THURBER ENGINEERING LTD.

March 28, 2023 File No.: 32079-20

Associated Engineering (B.C.) Ltd.
#500 – 2889 East 12th Ave
Vancouver, BC, V5M 4T5

Attention: Priscilla Tsang, M.Eng., P.Eng.

HIGHWAY 1 – 264 STREET TO WHATCOM ROAD
WAR#4 - BRADNER ROAD REST AREA IMPROVEMENTS
GEOTECHNICAL REPORT FOR ISSUED FOR TENDER

Dear Priscilla:

At the request of Associated Engineering (B.C.) Ltd. (AE), Thurber Engineering Ltd. (Thurber) has conducted a geotechnical investigation for the above-mentioned project in Abbotsford, BC. This letter presents the results of the investigation and provides our recommendations. This report supersedes the version which was issued on October 21.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

1. BACKGROUND

We understand that the British Columbia Ministry of Transportation and Infrastructure (MoTI) proposes to improve the Bradner Road Rest Area as part of the Fraser Valley Highway 1 Corridor Improvement Program. We have reviewed design drawings which comprise part of the Issued for Tender (IFT) package. The improvements will include an expansion of the parking area and construction of a multi-use path with the installation of the following features requiring geotechnical input:

- A dual bay sanitary dump station with holding tank and decommissioning of the existing station.
- Three luminaire posts with 1.3 m by 1.3 m custom bases founded 2.3 m below finished grade.
- Parking lot drainage system (surface drainage, perimeter ditches, storm line, catch basins, catch basin leads and stormceptors).
- Sanitary sewer and watermain to service the new sanitary station.
- Headwall for a culvert through the parking area expansion

As per the IFT drawings, the proposed parking lot expansion will extend roughly 150 m west of the existing road and roughly 140 m north of the on-ramp to Highway 1. The northern portion of the expansion will comprise parking stalls and require fill up to 2 m high. The southern portion of the expansion will comprise the sanitary dump station and exit lanes and will require cuts up to 3.5 m high.

Our scope of work included completing geotechnical investigations during the Preliminary Design and Functional Design phases to assess the soil and groundwater conditions within the proposed parking area expansion and new sanitary dump location and provide our geotechnical recommendations for design and construction. Pavement design was not included in our scope.

2. DESIGN CRITERIA

The geotechnical design uses the following design guides and codes:

- BC MoTI Supplement to CSA-S6-19 (The Supplement)
- Canadian Highway Design Bridge Code (CSA-S6-19)
- AASHTO LRFD Bridge Design Specifications, Eighth Edition, 2017
- EGBC Professional Practice Guidelines for Retaining Wall Design, Version 1.1, February 2020
- FHWA-NHI-10-024 Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume 1 & Volume 2, November 2009
- Canadian Foundation Engineering Manual (CFEM), Fourth Edition, 2006

Further discussion on the geotechnical design criteria used for the Fraser Valley Highway 1 Corridor Improvement Program is outlined in our memo to Associated Engineering dated July 15, 2022.

2.1 Degree of Understanding

The Degree of Understanding will be ‘Typical’ for most geotechnical design elements. Some cut slopes where we were unable to complete test pits due to access will apply a ‘Low’ Degree of Understanding for design.

2.2 Consequence Factor

We will apply a ‘Typical’ Consequence Factor for the design of embankments and soil cut slopes. A ‘Low’ Consequence Factor may be applicable depending on the cut slope height and possible impacts to adjacent infrastructure at the top of the proposed cuts.

2.3 Slope Stability

Table 1 – Factors of Safety for Global Stability of Embankments and Cut Slopes (Table 6.2b in BC MoTI Supplement to S6-19)

Degree of Understanding	Low		Typical	
Consequence Factor from S6-19	Typical	Low	Typical	Low
FOS for Global Stability - Permanent	1.67	1.45	1.54	1.34
FOS for Global Stability - Temporary	1.43	1.24	1.33	1.16

Consideration should be given to applying a Low Consequence factor to cut slopes where failure will not impact the public or travelled lanes (i.e. not supporting travel lanes or parking areas) and or where slope failure can be easily cleaned up. Cut slope design for permanent conditions applying a Low Consequence factor can be designed using a FS of 1.34 or 1.45 based on a Typical and Low Degree of Understanding, respectively.

A horizontal acceleration of 0.22 g was used for pseudostatic slope stability assessment. This value corresponds to the Site Class C PGA for the 1:975-year seismic event obtained from the 2015 National Building code (NBCC) seismic hazard calculator.

3. GEOTECHNICAL CONDITIONS

3.1 Site Conditions

The proposed location of the parking lot expansion is currently undeveloped and covered by trees and vegetation. The area within about 50 m of the western edge of the existing paved surface is relatively flat and contains a series of gravel walking trails. Beyond this area, the site is densely covered with trees and vegetation. The site slopes down slightly to the north and west of the expansion area. The northwest of the proposed expansion is a low point of the treed area, and we observed that the existing ground surface was wet and marshy at the time of the investigation.

3.2 Surficial Geology

Based on the publicly available Geological Survey of Canada surficial geology *Map 148A, dated 1976, Mission, British Columbia*, the surficial geology of the site is expected to comprise glaciomarine stony silt to loamy clay, 8 m to 100 m thick, of the Fort Langley Formation.

Soil conditions near the Rest Area as observed during our preliminary investigation for Segment 1 of the project generally comprise variable thickness of fill or organic silt overlying stiff to very stiff, silty clay. The stiff to very stiff, silty clay varies in thickness between 2.5 m and 15 m and is underlain by layers of dense sand to sand and gravel and stiff to very stiff clay.

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3.3 Geotechnical Investigation

Thurber completed three test pits (TP22-BRA-01 to TP22-BRA-03) and one test hole (TH22-BRA-01) within the proposed parking lot expansion area between March 2 to 3, 2022. The test pits were advanced using an excavator operated by Atlas Leasing Ltd. to depths between 2.3 m and 2.5 m. Upon completion of digging, the test pits were backfilled with the excavated soil and compacted with the excavator's bucket. The investigation was supervised by an experienced Thurber field engineer who logged the test holes and test pits and collected representative soil samples at regular intervals

The test hole was advanced using a track-mounted solid stem auger drill rig operated by On-Track Drilling Inc. to a depth of about 9.1 m. A dynamic cone penetration test (DCPT) was conducted at the test hole to assess soil strength and relative density. Upon completion of drilling, a vibrating wire piezometer (VWP) was installed in the test hole at a depth of 6.8 m and the test hole was back filled with cementitious grout.

An additional test hole (TH22-BRA-02) was completed on May 24, 2022, to investigate the soil conditions at the location of the sanitary dump station revised for Functional Design. The test hole with DCPT was advanced using a track-mounted solid stem auger drill rig operated by On-Track Drilling Inc. to a depth of about 12.2 m. Upon completion of drilling, a vibrating wire piezometer (VWP) was installed in the test hole at a depth of 6.1 m and the test hole was back filled with cementitious grout. A Shelby tube sample was collected adjacent to the test hole between 1.5 m and 2.1 m depth for consolidation testing.

An additional bulk sample of the native soils at roughly 1.5 m to 2.1 m depth was collected adjacent to TH22-BRA-02 on June 17, 2022, for compaction testing to determine suitability of the native soils for use as embankment fill as requested by ISL. The sample was collected using an excavator operated by Country Green Excavating.

The footprint of the investigation does not provide widespread coverage for the proposed parking area, and the test holes and test pits are limited to the eastern half of the site. The incomplete state of the environmental assessment limited access to the site. The AE Environmental representative present on site advised that large trees must not be cleared, minimal vegetation should be removed and travel through marshy areas should be avoided to reduce environmental disturbance. It was determined that the safest and most environmentally friendly path was to closely follow the existing gravel walking path and only move small trees and brush where necessary. This path restricted our access to the center and west half of the proposed expansion and therefore the investigation could not be completed in these areas.

3.4 Laboratory Testing

Soil samples collected at regular intervals were returned to our laboratory for routine water content testing and visual classification. Select samples were submitted to the laboratory for Atterberg Limits and fines content (percent passing #200 sieve) testing. The Shelby tube sample collected at TH22-BRA-02 was submitted for one-dimensional consolidation testing. Standard Proctor testing was completed on the bulk sample collected adjacent to TH22-BRA-02 on June 17, 2022.

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3.5 Soil Conditions

The results of the geotechnical investigation and laboratory testing are presented in the attached test hole logs. The logs provide detailed descriptions of the soil and groundwater conditions encountered during the investigation and must be used in preference to the generalized descriptions presented below.

The locations of the test pits and test hole are shown in Drawing 32079-20-1. The locations shown on the drawing are approximate. We understand that the test pits and test hole locations from the March 2022 investigation were surveyed by the project team after completion of the geotechnical investigation. The remainder of the investigation locations are approximate and based on hand-held GPS.

The test pits and test holes generally encountered very soft to soft, organic silt over stiff to hard clay. The organic silt was encountered to depths between 0.5 m to 0.9 m. The moisture content of this soil ranged from 58% to 78%.

The clay layer was observed beneath the organic silt to the base of each test pit and test hole. The consistency of the clay varied with depth. While advancing the test pits, the excavator operator noted that the top of the clay layer was very stiff and gradually became more difficult to dig with depth. In TH22-BRA-01, the clay layer was stiff to hard within the depths encountered. The moisture content of the clay ranged between 21% to 27%. The Atterberg Limit results indicate the liquid limit ranged between 31% to 33% and the plastic limit ranged between 18% to 21%. The standard Proctor test indicates that the optimum moisture content for compaction is about 19.3%. A preconsolidation pressure of approximately 500 kPa was recorded during the oedometer testing of this unit.

3.6 Groundwater Conditions

In the test pits, minor seepage was observed between the organic silt layer and the clay layer. In the test hole, water was measured at a depth of 2.7 m upon completion of drilling. Readings were taken from the VWP at TH22-BRA-01 on March 7, 2022, and March 31, 2022, and the groundwater table was observed to be near the ground surface. Readings were taken from the VWP at TH22-BRA-02 on June 2, 2022, and the groundwater table was observed to be about 1.8 m below ground surface. It is expected that these measurements represent a perched water table and not the regional groundwater table.

Our design and assessment generally assumed the groundwater table to be at ground surface. Our slope stability assessment of the drained condition for cut slopes assumed that the groundwater table was about 1 m below the face of the slope.

3.7 Geotechnical Design Parameters

Table 2 below summarizes the geotechnical parameters we have used for analysis. The upper organic silt is not included as we are recommending it be stripped. We have also estimated geotechnical parameters for imported granular fill.

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Table 2. Estimated Soil Parameters

Soil Unit/Description	Unit Weight	Friction Angle	Undrained Shear Strength, S_u	Average OCR	Consolidation Parameters		
					$Cc/1+e_0$	$Cr/(1+e_0)$	C_v
	(kN/m^3)	(degrees)	(kPa)				(m2/year)
Stiff to Hard Clay	18-19	29-32*	75-100	8-10**	0.10-0.15	0.015-0.020	50-75
Granular Embankment Fill	19.5-20.5	35-36	-	-	-	-	-

*Applies to drained condition only
**Based on a preconsolidation pressure of 500 kPa

Our estimates for soil unit weight, friction angle and undrained shear strength are based on typical values obtained from the Canadian Foundation Engineering Manual (4th Edition) for similar soil types and from our investigations for Segment 1 and Segment 2. Consolidation parameters were interpreted from the results of the consolidation test completed on a sample of the clay.

4. GEOTECHNICAL DISCUSSION AND RECOMMENDATIONS

4.1 Stripping

The footprint of the parking lot expansion area should be stripped to expose subgrade that is free of deleterious, loose, or otherwise unsuitable soil. A clean-up bucket should be used over clay subgrade and efforts should be taken to reduce disturbance of the subgrade.

The anticipated stripping depth will be between 500 mm and 900 mm, based on the results of our geotechnical investigation. We recommend using a stripping depth of 900 mm within the parking lot expansion and a stripping depth of 300 mm inside the existing parking lot boundaries.

4.2 Suitability of Cut Material for Use in Fills

The native stiff to hard clay encountered at the Rest Area had in-situ water contents of 21% to 27% which is higher than the optimum moisture content for compaction as determined by the standard Proctor testing. To re-use this material as embankment fill, it must be dried to within 2% of optimum moisture.

We anticipate drying the native clay will only be feasible during the relatively dry summer months. These soils are moisture sensitive and will require significant effort for the contractor to adequately dry the material and keep it dry. Given these constraints, we do not recommend the re-use of excavated native soils for embankment construction.

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4.3 Embankments

All embankments should be constructed in accordance with MoTI Standard Specifications. The subgrade should be free from deleterious, wet, loose, or otherwise unsuitable soils. The subgrade should be inspected by Thurber prior to fill placement. Localized subexcavation and replacement may be required where unsuitable soils are encountered.

Embankments constructed out of Type D suitable material (eg. well-graded granular fill) or granular borrow should have side slopes no steeper than 2.5H:1V. The calculated static FS for an embankment constructed with 2.5H:1V side slopes was 1.52 for the drained condition and 2.22 for the undrained condition. Under pseudostatic loading, the FS was 1.33. We anticipate that it will be possible to re-use the existing embankment fill and SGSB from the truck parking rehabilitation area as embankment fill as long as it is sufficiently well-graded.

The SGSB from the existing truck parking area may be used to construct the multi-use path below the base gravel.

4.4 Cut Slopes

We anticipate cut slopes at 2.5H:1V are feasible. The calculated static FS was 1.37 for the drained condition and 7.32 for the undrained condition. Under pseudostatic loading, the FS was 2.46.

The calculated FS for the drained condition under static was 1.37 which is less than 1.54 for Typical Degree of Understanding and Typical Consequence Factor but greater than 1.34 for Typical Degree of Understanding and Low Consequence Factor. We think the Ministry should consider adopting a Low Consequence Factor as the impact of the cut slope sloughing is anticipated to be minor and easily repaired (i.e. ditch maintenance).

It should be noted that the piezometers indicate that the groundwater table is high within the Bradner Rest Area which could result in seepage from the new cut slopes. Seepage from clay soil is anticipated to be minor and likely will result in softening of the exposed cut slope face. However, there is the potential that thin sand layers may be encountered which can seep and cause erosion. We recommend that the Ministry be prepared to place riprap surfacing on any portion of the cut slope where seepage is identified during construction. Riprap may also be required if there is significant softening of the cut slope.

4.5 Settlement

We anticipate that some consolidation of the clay layer will occur from the proposed fill heights outlined in the 100% Functional Design drawings. Oedometer testing results indicate a preconsolidation pressure of 500 kPa for a sample taken at 1.5 m to 2.1 m depth, and settlements were estimated entirely on the recompression curve. We estimate total settlements between 25 mm and 50 mm will occur where the fill height approaches 2 m.

We recommend that settlement gauges or settlement pins be used to monitor settlement across the parking area expansion. They should be placed on the ground surface upon completion of stripping and prior to fill placement. We recommend that weekly readings are completed during

and after fill placement. Thurber should review the monitoring data and determine whether the rate of settlement is low enough that construction of buried utilities, luminaire bases, pavement structure and surface grading may proceed. We anticipate that fill would need to be in place for about a month to reduce post-construction settlements to less than 25 mm. A drawing showing the proposed settlement gauge locations is attached to this report.

4.6 Sewer and Water Lines

The surface drainage system will be installed using conventional trenching in the fill material. Trench excavations for installation of sewer and water lines should not proceed until a majority of the settlement has occurred. All trench excavations should be advanced in accordance with WorkSafe BC guidelines by either sloping the excavation or using temporary shoring, such as a trench box when necessary. Generally, significant seepage into excavations for installation of services is not anticipated and it should be possible to control any seepage that occurs using conventional sumps and pumps.

4.7 Luminaire Foundations

We understand that three of luminaire bases in the center of the parking area will comprise custom foundations which will be 1.3 m x 1.3 m and buried at 2.3 m depth below finished grade. Other luminaires will be behind curbs or on the outside shoulders and will be on regular bases. We anticipate that the luminaire bases will bear on either very stiff to hard clay or compacted fill. For the proposed configuration, a factored bearing resistance of 215 kPa is suitable for Ultimate Limit State design and 150 kPa is suitable for Serviceable Limit State design, both include a geotechnical resistance factor of 0.5.

Bearing surfaces should be reviewed and approved by Thurber prior to foundation installation.

4.8 Sanitary Dump Station

The new sanitary dump station will be designed in accordance with BC Parks Road Design Guidelines under the Special Use Roads Category. The design of the sanitary dump station must account for buoyancy, assuming the water table at the elevation of the current ground surface. Excavation for the installation of the storage tank should be completed in accordance with MoTI Standard Specifications and WorkSafe BC guidelines by either sloping the excavation or using temporary shoring, such as a trench box. We anticipate that temporary dewatering may be required during construction of the sanitary dump station.

4.9 Culvert Headwall

We understand that the westernmost culvert outlet within the parking expansion area will require a headwall. We anticipate that the subgrade for the culvert headwall will comprise stiff to hard clay or compacted granular fill. The subgrade should be free from deleterious, wet, loose, or otherwise unsuitable soils and should be inspected by Thurber prior to fill placement. Localized subexcavation and replacement may be required where unsuitable soils are encountered. Bearing resistances given in Section 4.7 are appropriate for the culvert headwall.

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5. CLOSURE

We trust this information meets your present needs. If you have any questions, please contact the undersigned at your convenience.

Yours truly,
Thurber Engineering Ltd.

Paul Evans, P.Eng.
Review Principal

Thurber Engineering Ltd.
Permit to Practice #1001319

Bryant Ward, P.Eng.
Project Engineer

Renee McAnerney, EIT
Geotechnical Engineer

Attachments

- Statement of Limitations and Conditions
- Investigation Location Plan
- Test Hole and Test Pit Logs
- Lab Testing Results (Standard Proctor, One-Dimensional Consolidation Test)
- Slope Stability Outputs for 2.5H:1V Cut Slope and 2.5H:1V Fill Slope

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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client, the BC Ministry of Transportation and Infrastructure (MoTI) and Authorized Users as defined in the MoTI Special Conditions Form H0461d. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Any use which an unauthorized third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any unauthorized third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

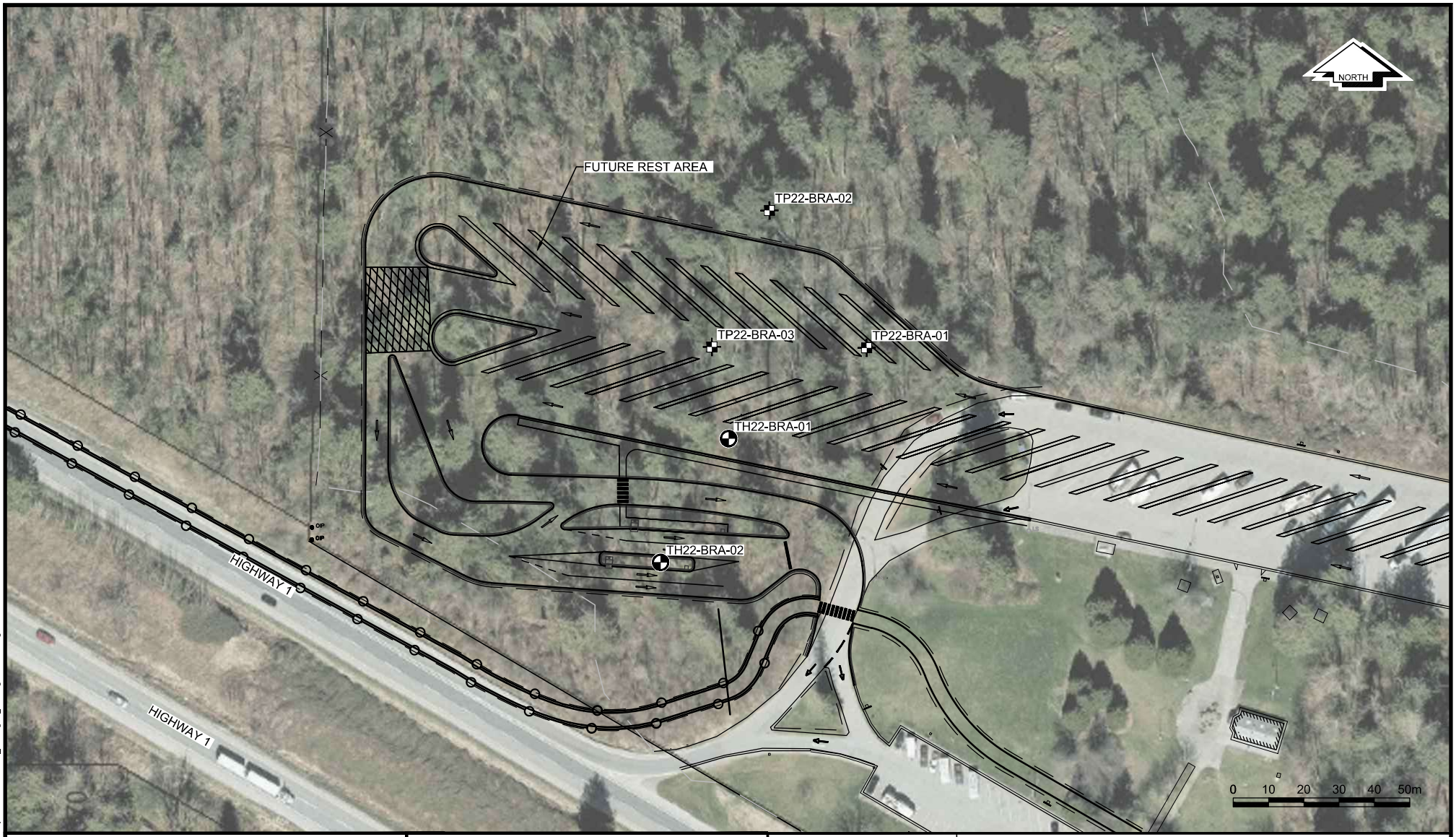
6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

Plotted: June 20, 2022



LEGEND:

- AUGER HOLE
- TEST PIT

NOTES:

1. AERIAL IMAGE TAKEN FROM ABBOTSFORD MAP VIEWER.
2. INVESTIGATION LOCATIONS ARE APPROXIMATE.
3. FUTURE REST AREA TAKEN FROM "GEOMLANE-BRADNER_RA_ALTERNATIVE.DWG".
4. EXISTING REST AREA AND SAMPLING LOCATIONS BASEPLAN TAKEN FROM CAD FILE "SURVBASE_COG-2D.DWG." BY ISL ENGINEERING.

THURBER ENGINEERING LTD.

MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

INVESTIGATION LOCATION PLAN

BRADNER ROAD REST AREA — ABBOTSFORD, BC

DESIGNED	DRAWN	APPROVED	DATE	SCALE	PROJECT No.	DWG. NO.	REV.
REM	MOM		JUNE 20, 2022	1:1000	32079-20 - 1		0

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SUMMARY LOG

Drill Hole #: **TH22-BRA-01**

Ministry of Transportation and Infrastructure

Project: **Bradner Road Rest Area**

Location: Abbotsford, BC

Prepared by: 32079 Thurber Engineering Ltd.

Logged by: RM Reviewed by:

Datum: UTM-Nad-83 Alignment:

Northing/Easting: 5436563.76 , 541182.35 Station/Offset:

Elevation: *Coordinates Surveyed*

Date(s) Drilled: March 3, 2022

Company: On-Track Drilling Inc.

Driller: Andrew

Drill Make/Model: Track

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0		68.9		1			OH - ORGANIC SILT, some sand, trace rootlets, dark brown, soft.	OH		0
							0.46m			
1		20.5		2			CL - SILTY CLAY, some sand, grey-brown-orange, very stiff to hard.	CL	**Atterberg** (Sa#2): PL:20% LL:31%	1
									Water level estimated at 0.0 m depth from VWP127422 read on March 31, 2022	
							1.52m			
2		24.6		3			CL - SILTY CLAY, trace sand, trace gravel, grey-orange-brown, hard.	CL		2
		23.7		4			- very stiff below 2.5 m depth	CL		
3										3
4		22.9		5			- stiff, occasional pockets of sand at 3.7 m depth	CL	**Atterberg** (Sa#5): PL:20% LL:33%	4
5							- blue-grey below 4.9 m depth			5
		25.3		6				CL	**Atterberg** (Sa#6): PL:18% LL:33%	
6										6
7		23.9		7			- very stiff below 6.7 m depth	CL		7
8		23.8		8				CL		8
9							9.14m			9
							End of hole at required depth. Hole open to 5.8 m depth. Water observed at 2.7 m depth upon completion of test hole. Vibrating Wire Piezometer VW127422 installed at 6.8 m depth.			
10										10
10.5										

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

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

Final Depth of Hole: 9.1 m

Depth to Top of Rock:

MOTI-SOIL-REV3 32079_BRADNER.GPJ MOTI_DATATEMPLATE_REV3.GDT 22-10-21

BRITISH COLUMBIA — Ministry of Transportation and Infrastructure

SUMMARY LOG

Drill Hole #: **TH22-BRA-02**

Project: **Bradner Road Rest Area**

Location: Abbotsford, BC

Prepared by: 32079 Thurber Engineering Ltd.

Logged by: MJCM Reviewed by:

Datum: UTM-Nad-83 Alignment:

Northing/Easting: 5436529 , 5411163 Station/Offset:

Elevation: *Coordinates taken with GPS*

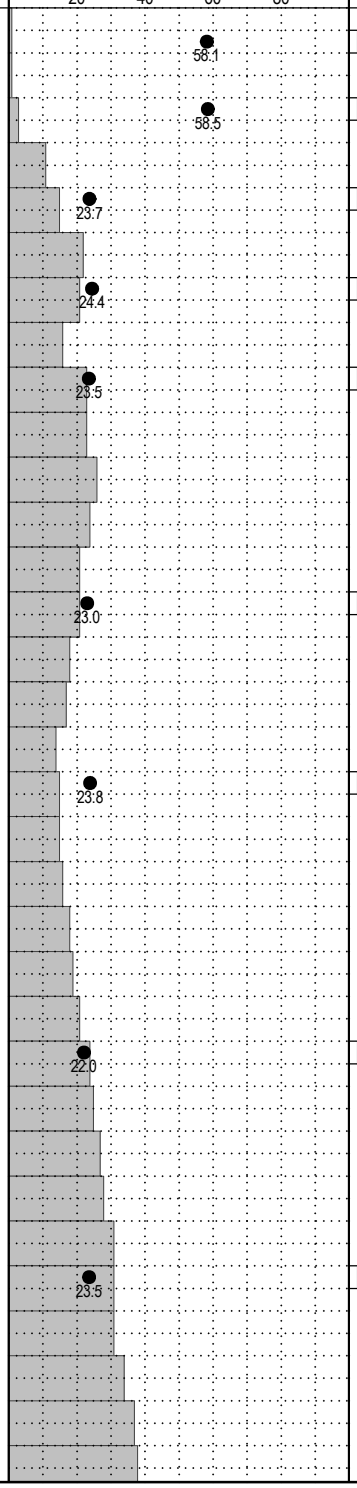
Date(s) Drilled: May 24, 2022

Company: On-Track Drilling Inc.

Driller: Andrew

Drill Make/Model: Track

Drilling Method: Solid Stem Auger / DCPT



DEPTH (m)	DRILLING DETAILS	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate *{G % S % F %}*	DEPTH (m)
0			1			OH - ORGANIC SILT, trace clay, trace sand, brown with pockets of orange mottling, soft to very soft.	OH		0
			2				OH		
1						0.91m CL - SILTY CLAY, trace sand, trace organics, grey-brown with brown-orange staining, very stiff to stiff.			1
			3				CL		
2	1.8m		4				CL	Water level estimated at 1.8 m depth from VWP138746 read on June 3, 2022	2
			5				CL		
3									3
4			6				CL		4
						4.57m CL - SILTY CLAY, trace gravel, grey, very stiff to stiff.			
5			7				CL		5
6						- very stiff below 6.1 m depth			6
7			8				CL		7
8						- hard below 8.3 m depth			8
9			9				CL		9
10									

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

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

Final Depth of Hole: 12.2 m

Depth to Top of Rock:

MOTI-SOIL-REV3 32079_BRADNER.GPJ MOTI_DATATEMPLATE_REV3.GDT 22-10-21

Ministry of Transportation and Infrastructure

SUMMARY LOG

Drill Hole #: **TH22-BRA-02**

Project: **Bradner Road Rest Area**

Location: Abbotsford, BC

Prepared by: 32079 Thurber Engineering Ltd.

Logged by: MJCM Reviewed by:

Datum: UTM-Nad-83 Alignment:

Northing/Easting: 5436529 , 5411163 Station/Offset:

Elevation: *Coordinates taken with GPS*

Date(s) Drilled: May 24, 2022

Company: On-Track Drilling Inc.

Driller: Andrew

Drill Make/Model: Track

Drilling Method: Solid Stem Auger / DCPT

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
10		23.1		10			CL - SILTY CLAY, trace gravel, grey, very stiff to stiff. *(continued)*	CL		10
11										11
		23.3		11				CL		
12							12.19m			12
							End of hole at required depth. Hole open to 11.1 m depth. Vibrating Wire Piezometer VW138746 installed at 6.1 m depth.			
13										13
14										14
15										15
16										16
17										17
18										18
19										19
20										

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

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

Final Depth of Hole: 12.2 m

Depth to Top of Rock:

MOTI-SOIL-REV3 32079_BRADNER.GPJ MOTI_DATATEMPLATE_REV3.GDT 22-10-21

TEST PIT LOG

Test Pit #: **TP22-BRA-01**

Ministry of Transportation and Infrastructure

Project: **Bradner Road Rest Area**

Location: Abbotsford, BC

Date(s) Drilled: March 2, 2022

Company: On-Track Drilling Inc.

Operator: Troy

Excavator: Excavator

Prepared by: 32079
Thurber Engineering Ltd.

Logged by: RM Reviewed by:

Datum: UTM-Nad-83 Alignment:

Northing/Easting: 5436589.46 , 541221.45 Station/Offset:

Elevation: *Coordinates Surveyed*

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate *{G % S % F %}*	DEPTH (m)
0		62.0		1			OH - ORGANIC SILT, some sand, trace rootlets, dark brown, soft.	OH		0
0.91m										
1							CL - SILTY CLAY, trace sand, trace brown staining, grey-brown, stiff to hard.		Difficult digging with excavator below 1.5 m depth	1
2		21.0 ×		2				CL		2
2.5m							End of test pit at required depth. Test pit open to 2.5 m depth. Seepage observed at 0.9 m depth during excavation.			
3										3
4										4
5										5
6										6
7										7
8										8
9										9
10										

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

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

Final Depth of Hole: 2.1 m

Depth to Top of Rock:

MOTI-SOIL-REV3 32079_BRADNER.GPJ MOTI_DATATEMPLATE_REV3.GDT 22-10-21

TEST PIT LOG

Test Pit #: **TP22-BRA-02**

Ministry of Transportation and Infrastructure

Project: **Bradner Road Rest Area**

Location: Abbotsford, BC

Date(s) Drilled: March 2, 2022

Company: On-Track Drilling Inc.

Operator: Troy

Excavator: Excavator

Prepared by: 32079 Thurber Engineering Ltd.

Logged by: RM Reviewed by:

Datum: UTM-Nad-83 Alignment:

Northing/Easting: 5436628.36 , 541193.91 Station/Offset:

Elevation: *Coordinates Surveyed*

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate *{G % S % F %}*	DEPTH (m)
0		78.2		1			OH - ORGANIC SILT, some sand, trace rootlets, dark brown, soft.	OH		0
							0.61m			
1							CL - SILTY CLAY, some sand, grey, stiff to hard.		Difficult digging with excavator	1
2		22.4 ×		2				CL		2
							2.29m			
3							End of test pit at required depth. Test pit open to 2.3 m depth. Seepage observed at 0.6 m depth during excavation.			3
4										4
5										5
6										6
7										7
8										8
9										9
10										

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

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

Final Depth of Hole: 2.1 m

Depth to Top of Rock:

MOTI-SOIL-REV3 32079_BRADNER.GPJ MOTI_DATATEMPLATE_REV3.GDT 22-10-21

TEST PIT LOG

Ministry of Transportation and Infrastructure

Test Pit #: **TP22-BRA-03**

Project: **Bradner Road Rest Area**

Location: Abbotsford, BC

Date(s) Drilled: March 2, 2022

Company: On-Track Drilling Inc.

Operator: Troy

Excavator: Excavator

Prepared by: 32079 Thurber Engineering Ltd.

Logged by: RM Reviewed by:

Datum: UTM-Nad-83 Alignment:

Northing/Easting: 5436589.73 , 541177.6 Station/Offset:

Elevation: *Coordinates Surveyed*

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp% 20 W% 40 60 WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate *{G % S % F %}*	DEPTH (m)
0		73.4		1			OH - ORGANIC SILT, some sand, trace rootlets, dark brown, soft.	OH		0
							0.76m			
1							CL - SILTY CLAY, some sand, grey, stiff to hard.		Difficult digging with excavator	1
		27.1		2				CL	**Atterberg** (Sa#2): PL:21% LL:31%	
2							2.29m			2
							End of test pit at required depth. Test pit open to 0.8 m depth. Seepage observed at 0.8 m depth during excavation.			
3										3
4										4
5										5
6										6
7										7
8										8
9										9
10										

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

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

Final Depth of Hole: 2.1 m

Depth to Top of Rock:

MOTI-SOIL-REV3 32079_BRADNER.GPJ MOTI_DATATEMPLATE_REV3.GDT 22-10-21

SAMPLE INFORMATION

As-Received Moisture: 26.4 %

Sampled By:	REM
Date Sampled:	June 17, 2022
Date Received:	June 17, 2022
Supplier:	N/A
Source:	TP22-BRA-04-1 @ 1.2 - 1.7 m

COMPACTION INFORMATION

	Standard
Compaction Standard:	ASTM D698
Compaction Method:	Method A
Rammer Type:	Automatic
Preparation:	Moist
Proctor Test No.:	1
Number of Trials:	4

MATERIAL IDENTIFICATION

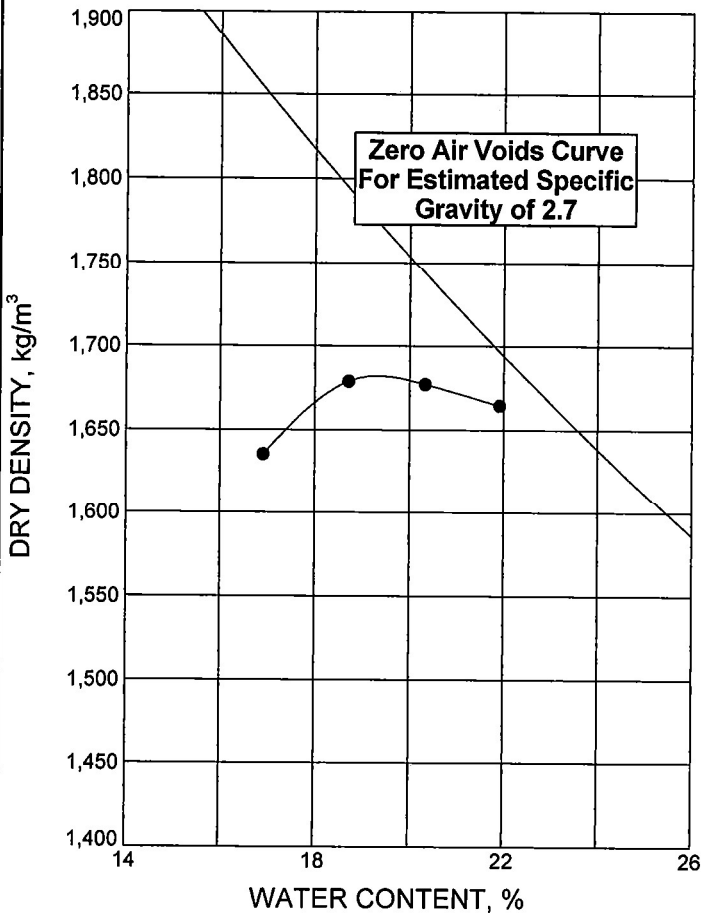
Soil Identification: Sa. 1

Description: Clayey SILT, trace sand and gravel (ML/CL).

OVERSIZE MATERIALS

Retained on 4.75 mm Screen: 1 %

Oversize Specific Gravity: 2.7



Trial Number	Wet Density (kg/m^3)	Dry Density (kg/m^3)	Moisture Content (%)
1	1993	1679	18.7
2	2018	1677	20.3
3	2029	1665	21.9
4	1912	1636	16.9

	Maximum Dry Density (kg/m^3)	Optimum Moisture Content (%)
Calculated	1682	19.3
Oversize Corrected	---	---

Comments:

Tested by: DZM

Checked By: _____

THURBER ENGINEERING LTD.

MOISTURE-DENSITY RELATIONSHIP

CLIENT: BCMoTI

PROJECT: Highway 1 - Bradner Rest Area

FILE NO.: 32079 - 20.21

THURBER ENGINEERING LTD.

One-Dimensional Consolidation Test Report Co 22-2
Summary of Test Data

Client: MoTI
Project: Highway 1 - FVCIP
File No.: 32079

Sample: TH22-BRA-02 @ 5' - 7'
Report Date: June 30, 2022
Test Dates: June 10-27, 2022

Sample Details	**Initial**	**Final**		
Wet Density (kg/m^3):	1911	2057	Sand:	---
Dry Density (kg/m^3):	1557	1679	Silt:	---
Moisture Content (%):	22.7	22.5	Clay:	---
Void Ratio:	0.734	0.608	Liquid Limit:	---
Saturation:	84	100	Plastic Limit:	---
Specific Gravity (assumed):	2.7		Plasticity Index:	---

Description: Silty SAND, some gravel.

Test Method

ASTM D2435-03, method B, C_v calculated by the root of time method

Trimming

The specimen was trimmed to a diameter of 63.45 mm and a height of 19.88 mm and placed in a fixed ring oedometer.

Procedure

The oedometer was flooded with distilled water immediately after the application of the first load of 25 kPa. Subsequent loads were applied after primary consolidation was complete.

Vertical Stress, σ_v (kPa)	Void Ratio (End of Increment)	C_v (cm^2/sec)	C_v (m^2/yr)	m_v (cm^2/g)	k (cm/sec)
25	0.730	3.23E-02	102	1.06E-05	3.41E-07
50	0.725	1.61E-02	51	1.19E-05	1.92E-07
100	0.713	1.37E-02	43	1.32E-05	1.80E-07
200	0.697	1.45E-02	46	9.37E-06	1.36E-07
400	0.672	6.16E-03	19	7.25E-06	4.47E-08
800	0.628	9.37E-03	30	6.41E-06	6.01E-08
1600	0.566	5.57E-03	18	4.69E-06	2.61E-08
3200	0.498	4.95E-03	16	2.66E-06	1.31E-08
1600	0.500				
400	0.511				
100	0.535				
12	0.573				

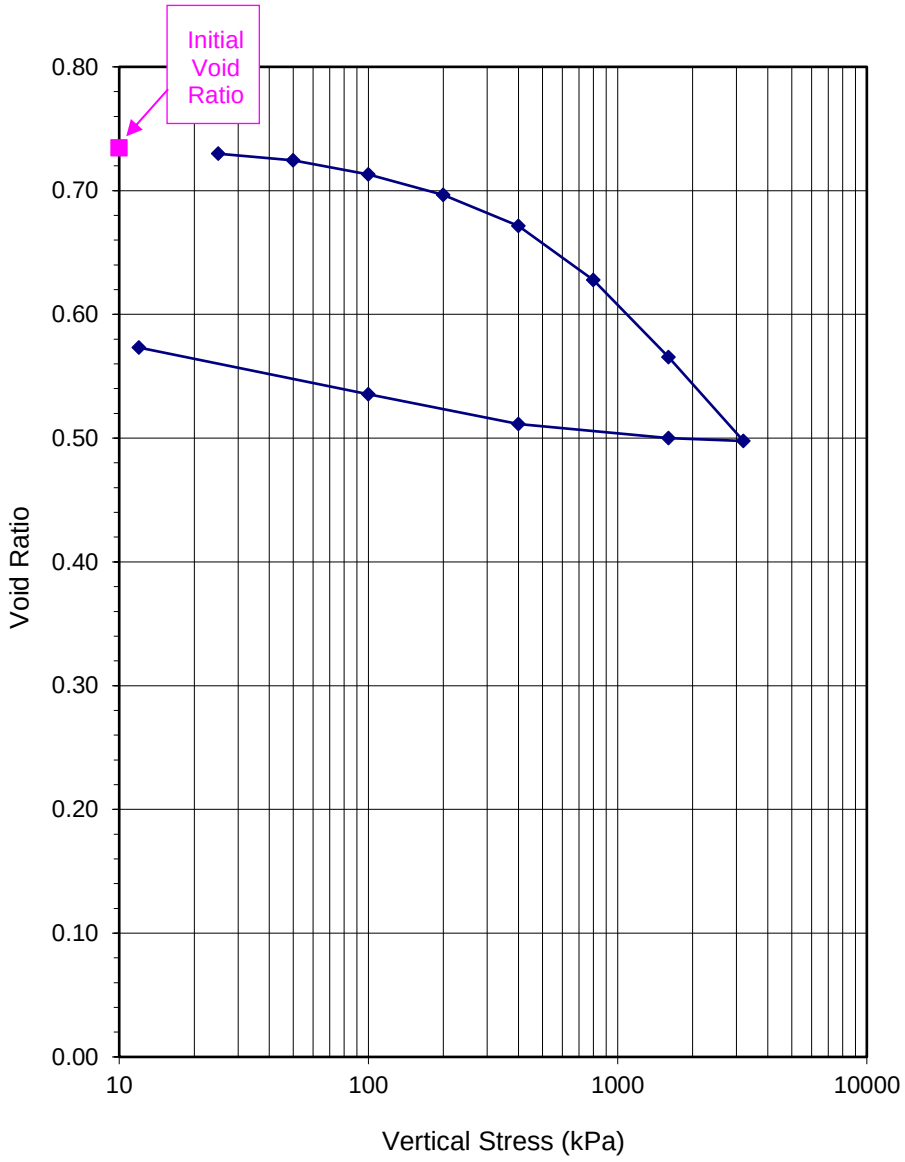
THURBER ENGINEERING LTD.

One-Dimensional Consolidation Test Report Co 22-2
Summary of Test Data

Client: MoTI
Project: Highway 1 - FVCIP
File No.: 32079

TH22-BRA-02 @ 5' - 7'
Report Date: June 30, 2022
Test Dates: June 10-27, 2022

Void Ratio (end of load increment) Vs Log of Pressure

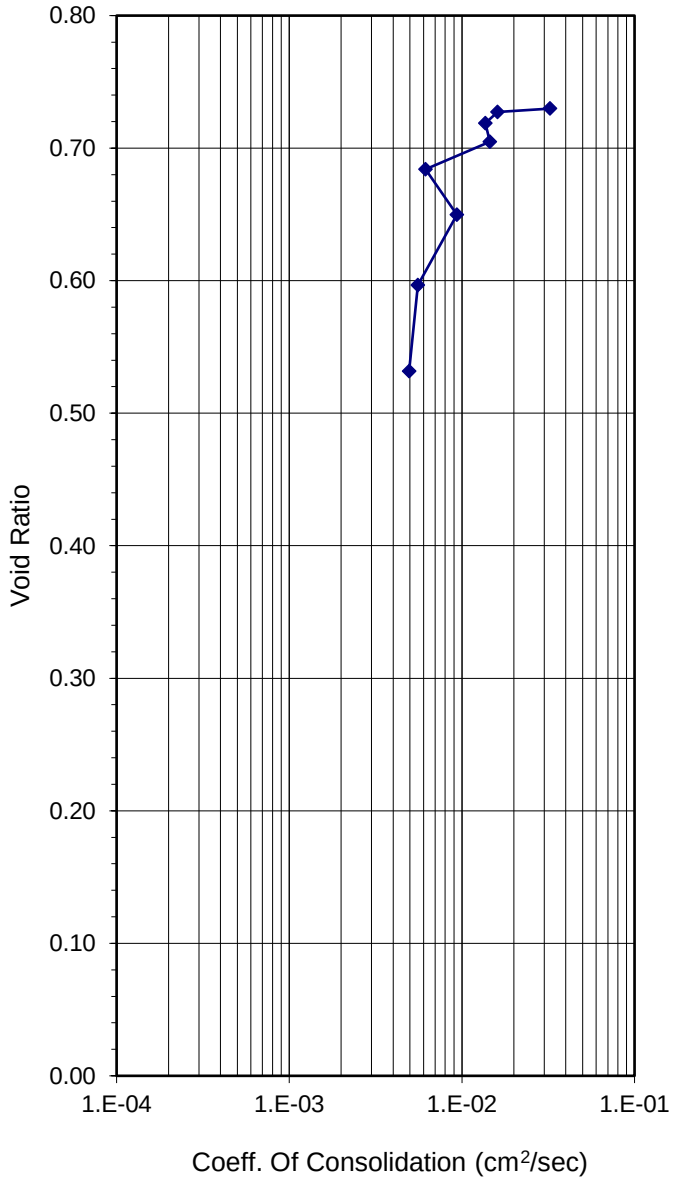


THURBER ENGINEERING LTD.

One-Dimensional Consolidation Test Report Co 22-2
Summary of Test Data

Client: MoTI
Project: Highway 1 - FVCIP
File No.: 32079

TH22-BRA-02 @ 5' - 7'
Report Date: June 30, 2022
Test Dates: June 10-27, 2022

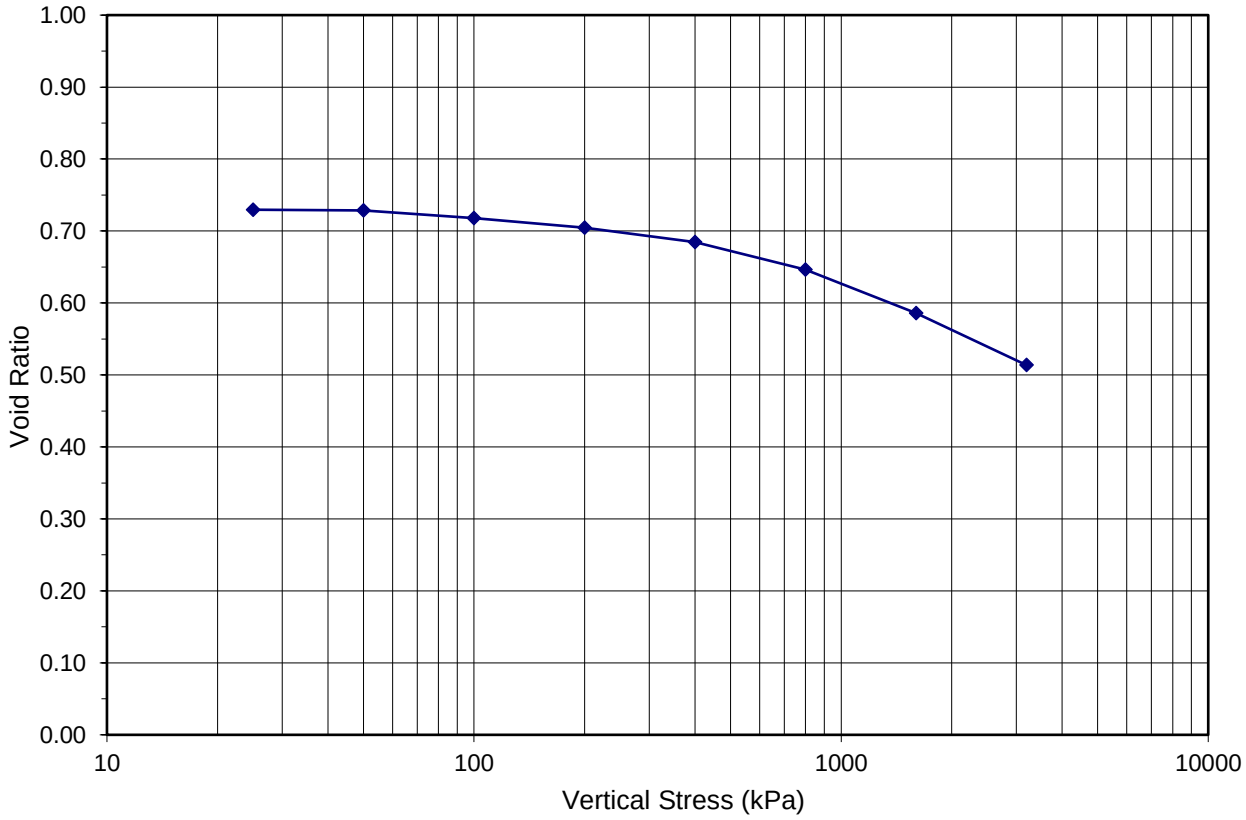


THURBER ENGINEERING LTD.

One-Dimensional Consolidation Test Report Co 22-2
Summary of Test Data

Client:	MoTI	TH22-BRA-02 @ 5' - 7'
Project:	Highway 1 - FVCIP	Report Date: June 30, 2022
File No.:	32079	Test Dates: June 10-27, 2022

Void Ratio (@T_{100}) Vs Log of Pressure

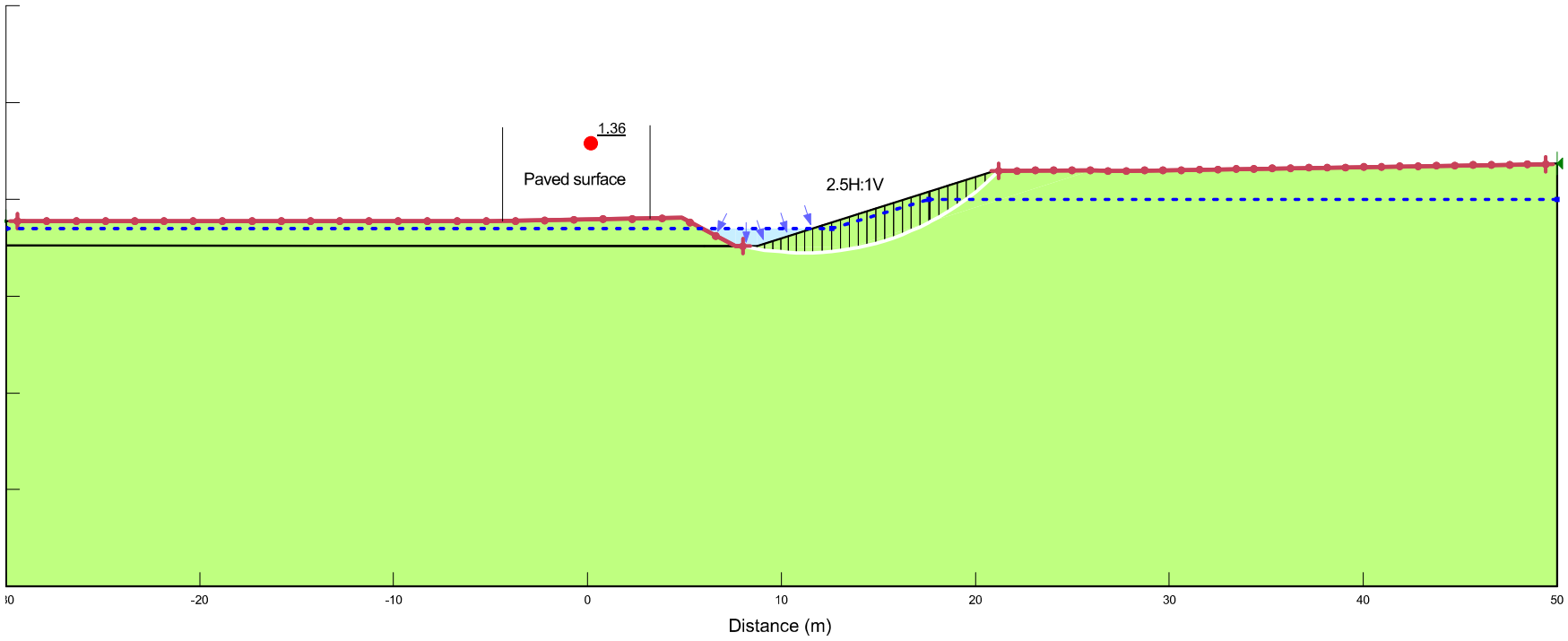


Highway 1 - 264 to Whatcom Road
Bradner Road Rest Area
Project No. 32079

Name: Native Soil Cut (Drained)
Method: Spencer

Horz Seismic Coef.: 0

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Stiff Silt and Clay (Drained)	18.5	0	31



NOTES:

THURBER ENGINEERING LTD.

BC Ministry of Transportation and Infrastructure

Native Soil Cut (Drained)

DESIGNED BMW

DATE June 13, 2022

SCALE 1:350

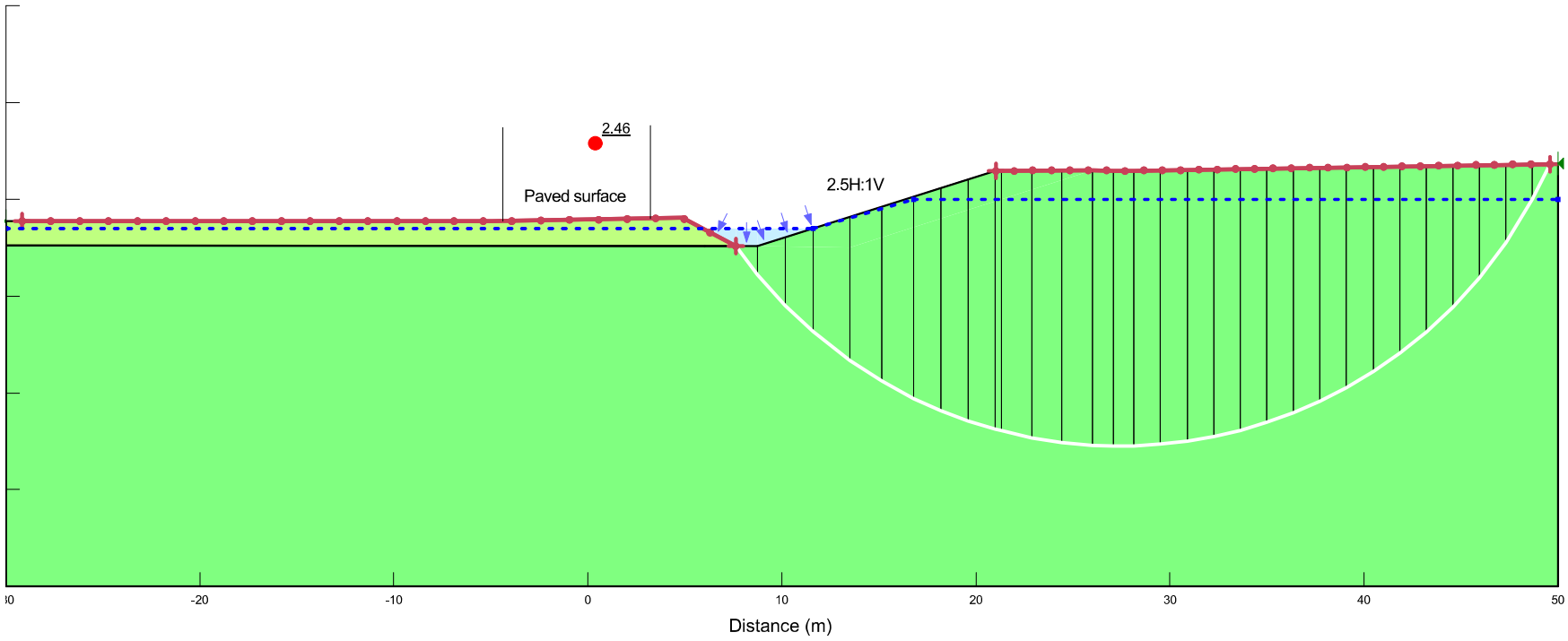
PROJECT No. 32079

Highway 1 - 264 to Whatcom Road
Bradner Road Rest Area
Project No. 32079

Name: Native Soil Cut (Pseudostatic)
Method: Spencer

Horz Seismic Coef.: 0.22

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Stiff Silt and Clay (Drained)	18.5		0	31
	Stiff Silt and Clay (Undrained)	18.5	75		



NOTES:

THURBER ENGINEERING LTD.

BC Ministry of Transportation and Infrastructure

Native Soil Cut (Pseudostatic)

DESIGNED BMW

DATE June 13, 2022

SCALE 1:350

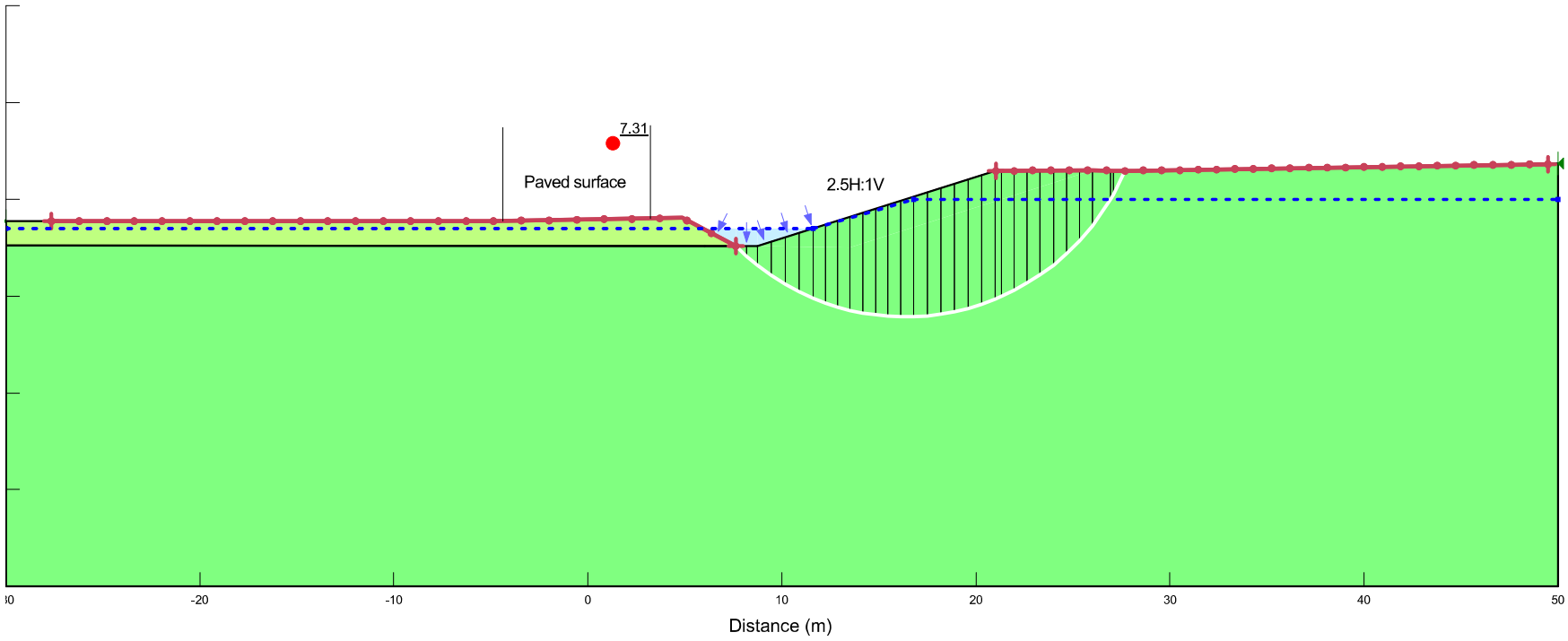
PROJECT No. 32079

Highway 1 - 264 to Whatcom Road
Bradner Road Rest Area
Project No. 32079

Name: Native Soil Cut (Undrained)
Method: Spencer

Horz Seismic Coef.: 0

Color	Name	Unit Weight (kN/m³)	Cohesion (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Stiff Silt and Clay (Drained)	18.5		0	31
	Stiff Silt and Clay (Undrained)	18.5	75		



NOTES:

THURBER ENGINEERING LTD.

BC Ministry of Transportation and Infrastructure

Native Soil Cut (Undrained)

DESIGNED BMW

DATE June 13, 2022

SCALE 1:350

PROJECT No. 32079