



THURBER ENGINEERING LTD.

**Foundation Investigation and Design Report
Highway 9 Carrick Creek Culvert Rehabilitation
Township of Carrick, Ontario
G.W.P. 3076-14-00, Site No. 02X-0469/C0
Latitude: 44.006271°, Longitude: -81.050075°
GEOCRES No. 41A03-002**

Client Name: R.V. Anderson Associates Limited

Date: April 19, 2024

File: 34935

TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION.....	1
2.	SITE DESCRIPTION.....	1
3.	SITE INVESTIGATION AND FIELD TESTING	2
4.	LABORATORY TESTING	3
5.	DESCRIPTION OF SUBSURFACE CONDITIONS.....	4
5.1	Asphalt	4
5.2	Sand and Gravel to Gravelly Sand Fill	4
5.3	Sandy Silt Fill.....	5
5.4	Clayey Silt Fill.....	5
5.5	Sand and Silt Fill	6
5.6	Topsoil.....	7
5.7	Clayey Silt	7
5.8	Silty Clay	8
5.9	Sand and Gravel	9
5.10	Groundwater Conditions.....	10
6.	CLOSURE	10

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7.	GENERAL	12
8.	GABION RETAINING WALLS	13
9.	SETTLEMENT	15
10.	EXCAVATION AND GROUNDWATER CONTROL	15
11.	BACKFILL AND LATERAL EARTH PRESSURES	16
12.	SEISMIC CONSIDERATIONS	18
13.	GLOBAL SLOPE STABILITY OF GABION WALLS.....	18
14.	CONSTRUCTION CONCERNS.....	19
15.	CLOSURE	20

STATEMENT OF LIMITATIONS AND CONDITIONS

IN-TEXT TABLES

Table 3.1 Borehole Completion Details	3
Table 5.1 Groundwater Measurements	10
Table 11.1 Lateral Earth Pressure Coefficients (K)	17
Table 12.1 Seismic Earth Pressure Parameters	18

APPENDICES

APPENDIX A	
Borehole Locations and Soil Strata Drawings	
APPENDIX B	
Record of Borehole Sheets	
APPENDIX C	
Geotechnical Laboratory Test Results	
APPENDIX D	
Site Photographs	
APPENDIX E	
Slope Stability Analysis Figures	
APPENDIX F	
List of OPSS Documents	
APPENDIX G	
Preliminary Draft General Arrangement and Gabion Structure Drawings	

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 9 CARRICK CREEK CULVERT REHABILITATION
TOWNSHIP OF CARRICK, ONTARIO
G.W.P. 3076-14-00, SITE NO. 02X-0469/C0
LATITUDE: 44.006271°, LONGITUDE: -81.050075°
GEOGRES No. 41A03-002**

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for rehabilitation of the Carrick Creek Culvert (Site No. 02X-0469/C0). The Carrick Creek Culvert is located on Highway 9, between Mildmay and Clifford, in Carrick Township, Ontario. This site is part of an overall detailed design project for improvements to Highway 9 between Mildmay and Clifford.

The purpose of this investigation was to explore the subsurface conditions at the culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to R.V. Anderson Associates Limited (RVA), under the Ministry of Transportation Ontario (MTO) West Region, Retainer Agreement Number 3020-E-0004, Work Item No. 23.

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.

2. SITE DESCRIPTION

The site is located on Highway 9, approximately 300 m southeast of Side Road 41, near Mildmay, Ontario. The centreline of the existing culvert is located at approximate Highway 9 Station 24+515. Carrick Creek flows in a generally southwest to northeast direction and passes under Highway 9 through the culvert. Highway 9 is a two-lane road with an asphalt paved surface and gravel shoulders, which is aligned in a northwest / southeast direction at the culvert site.

Existing site information provided by RVA and MTO, includes a 2021 Structure Inspection Report (OSIM report) for the culvert and in progress drawings for the current Highway 9 project. The information indicates that the existing structure is an approximately 19.4 m long, open-footing,

concrete box culvert, with a height of 2.0 m and an alignment shift at the approximate centreline of Highway 9. The culvert span is approximately 3.8 m at the inlet and 4.4 m at the outlet. The estimated culvert base (stream bed level) is at approximate Elevation 329.7 m. The existing road grade at the culvert location is at approximate Elev. 332.2 m, and there is approximately 0.5 m of fill above the culvert. The site topography within the culvert area is relatively flat, with agricultural open fields surrounding the culvert site on both sides of Highway 9.

The Highway 9 embankment is approximately 1.7 to 2.2 m high near the culvert, with side slopes beyond the culvert structure typically inclined at approximately 2H:1V or flatter. Existing gabion retaining walls (approximately 2 m long and 1.1 m high) are located at the northeast and northwest corners of the culvert outlet.

Photographs in Appendix D show the general nature of the site and the existing culvert.

Based on published geological mapping, the quaternary geology in the area of the culvert site typically consists of glaciofluvial ice-contact deposits including gravel, sand and minor till. The bedrock in the area is classified as the Salina Formation, which consists of limestone, dolostone, shale, sandstone, gypsum, and salt.

3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field-testing program for this project was carried out between October 10 and 27, 2023. The field program consisted of drilling and sampling five (5) boreholes (CULV3-01 to CULV3-05) to depths from 9.8 to 15.2 m below the ground surface (Elev. 321.4 to 316.7 m).

Boreholes CULV3-02 and CULV3-03 were drilled through the Highway 9 embankment. Boreholes CULV3-01, CULV3-04, and CULV3-05 were drilled off-road near the inlet and outlet of the existing culvert. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix A.

Utility clearances were obtained prior to the start of drilling. The horizontal coordinates and ground surface elevations at the boreholes were obtained by Thurber using a Trimble R12i GNSS system. The coordinate system MTM NAD 83, Zone 11 was used for the boreholes.

The boreholes through the embankment were advanced using a rubber track-mounted D-50 drill rig, using hollow stem augers and wash boring techniques. The off-road boreholes were advanced using a portable drill and tripod equipment using wash boring techniques. In all boreholes, soil

samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT).

The drilling and sampling operations were supervised on a full-time basis by members of Thurber's technical staff. The supervisors logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operation. A standpipe piezometer was installed in Borehole CULV3-05 to permit additional measurement of the groundwater level. The piezometer consisted of a 19 mm diameter Schedule 40 PVC pipe with a 3.0 m long slotted screen, enclosed in a column of filter sand. Piezometer installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets in Appendix B.

Details of the drilling program, including drilling depths, piezometer installation and completion details are summarized in Table 3.1.

Table 3.1 Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
CULV3-01	9.8 / 320.4	-	Backfilled with bentonite holeplug from 9.8 m to ground surface.
CULV3-02	12.8 / 319.2	-	Backfilled with bentonite grout from 12.8 to 0.6 m, bentonite holeplug to 0.2 m, then cold patch asphalt to ground surface.
CULV3-03	15.2 / 316.7	-	Backfilled with bentonite grout from 15.2 to 0.9 m, bentonite holeplug to 0.2 m, then cold patch asphalt to ground surface.
CULV3-04	9.8 / 320.2	-	Backfilled with bentonite holeplug from 9.8 m to ground surface.
CULV3-05	9.8 / 321.5	9.1 / 322.2	Backfilled filter sand from 9.8 to 5.8 m, bentonite holeplug to 5.2 m, then bentonite mixed with cuttings to ground surface.

4. LABORATORY TESTING

The recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses

(sieve and/or hydrometer), and Atterberg Limits testing where appropriate. The laboratory test results are summarized on the Record of Borehole sheets included in Appendix B and the figures included in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the subsurface conditions encountered during the foundation investigation are presented in the Record of Borehole sheets and the Borehole Locations and Soil Strata Drawing included in Appendices A and B.

A general description of the soil stratigraphy is given below. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It should be recognized and expected that soil and rock conditions will vary between and beyond borehole locations.

In general, the subsurface stratigraphy below the asphalt typically consists of embankment fill comprised of sand and gravel, sandy silt and clayey silt fill, underlain by layers of native clayey silt, silty clay, and sand and gravel. The travelled portion of Highway 9 is paved with asphalt. More detailed descriptions of the individual strata are presented below.

5.1 Asphalt

The asphalt thickness at Borehole CULV3-02, which was drilled near the edge of the Highway 9 pavement surface was 190 mm.

5.2 Sand and Gravel to Gravelly Sand Fill

Embankment fill was encountered below the asphalt in Borehole CULV3-02 and at the ground surface in Borehole CULV3-03, which was drilled through the gravel shoulder of Highway 9. The fill ranged in composition from sand and gravel to gravelly sand with trace to some silt and trace clay. A 1.0 m thick layer of sandy gravel fill with some silt was also encountered below the topsoil in Borehole CULV3-01 near the base of the Highway 9 embankment.

The sand and gravel to gravelly sand fill extended to depths from 2.2 to 4.0 m below the Highway 9 embankment surface, and 1.6 m below the ground surface at Borehole CULV3-01 (base encountered ranging from Elev. 329.7 to 328.0 m).

A layer of buried concrete, approximately 510 mm in thickness, was encountered at a depth of 4.0 m at the base of the fill in Borehole CULV3-03, which extended to a depth of 4.5 m (Elev. 327.5 m). Due to the presence of concrete, the borehole was moved 3 m to the south to continue drilling and sampling below the concrete.

SPT 'N' values in the sand and gravel to gravelly sand fill ranged from 10 to 31 blows per 0.3 m penetration, indicating the fill is compact to dense (typically compact).

The measured moisture contents generally ranged from 1 to 13%.

The results of a grain size analysis conducted on a sample of the sand and gravel to gravelly sand fill are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C1 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	29
Sand	49
Silt	20
Clay	2

5.3 Sandy Silt Fill

A 0.6 m thick layer of sandy silt fill with trace gravel and some organics was encountered below the topsoil in Borehole CULV3-05. The sandy silt fill extended to a depth of 0.7 m (Elev. 330.6 m).

The sandy silt fill was loose, based on an SPT 'N' value of 5 blows per 0.3 m penetration. The moisture content of a sample of the sandy silt fill was 20%.

5.4 Clayey Silt Fill

A 1.5 m thick layer of clayey silt fill with some sand and trace gravel was encountered below the sandy silt fill in Boreholes CULV3-05, which extended to a depth of 2.2 m (Elev. 329.1 m).

SPT 'N' values recorded within the clayey silt fill were 4 to 5 blows per 0.3 m penetration, indicating that the fill is firm.

The moisture content of samples of the clayey silt fill ranged from 13 to 24%.

The results of a grain size analysis conducted on a sample of the clayey silt fill are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C2 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	1
Sand	17
Silt	68
Clay	14

The results of an Atterberg Limits test conducted on a sample of the clayey silt fill are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C7 of Appendix C. The results are summarized in the table below. The results indicate that the clayey silt typically has low plasticity, with a group symbol of CL.

Parameter	Percentage (%)
Liquid Limit	24
Plastic Limit	17
Plasticity Index	7

5.5 Sand and Silt Fill

A 0.8 m thick layer of sand and silt fill with trace gravel and trace clay was encountered below the sand and gravel to gravelly sand fill in Boreholes CULV3-02, which extended to a depth of 3.0 m (Elev. 329.0 m).

An SPT 'N' value of 7 blows per 0.3 m penetration was recorded within the sand and silt fill, indicating that the fill is loose.

The moisture content of a sample of the sand and silt fill was 13%.

The results of a grain size analysis conducted on a sample of the sand and silt fill are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C3 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	9
Sand	42
Silt	42
Clay	7

5.6 Topsoil

Beyond the Highway 9 embankment, a layer of topsoil was encountered at the ground surface in Boreholes CULV3-01, CULV3-04 and CULV3-05. The topsoil contained some silt, some sand, trace gravel and occasional rootlets and ranged in thickness from 50 mm in Borehole CULV3-05 to 0.6 m in Boreholes CULV3-01 and CULV3-04.

SPT 'N' values of 1 and 3 blows per 0.3 m penetration were recorded in the topsoil, indicating a very loose consistency.

The measured moisture content of the topsoil was 52 to 53%.

5.7 Clayey Silt

A layer of native clayey silt with trace sand was encountered below the fill and topsoil layers in all of the boreholes at the site. The clayey silt layer ranged in thickness from 2.5 to 6.6 m and extended to depths from 4.1 to 8.7 m (Elev. 326.0 to 322.8 m).

SPT 'N' values recorded within the clayey silt layer ranged from 6 to 35 blows per 0.3 m penetration, indicating that clayey silt has a firm to hard consistency (typically stiff to very stiff).

The moisture content of samples of the clayey silt ranged from 12 to 22%.

The results of grain size analyses conducted on samples of the clayey silt are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C4 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 9
Silt	74 to 85
Clay	15 to 18

The results of Atterberg Limits tests conducted on samples of the clayey silt are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C8 of Appendix C. The results are summarized in the table below. The results indicate that the clayey silt typically has low plasticity, with group symbols of CL to CL-ML.

Parameter	Percentage (%)
Liquid Limit	21 to 23
Plastic Limit	14 to 16
Plasticity Index	6 to 8

5.8 Silty Clay

A layer of silty clay with trace sand was encountered below the clayey silt in all of the boreholes at the site. Where fully penetrated in Boreholes CULV3-02 and CULV3-03, the silty clay layer ranged in thickness from 1.5 to 3.0 m and extended to depths from 10.2 to 11.7 m (Elev. 321.8 to 320.2 m). Boreholes CULV3-01, CULV3-04 and CULV3-05 were each terminated within the silty clay layer at a depth of 9.8 m (Elev. 321.5 to 320.2 m). In Borehole CULV3-01, the encountered silty clay layer was 5.7 m thick before the borehole was terminated.

Gravelly sand lenses and artesian groundwater pressure were encountered within the silty clay at the base of Borehole CULV3-01 at a depth of 9.8 m (Elev. 320.4 m). The artesian groundwater pressure was measured at approximately 1.5 m above the ground surface before the borehole was terminated and backfilled with bentonite holeplug.

SPT 'N' values recorded within the silty clay layer ranged from 9 to 31 blows per 0.3 m penetration, indicating that the silty clay has a stiff to hard consistency (typically stiff to very stiff).

The moisture content of samples of the silty clay ranged from 11 to 22%.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C5 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	1 to 5
Silt	71 to 85
Clay	14 to 24

The results of Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C9 of Appendix C. The results are summarized in the table below. The results indicate that the silty clay typically has low plasticity, with a group symbols of CL.

Parameter	Percentage (%)
Liquid Limit	21 to 26
Plastic Limit	12 to 13
Plasticity Index	8 to 13

5.9 Sand and Gravel

In Boreholes CULV3-02 and CULV3-03, a deposit of sand and gravel with some silt to silty and trace clay was encountered for 1.1 to 5.0 m below the silty clay layer, prior to borehole termination at depths of 12.8 to 15.2 m (Elev. 319.2 to 316.7 m). Coring methods were used to penetrate a 0.9 m thick zone of gravel and cobbles from 13.1 to 14.0 m depth in Borehole CULV3-03.

SPT 'N' values ranging from 24 to 69 blows per 0.3 m penetration were recorded in the sand and gravel, indicating that the density ranges from compact to very dense.

The measured moisture content of the sand and gravel ranged from 9 to 12%.

The results of a grain size analysis conducted on a sample of the sand and gravel are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C6 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	30
Sand	31
Silt	34
Clay	5

An Atterberg Limits test was conducted on a sample of the deposit where the sand and gravel was silty with trace clay. The results are provided on the Record of Borehole sheets in Appendix B and plotted on Figure C10 of Appendix C. The results are summarized in the table below. The tested sample had low plasticity, with a group symbol of CL-ML.

Parameter	Percentage (%)
Liquid Limit	20
Plastic Limit	14
Plasticity Index	6

5.10 Groundwater Conditions

A standpipe piezometer was installed in Borehole CULV3-05 for measurement of the groundwater level. Groundwater conditions were also observed in the open boreholes throughout the drilling operation. The measured groundwater levels are summarized in Table 5.1 below.

Table 5.1 Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
CULV3-01	October 27, 2023	- 1.5	331.7	Open Borehole
CULV3-02	October 16, 2023	2.1	329.9	Open Borehole
CULV3-03	October 12, 2023	5.8	326.2	Open Borehole
CULV3-04	October 26, 2023	4.7	325.3	Open Borehole
CULV3-05	October 12, 2023	5.2	326.1	Piezometer
	December 1, 2023	-0.5	331.8	
	January 31, 2024	-0.9	332.2	

Artesian pressure was noted in Boreholes CULV3-01 (measured inside the drilling casing) and CULV3-05 (in the standpipe piezometer), resulting in water level measurements above the ground surface.

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CLOSURE

The field investigation was supervised on a full-time basis by Mr. Sergey Gladkiy of Thurber. Overall supervision of the field program was provided by Mr. Rod de Castro, P.Eng. Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory.

Interpretation of the field data and report preparation was carried out by Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.

Thurber Engineering Ltd.



Mark Farrant, P.Eng.
Associate, Senior Geotechnical Engineer



P.K. Chatterji, P.Eng.
Principal, Designated MTO Contact

Date: April 19, 2024

File: 34935

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 9 CARRICK CREEK CULVERT REHABILITATION
TOWNSHIP OF CARRICK, ONTARIO
G.W.P. 3076-14-00, SITE NO. 02X-0469/C0
LATITUDE: 44.006271°, LONGITUDE: -81.050075°
GEOGRES NO. 41A03-002**

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report provides an interpretation of the factual data from Part 1 of the report and presents foundation recommendations for the rehabilitation of the existing Carrick Creek culvert crossing Highway 9. The discussion and recommendations presented in this report are based on the information provided by R.V. Anderson (RVA), the structural designer Doug Dixon and Associates Inc. (DDA), and on the factual data obtained during the course of the investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and their designers, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

Existing site information provided by RVA and MTO indicates that the existing structure is an approximately 19.4 m long, open-footing, concrete box culvert, with a height of 2.0 m and an alignment shift at the approximate centreline of Highway 9. The culvert span is approximately 3.8 m at the inlet and 4.4 m at the outlet. The estimated culvert base (stream bed level) is at approximate Elevation 329.7 m. The existing road grade at the culvert location is at approximate Elev. 332.2 m, and there is approximately 0.5 m of fill above the culvert.

The Highway 9 embankment is approximately 1.7 to 2.2 m high near the culvert, with side slopes beyond the culvert structure typically inclined at approximately 2H:1V or flatter. Existing gabion retaining walls (approximately 2 m long and 1.1 m high) are located at the northeast and northwest corners of the culvert outlet.

Based on discussions with RVA and DDA, as well as a preliminary draft General Arrangement (GA) and gabion wall drawings, it is understood that the proposed culvert rehabilitation works will include installation of new gabion retaining walls at all four corners of the culvert, as well as other non-foundation works such as patching of the existing concrete. The preliminary GA and gabion wall drawings are included in Appendix G for reference.

The preliminary drawings indicate that new gabion walls, approximately 4.5 to 5.0 m long and 2.8 to 3.0 m high, are proposed at the four corners of the culvert. The existing gabion walls at the culvert inlet will be replaced. The gabion walls are proposed to be typically 2 m deep, with the base founded at the existing culvert base / stream bed level (approximate Elev. 329.7 m).

No significant grade raise is anticipated for Highway 9 as part of the culvert rehabilitation.

It is understood that Highway 9 will be closed to traffic during construction and that staged construction and temporary roadway protection systems will not be required. No in water works are planned as part of the rehabilitation.

Recommendations for the design and installation of the proposed gabion walls are presented below.

8. GABION RETAINING WALLS

The foundations for the proposed new gabion walls are anticipated to be at approximate Elev. 329.7 m. It is recommended that the gabion walls be supported on minimum 300 mm thick engineered granular fill pads to provide subgrade uniformity along the gabion wall alignments. The granular fill pads should consist of OPSS.PROV 1010 Granular A or Granular B Type II and be compacted as per OPSS.PROV 501. The granular fill pads should be founded at or below Elev. 329.4 m, on the firm to stiff native clayey silt. Any topsoil, fill, or other soft or loose soils encountered at the subgrade level should be removed so the granular fill pads can be placed on competent native soil.

The depth of frost penetration at this site is approximately 1.4 m based on OPSD 3090.101. Since the gabion walls are greater than 2.0 m in height, frost protection must follow the MTO RSS Design Guidelines, which state that minimum soil cover of the greater of 800 mm or 40% of the frost depth at the site (560 mm) must be provided above the base of the RSS leveling pad. Therefore, the base of the gabion walls must be provided with a minimum soil cover of 800 mm. The burial depths in front of the walls should also be deep enough to resist the effects of scour and erosion, and to meet lateral stability requirements. This is critical wherever the watercourse is in close proximity to the gabion walls.

The following geotechnical resistances are recommended for the design of gabion walls founded on 300 mm thick granular fill pads at or below Elevation 329.4 m on the firm to stiff native clayey silt:

Geotechnical Resistance	Approx. 2 m Wide Gabion Wall
Factored Geotechnical Resistance at ULS	150 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	100 kPa

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the gabion wall footing size (base width), configuration and applied loads; the geotechnical resistances should therefore be reviewed if the wall width or founding elevation differs significantly from that given above.

It should be noted that the embankment fill to be retained by the gabion walls is sloping with an inclination of approximately 2H:1V. The design of the gabion walls must include the appropriate higher coefficient of earth pressure for the sloping fill being retained by the walls (refer to Section 11).

To satisfy global slope stability of the highway embankment, the minimum width of the base of the gabion walls should be 2 m (refer to Section 13). However, the internal stability of the gabion walls must be checked against various modes of failure including but not limited to sliding and overturning. In addition, the gabion walls should be designed to resist external loadings including lateral earth pressures, hydrostatic pressure, weight of backfill, and surcharge due to construction equipment.

Resistance to lateral forces / sliding should be calculated assuming ultimate coefficients of friction of 0.60 between the gabion basket and the underlying granular pad material and 0.35 between the bedding material and the native clayey silt. A resistance factor of 0.8 should be applied to these ultimate values.

Prior to constructing the engineered fill pads, the subgrade should be inspected, and any surficial or buried topsoil, loose, soft soils, loose or firm existing fill, or otherwise disturbed materials should be sub-excavated and replaced with well compacted granular fill. The exposed clayey silt

subgrade must be properly prepared to avoid prolonged exposure. A geotextile should be placed on the native subgrade soil as a separation layer prior to granular fill placement. Placement and compaction of the granular pads must be carried out in the dry in general accordance with OPSS.PROV 501.

Excavation and backfilling for gabion wall construction should be carried out with reference to the requirements in OPSS.PROV 902. Special attention and care should be given to excavation operations in order not to destabilize the existing slopes.

Material specifications for components used for the construction of the gabion walls (e.g., durable hard aggregates, wire mesh, PVC coating, fasteners, etc.) should meet the requirements of OPSS.PROV 1430 and OPSS.PROV 1004.

9. SETTLEMENT

Foundation settlement in response to the fill placement behind the gabion walls is estimated to be less than 25 mm and will be essentially complete at the end of construction. It is anticipated that post-construction foundation settlement is negligible.

10. EXCAVATION AND GROUNDWATER CONTROL

Temporary excavations of approximately 2 to 3 m deep will be required for gabion wall construction at this site. All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the sand and gravel fill and other fills at this site are classified as Type 3 soils above the water table. Below the water table (i.e., if the groundwater flow is not controlled), the fill soils would be classified as Type 4 soils. The native soils within the excavation depth consist of firm to stiff clayey silt, which is below the water table and should be classified as Type 3 soil. Topsoil or other surficial alluvial deposits that are anticipated in the inlet and outlet areas are also classified as Type 4 soils.

Excavation and backfilling for gabion wall construction should be carried out in accordance with OPSS.PROV 902. Excavations are anticipated to be carried out through the existing fill and into the native clayey silt and up to approximately 1 m below the water table.

Selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment, and interpretation of the site conditions.

Installation of the gabion walls must be carried out in the dry. As the excavations will be carried out below the creek water level and the groundwater level, surface water runoff and groundwater seepage from the embankment fill and native soils should be anticipated and will accumulate into the excavations if not controlled. The Contractor must make provisions to control the water seepage and accumulation to maintain dry excavations. Depending on the time of construction, pumping from a sufficient number of properly filtered sumps within cofferdam enclosures may be required to maintain dry excavations and remove any accumulated water from the foundation base prior to compacting granular fill for gabion wall construction.

Artesian groundwater pressure was observed in Boreholes CULV3-01 and CULV3-05 in the native silty clay near the underlying sand and gravel; below approximate Elev. 325 m or deeper. As the shallow excavations for gabion wall construction are expected to remain above approximate Elev. 329 m or higher, it is not anticipated that artesian groundwater conditions will be encountered or have an impact on foundation construction.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 and OPSS.PROV 517. A preconstruction survey is not required at this site. Thus, Designer Fill-In ** in SP FOUN0003 should be "N/A".

The groundwater level will fluctuate and the minimum groundwater elevation at the time of the proposed work should be taken as the creek water level or the design storm return period defined by the contract documents for the temporary dewatering system.

Dewatering must remain operational and effective to lower the groundwater level to a minimum of 0.5 m below the base of the excavation until the gabion wall foundations are constructed.

11. BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the gabion retaining walls should be done in accordance with OPSS.PROV 902. Any backfill to the walls should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS.PROV 1010. A geotextile should be placed on the back face of the gabion walls as a separation layer prior to backfilling.

Lateral earth pressures acting on the gabion walls may be assumed to be a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2019, but are generally given by the expression:

$$p_h = K (\gamma h + q)$$

where,

p_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see table below)
γ	=	bulk unit weight of retained soil (see table below)
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill behind the gabion walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 11.1 below.

Table 11.1 Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I (modified) or Type III $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active, K_A (Unrestrained Wall)	0.27	0.40*	0.31	0.48*
At-rest, K_0 (Restrained Wall)	0.43	-	0.47	-
Passive, K_P (Movement towards soil mass)	3.7	-	3.2	-

* For 2H:1V backfill slope behind gabion walls

Note: Submerged unit weight should be used below the groundwater level/high creek level.

If the gabion walls are permitted to yield (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the wall. If the walls are not allowed to yield (restrained system), at-rest horizontal earth pressures should be used.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the walls.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill and decrease to 0 kPa at a depth of 1.7 m for Granular B Type I, or at a depth of 2.0 m for Granular A or B Type II.

12. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy. Based on the presence of typically stiff to very stiff native clayey silt and silty clay, underlain by compact to dense sand and gravel, the site is classified as Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2,475-year return period seismic event (2% probability of being exceeded in 50 years) at this site is 0.113 g as per the National Building Code of Canada (NBCC 2020).

The coefficients of horizontal earth pressures for seismic loading on walls assuming a level backfill, a Site Class D, and a reference PGA of 0.113 are presented in Table 12.1 below. The vertical acceleration coefficient k_v has been ignored ($k_v = 0$).

Table 12.1 Seismic Earth Pressure Parameters

Loading Condition	Horizontal Acceleration Coefficient, k_h	Seismic Earth Pressure Coefficients (K_{AE})	
		OPSS Granular A or Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I (modified) or Type III $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$
Active (Unrestrained Wall)	0.057	0.30	0.34
Active (Restrained Wall)	0.113	0.34	0.38

In view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

13. GLOBAL SLOPE STABILITY OF GABION WALLS

Based on slope configurations on cross-sections provided by RVA, slope stability analysis was conducted to assess the global stability of the gabion retaining walls. A critical section at approximate Station 24+520 through the northeast gabion wall was selected for analysis due to its proximity to the creek channel. The stability assessment assumes the wall backfill will consist of Granular A or Granular B Type II, and a minimum gabion wall base of 2 m wide will be used.

A minimum Factor of Safety (F.S.) of 1.5 is considered to be acceptable for permanent conditions for the embankment slopes with gabion walls at this site.

The results of the slope stability analysis are presented in Figure E1 in Appendix E. Figure E1 shows an F.S. of 1.8 for drained conditions (permanent) for the critical section analyzed. Based on the results of the analysis, minimum 2 m wide gabion walls with the base founded at Elev. 329.4 m on minimum 300 mm thick granular fill pads are expected to be stable at this site.

Minimum 2 m wide gabion walls are recommended from a global stability perspective; however the dimensions of the gabion walls, including the width, will be governed by the lateral earth pressures imposed on the walls. As noted in Section 8, the internal stability of the gabion walls must be checked by the designer. The design should also include appropriate erosion protection measures where the gabion walls are in close proximity to the creek.

14. CONSTRUCTION CONCERNS

During construction, the Contract Administrator should employ experienced foundation / geotechnical staff to observe construction activities.

Potential construction concerns include, but are not necessarily limited to:

- The water level in the watercourse may fluctuate and be at a higher elevation at the time of construction than indicated in the report.
- Care must be exercised during excavation to avoid disturbing the founding subgrade for the gabion walls. When the excavation reaches the required elevation, the subgrade should be inspected and approved by qualified geotechnical personnel.



THURBER ENGINEERING LTD.

15. CLOSURE

Engineering analyses were carried out by Mr. Mark Farrant, P.Eng. and Ms. Alysha Kobylinski, P.Eng. Preparation of the foundation design report was carried out by Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



Mark Farrant, P.Eng.
Associate, Senior Geotechnical Engineer



P.K. Chatterji, P.Eng.
Principal, Designated MTO Contact

Date: April 19, 2024
File: 34935

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. 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. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any 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

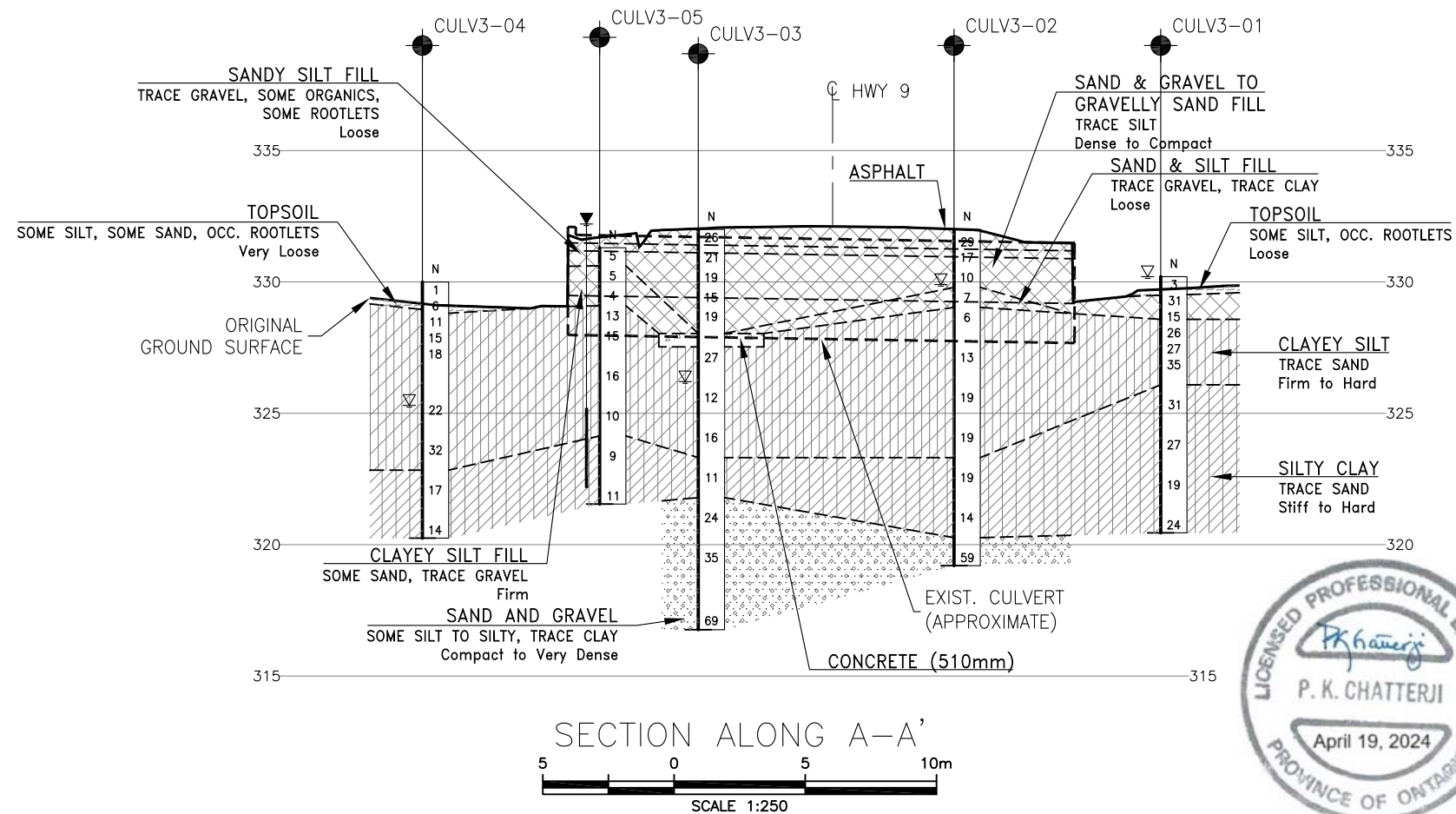
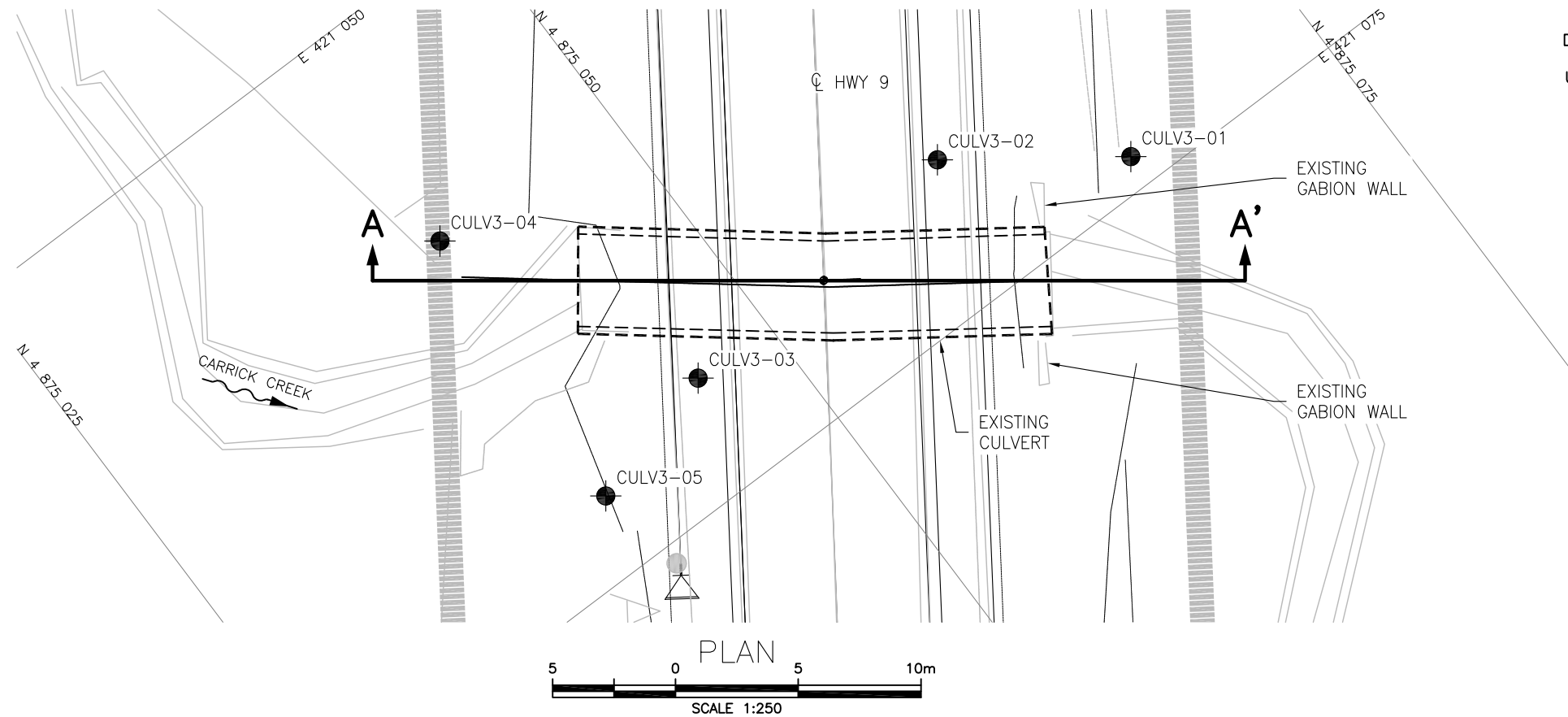
The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or 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.



THURBER ENGINEERING LTD.

APPENDIX A

Borehole Locations and Soil Strata Drawings



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No	(
GWP No 3076-14-00	

CARRICK CREEK CULVERT
(SITE 02X-0469/C0)
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA








SHEET



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 11.

GEOCRES No. 41A03-002

[illegible]

APPENDIX B

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No CULV3-01

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 065.9 E 421 073.7 ORIGINATED BY SG
DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC
DATUM Geodetic DATE 2023.10.27 - 2023.10.27 LATITUDE 44.006379 LONGITUDE -81.050021 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
330.2	GROUND SURFACE							20	40	60	80	100	PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	
0.0	TOPSOIL, some silt, some sand, trace gravel, occasional rootlets Loose Dark Brown Wet		1	SS	3		330									
329.5																
0.6	Sandy GRAVEL, some silt Dense to Compact Grey Wet (FILL)		2	SS	31		329									
328.5			3	SS	15											
1.6	Clayey SILT, trace sand Very Stiff to Hard Brown Moist to Wet (CL)		4	SS	26		328									
			5	SS	27											0 2 80 18
			6	SS	35		327									
326.0																
4.1	Silty CLAY, trace sand Very Stiff to Hard Brown Wet (CL)		7	SS	31		326									0 3 73 24
							325									
			8	SS	27		324									
							323									
			9	SS	19		322									0 5 71 24
							321									
320.4	Gravelly sand lenses encountered at 9.8m		10	SS	24											
9.8	END OF BOREHOLE AT 9.8m.															

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CULV3-01

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 065.9 E 421 073.7 ORIGINATED BY SG
DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC
DATUM Geodetic DATE 2023.10.27 - 2023.10.27 LATITUDE 44.006379 LONGITUDE -81.050021 CHECKED BY MEF





SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P					
	Continued From Previous Page													
	* ARTESIAN CONDITIONS ENCOUNTERED AT 9.8m. WATER LEVEL APPROX. 1.5m ABOVE EXISTING GRADE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

RECORD OF BOREHOLE No CULV3-02

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 059.5 E 421 069.1 ORIGINATED BY SG
DIST West HWY 9 BOREHOLE TYPE Hollow Stem Augers / Wash Boring / HQ Core Barrel COMPILED BY RdC
DATUM Geodetic DATE 2023.10.13 - 2023.10.16 LATITUDE 44.006322 LONGITUDE -81.050080 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
332.0	GROUND SURFACE												
0.0	ASPHALT: (190mm)												
0.2	SAND and GRAVEL to Gravelly SAND, trace silt Compact Brown Moist (FILL)		1	SS	29		331						
			2	SS	17								
			3	SS	10								
329.7													
2.2	SAND and SILT, trace gravel, trace clay Loose Brown Moist (FILL)		4	SS	7		329						
329.0													
3.0	Clayey SILT, trace sand Firm to Very Stiff Grey Wet (CL)		5	SS	6		328						
			6	SS	13		327						
			7	SS	19		326						
			8	SS	19		324						
323.3													
8.7	Silty CLAY, trace sand Very Stiff Grey Wet (CL)		9	SS	19		323						
							322						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity



20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CULV3-02

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 059.5 E 421 069.1 ORIGINATED BY SG
DIST West HWY 9 BOREHOLE TYPE Hollow Stem Augers / Wash Boring / HQ Core Barrel COMPILED BY RdC
DATUM Geodetic DATE 2023.10.13 - 2023.10.16 LATITUDE 44.006322 LONGITUDE -81.050080 CHECKED BY MEF





SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100						
	Silty CLAY , trace sand Stiff Grey Wet (CL)		10	SS	14		321							
320.2														
11.7	SAND and GRAVEL , some silt Very Dense Grey Wet		11	SS	59		320							
319.2														
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL AT 2.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO 0.6m, BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.													

RECORD OF BOREHOLE No CULV3-03

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 046.4 E 421 070.3 ORIGINATED BY SG
DIST West HWY 9 BOREHOLE TYPE Hollow Stem Augers / Wash Boring / HQ Core Barrel COMPILED BY RdC
DATUM Geodetic DATE 2023.10.10 - 2023.10.12 LATITUDE 44.006204 LONGITUDE -81.050067 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
332.0	GROUND SURFACE							20 40 60 80 100							
0.0	SAND and GRAVEL to Gravelly SAND , some silt, trace clay Compact Brown Moist (FILL)		1	SS	26		331								
			2	SS	21										
			3	SS	19										
			4	SS	15		329								
			5	SS	19										
328.0							328								
4.0	CONCRETE: (510mm) With rebar														
327.5															
4.5	Clayey SILT , trace sand Very Stiff to Stiff Grey Wet		6	SS	27		327								
			7	SS	12		326								
							325								
			8	SS	16		324								
323.3															
8.7	Silty CLAY , trace sand Stiff Grey Wet (CL)						323								
			9	SS	11										
							322								

Continued Next Page


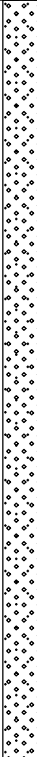




+³, ×³: Numbers refer to Sensitivity
20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CULV3-03

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 046.4 E 421 070.3 ORIGINATED BY SG
 DIST West HWY 9 BOREHOLE TYPE Hollow Stem Augers / Wash Boring / HQ Core Barrel COMPILED BY RdC
 DATUM Geodetic DATE 2023.10.10 - 2023.10.12 LATITUDE 44.006204 LONGITUDE -81.050067 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100				W P W W L				
Continued From Previous Page																
321.8																
10.2	SAND and GRAVEL , some silt Compact to Very Dense Brown Wet		10	SS	24		321									
							320									
			11	SS	35											
							319									
	Cored through gravel and cobbles from 13.1m to 14.0m															
							318									
	Becoming silty, trace clay (CL-ML)		12	SS	69		317						 			30 31 34 5
316.7																
15.2	END OF BOREHOLE AT 15.2m. WATER LEVEL AT 5.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO 0.9m, BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.															

ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-34935.GPJ 2/16/24

RECORD OF BOREHOLE No CULV3-04

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 041.4 E 421 059.5 ORIGINATED BY SG
DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC
DATUM Geodetic DATE 2023.10.26 - 2023.10.26 LATITUDE 44.006160 LONGITUDE -81.050203 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
330.0	GROUND SURFACE							20 40 60 80 100		PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	
0.0	TOPSOIL, some silt, some sand, occasional rootlets Very Loose Dark Brown Wet		1	SS	1			20 40 60 80 100					
329.4													
0.6	Clayey SILT, trace sand Firm to Hard Brown Moist to Wet (CL-ML)		2	SS	6		329						0 9 74 17
			3	SS	11								
			4	SS	15		328						
			5	SS	18								
							327						
							326						
			6	SS	22		325						0 5 79 16
							324						
			7	SS	32								
							323						
322.8													
7.2	Silty CLAY, trace sand Very Stiff to Stiff Brown Wet (CL)		8	SS	17		322						
							321						
			9	SS	14								0 4 76 20
320.2													
9.8	END OF BOREHOLE AT 9.8m.												

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No CULV3-05

1 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 040.5 E 421 071.8 ORIGINATED BY SG
DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC
DATUM Geodetic DATE 2023.10.12 - 2023.10.12 LATITUDE 44.006151 LONGITUDE -81.050049 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
331.3	GROUND SURFACE							20 40 60 80 100		W P W W L				
0.0	TOPSOIL: (50mm)							20 40 60 80 100						
330.6	Sandy SILT , trace gravel, some organics, some rootlets Loose Dark Brown Moist (FILL)		1	SS	5		331							
0.7	Clayey SILT , some sand, trace gravel Firm Brown Moist (FILL)(CL)		2	SS	5		330							
329.1			3	SS	4		329					1 17 68 14		
2.2	Clayey SILT , trace sand Stiff to Very Stiff Brown Wet (CL-ML)		4	SS	13		328					0 0 85 15		
			5	SS	15		327							
			6	SS	16		326							
			7	SS	10		325							
324.1							324							
7.2	Silty CLAY , trace sand Stiff Brown Wet (CL)		8	SS	9		323					0 1 83 16		
			9	SS	11		322							
321.5														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CULV3-05

2 OF 2

METRIC

GWP# 3076-14-00 LOCATION Highway 9; MTM 83-11: N 4 875 040.5 E 421 071.8 ORIGINATED BY SG
DIST West HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Rig COMPILED BY RdC
DATUM Geodetic DATE 2023.10.12 - 2023.10.12 LATITUDE 44.006151 LONGITUDE -81.050049 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.																
	WATER LEVEL READINGS																
	DATE DEPTH(m) ELEV.(m)																
	2023.10.12 5.2 326.1																
	2023.12.01 -0.5 331.8																
	2024.01.31 -0.9 332.2																
	"-" Above ground surface																
	* Artesian groundwater pressure recorded in piezometer at 0.9m above existing grade.																



THURBER ENGINEERING LTD.

APPENDIX C

Geotechnical Laboratory Test Results

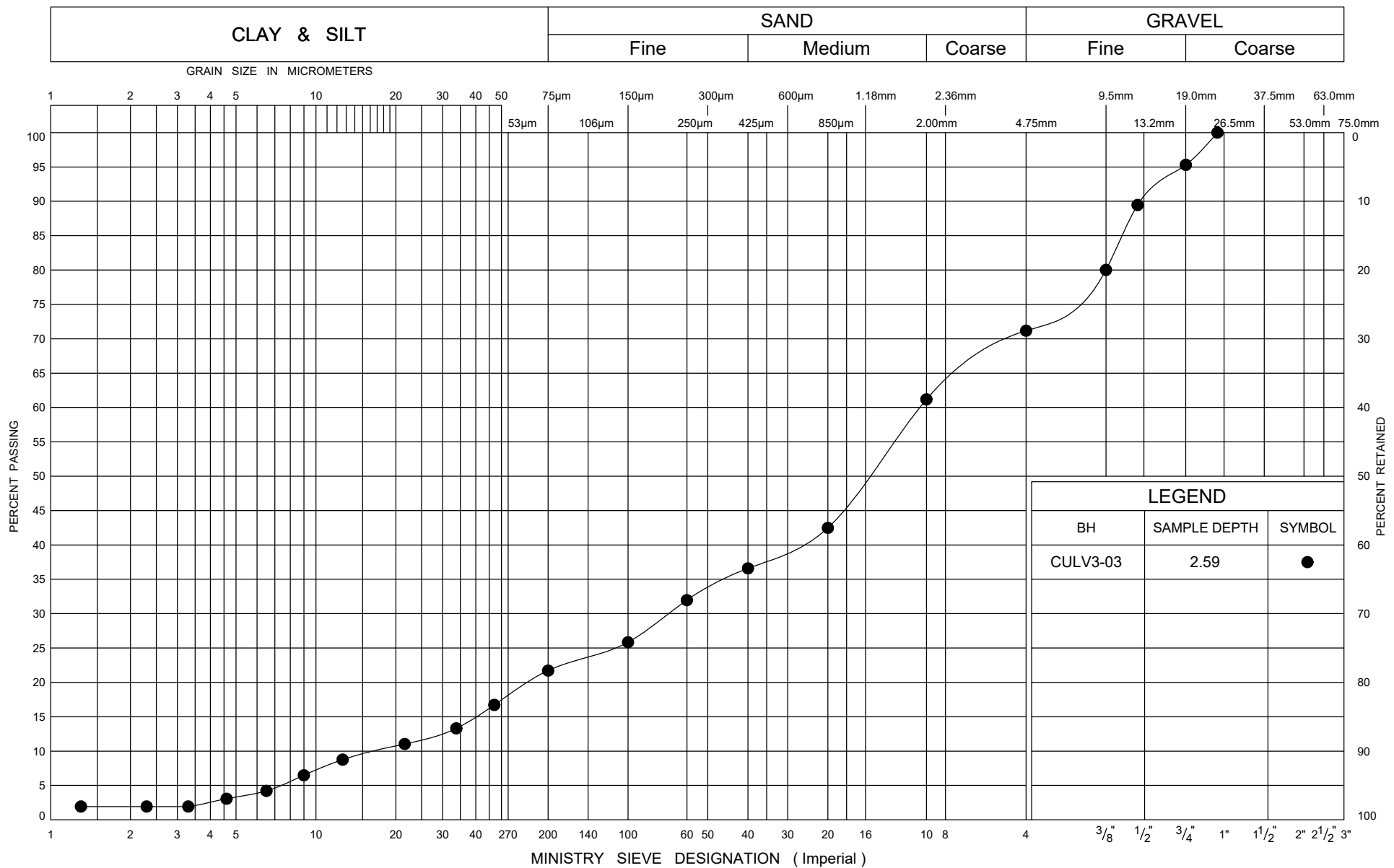
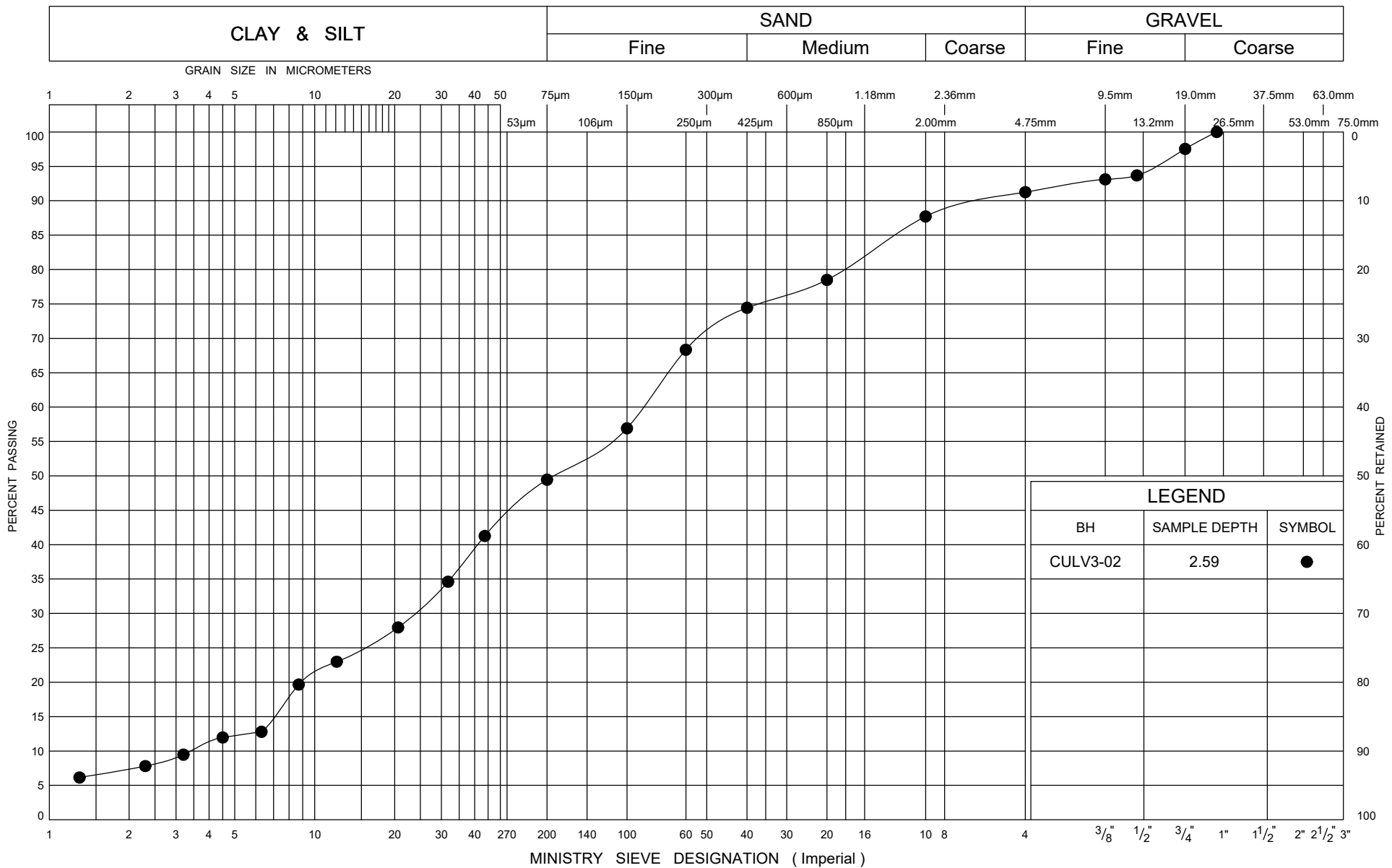


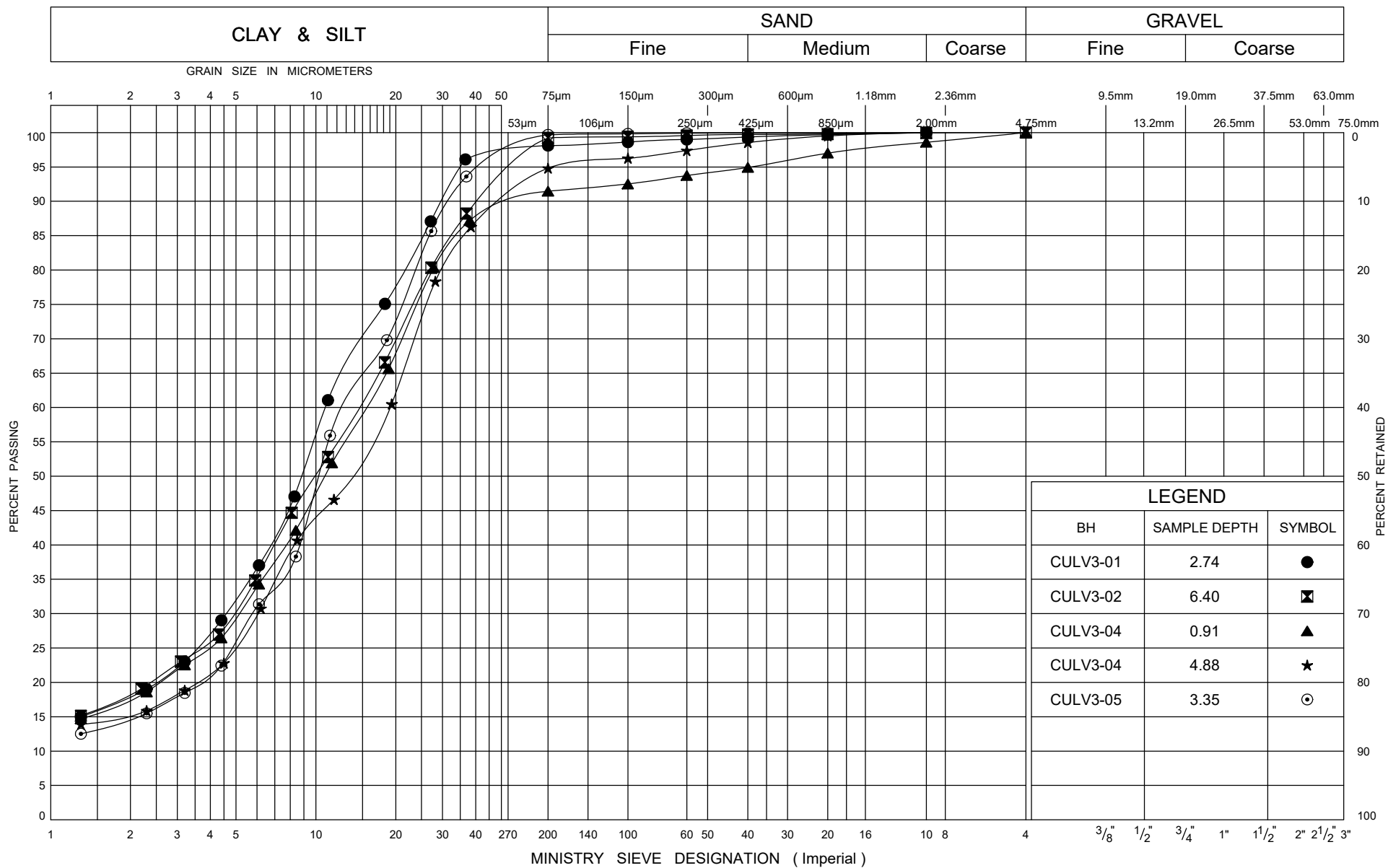


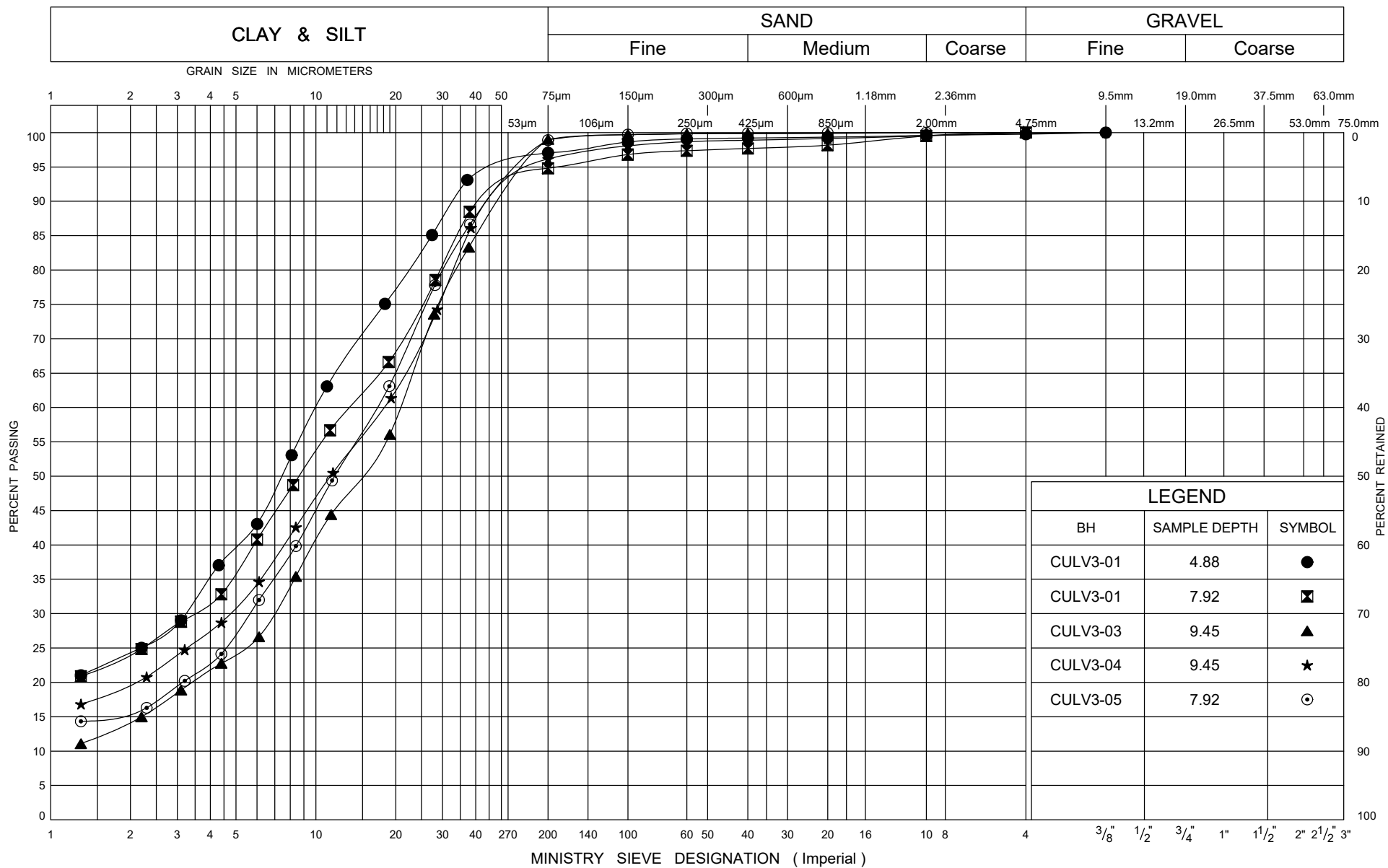
FIG No C2

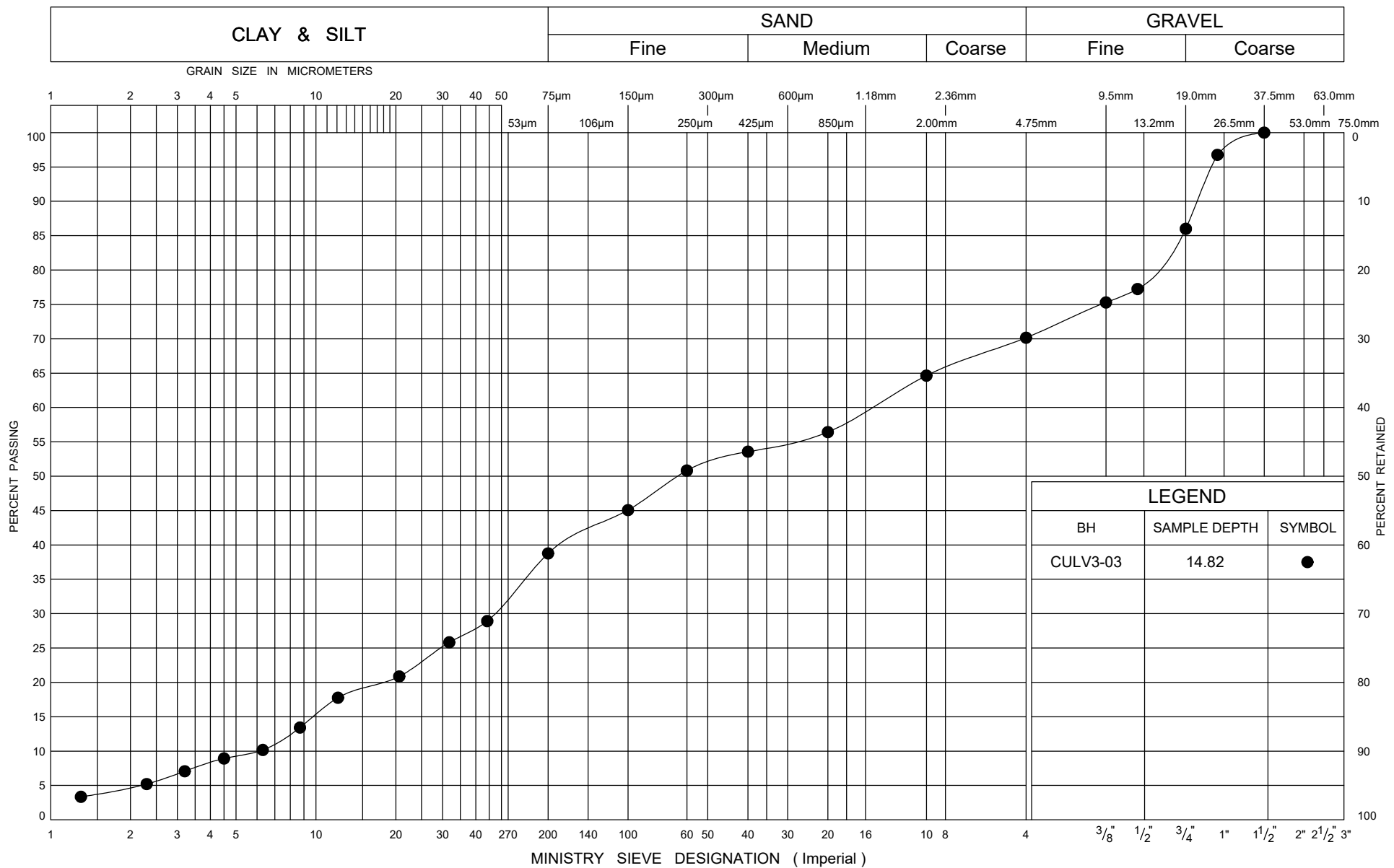
GWP# 3076-14-00

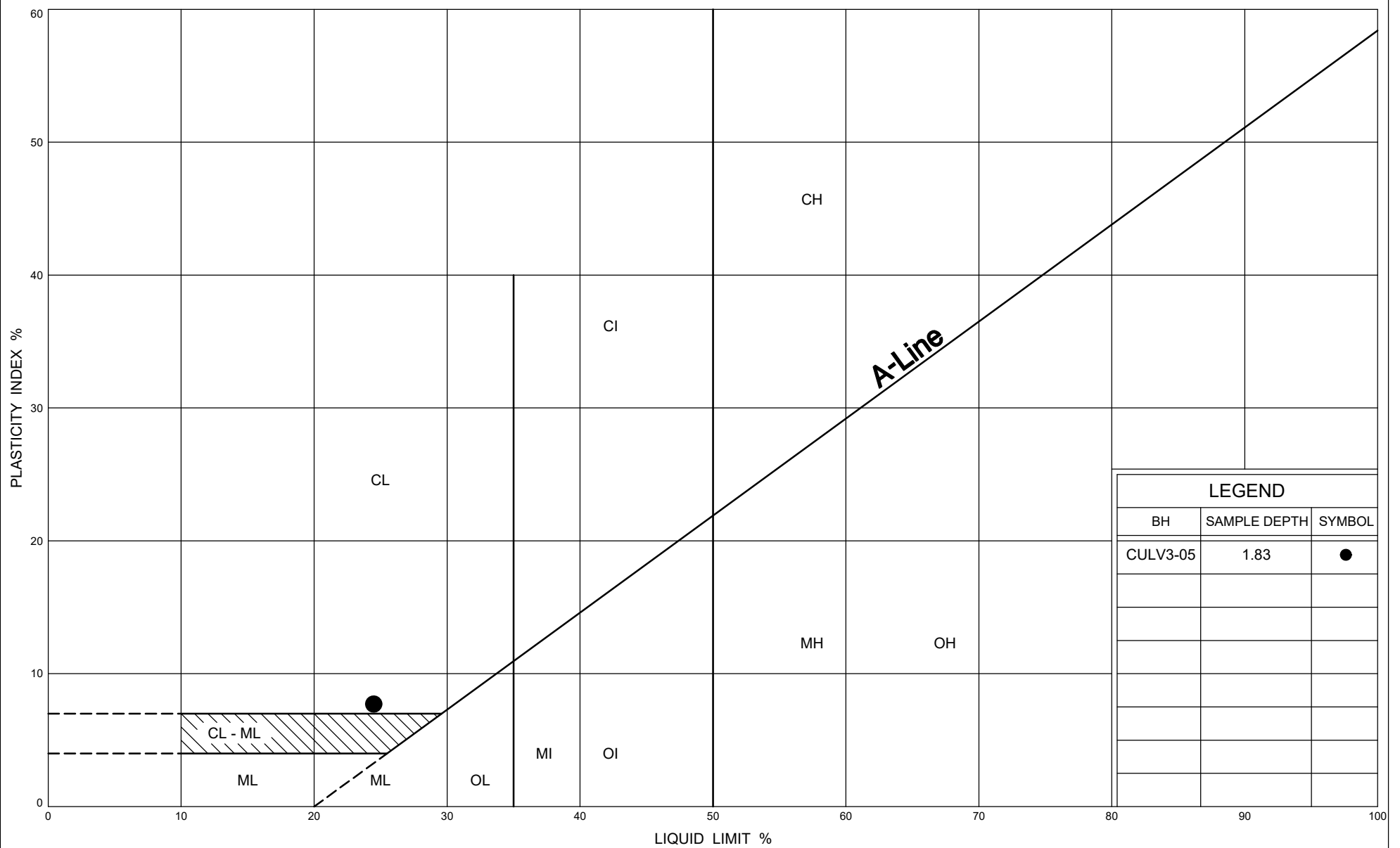
Highway 9











Ministry of
Transportation

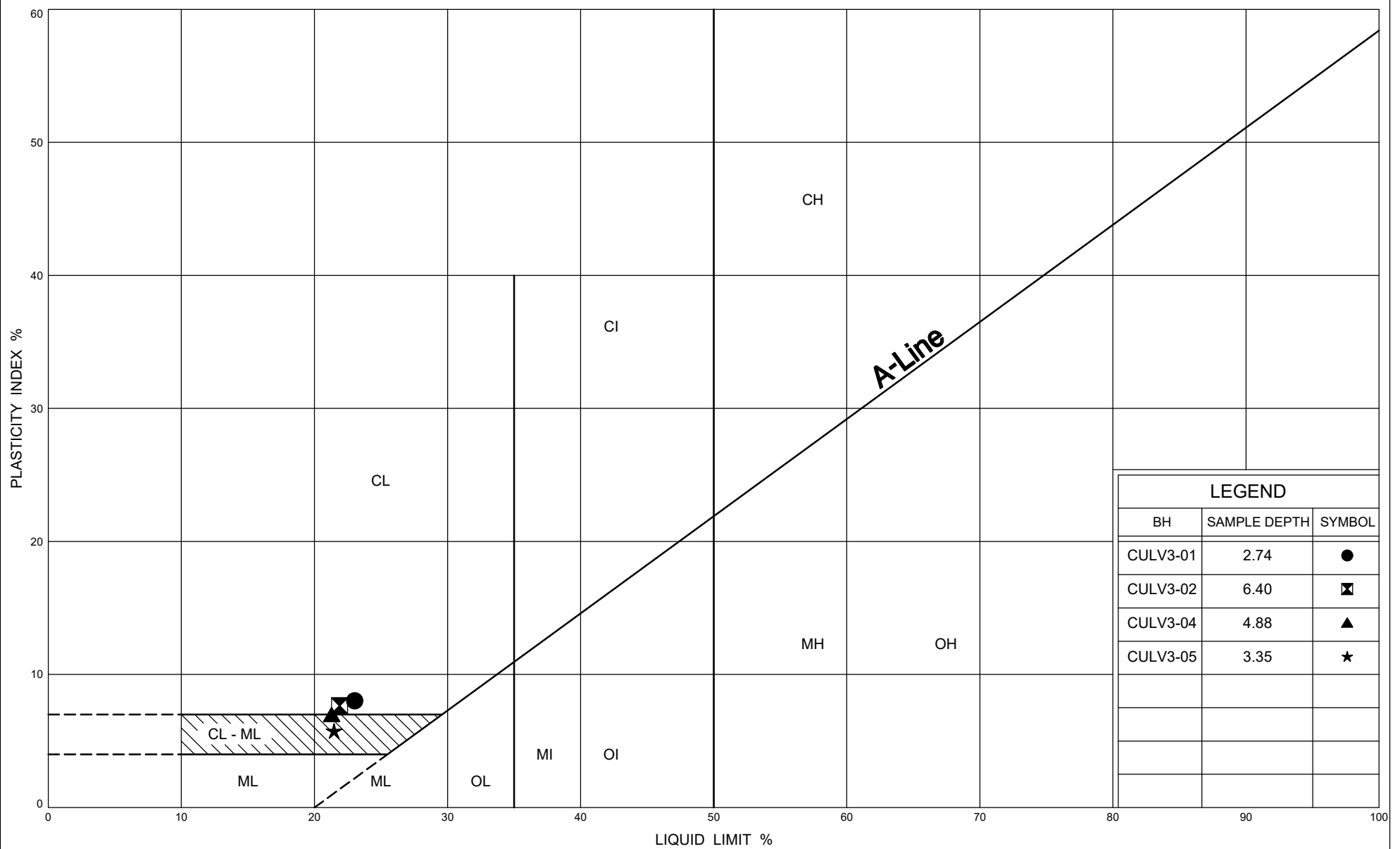
PLASTICITY CHART

Clayey SILT FILL

FIG No C7

GWP# 3076-14-00

Highway 9



Ministry of
Transportation

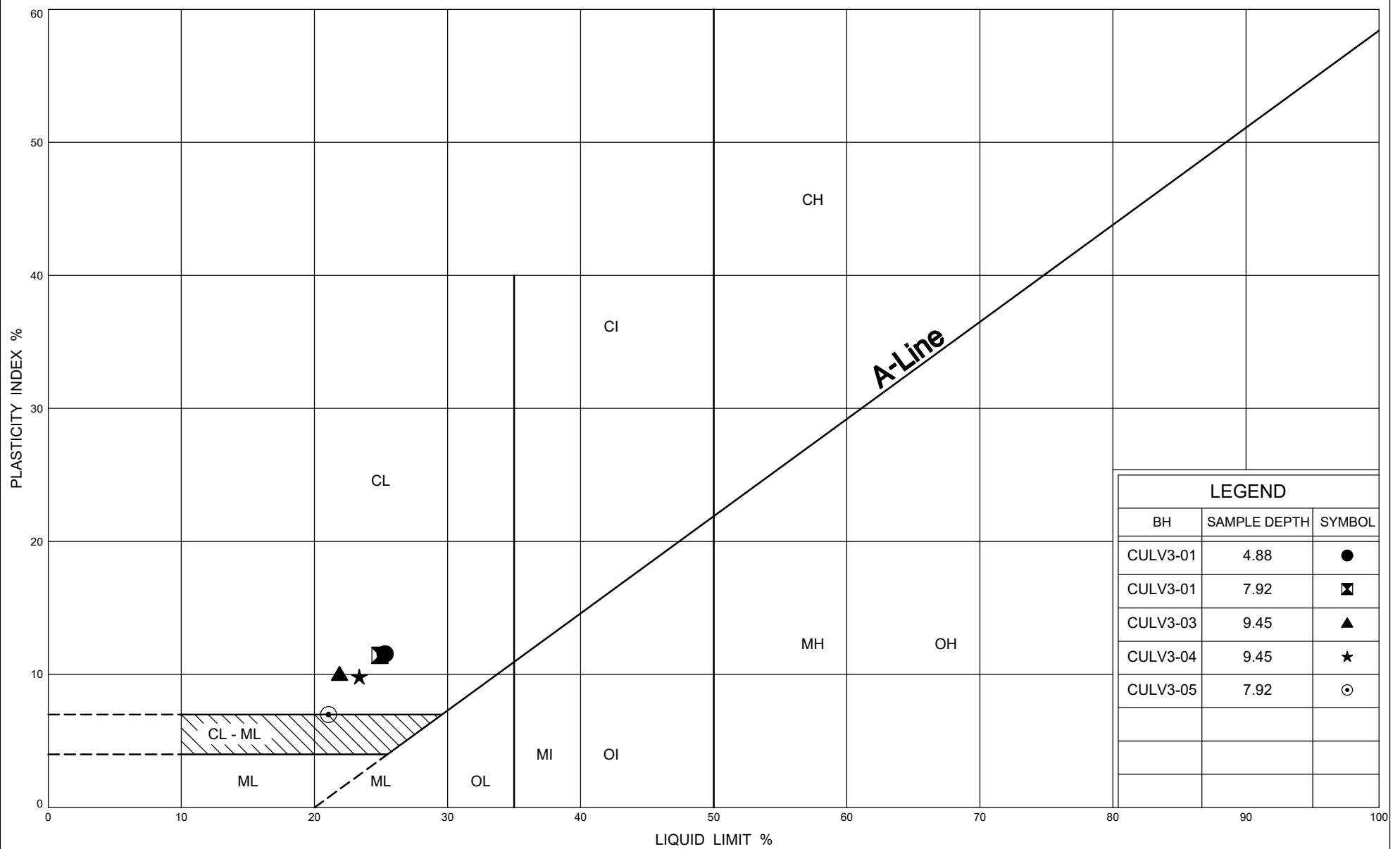
PLASTICITY CHART

Clayey SILT

FIG No C8

GWP# 3076-14-00

Highway 9



Ministry of
Transportation

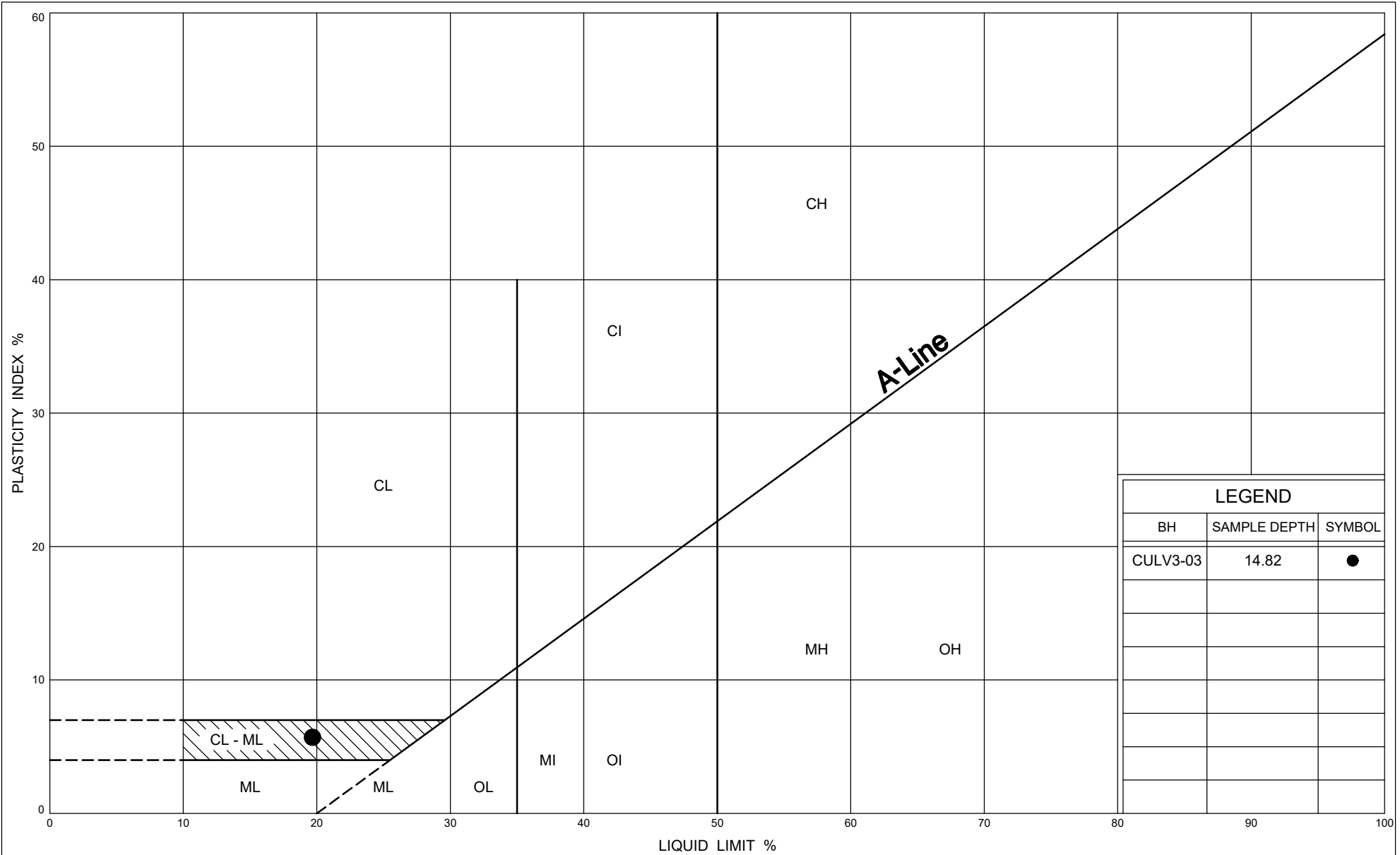
PLASTICITY CHART

Silty CLAY

FIG No C9

GWP# 3076-14-00

Highway 9



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
CULV3-03	14.82	●

APPENDIX D

Site Photographs



Photo 1: Looking east at culvert outlet and creek channel.
Photo taken September 13, 2023



Photo 2: Looking west towards culvert inlet and creek channel.
Photo taken June 23, 2023



Photo 3: Looking northwest from culvert outlet along northeast slope of Highway 9 embankment. Photo taken June 23, 2023



Photo 4: Looking northwest along Highway 9 shoulder near culvert outlet. Photo taken September 13, 2023



Photo 5: Looking northwest from culvert inlet along southwest slope of Highway 9 embankment. Photo taken June 23, 2023



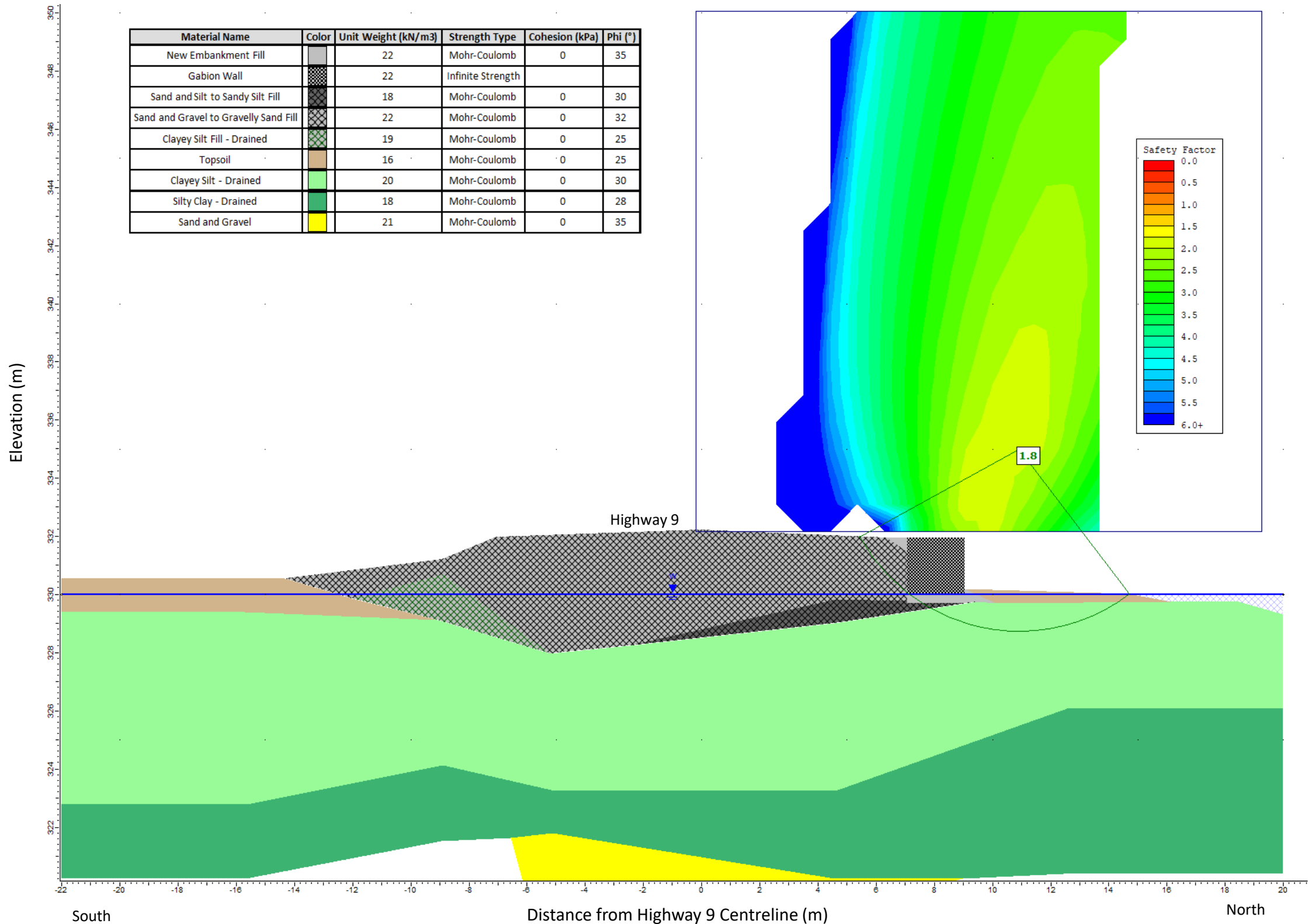
Photo 6: Looking northwest towards culvert inlet along southwest slope of Highway 9 embankment. Photo taken June 23, 2023

APPENDIX E

Slope Stability Analysis Figures

Culvert 3 – Global Stability (approximate STA 24+520) North Slope with Gabion Wall (Permanent / Drained Condition)

Figure E1



APPENDIX F

List of OPSS Documents



THURBER ENGINEERING LTD.

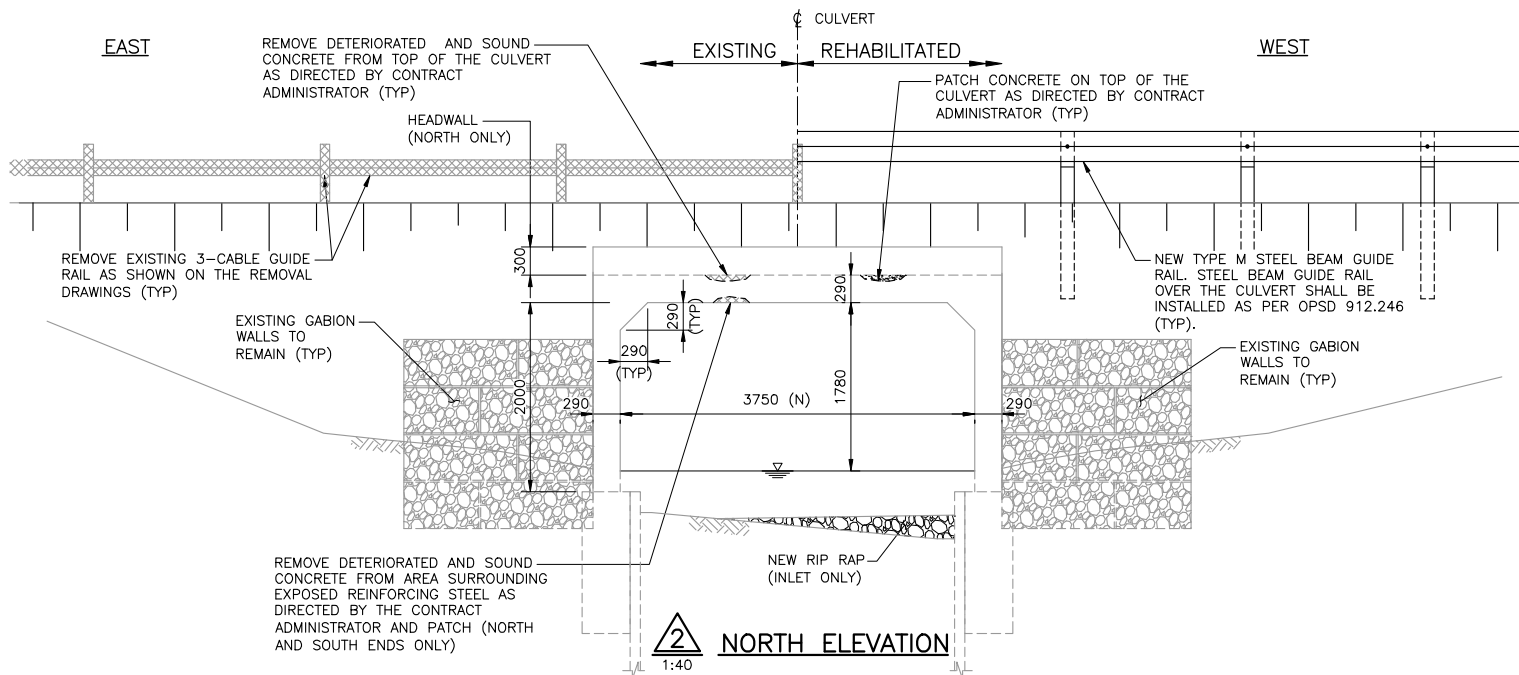
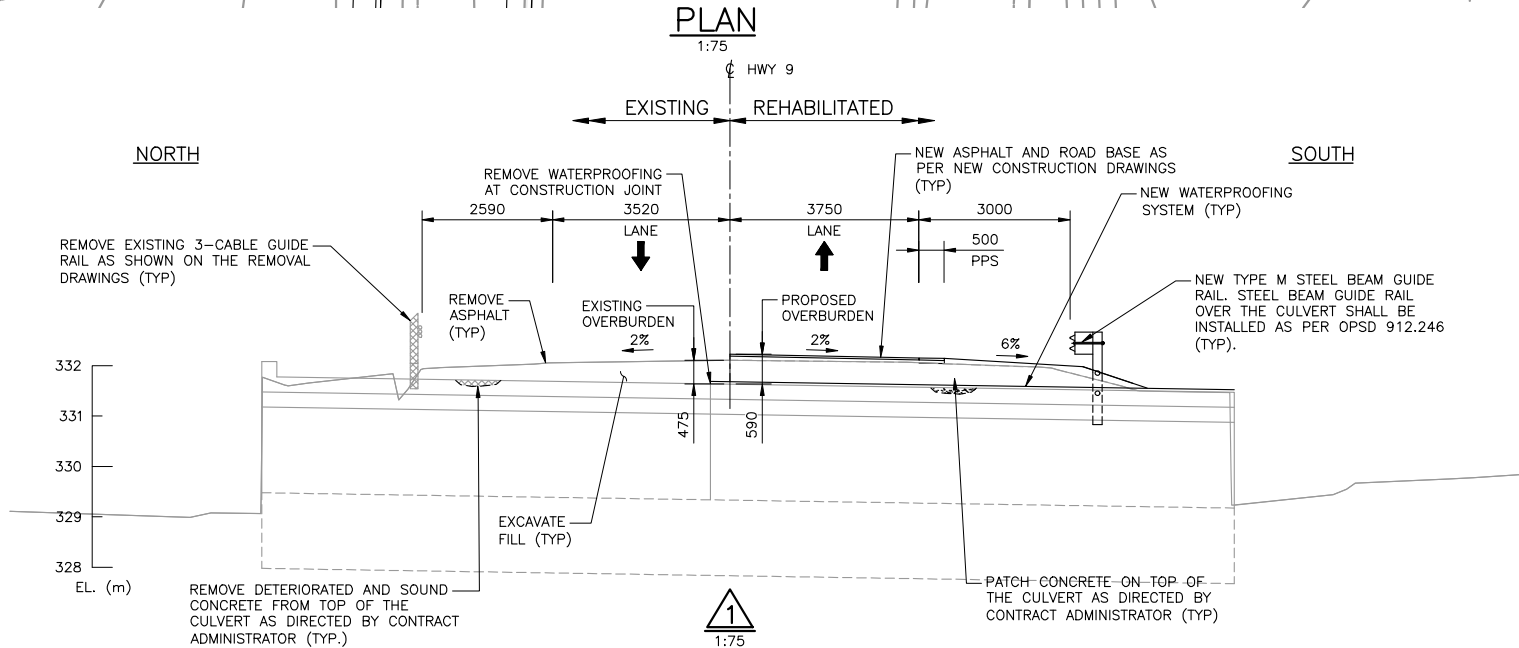
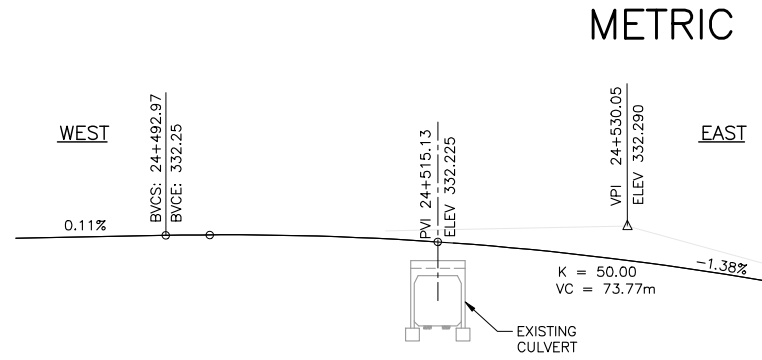
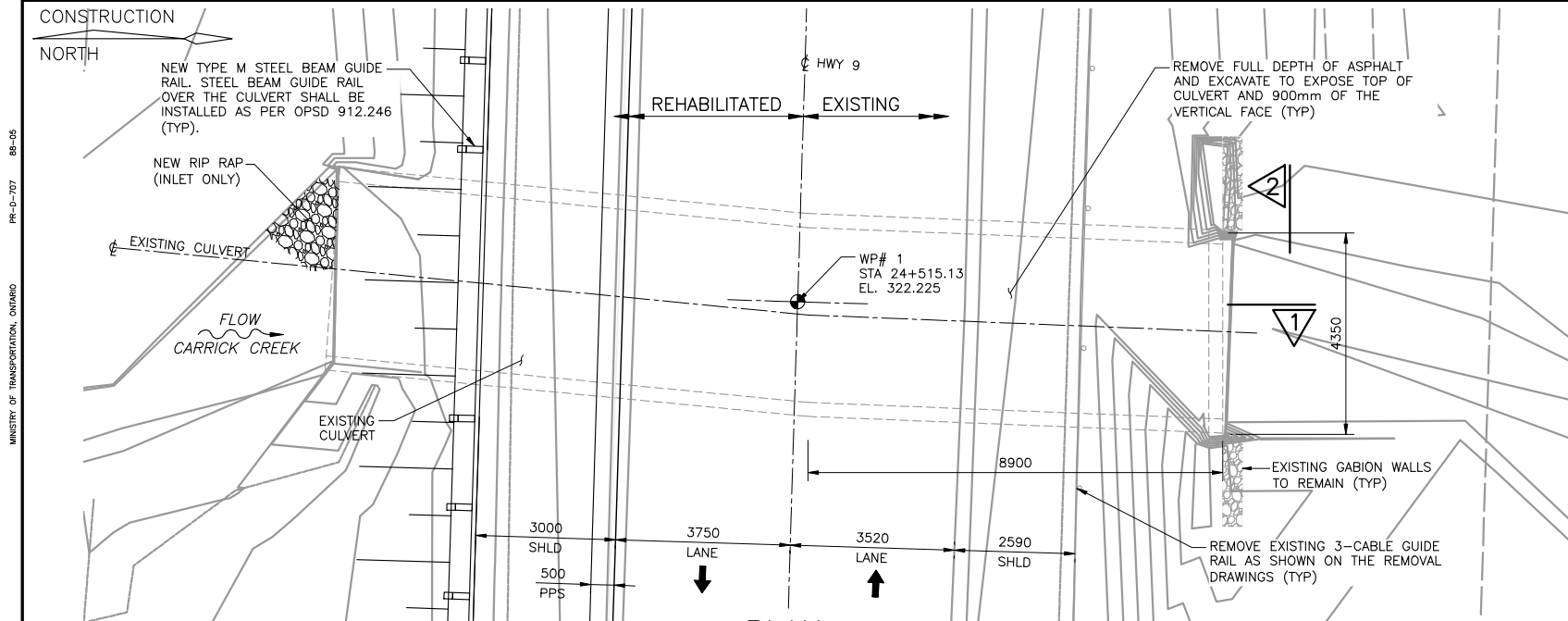
1. The following OPSS Documents are referenced in this report:

OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
SP FOUN0003	Dewatering Structure Excavations
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1430	Material Specification for Gabion Baskets and Mats
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario

APPENDIX G

Preliminary Draft General Arrangement and Gabion Structure Drawings

CAD FILE: P:\Projects\21-113 Highway 9 Greenock Creek Bridge DB Reedy GHD\113E Hwy 9 Culverts\DDA CAD files\2-469\21-113E-469-001GA.dwg
MODIFIED: 2023-06-21 10:51:08 AM Zhenlin Pan
PLOTTED: 2023-06-21 11:21:37 AM Zhenlin Pan



CONT. No.
WP No. 3104-21-01

CONCRETE CULVERT
02X-0469/C0

PRELIMINARY GENERAL ARRANGEMENT

DOUG DIXON & ASSOCIATES INC

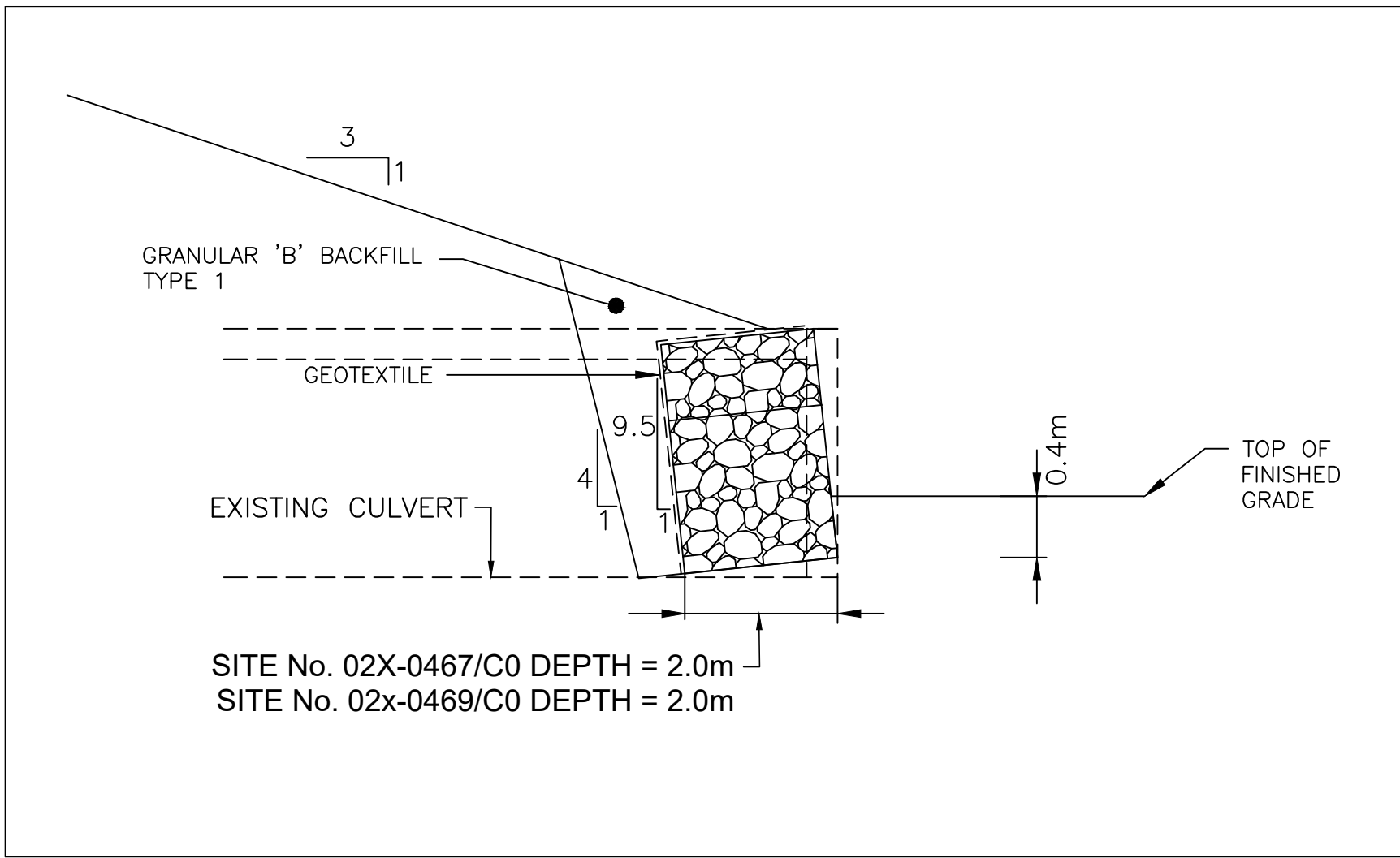
GHD

SHEET
54

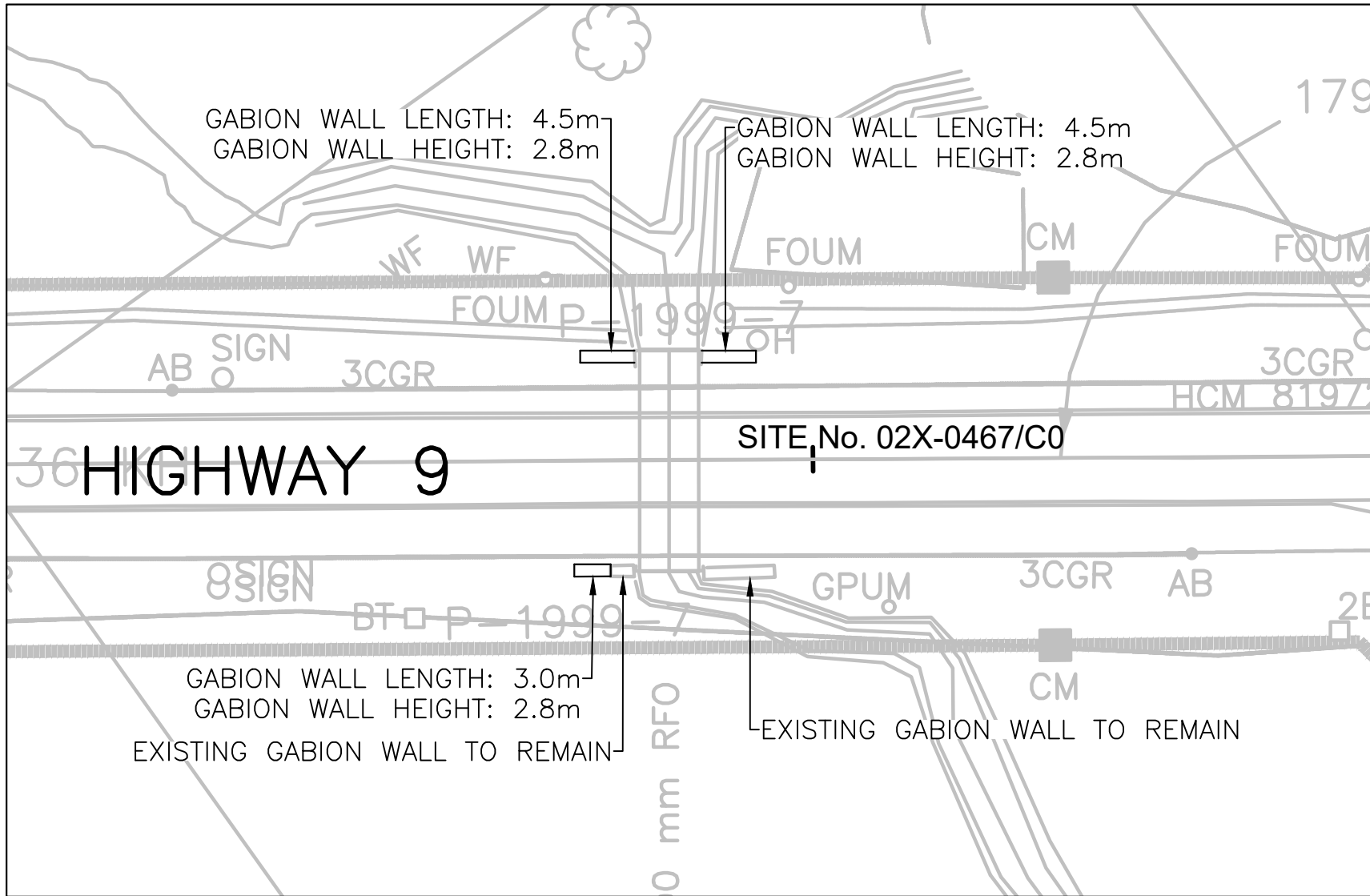
- GENERAL NOTES:**
- SPECIFIED 28-DAY COMPRESSIVE STRENGTH**
- ALL CONCRETE 30MPa
- CONSTRUCTION NOTES:**
- THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, DETAILS AND ELEVATIONS OF THE EXISTING STRUCTURE THAT ARE RELEVANT TO THE WORK SHOWN ON THE DRAWINGS PRIOR TO THE COMMENCEMENT OF THE WORK. ANY DISCREPANCIES SHALL BE REPORTED TO THE CONTRACT ADMINISTRATOR AND THE PROPOSED ADJUSTMENT OF THE WORK TO MATCH THE EXISTING STRUCTURE SHALL BE SUBMITTED FOR APPROVAL.
 - ABRASIVE BLAST CLEAN ALL EXISTING REINFORCING STEEL TO REMAIN.
 - ALL CONCRETE SURFACES AGAINST WHICH NEW CONCRETE IS TO BE PLACED SHALL BE ABRASIVE BLAST CLEANED AND ROUGHENED.
- ABBREVIATIONS:**
- TYP - DENOTES TYPICAL
SHLD - DENOTES SHOULDER
EL. - DENOTES ELEVATION
PPS - PARTIALLY PAVED SHOULDER

REVISIONS		DESCRIPTION			
DESIGN	DD	CHK	DD	CODE	CHBDC 2019
DRAWN	ZP	CHK		SITE	2-469/C0
				STRUCT	
				SCHEME	
				DWG	PGA
				DATE	JUN/23

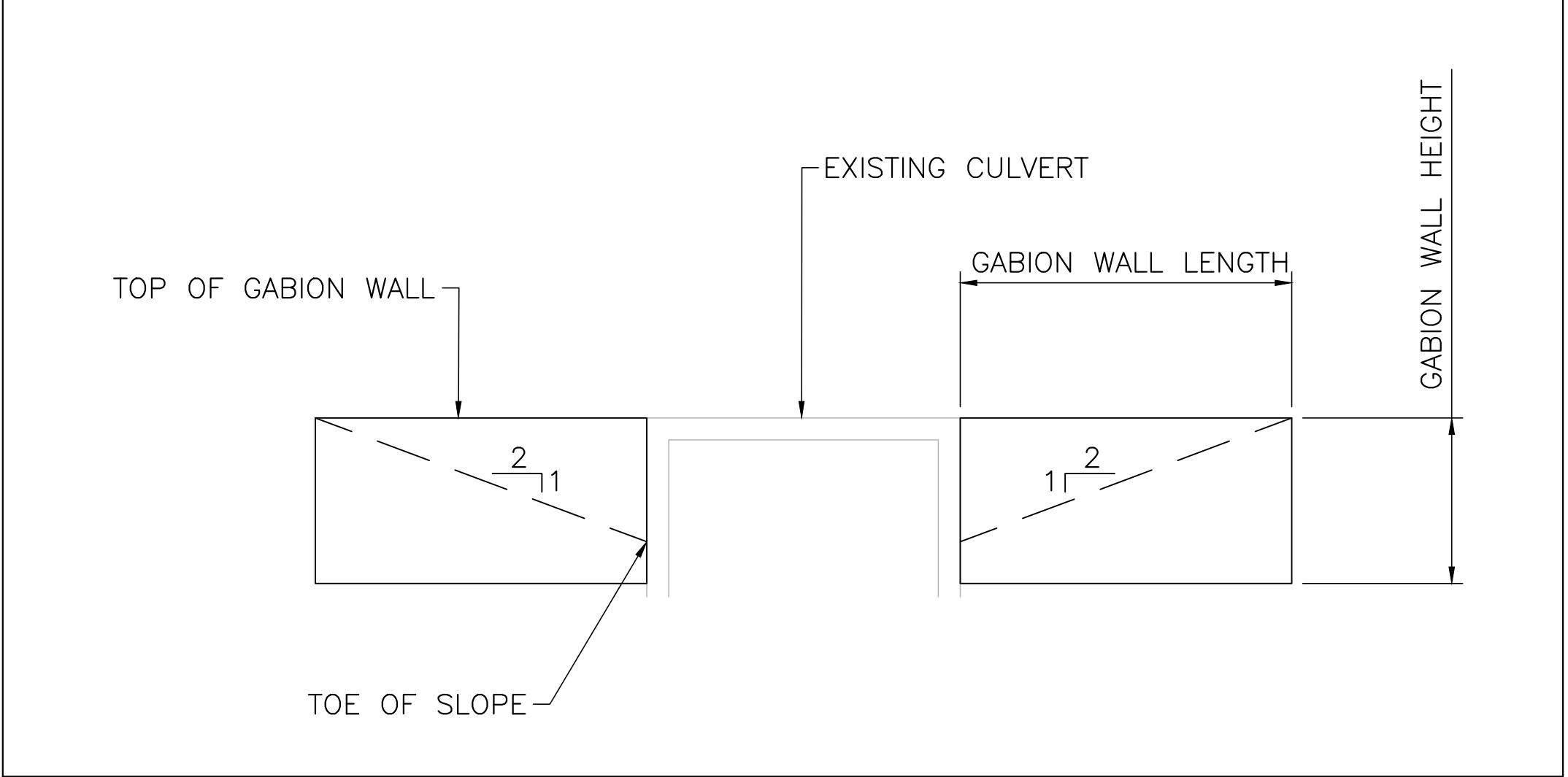
FILE NAME: R:\2022\226515 - MTD GHD-Retainer-Hwy 9 Clifford-Mildmay\10 CAD\dwg\01 Linear\04 Sheets\226515 Gabion Structures.dwg
CREATED: 2023-09-27
MODIFIED: 2023-09-27 13:31



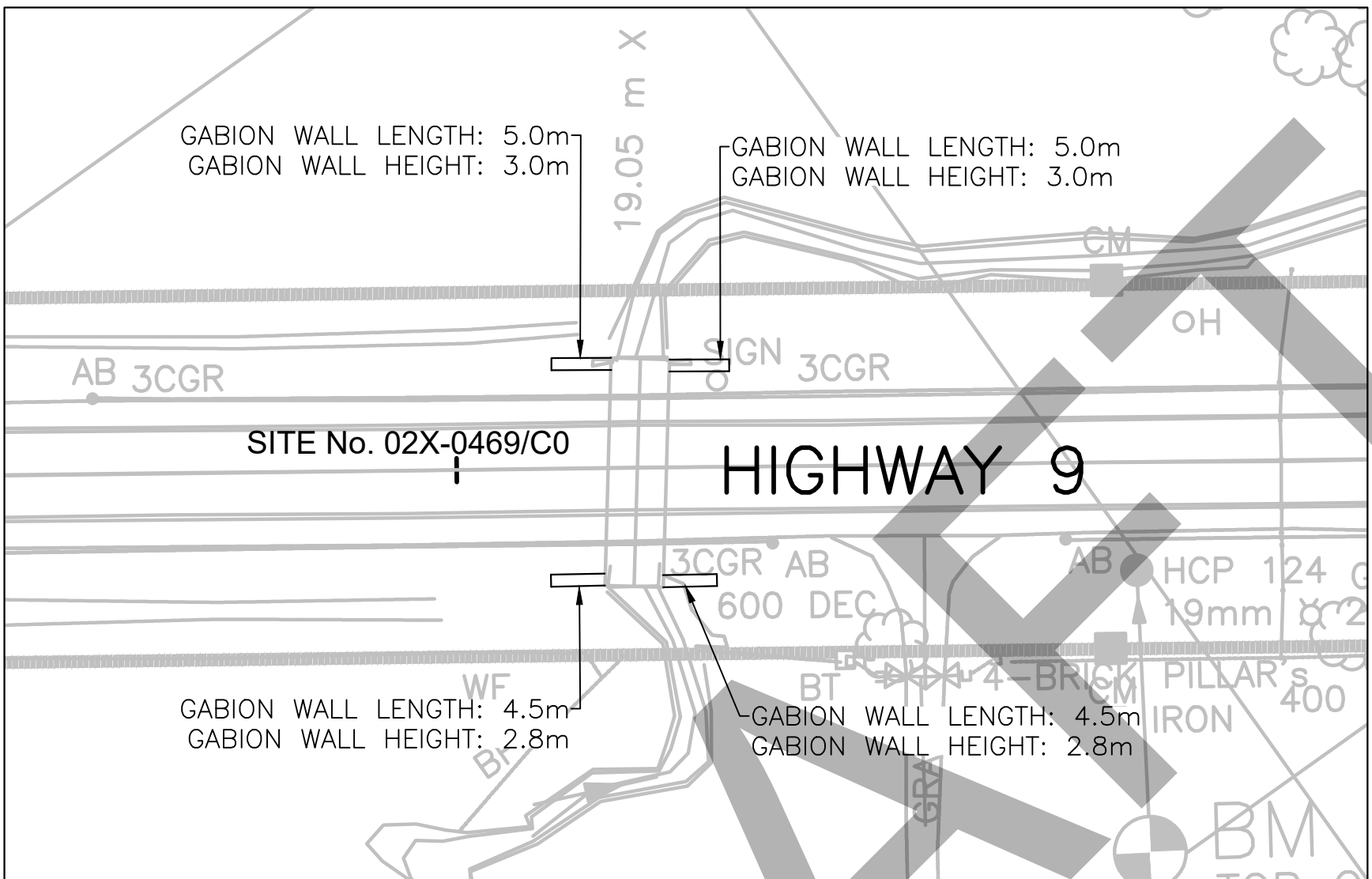
GABION WALL TYPICAL



21+688



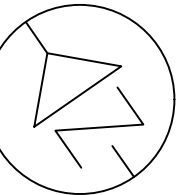
CULVERT SIDE VIEW



24+515

METRIC

PLATE No 180-9/5-0
CONT WP 3076-14-00
GABION STRUCTURES
STA xx+xxx
Survey OCT 2015 Revised



SHEET 33

- NOTES:
1. ALL DIMENSIONS ARE IN mm UNLESS OTHER WISE SPECIFIED.
 2. BASKETS SHALL BE PVC COATED.
 3. FACTORED DESIGN SOIL BEARING CAPACITIES MUST BE VERIFIED BY QUALITY VERIFICATION ENGINEER ON SITE.
 4. BACKFILL TO BE FREE DRAINING COMPACTED GRANULAR 'B' (MIN. 95% SPMD)

NOT FOR CONSTRUCTION

N.T.S.