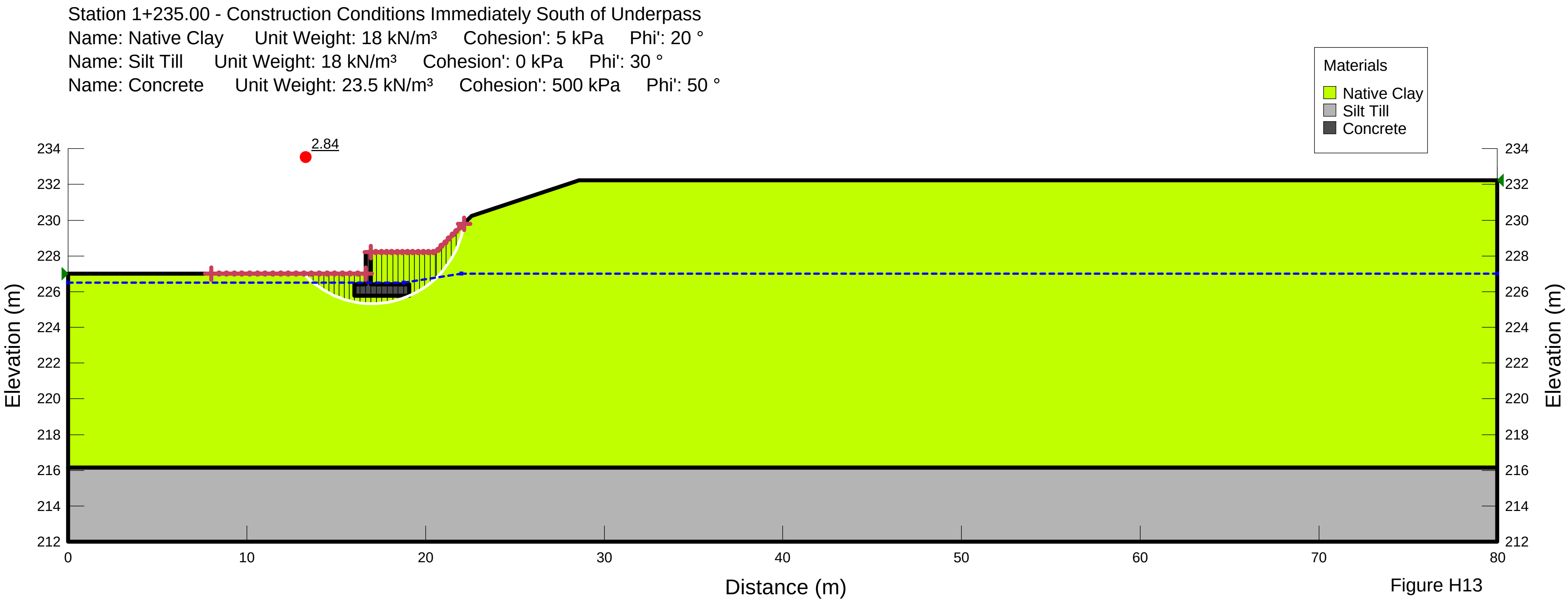
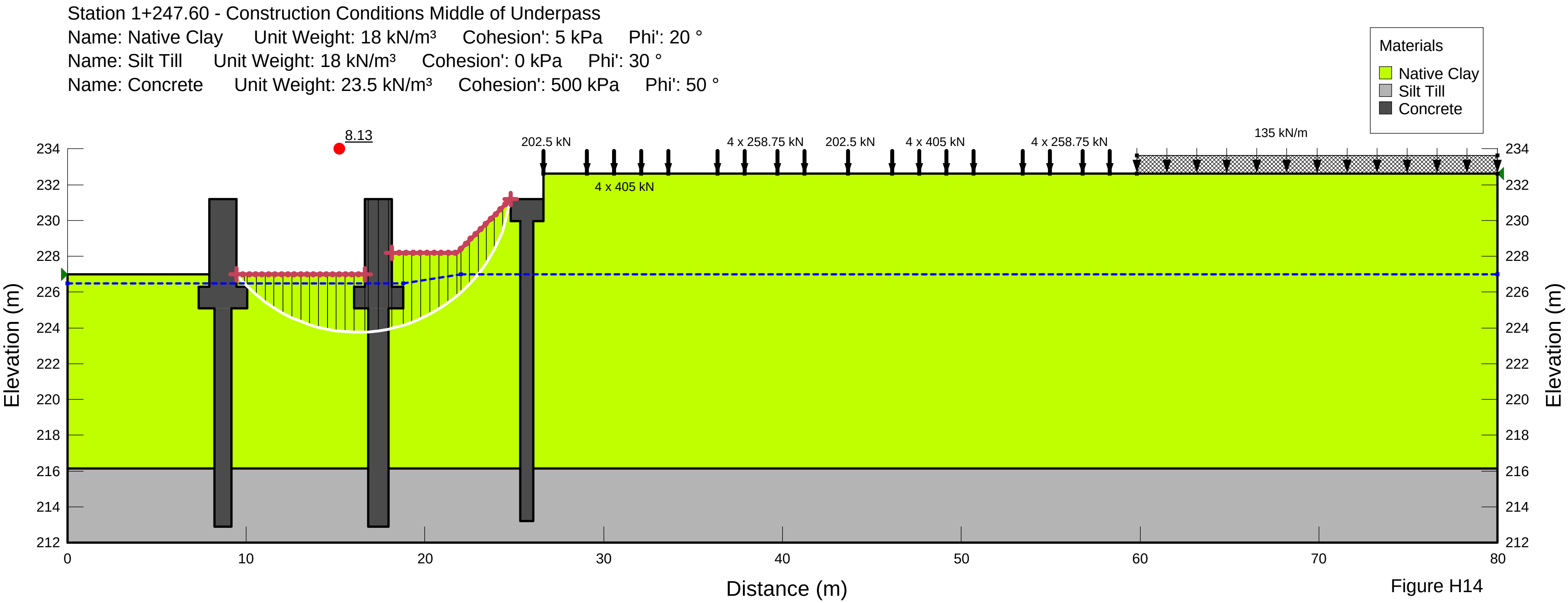

Station 1+235.00 - Construction Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
2.84
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure H13



Station 1+247.60 - Construction Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
8.13
202.5 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
4 x 405 kN
Elevation (m)
Distance (m)

Figure H14

Station 1+264.62 - Construction Conditions Immediately North of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

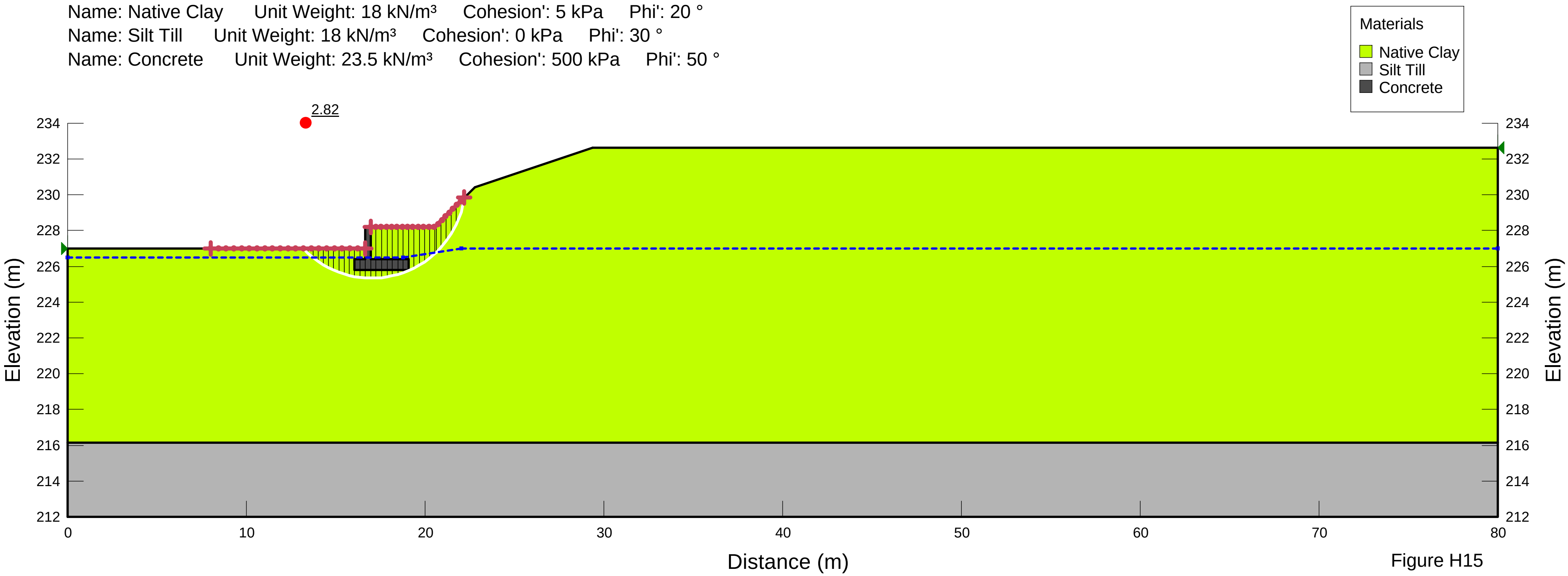


Figure H15

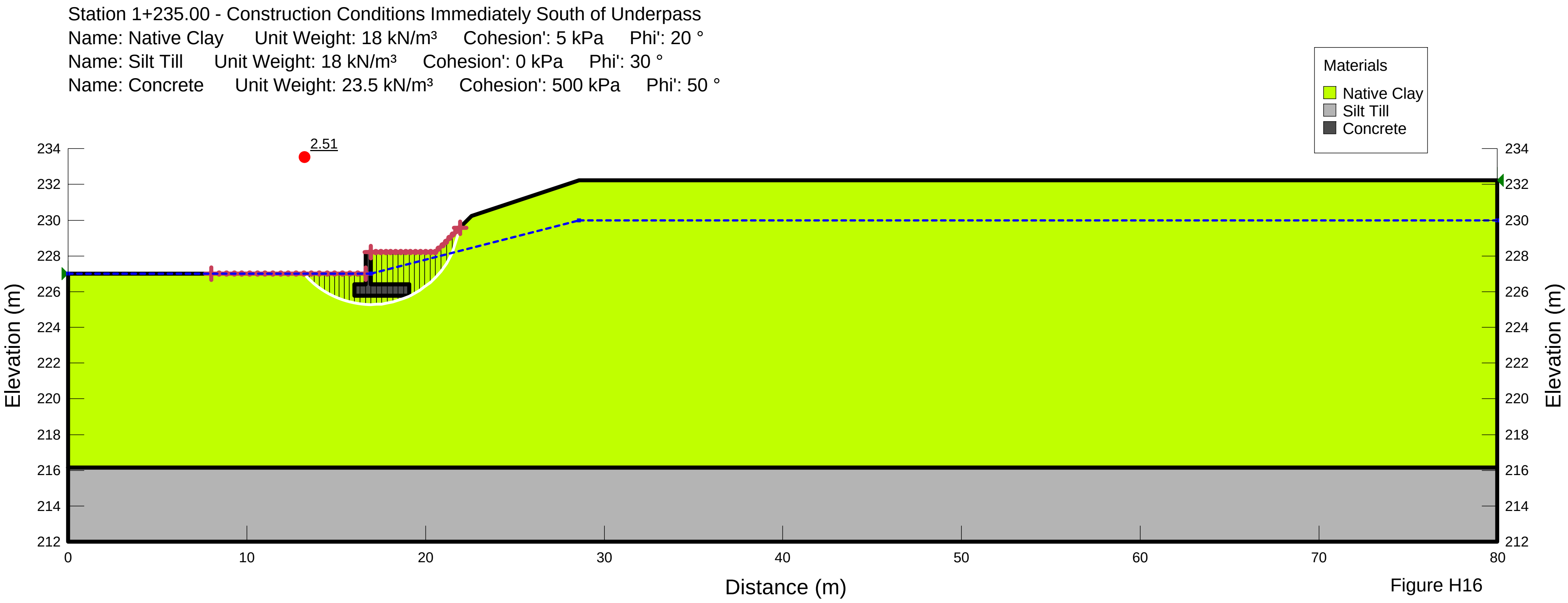

Station 1+235.00 - Construction Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
2.51
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure H16

Station 1+247.60 - Construction Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

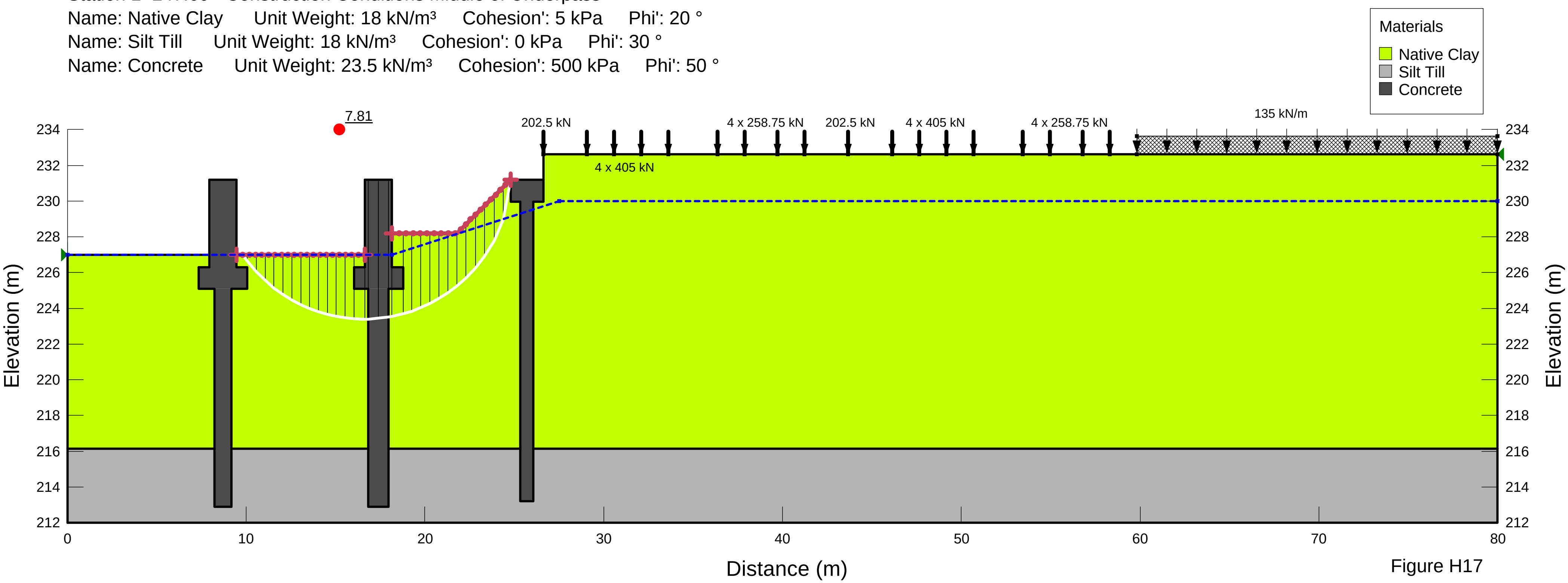


Figure H17

Station 1+264.62 - Construction Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

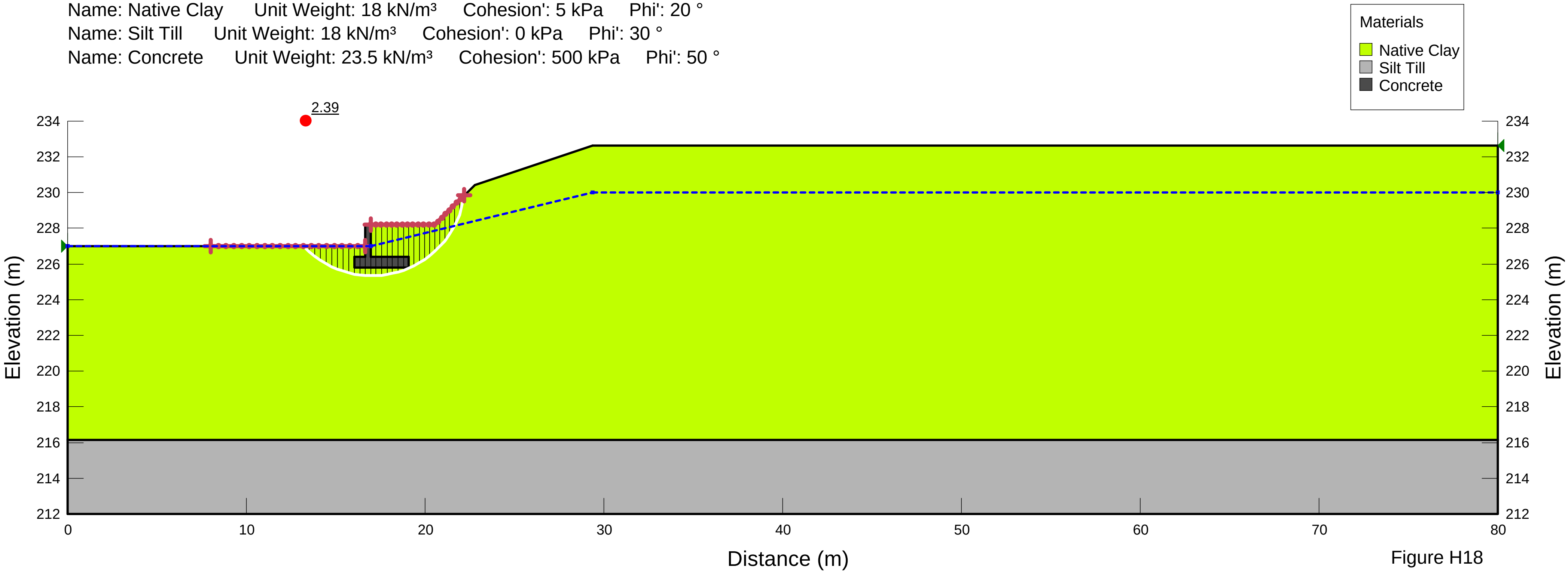


Figure H18

H.2 NORTH OF UNDERPASS STRUCTURE

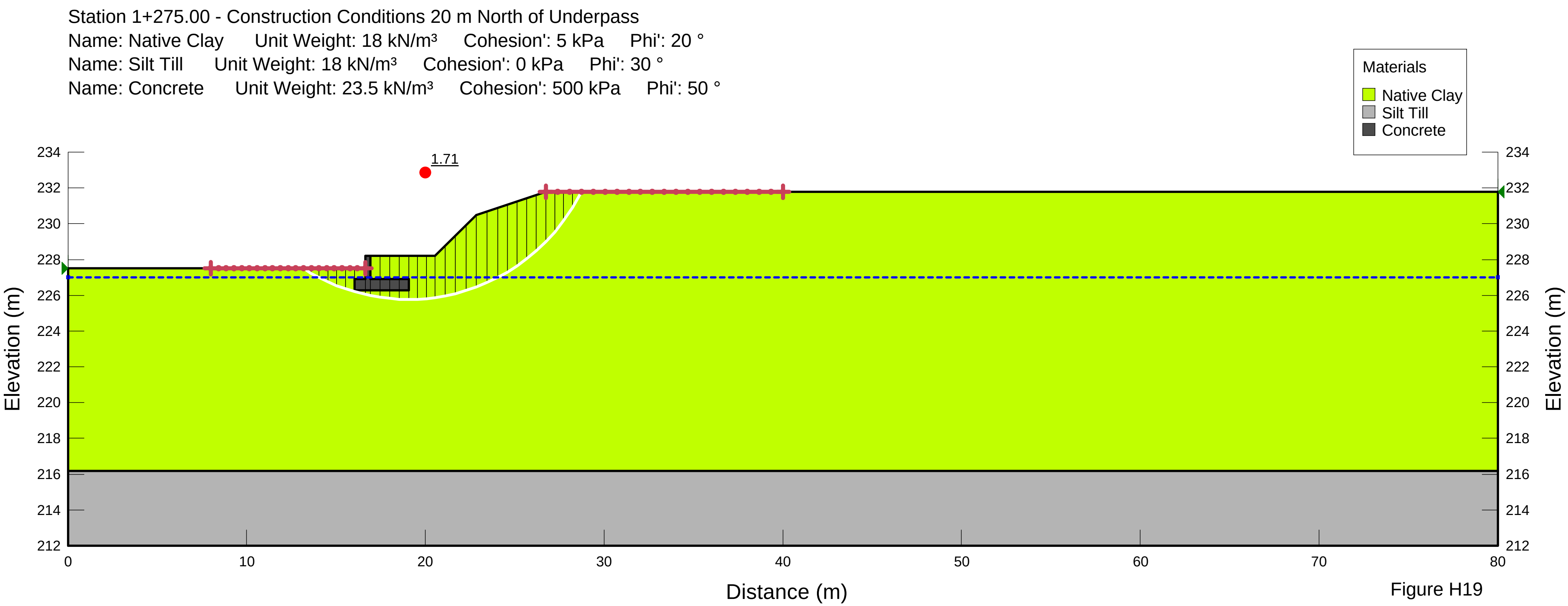

Station 1+275.00 - Construction Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.71
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure H19

Station 1+275.00 - Construction Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

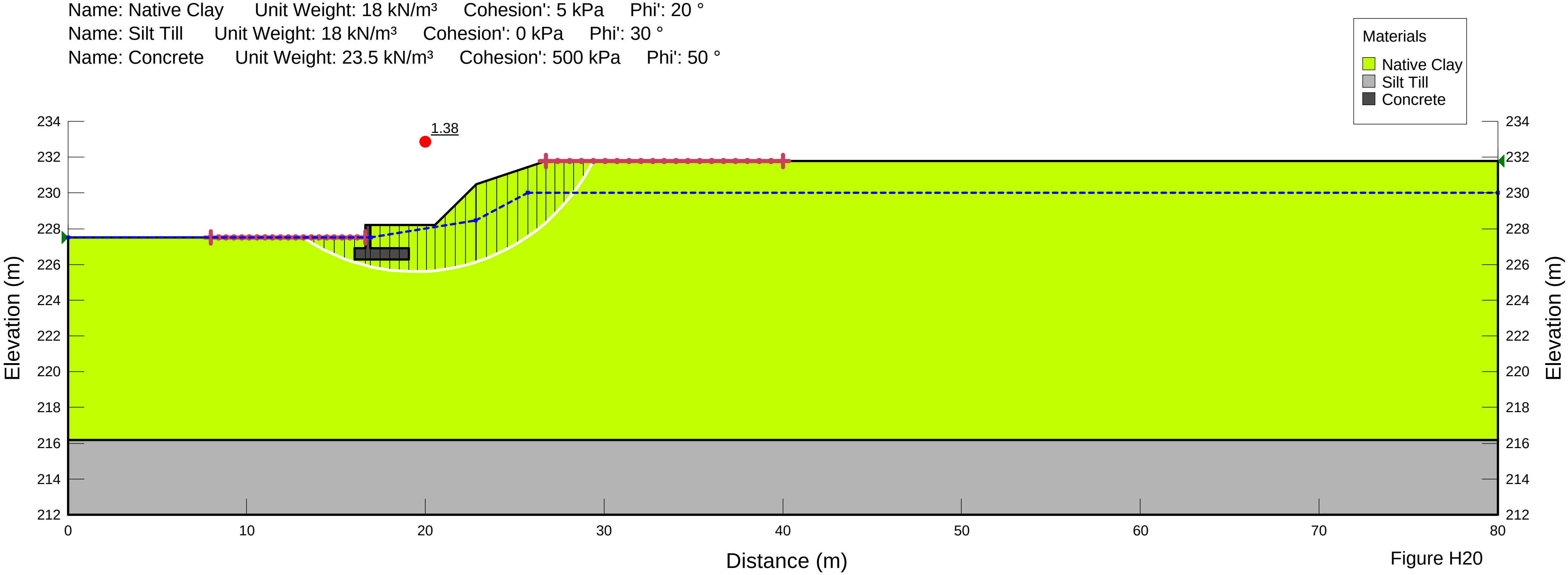


Figure H20

Station 1+275.00 - Construction Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

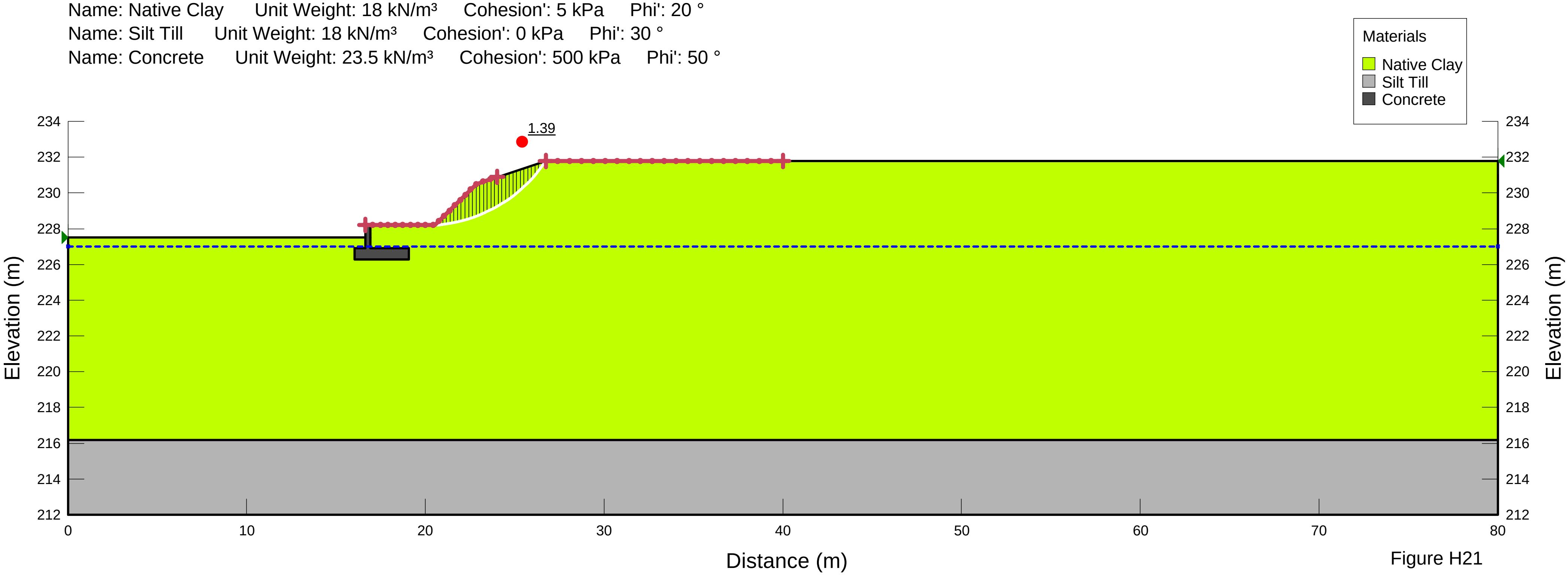


Figure H21

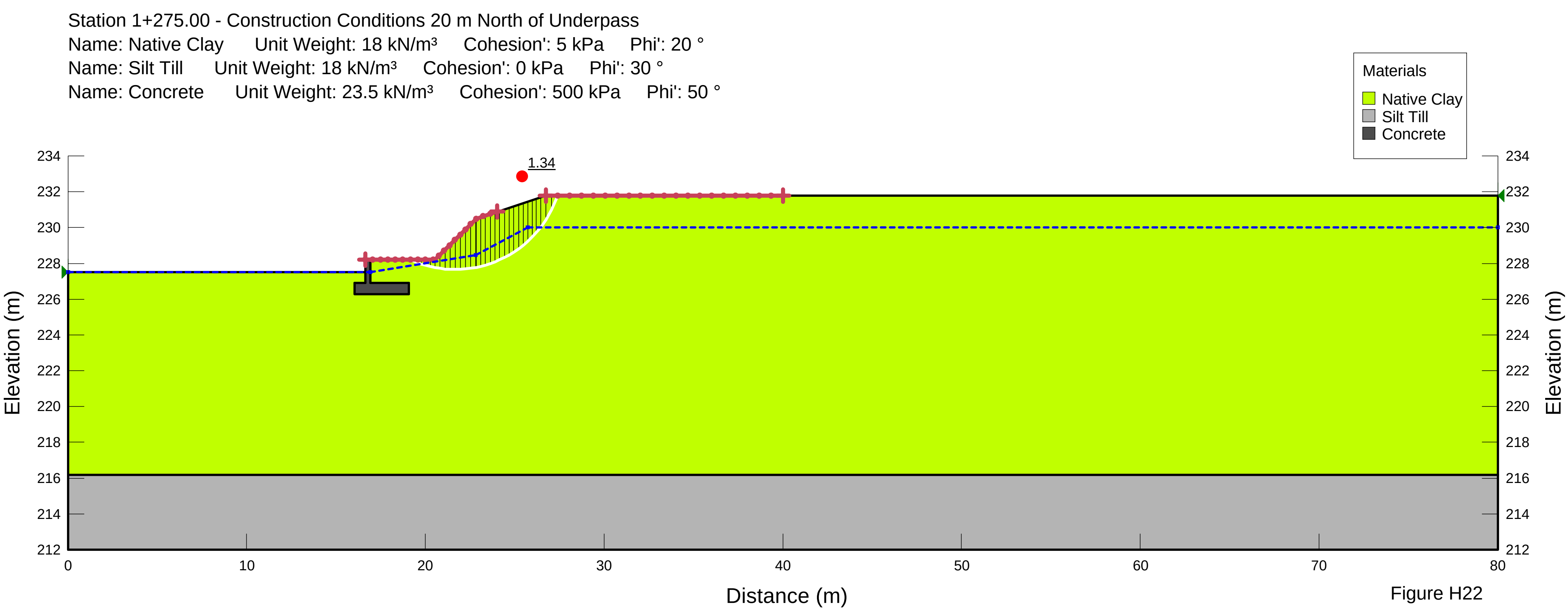

Station 1+275.00 - Construction Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.34
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure H22

Station 1+275.00 - Construction Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

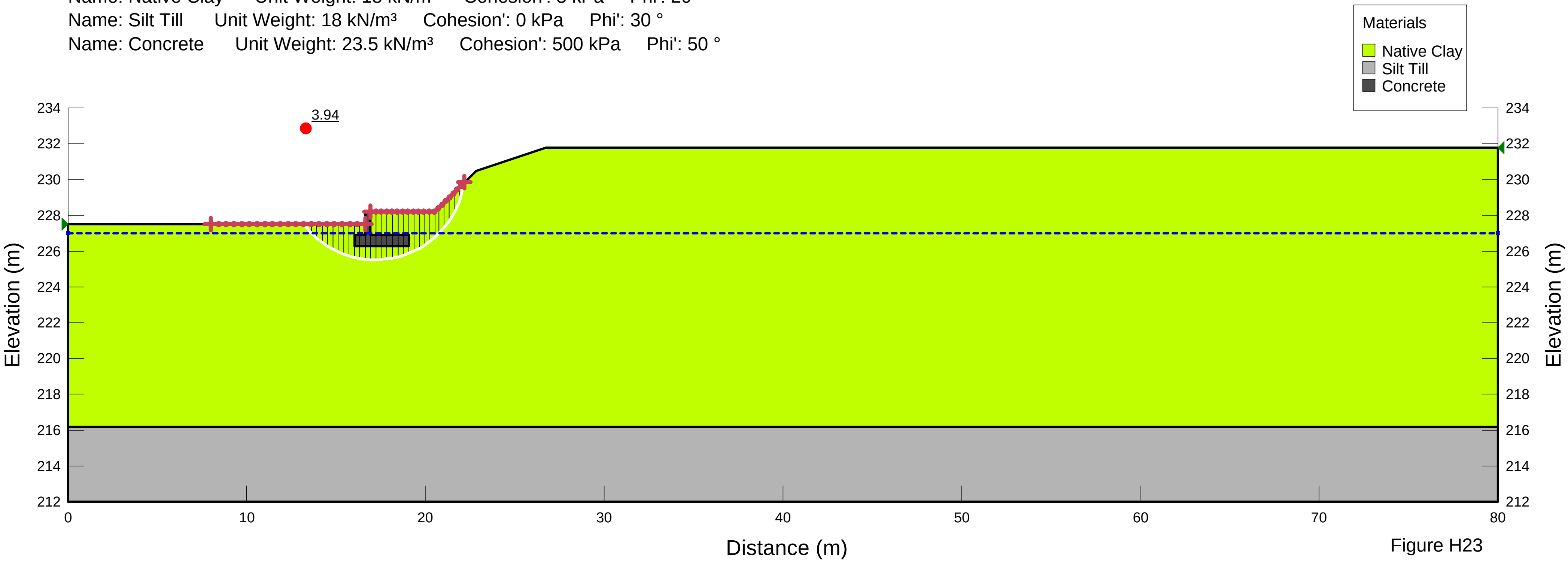


Figure H23

Station 1+275.00 - Construction Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

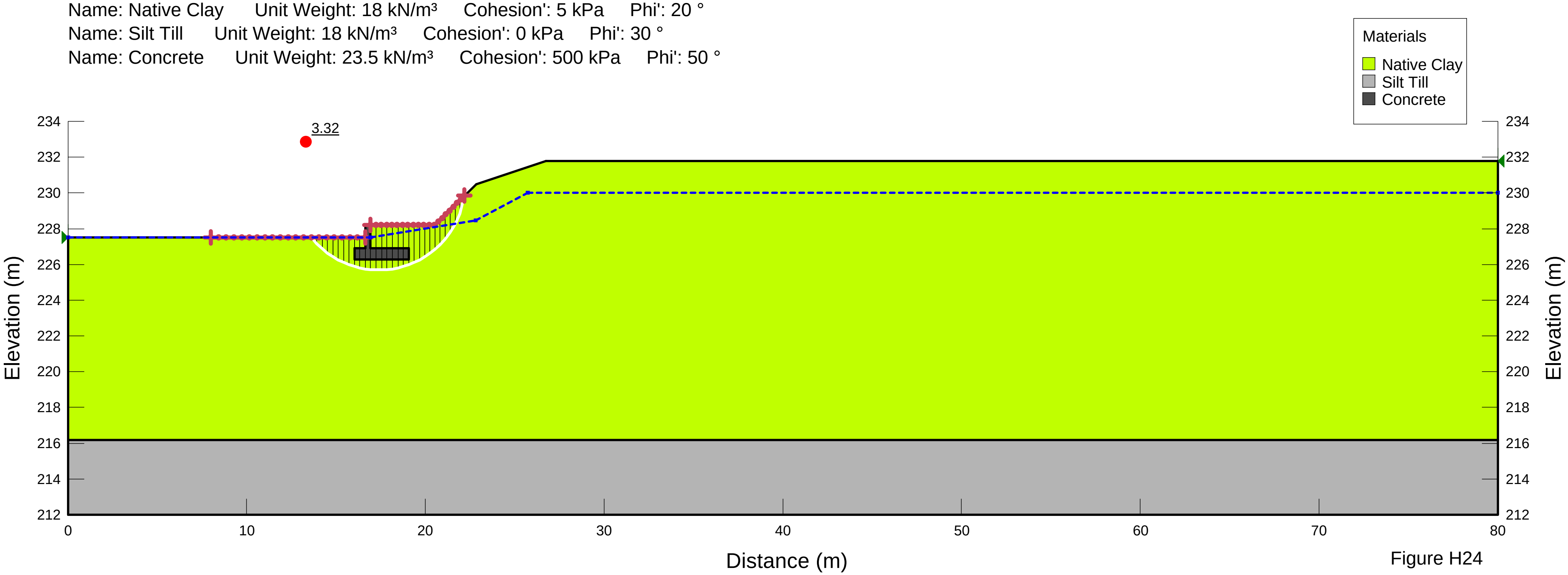


Figure H24

H.3 SOUTH OF UNDERPASS STRUCTURE

Station 1+215.00 - Construction Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

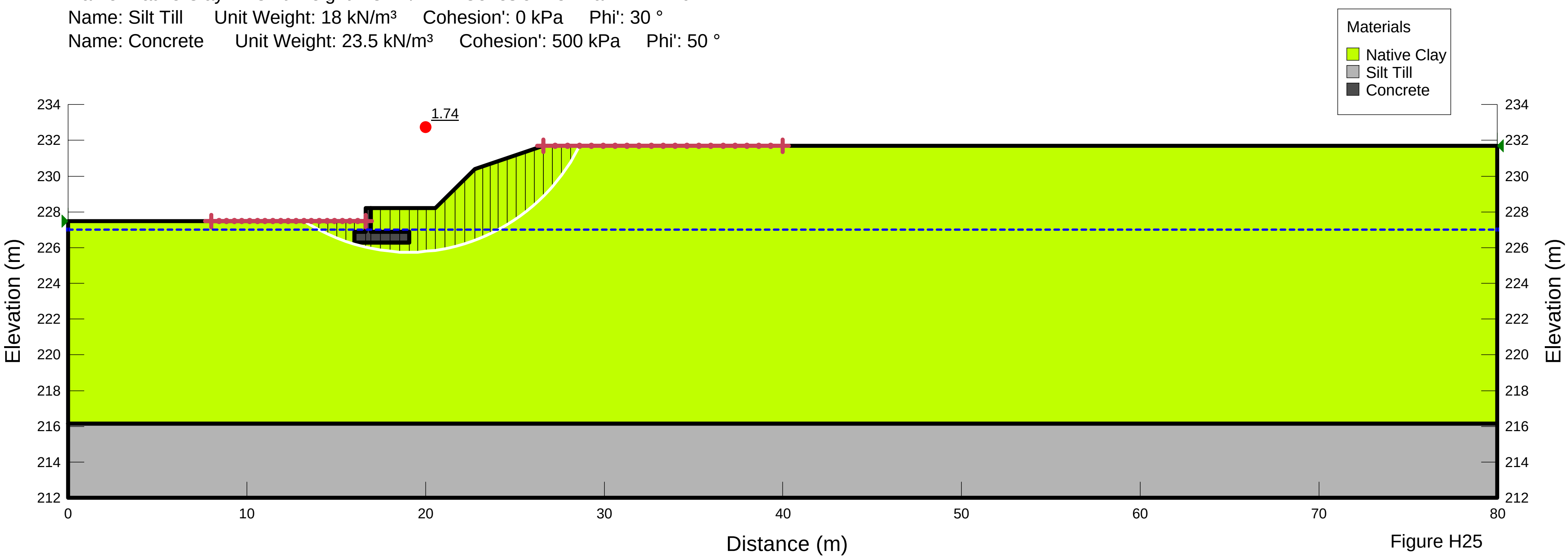


Figure H25

Station 1+215.00 - Construction Conditions 23 m South of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

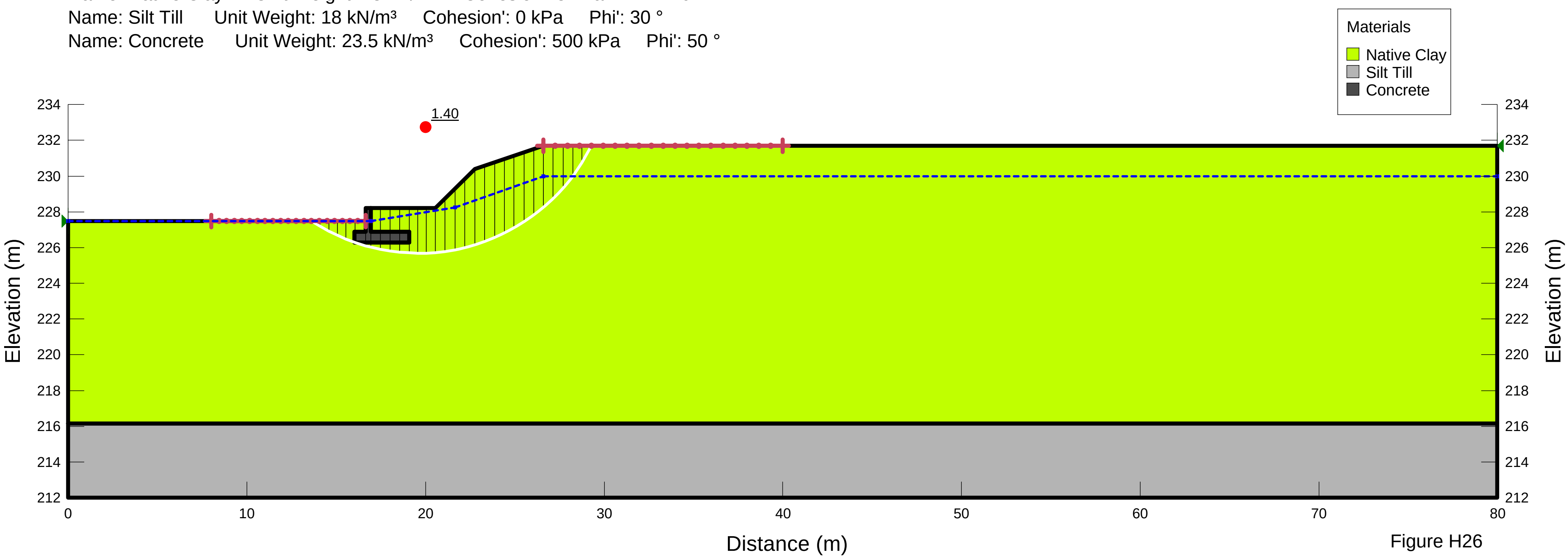


Figure H26

Station 1+215.00 - Construction Conditions 23 m South of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

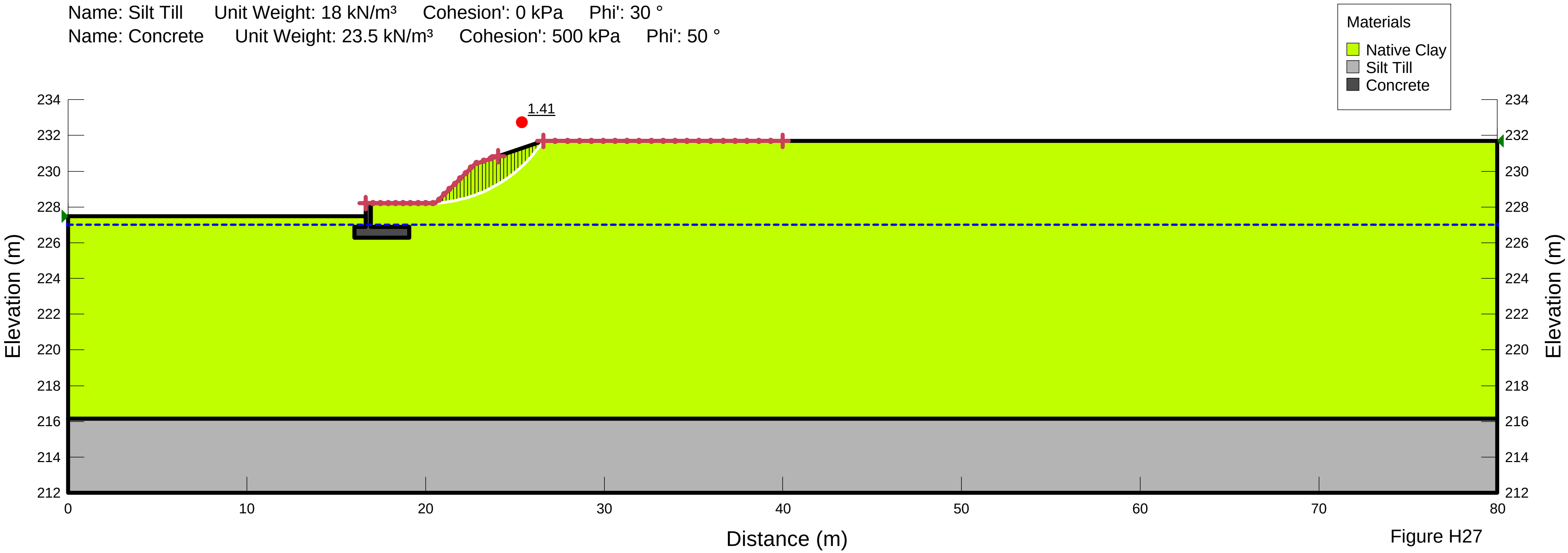


Figure H27

Station 1+215.00 - Construction Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

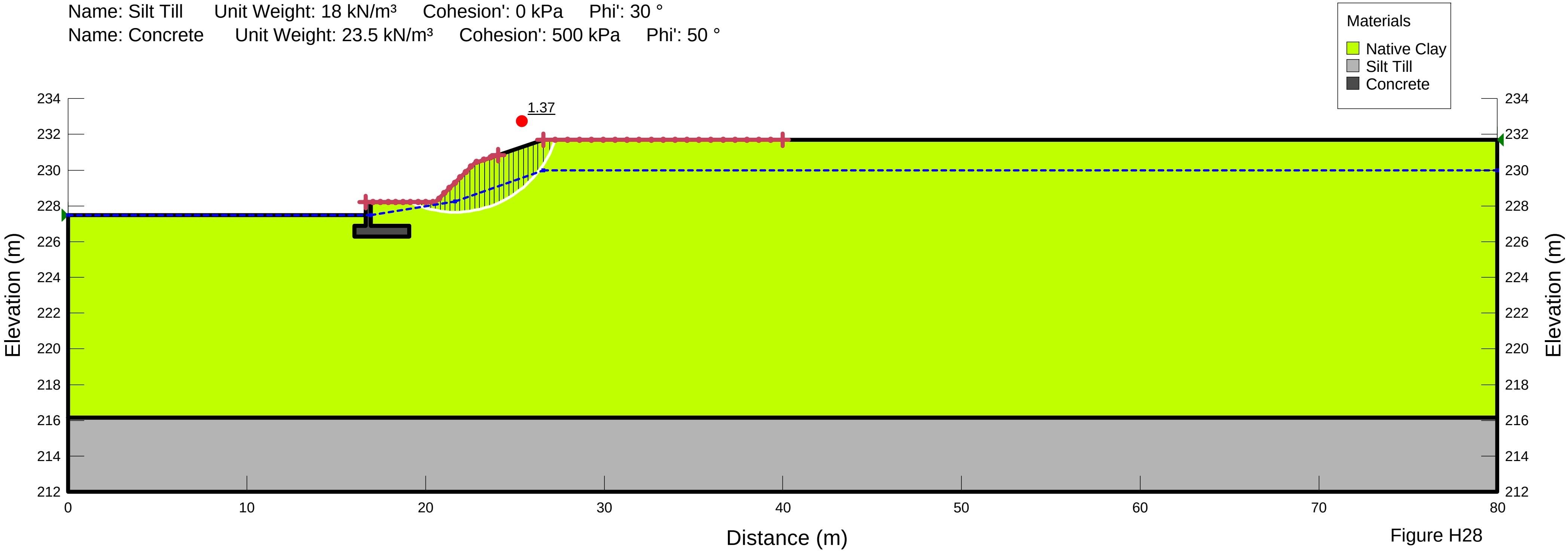


Figure H28

Station 1+215.00 - Construction Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

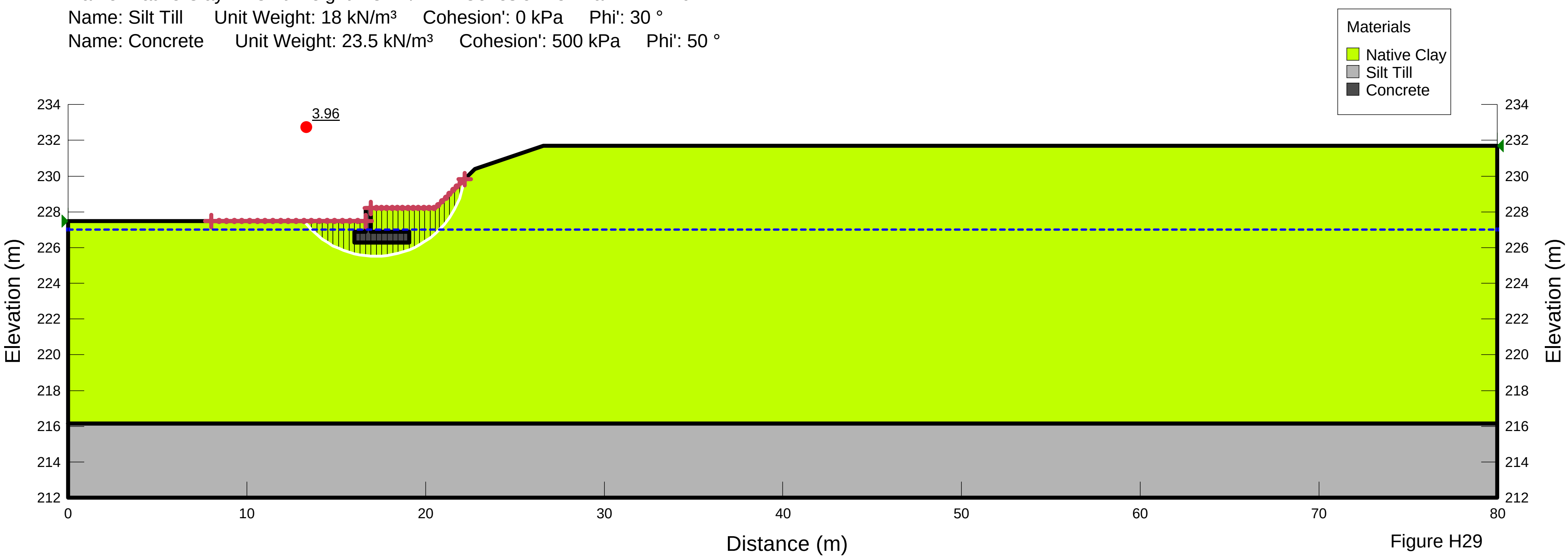


Figure H29

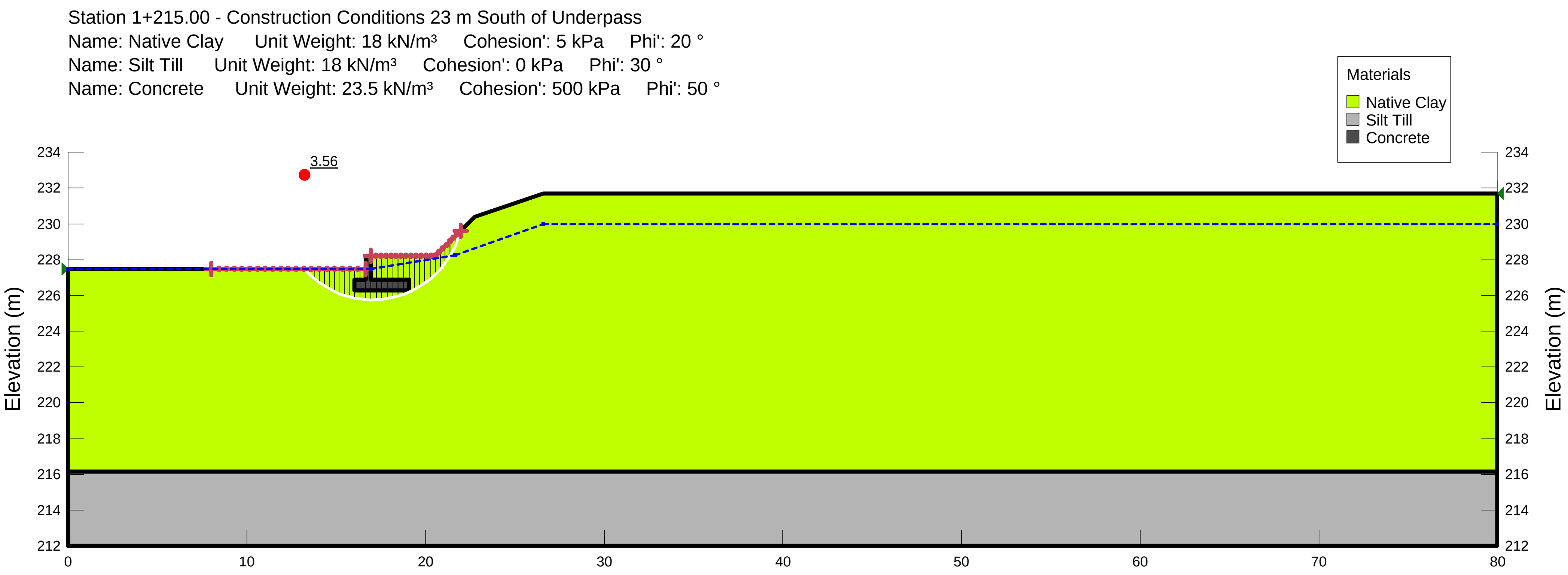
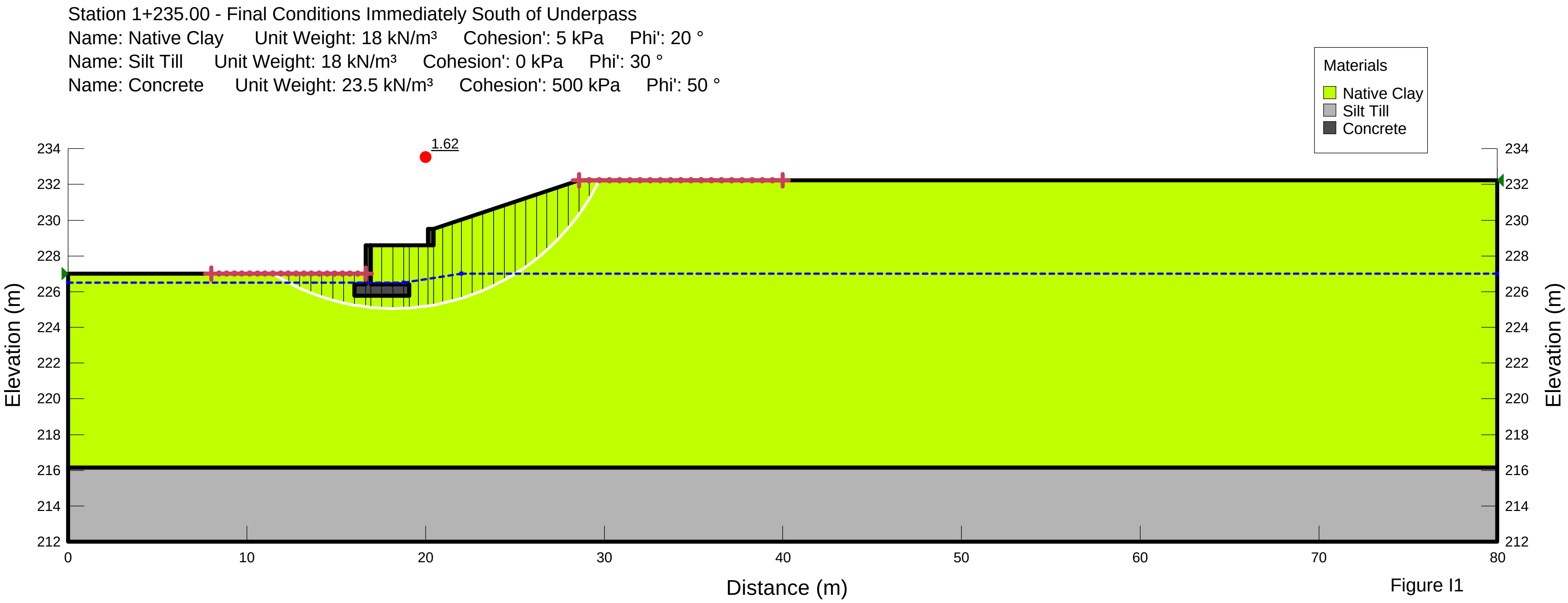

Station 1+215.00 - Construction Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
3.56
Elevation (m)
Distance (m)
212
214
216
218
220
222
224
226
228
230
232
234
0
10
20
30
40
50
60
70
80

Figure H30

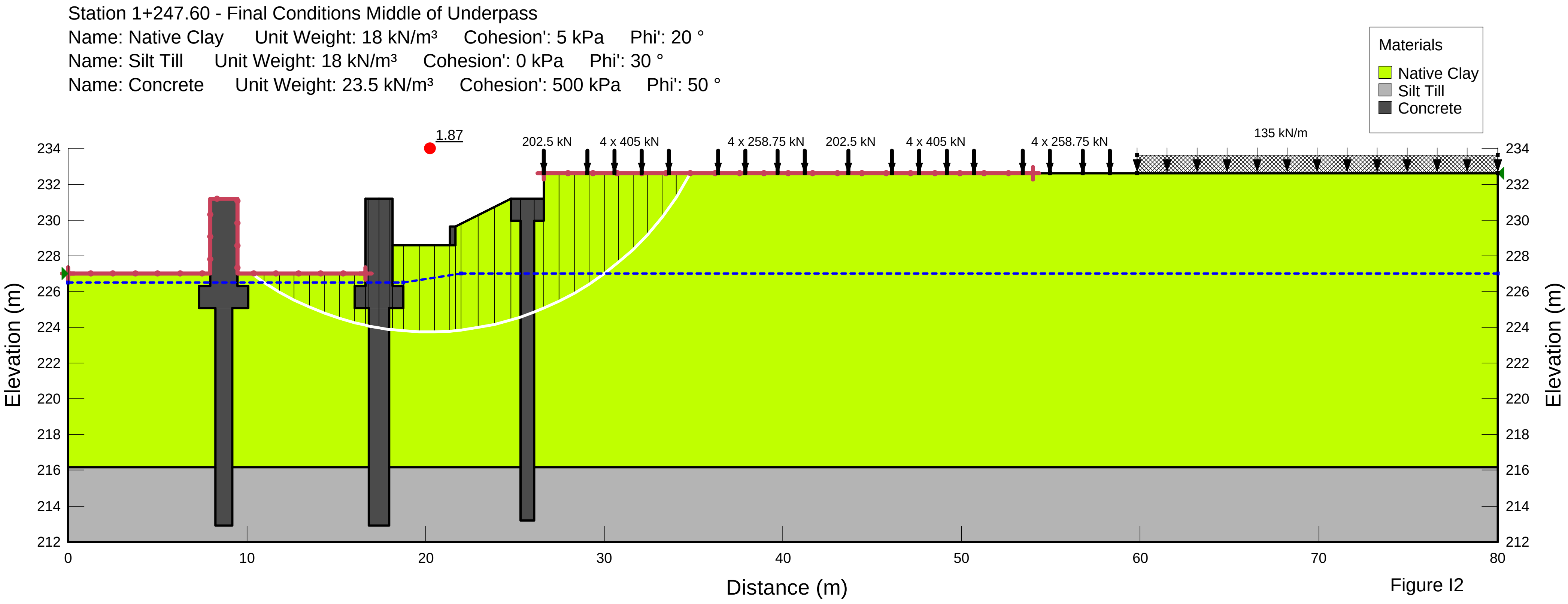
Appendix I
FINAL CONDITIONS SLOPE STABILITY RESULTS

I.1 AT UNDERPASS STRUCTURE



Station 1+235.00 - Final Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.62
Elevation (m)
Distance (m)

Figure I1



Station 1+247.60 - Final Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.87
202.5 kN
4 x 405 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
Elevation (m)
Distance (m)

Figure I2

Station 1+264.62 - Final Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

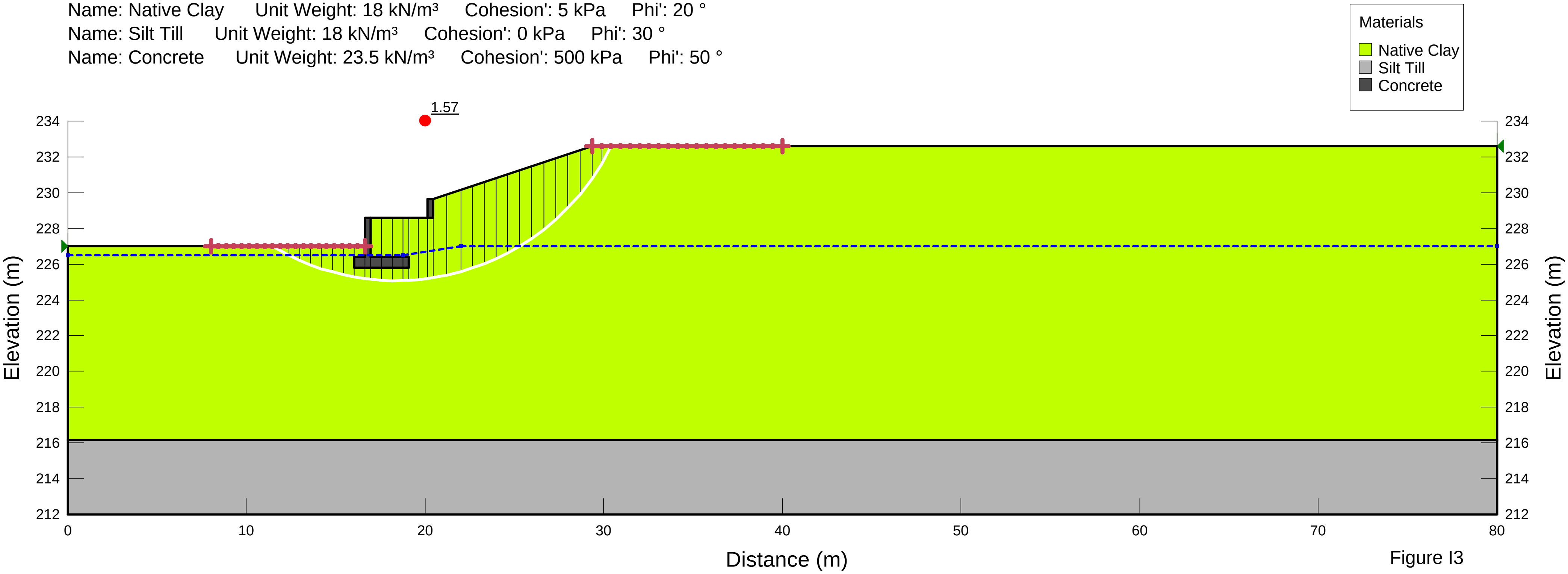


Figure I3

Station 1+235.00 - Final Conditions Immediately South of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

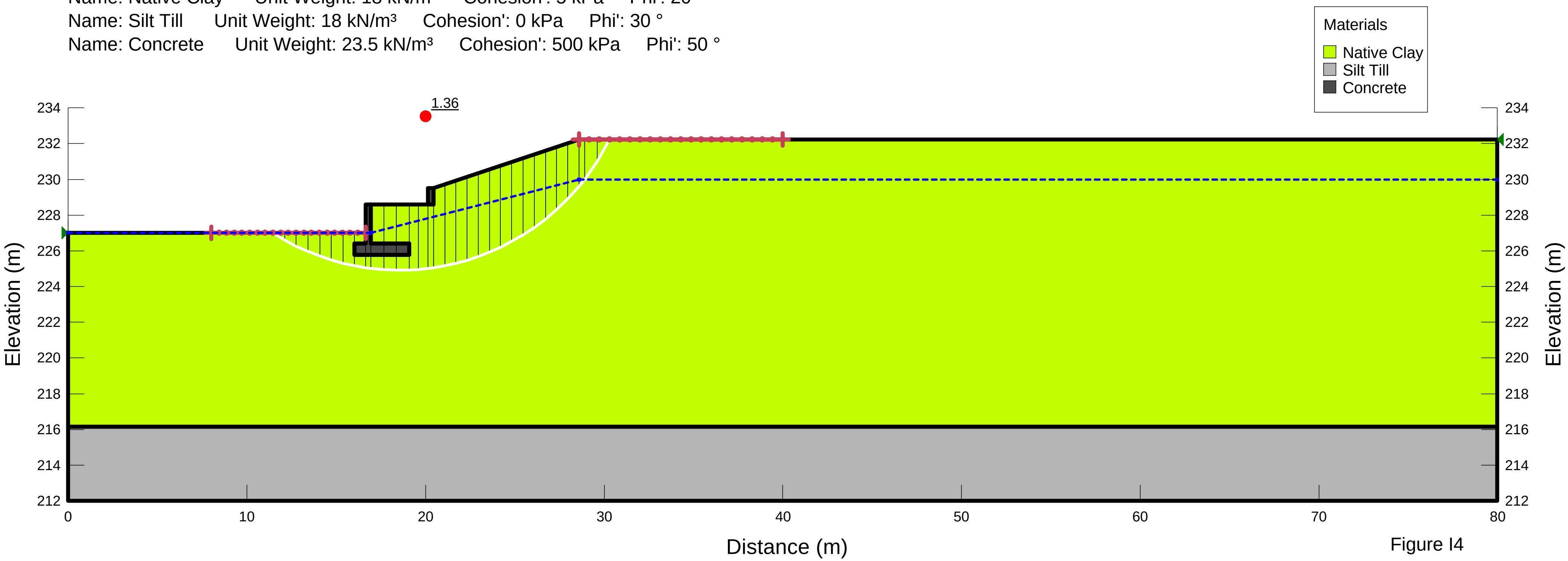


Figure I4

Station 1+247.60 - Final Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

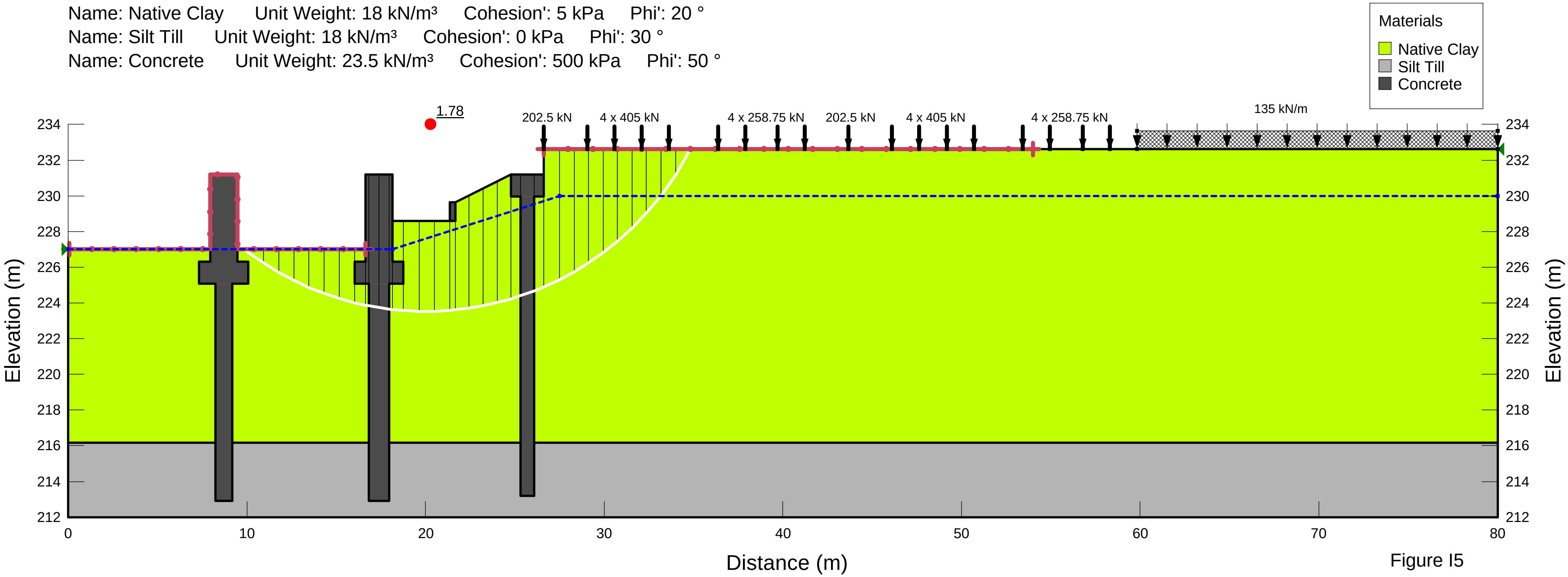


Figure I5

Station 1+264.62 - Final Conditions Immediately North of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

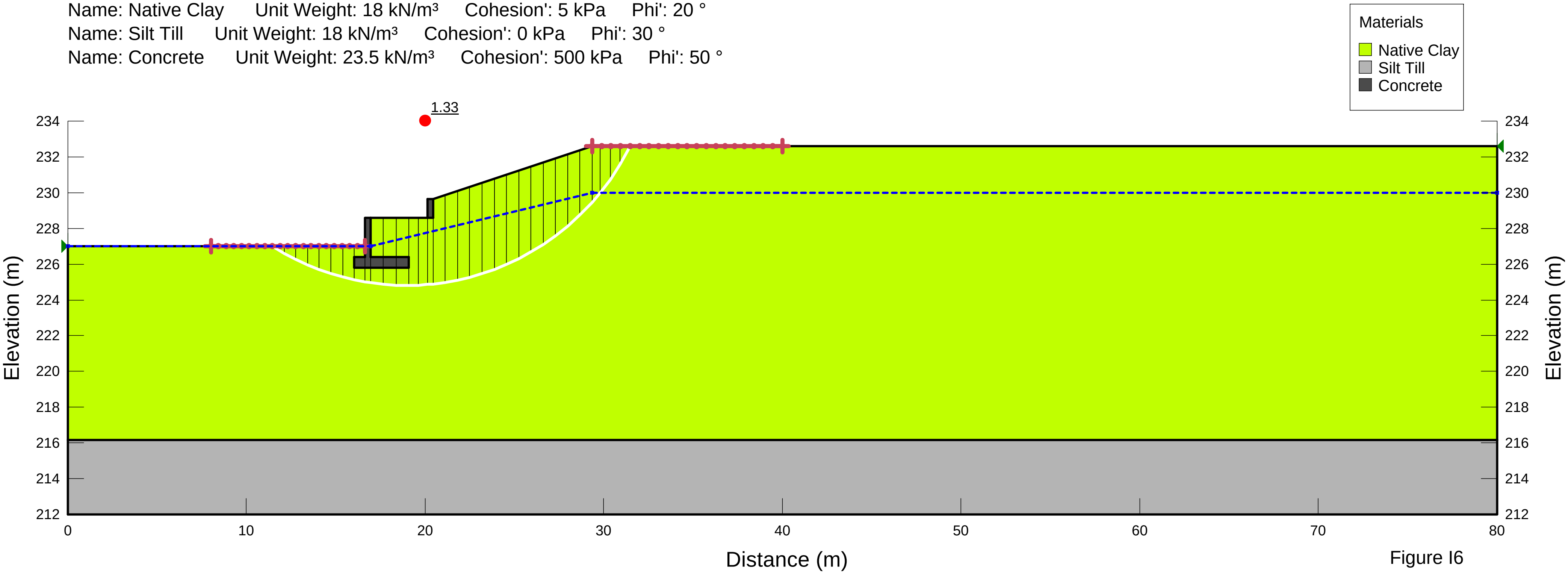


Figure I6

Station 1+235.00 - Final Conditions Immediately South of Underpass

Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °

Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °

Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

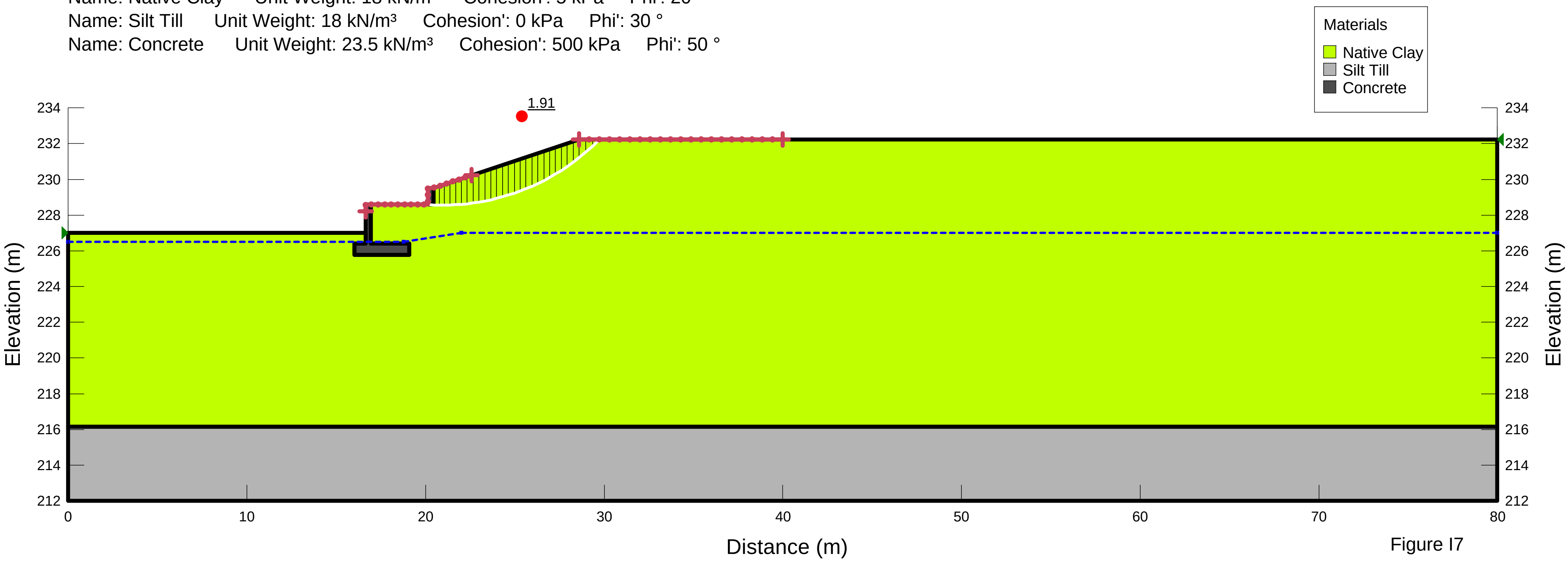


Figure I7

Station 1+247.60 - Final Conditions Middle of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

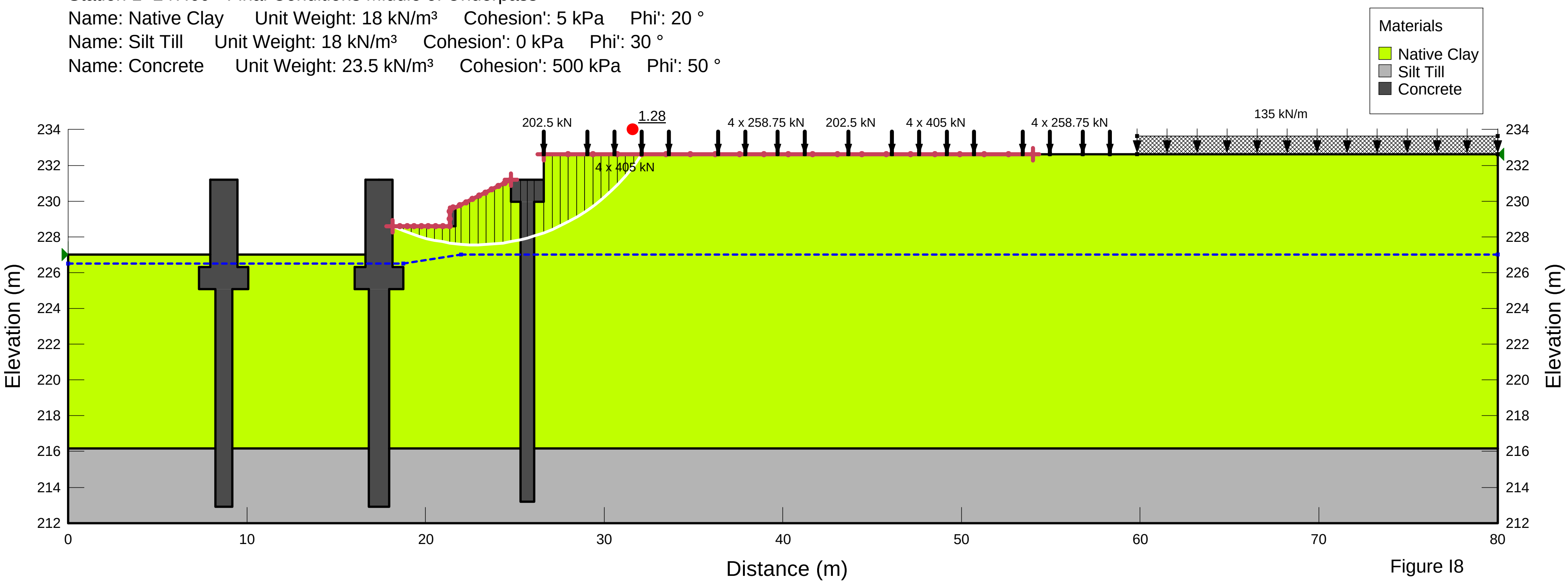


Figure I8

Station 1+264.62 - Final Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

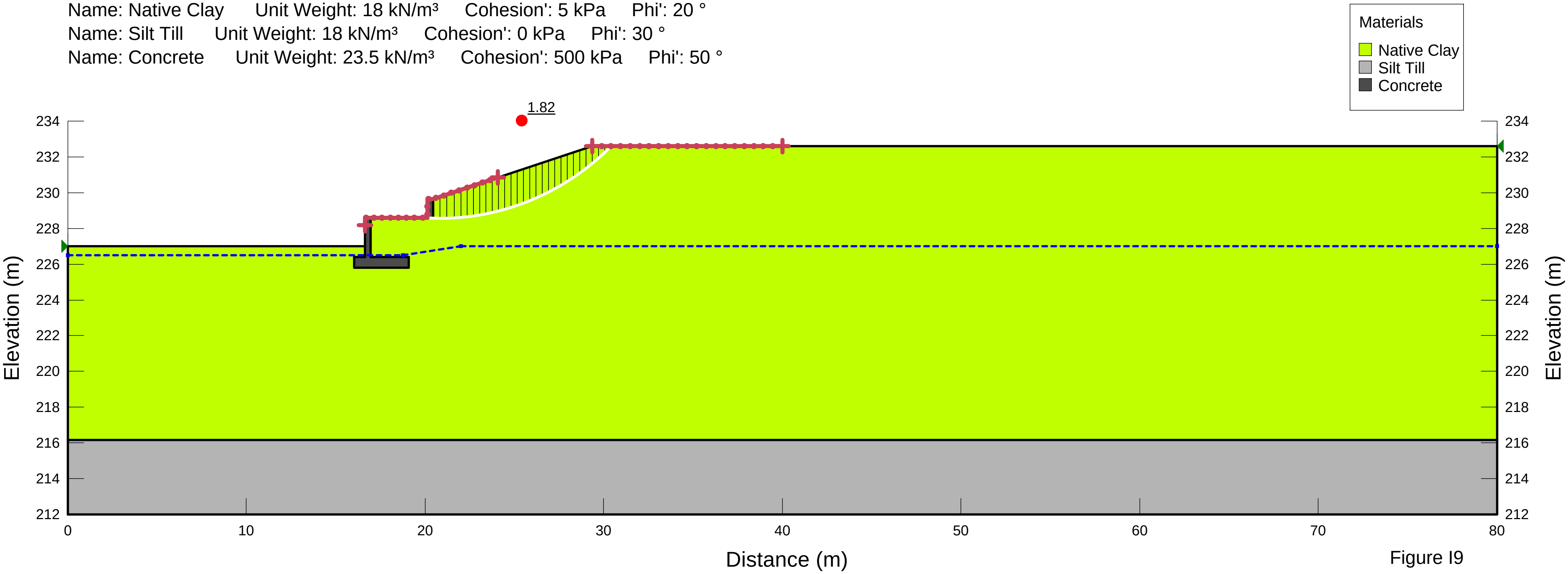


Figure I9

Station 1+235.00 - Final Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

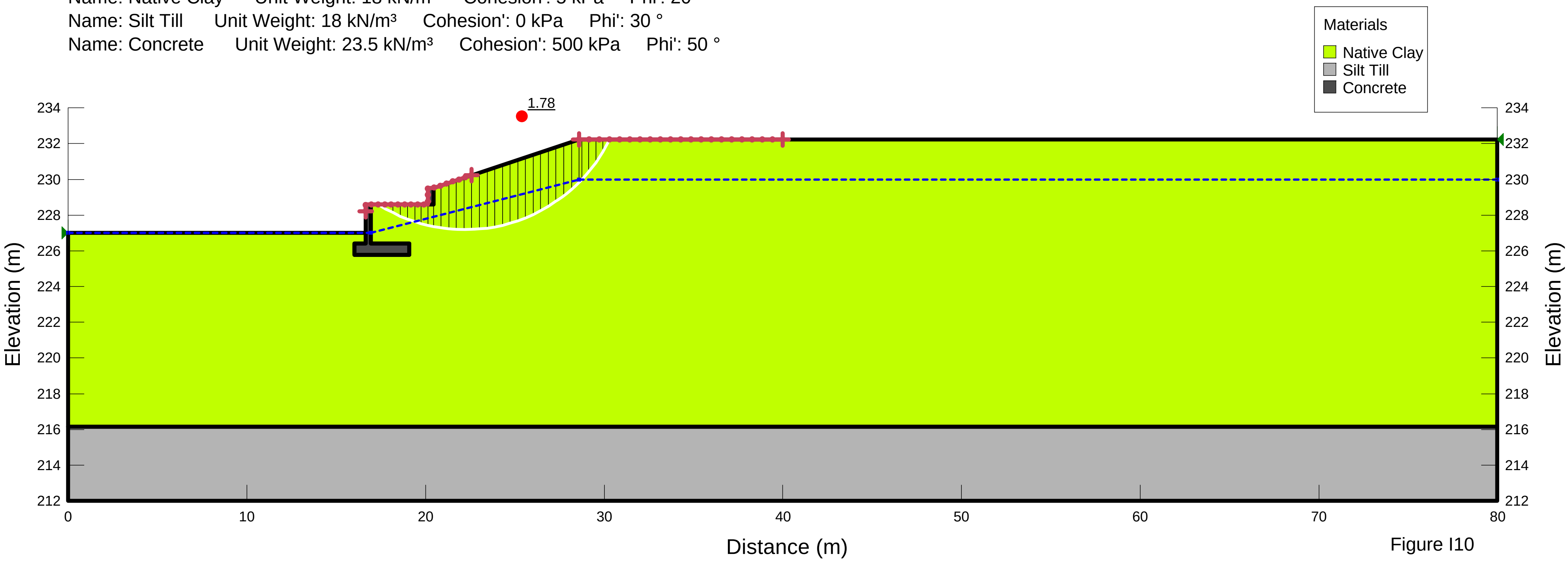


Figure I10

Station 1+247.60 - Final Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

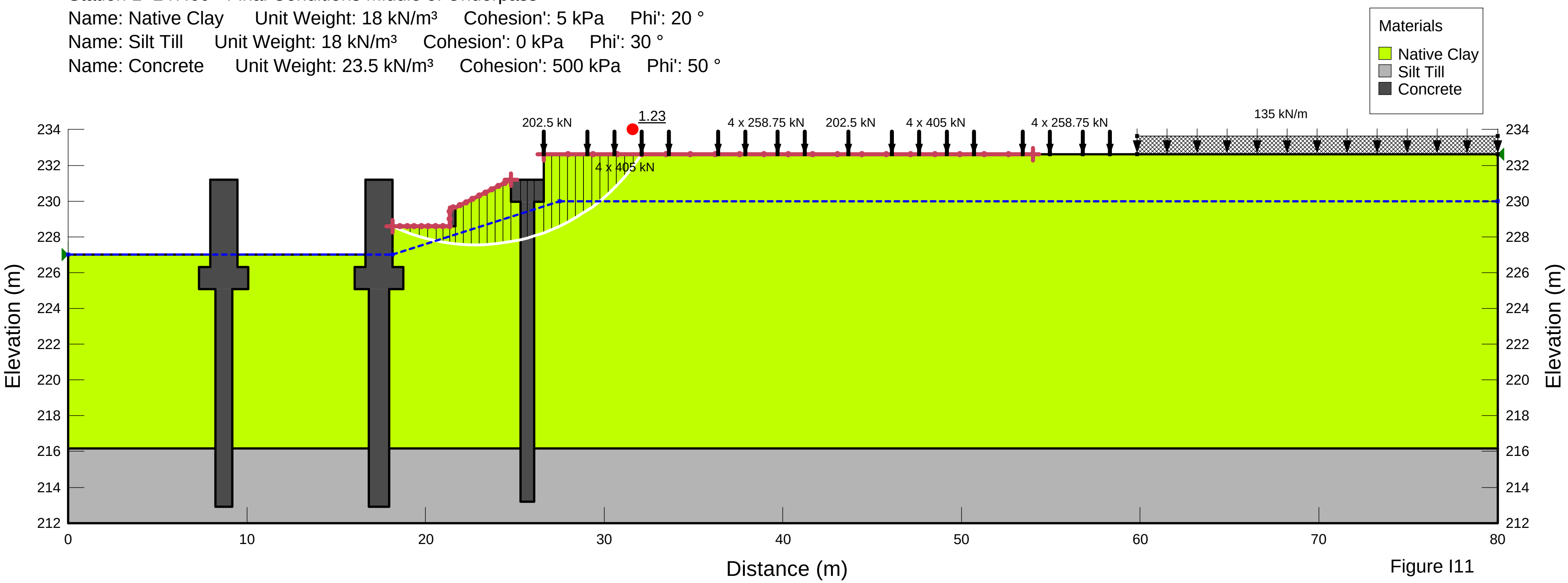


Figure I11

Station 1+264.62 - Final Conditions Immediately North of Underpass
Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °
Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

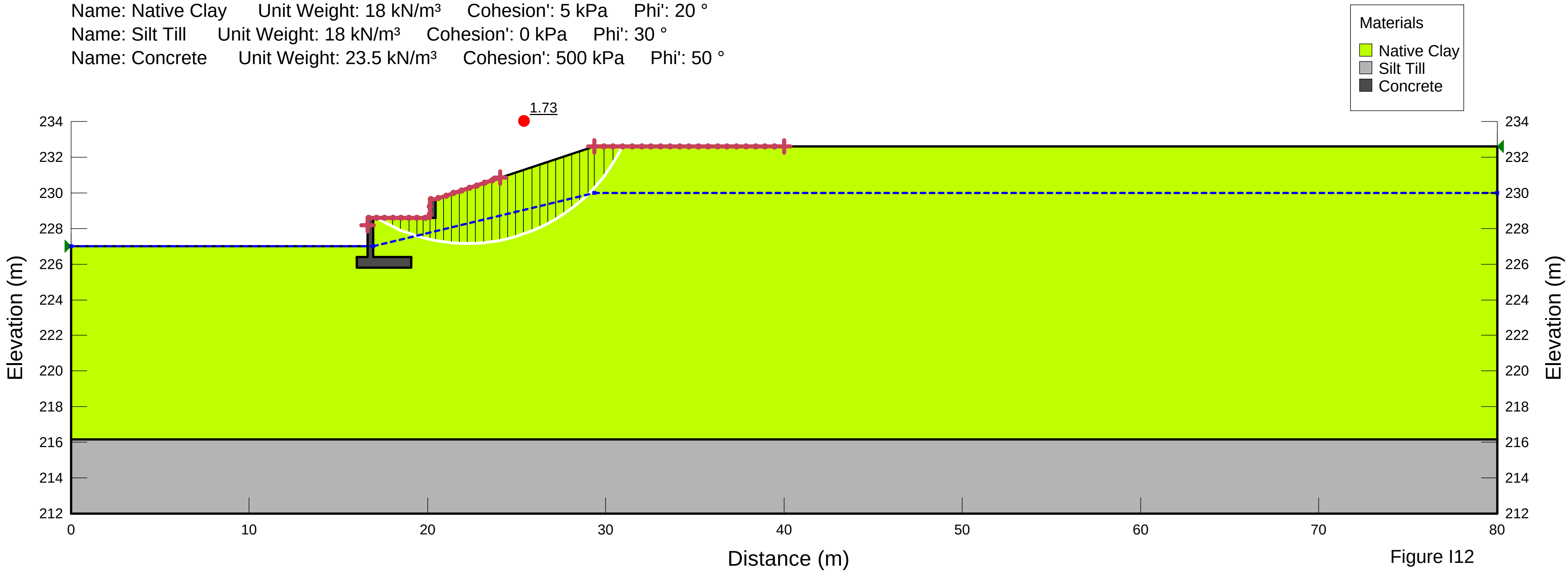


Figure I12

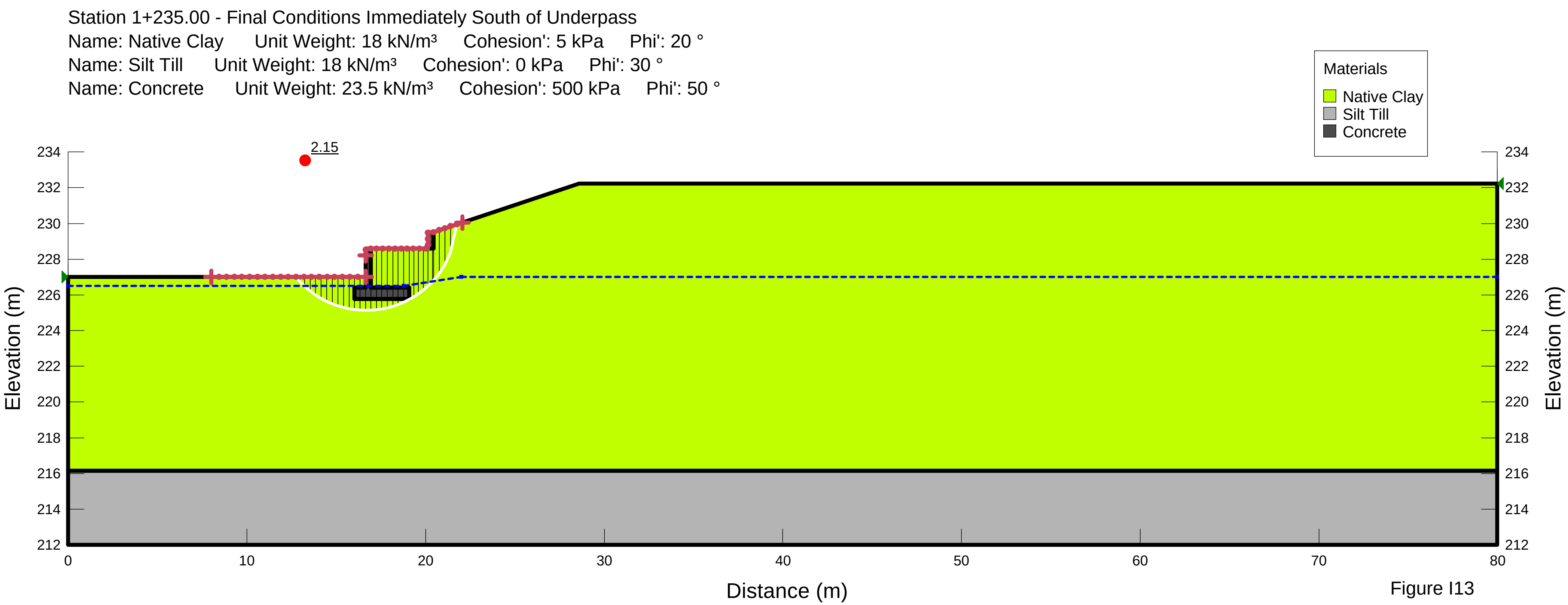

Station 1+235.00 - Final Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
2.15
Elevation (m)
Distance (m)
0
10
20
30
40
50
60
70
80
212
214
216
218
220
222
224
226
228
230
232
234

Figure I13

Station 1+247.60 - Final Conditions Middle of Underpass
Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °
Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

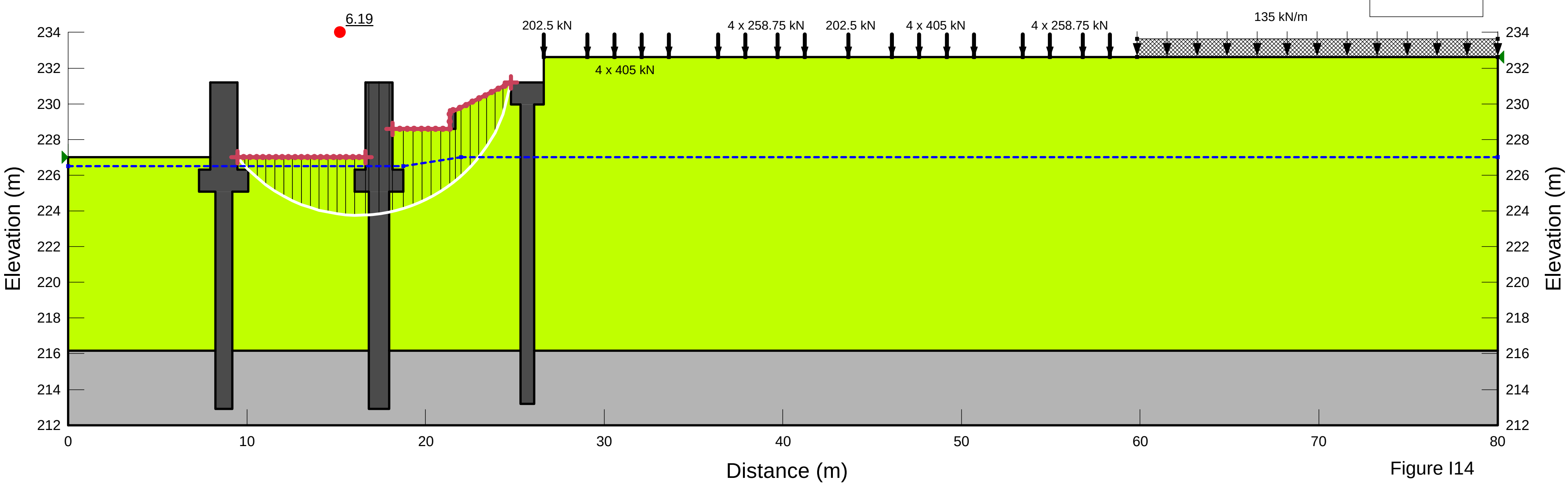


Figure I14

Station 1+264.62 - Final Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

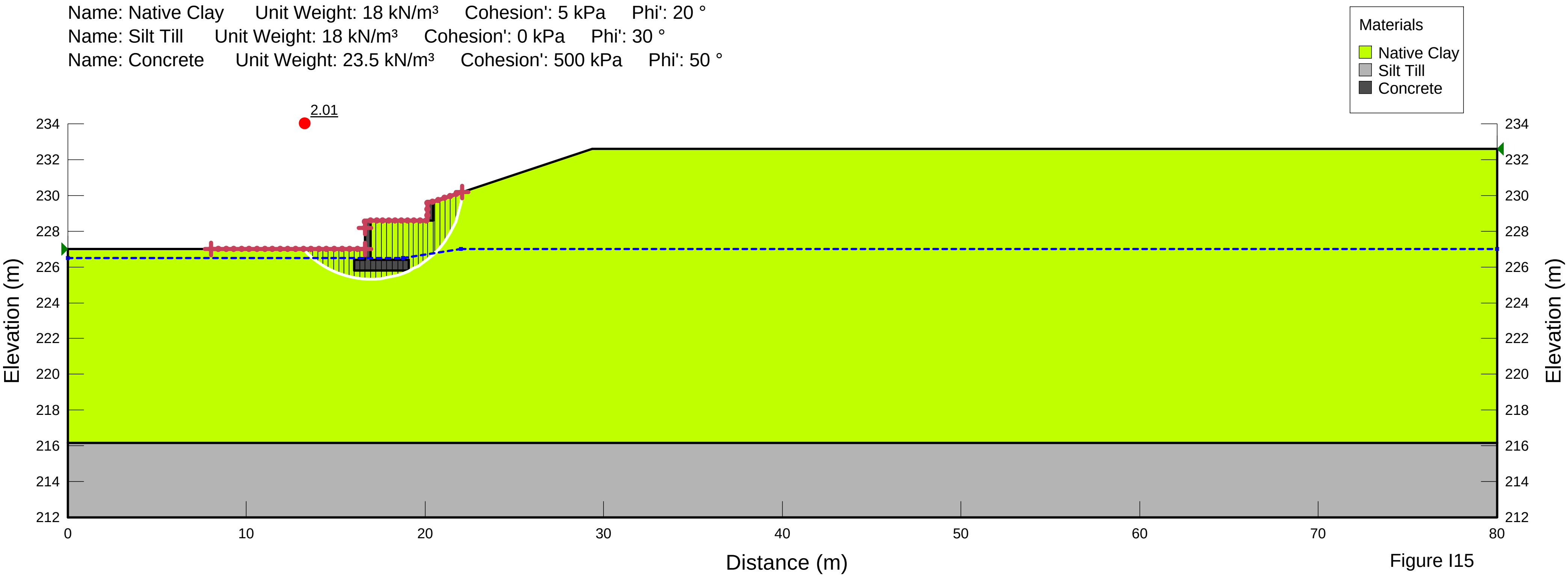
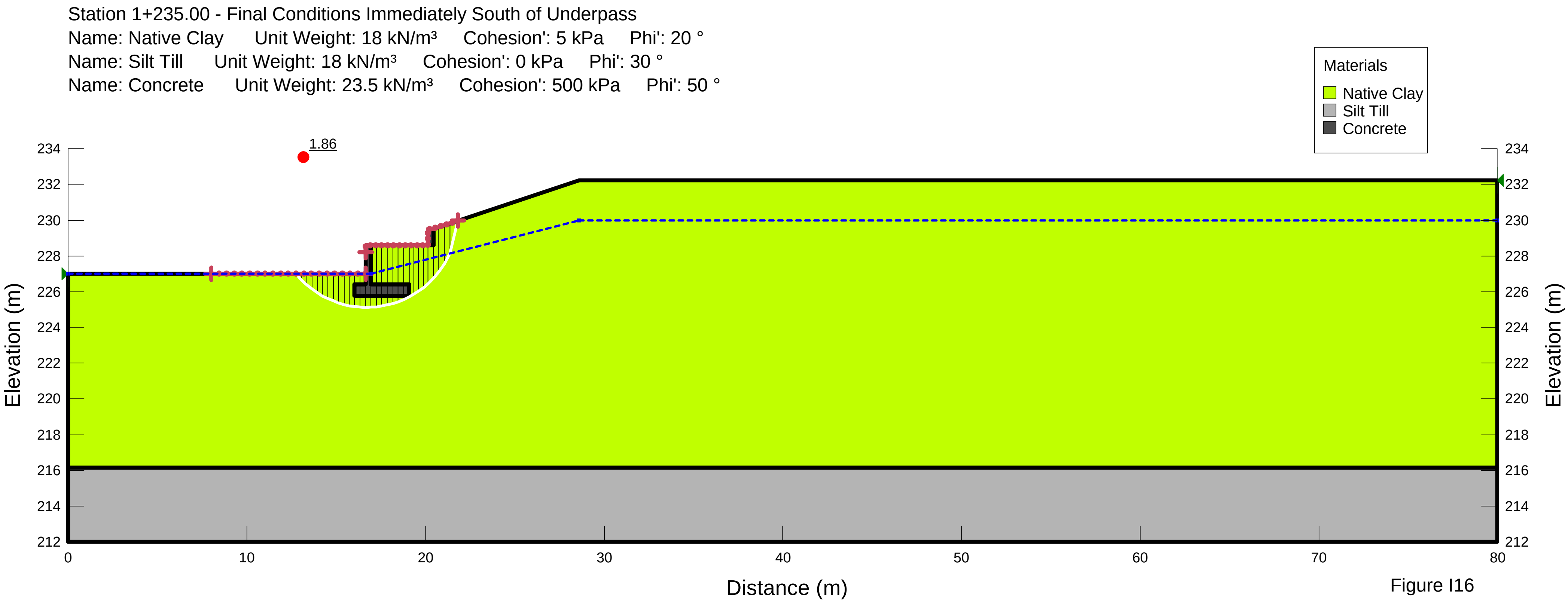
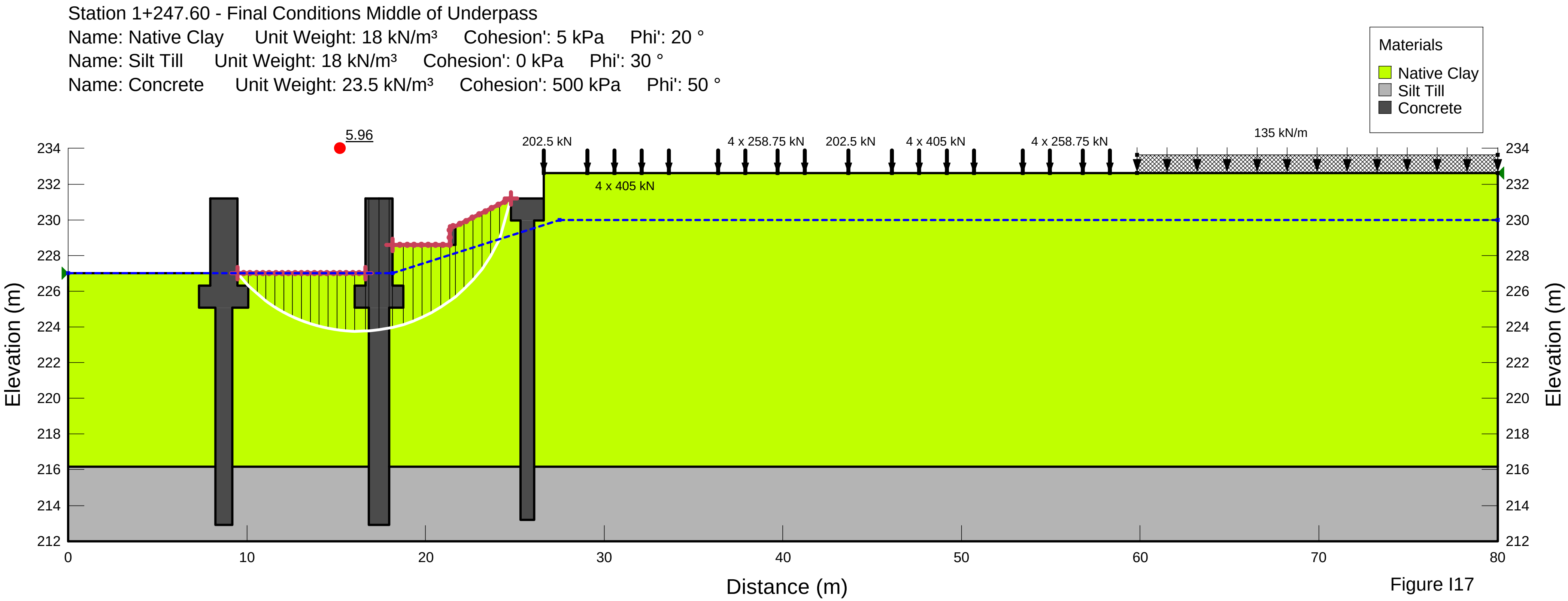


Figure I15



Station 1+235.00 - Final Conditions Immediately South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.86
Elevation (m)
Distance (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80

Figure I16



Station 1+247.60 - Final Conditions Middle of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
5.96
202.5 kN
4 x 405 kN
4 x 258.75 kN
202.5 kN
4 x 405 kN
4 x 258.75 kN
135 kN/m
Elevation (m)
Distance (m)
212
214
216
218
220
222
224
226
228
230
232
234
0
10
20
30
40
50
60
70
80

Figure I17

Station 1+264.62 - Final Conditions Immediately North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

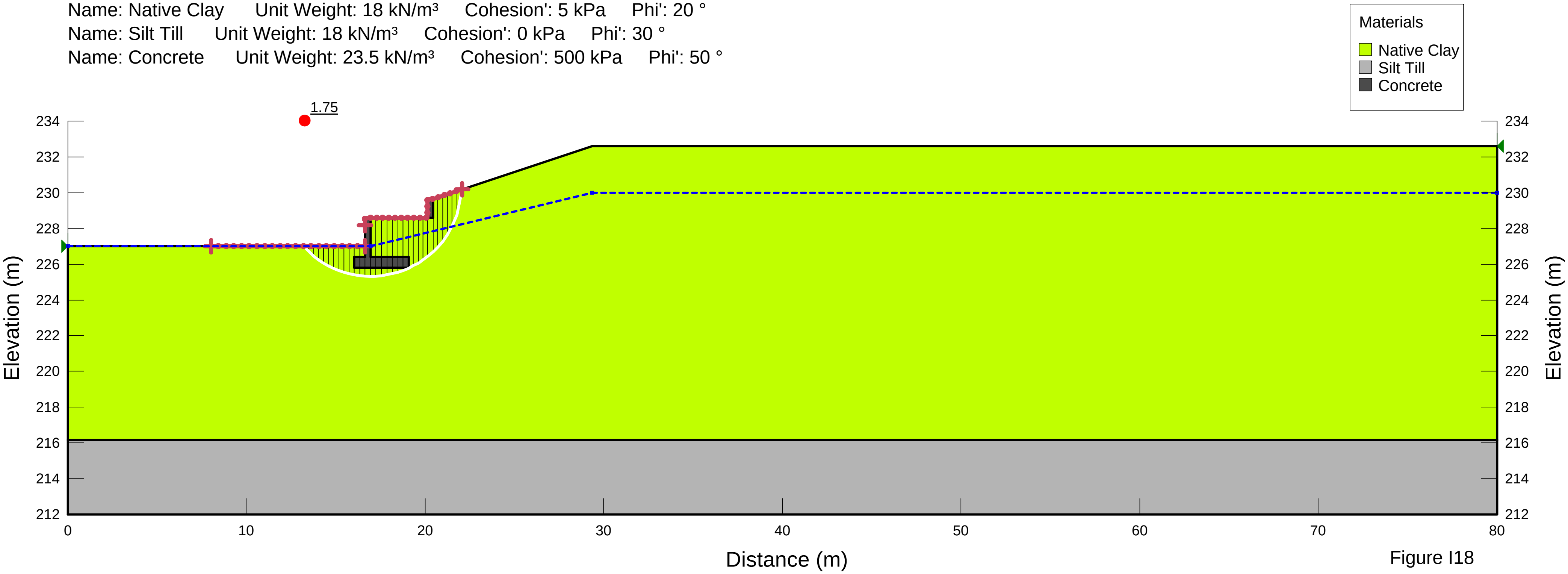


Figure I18

I.2 NORTH OF UNDERPASS STRUCTURE

Station 1+275.00 - Final Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

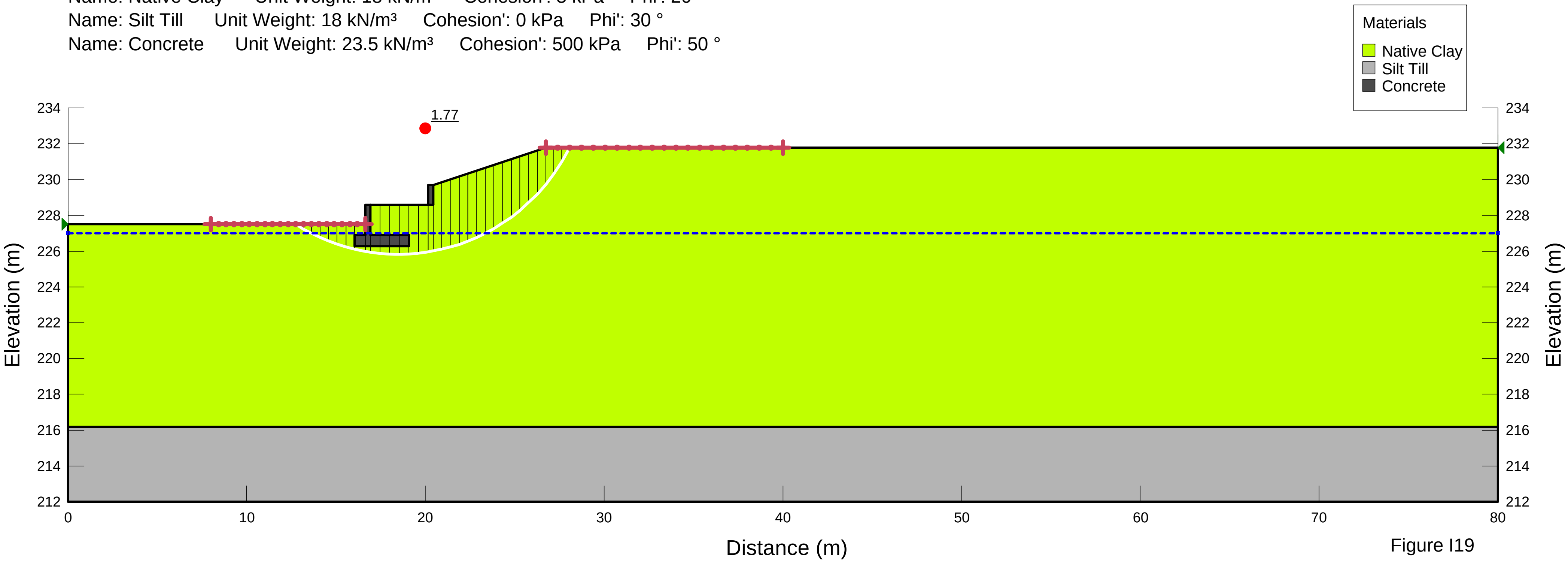


Figure I19

Station 1+275.00 - Final Conditions 20 m North of Underpass
Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °
Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

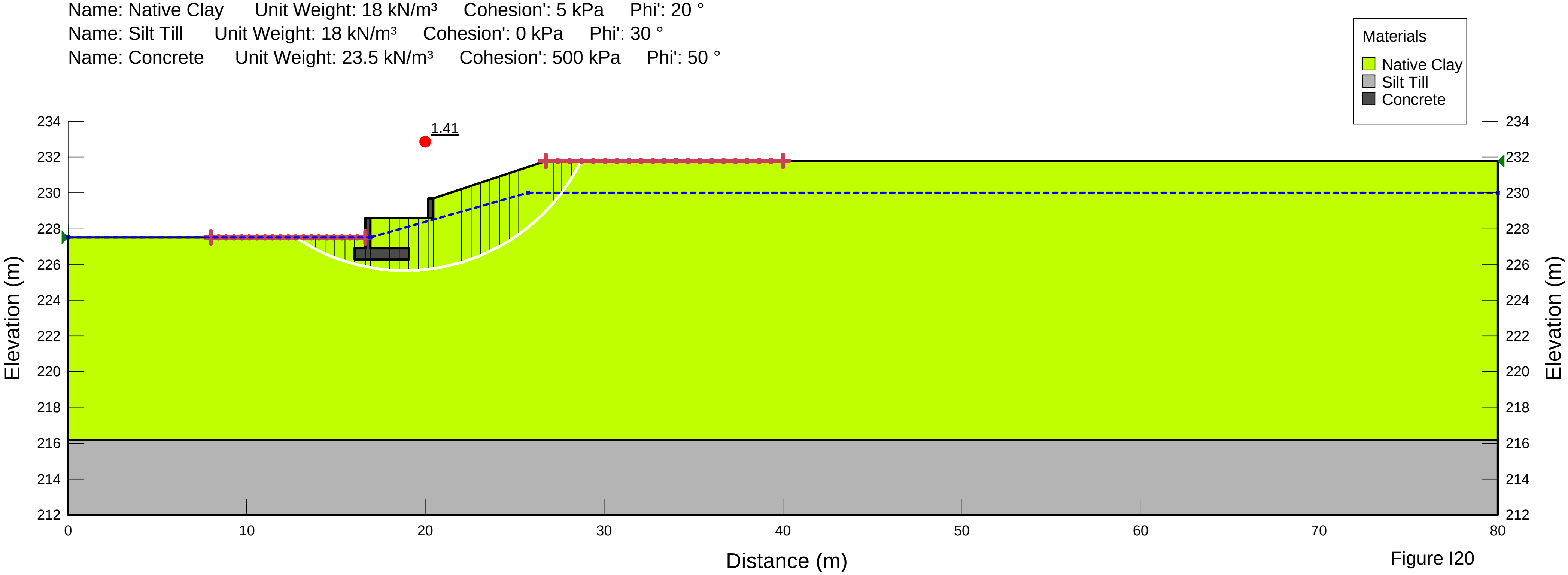


Figure I20

Station 1+275.00 - Final Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

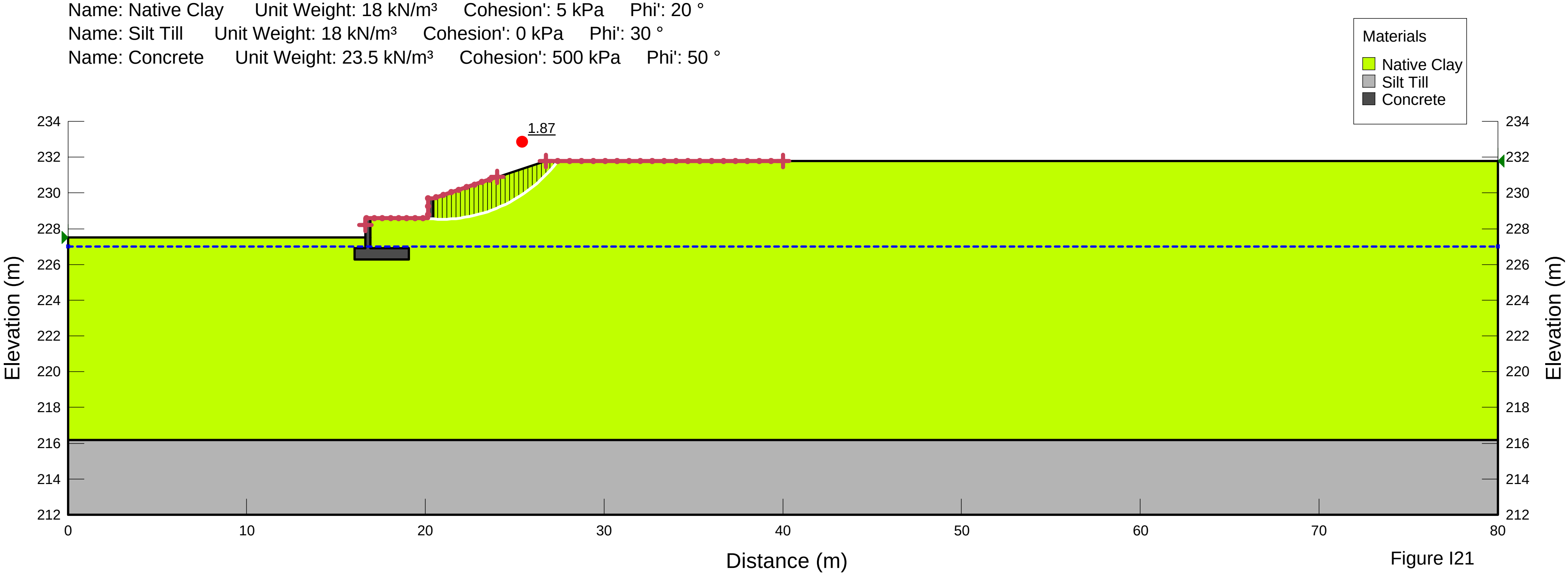


Figure I21

Station 1+275.00 - Final Conditions 20 m North of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

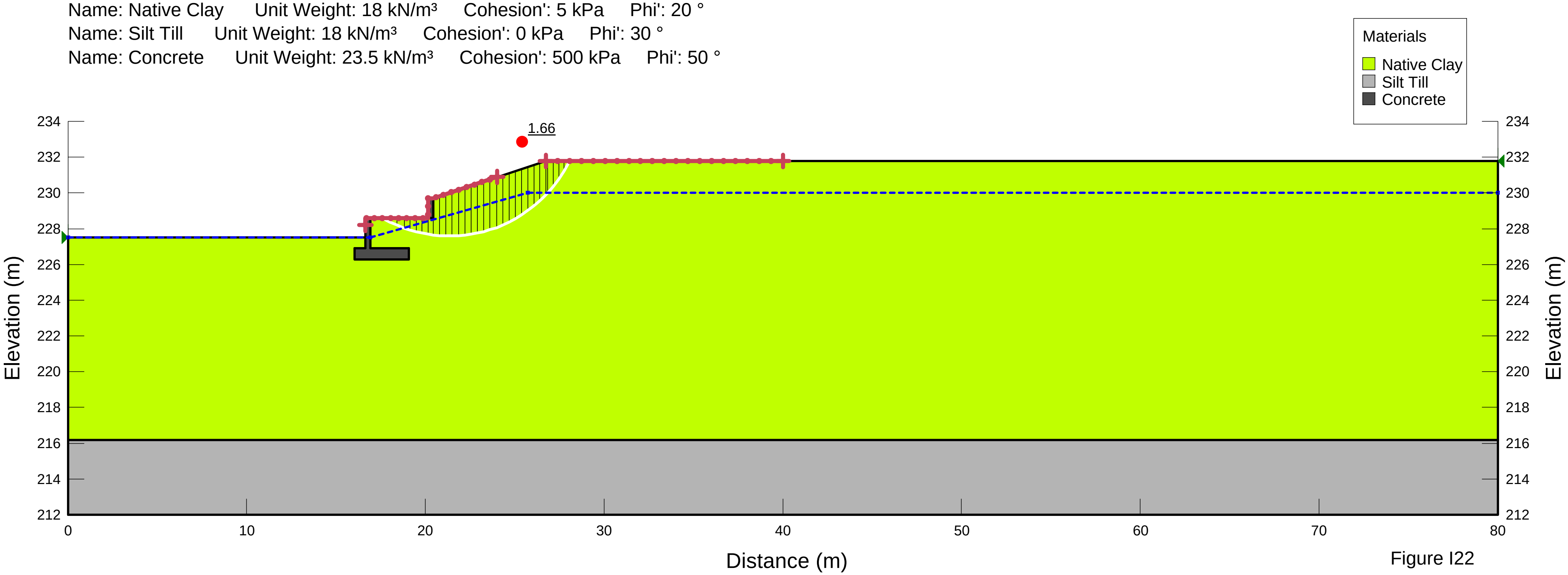
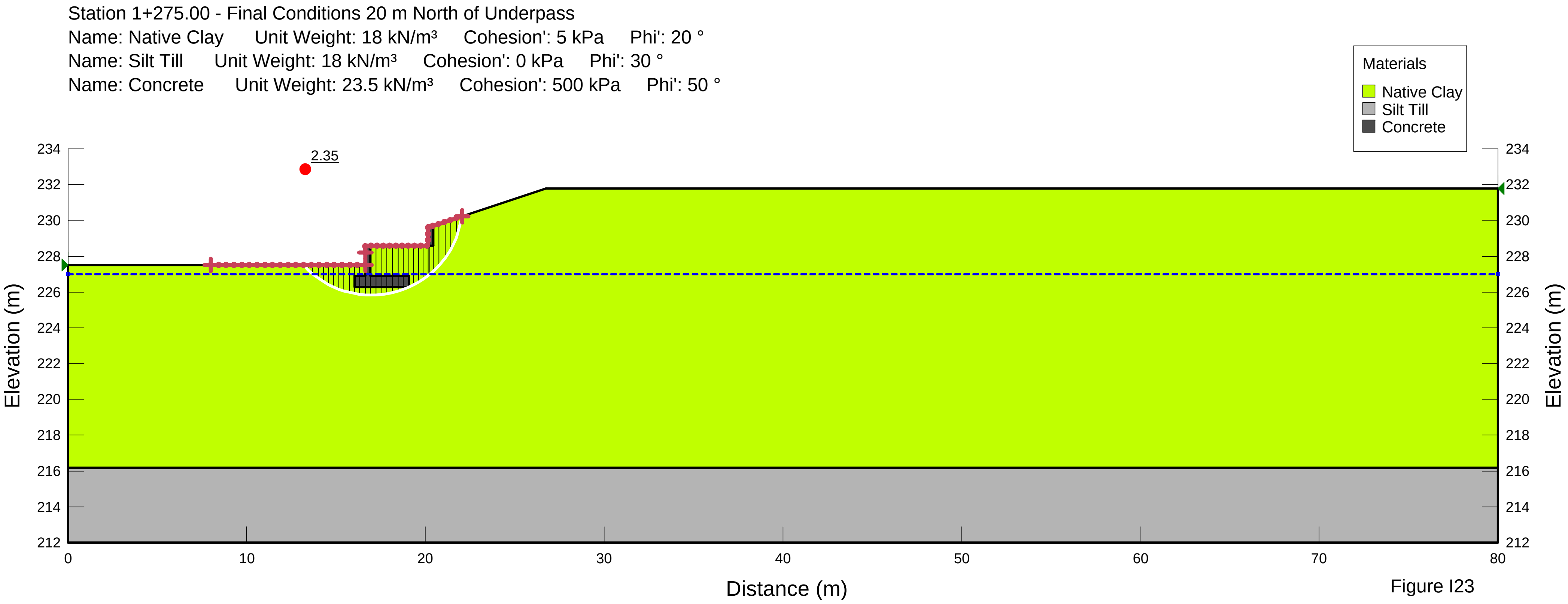
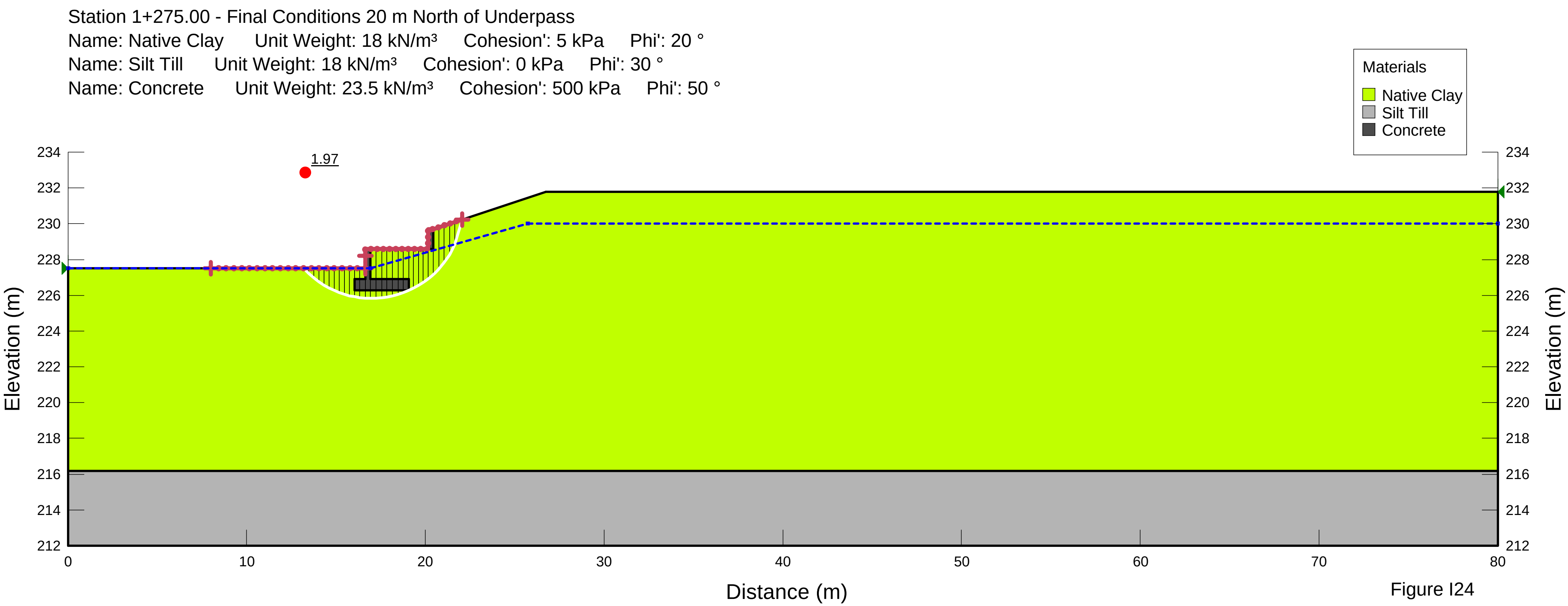


Figure I22



Station 1+275.00 - Final Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
2.35
Elevation (m)
Distance (m)

Figure I23



Station 1+275.00 - Final Conditions 20 m North of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.97
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80
Elevation (m)
Distance (m)

Figure I24

I.3 SOUTH OF UNDERPASS STRUCTURE

Station 1+215.00 - Final Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

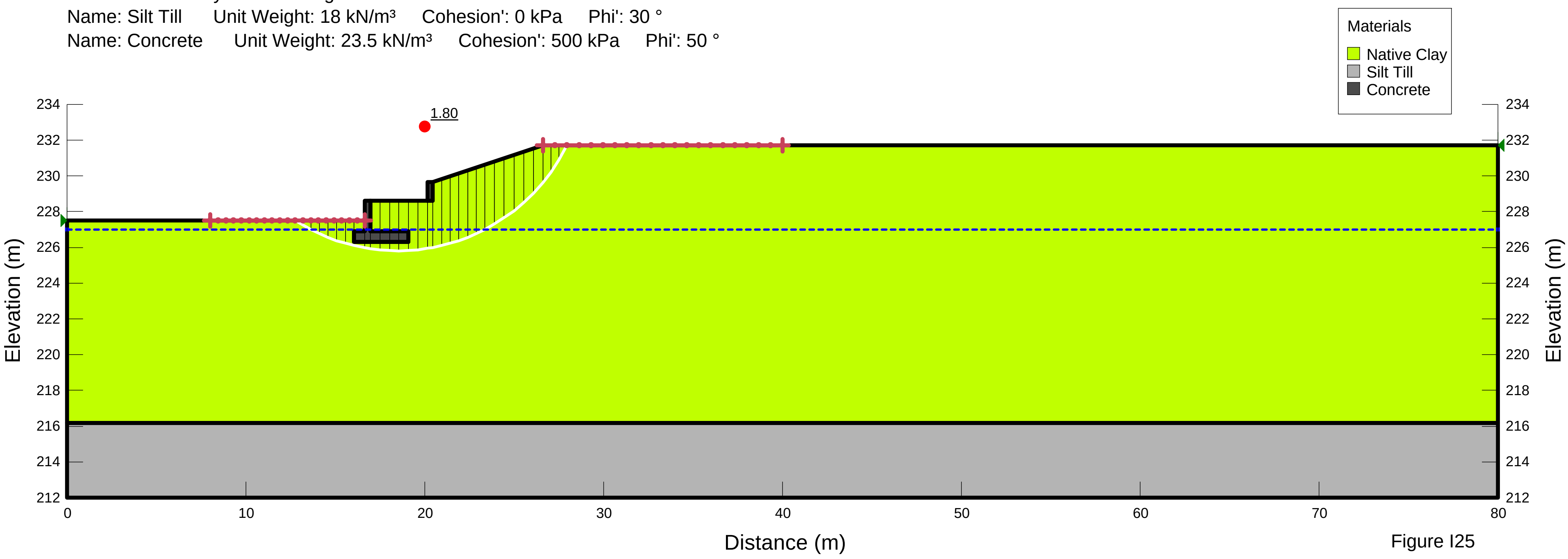


Figure I25

Station 1+215.00 - Final Conditions 23 m South of Underpass
Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °
Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

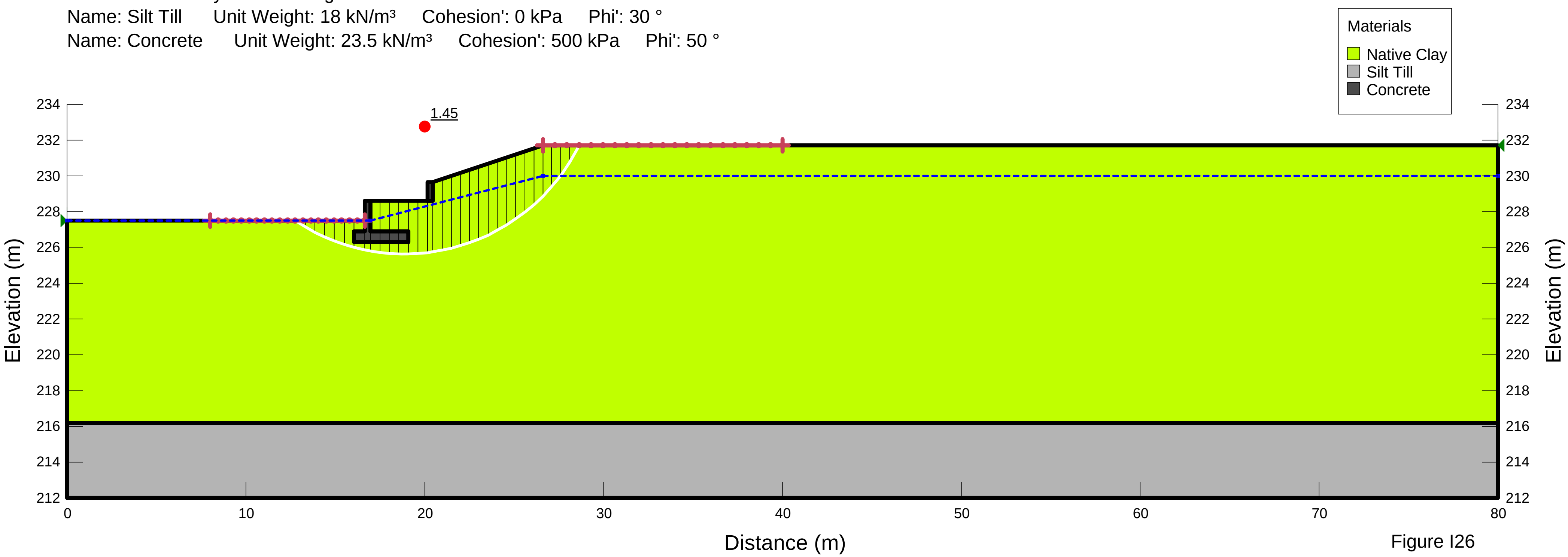
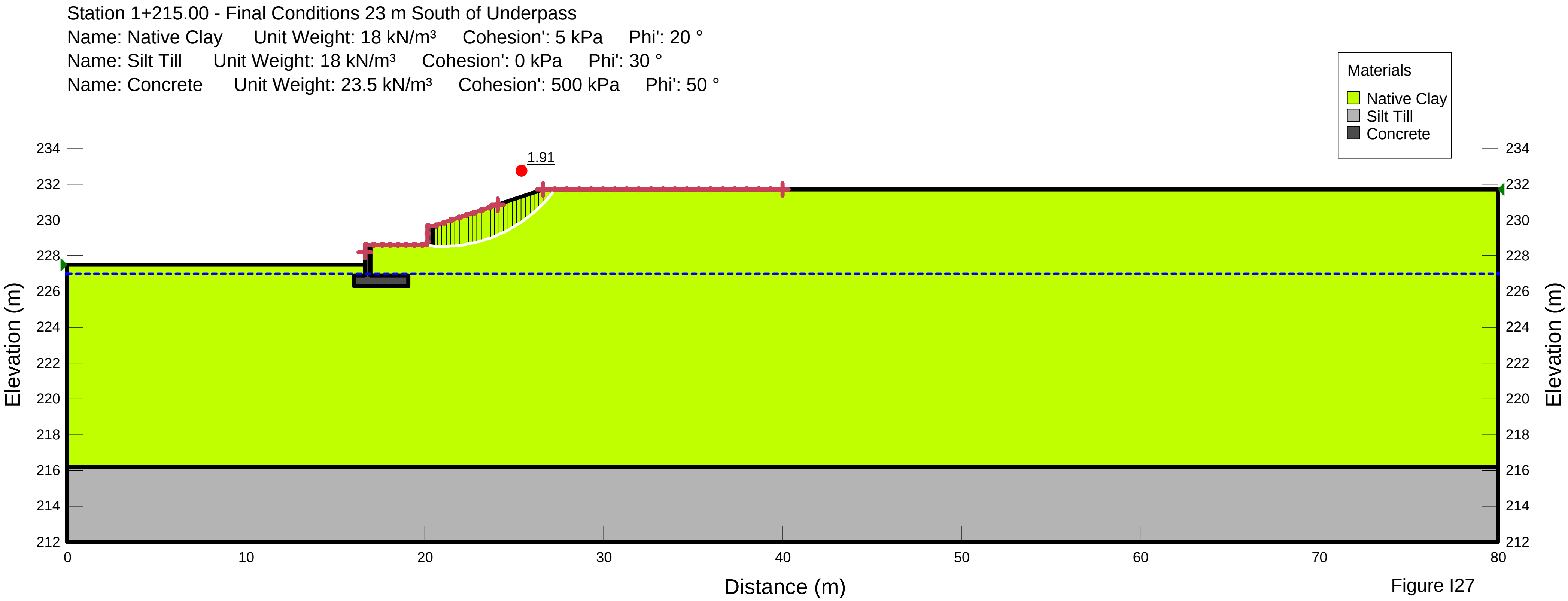


Figure I26


Station 1+215.00 - Final Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
1.91
Elevation (m)
Distance (m)
0
10
20
30
40
50
60
70
80
212
214
216
218
220
222
224
226
228
230
232
234
Figure I27

Station 1+215.00 - Final Conditions 23 m South of Underpass

Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °

Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °

Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °

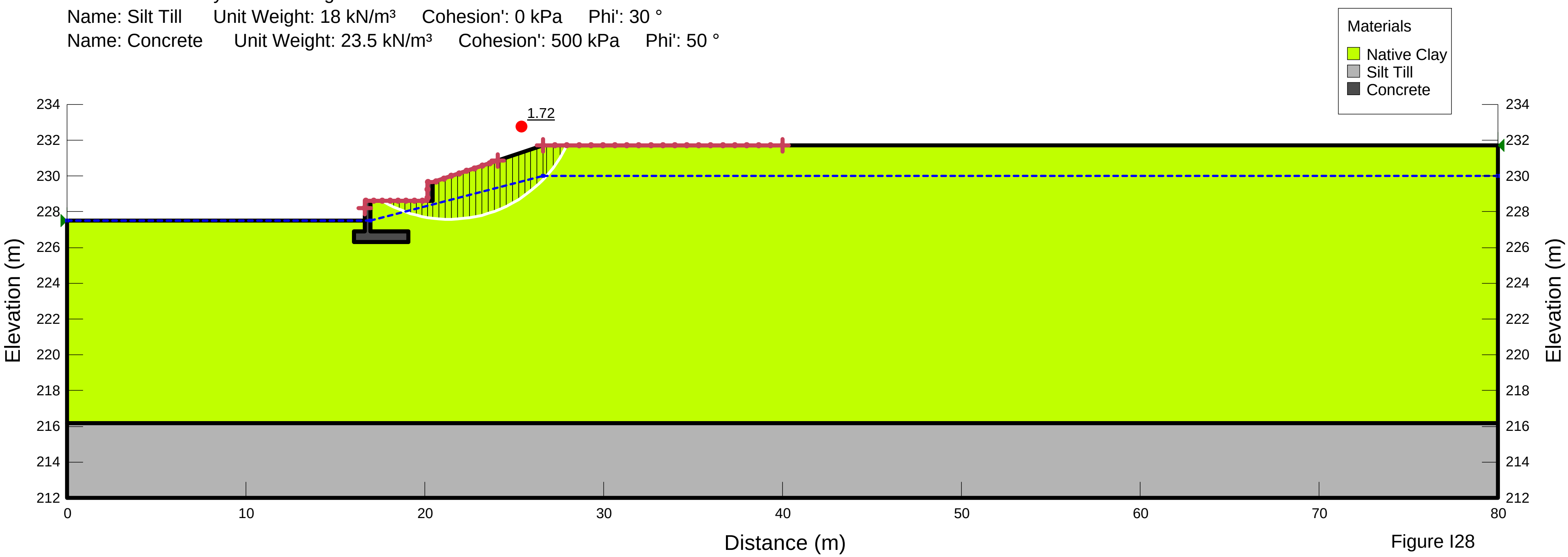
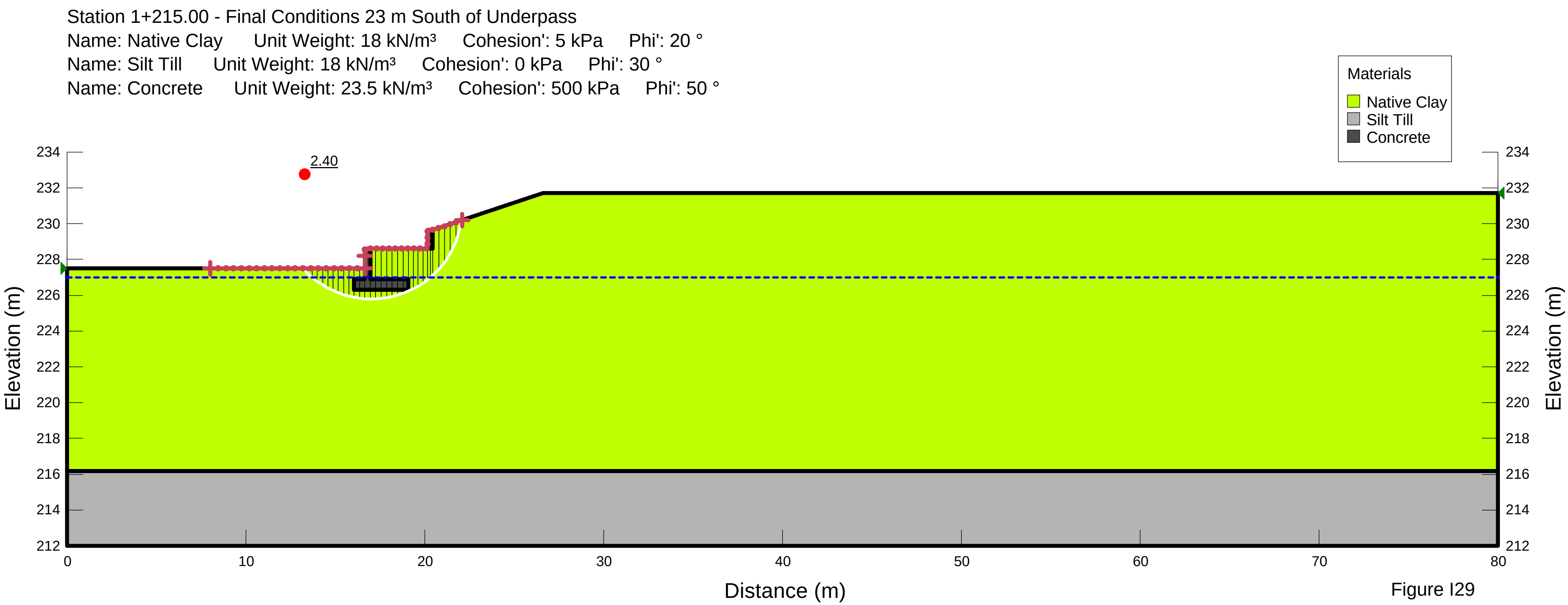


Figure I28


Station 1+215.00 - Final Conditions 23 m South of Underpass
Name: Native Clay Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Silt Till Unit Weight: 18 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Concrete Unit Weight: 23.5 kN/m³ Cohesion': 500 kPa Phi': 50 °
Materials
Native Clay
Silt Till
Concrete
2.40
Elevation (m)
234
232
230
228
226
224
222
220
218
216
214
212
0
10
20
30
40
50
60
70
80
Distance (m)
Figure I29

Station 1+215.00 - Final Conditions 23 m South of Underpass
Name: Native Clay   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Silt Till   Unit Weight: 18 kN/m³   Cohesion': 0 kPa   Phi': 30 °
Name: Concrete   Unit Weight: 23.5 kN/m³   Cohesion': 500 kPa   Phi': 50 °

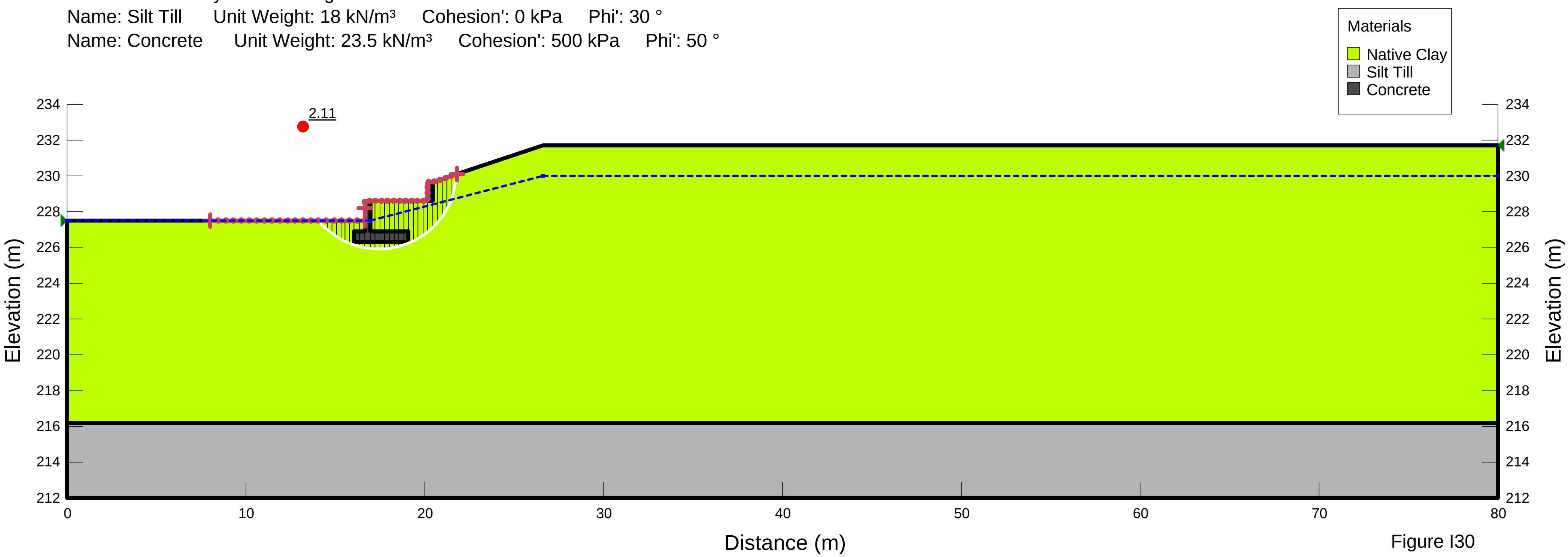


Figure I30