



**THURBER** ENGINEERING LTD.

**PRELIMINARY  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
GRINDSTONE CREEK CULVERT REHABILITATION  
HIGHWAY 403 AND HIGHWAY 6 INTERCHANGE  
HAMILTON, ONTARIO  
SITE 10-193/C  
WO#16-20004  
ASSIGNMENT NUMBER 2016-E-0027**

**GEOCRES NO. 30M5-357**

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**Report**

**to**

**AECOM**

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## **1.0 INTRODUCTION**

This report presents the factual findings obtained from a preliminary foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the preliminary design and environmental assessment of the culvert rehabilitation at the crossing of Grindstone Creek under Highway 403 located in Hamilton, Ontario.

The purpose of this investigation was to explore the subsurface conditions at a selected location at the site and, based on the data obtained, to provide a borehole location plan, record of borehole, a stratigraphic profile and a written description of the subsurface conditions. This new information is to supplement archive subsurface information available for this site.

Thurber was retained by AECOM to carry out this Phase 2 preliminary foundation investigation under the Ministry of Transportation Ontario (MTO) Assignment Number 2016-E-0027.

This site is a part of the overall Highway 403 and Highway 6 Interchange Improvements project where 14 bridges, 3 structural culverts and 15 retaining walls are planned to be replaced, reconstructed or rehabilitated.

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.

Reference has been made to information on subsurface conditions discussed in a Desktop Study carried out by Thurber as part of the Phase 1 scope of this project. The title of this Desktop Study as well as other references are listed as follows:



- Foundation Desktop Study Report, Preliminary Design and Environmental Assessment, Grindstone Creek Culvert Rehabilitation, Highway 403 and Highway 6 Interchange, Hamilton, Ontario, W.O. # 16-20004, Site 10/193C, Geocres No. 30M5-345, prepared by Thurber, dated November 9, 2022 (Reference 1).
- Foundation Investigation Report, Highway Bridge West of Aldershot crossing at Hidden Valley, Report No. S-500-505/55/T-93-1, Geocres No. 30M05-064 prepared by Racey, MacCallum and Associates Limited, dated July 19, 1955. (Reference 2).
- Fill Failure Memorandum, Highway 403 and Hidden Valley Road, Station 231+50 to Station 232+00, District No. 4 (Hamilton), W.J. 68-F-51, W.P. 16-56-1, Geocres No. 30M05-067, dated July 8, 1968. (Reference 3).

## **2.0 SITE AND PROJECT DESCRIPTION**

The existing culvert is located at the crossing of Grindstone Creek and Highway 403, approximately 2.5 km east of the Highway 6 and Highway 403 interchange, in the City of Hamilton, Ontario. The existing arch culvert carries Grindstone Creek under Highway 403.

Highway 403 in the vicinity of the site generally runs in an east to west orientation along relatively flat terrain. CN rail tracks run parallel to Highway 403 at approximately 75 m to the south. Hidden Valley Road is located approximately 50 m west of Grindstone Creek. The lands surrounding the site are generally residential and commercial. Grindstone Creek flows in a southerly direction. The width of the creek varies from approximately 8 m on the north side of the culvert (inlet) to about 5 m at the south end (outlet) of the culvert.

According to the archive drawings, the existing structure is a concrete arch culvert of approximately 112.2 m in length and 12.5 m in width. The culvert is oriented at an approximate 18° skew to the centreline of Highway 403. The maximum height of the opening inside the arch is approximately 6m. Based on a preliminary general arrangement (GA) drawing dated August 2022, the Highway 403 platform grade at the culvert decreases north to south from approximate Elevations 108.0 to 106.8. The highway embankment is up to the order of 14 m to 15 m in height and has no mid-height bench at this location. No record is available on the year of construction of the arch structure, or whether there was any previous rehabilitation completed at this site.

Selected photographs and observations noted during Thurber's site reconnaissance visit are presented in the Foundation Desktop Study Report (Reference 1).

The project area is situated within the physiographic region known as the Niagara Escarpment, which forms a north-south trending strip, and is a major topographic break in the bedrock between the carbonate Amabel Formation to the west and the soft sediments of the Queenston Formation to



the northeast. At many locations, the Queenston Formation consists of up to 1.2 m of very weathered bedrock (red clay) which grades downward into typical brick-red shale and often with green mottling. Thin to medium beds of grey-green and reddish argillaceous, hard limestone are present in most sections. The Queenston shale is overlain by Halton Till in the area of the site. The Halton Till is a red clay to clayey silt till and is exposed in the form of a till plain extending from Lake Ontario southward to the Niagara escarpment.

### **3.0 SITE INVESTIGATION AND FIELD TESTING**

The current borehole investigation and field testing program for this site was carried out on September 26 to 27, 2022, and consisted of drilling and sampling one (1) borehole, designated as Borehole GS-01. Borehole GS-01 was drilled through the Highway 403 westbound lane (WBL) embankment and terminated at 18.9 m depth (Elevation 89.3). Borehole GS-01 was advanced 3.2 m into shale bedrock by coring 2.0 m. The record of borehole sheet of the present investigation is provided in Appendix A.

A foundation investigation was conducted at the site in 1955 (Reference 2) for Hidden Valley Road Culvert and Grindstone Creek Culvert. These sites are located approximately 45 m to 50 m apart. Six boreholes (numbered 1 to 6) were drilled in proximity to the original culvert alignments. The actual locations of these boreholes in relation to the existing culvert cannot be confirmed since a co-ordinate system was not used at the time, and there was no available record of the as-drilled locations of the boreholes and as-built location of the culvert. Record of Borehole Sheets and a borehole location plan from the previous investigations are included in Appendix C.

The approximate locations of all the boreholes (previous and present investigations) are shown on the Borehole Location and Soil Strata drawing in Appendix E.

Thurber surveyed Borehole GS-01 in the field, and obtained the borehole coordinates and ground surface elevation. The coordinates are related to MTM NAD 83 Zone 10. The survey equipment used was a Trimble R10 GNSS system with a horizontal precision of 3 mm and a vertical precision of 3.5 mm. The coordinates and elevations of the borehole are given on the Borehole Location and Soil Strata drawing in Appendix E and on the Record of Borehole Sheet in Appendix A.

Lane closure and traffic control were implemented for drilling the borehole for the current investigation. Prior to commencement of drilling, utility clearances were obtained for the borehole location.

The current borehole was advanced using a truck-mounted drill rig with solid stem augers. Soil samples were obtained at selected depth intervals using a 50 mm outside diameter split-spoon sampler driven in conjunction with the Standard Penetration Test (SPT) which was performed in



accordance with ASTM D1586. HQ rock coring equipment was used to recover core samples of the underlying bedrock.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

The current field investigation was supervised on a full-time basis by a member of Thurber's technical staff who marked the borehole in the field, observed and recorded the drilling, sampling and in-situ testing operations, logged the borehole and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open borehole were observed throughout the current drilling operations.

Borehole GS-01 was backfilled upon completion of drilling in general accordance with O.Reg. 903. Asphalt was reinstated in Borehole GS-01 drilled through the highway platform.

#### **4.0 LABORATORY TESTING**

The recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were subjected to grain size distribution analyses (sieve and/or hydrometer), and Atterberg Limits testing. Geotechnical laboratory testing results of the current investigation are summarized on the Record of Borehole sheet included in Appendix A and are presented on the figures included in Appendix B.

Core samples of the shale bedrock were carefully protected to prevent drying during transport to the laboratory. Point load tests were carried out on selected samples of intact shale upon arrival at the laboratory to assist in evaluation of the compressive strength of the bedrock. Detailed results of point load tests are included in Appendix B and summarized results are presented on the Record of Borehole sheet in Appendix A. Rock core photos are presented in Appendix D.

For preliminary assessment of the potential for sulphate attack on concrete foundations, as well as the potential for metal corrosion associated with the structure, samples of the existing fills and native soils were collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing for corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 5.5 and are presented in Appendix B.

#### **5.0 SUBSURFACE CONDITIONS**

Details of the encountered subsurface stratigraphy are presented on the Record of Borehole sheet included in Appendix A, and on the Borehole Location and Soil Strata drawing in Appendix E. A



general description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheet governs any interpretation of the site conditions. It must be recognized and anticipated that soil conditions may vary between and beyond the borehole location.

The soil stratigraphy encountered at the site during the previous investigation, prior to culvert and Highway 403 embankment construction, consists of typically stiff to very stiff, red to occasionally grey-green silty clay. The thickness of the silty clay varied from 0.76 m to 1.3 m. The silty clay was underlain by shale bedrock of the Queenston Formation.

The subsurface stratigraphy encountered during the present investigation consists of pavement structure overlying silty clay fill and sand to silt/silty sand fill, which is underlain by shale bedrock of the Queenston Formation. Water was used during rock coring and, therefore, it was not possible to determine the groundwater level at this site during the field work.

More detailed descriptions of the individual stratum are presented below.

## **5.1 Pavement Structure**

Pavement structure consisting of approximately 250 mm asphalt overlying granular (sand and gravel fill with occasional cobbles and asphalt fragments) road base was encountered in Borehole GS-01. The thickness of the granular fill was 950mm.

An SPT N-value recorded in the sand and gravel fill was 52 blows per 0.3 m of penetration indicating a very dense state. Moisture content in the sand and gravel fill varied from 2 percent to 10 percent.

## **5.2 Embankment Fill**

Embankment fill was encountered underlying the pavement structure in the borehole. The embankment fill consisted of layers of cohesive and cohesionless soils. A 1.2 m thick layer of reddish brown sandy, silty clay fill containing trace gravel was contacted immediately below the granular road base. Layers of reddish brown to brown sand and silt fill and silty sand fill containing trace gravel, trace clay, occasional clay pocket and occasional cobbles were contacted below the cohesive fill. A layer of black sand and gravel with oily odour was encountered near Elevation 93.8. The thickness of the cohesionless fill was 13.3 m.

The depth to the base of the silty sand fill was at 15.7 m (Elevation 92.5).

An SPT N-value recorded in the silty clay fill was 12 blows per 0.3 m of penetration indicating a stiff consistency. SPT 'N' values recorded in the sand and silt and silty sand fill ranged from 5 to 81 indicating a loose to very dense state. Moisture contents in the cohesive fill were 12 percent and 15 percent. For the cohesionless fill, the moisture contents ranged from 9 percent to 22 percent.





The results of grain size distribution analyses carried out on a sample of the cohesive fill and several samples of the cohesionless fill are presented on the Record of Borehole Sheets and Figures B1 and B2, respectively, in Appendix B and also summarized below:

Soil Particle	Cohesive Fill Percentage (%)	Cohesionless Fill Percentage (%)
Gravel	3	0 to 3
Sand	25	59 to 67
Silt	48	27 to 39
Clay	24	2 to 8

The results of an Atterberg Limits test carried out on a sample of the silty clay fill are presented on the Record of Borehole Sheets and Figure B3 in Appendix B, and are summarized below:

Soil Property	Percentage (%)
Liquid Limit	27
Plastic Limit	16
Plasticity Index	11

The results of the Atterberg Limit tests indicate that the silty clay till has low plasticity with a group symbol of CL

### 5.3 Shale Bedrock

The soils described above were found to be underlain by shale bedrock of the Queenston Formation which was contacted at 15.7 m depth (Elevation 92.5) in Borehole GS-01. Bedrock was proved by coring to 18.9 m depth (Elevation 89.3). The upper 1.5 m of shale was described as red with grey limestone interbeds and occasional clay seams. The shale bedrock is highly weathered (augered through prior to coring) transitioning to highly to moderately weathered with depth. The distribution, thickness and strength of these layers vary from location to location, and the limestone layers typically exhibit less pronounced weathering than the shale.

Rock core photos are presented in Appendix D.

An SPT N-value obtained in the upper, highly weathered, portion of the shale bedrock was 100 blows per 0.175 m of penetration.

For the purpose of reporting herein, the upper zone of the shale will be referred to as weathered shale and the underlying sound portion will be considered as sound shale bedrock.



Depths and elevations of the top of bedrock encountered in the present and previous investigations are shown in Table 5.1.

**Table 5.1 – Approximate Depth and Elevation of Shale Along Grindstone Creek Culvert**

Approximate location relative to existing culvert	Borehole	Bedrock Depth <sup>(2)</sup> (m)	Bedrock Elevation <sup>(3)</sup> (m)	Comments
North side	6 <sup>(1,2,3)</sup>	0.8	93.6	Shale bedrock proven by coring
Middle	GS-01 <sup>(4)</sup>	15.7	92.5	Shale bedrock proven by coring
	5 <sup>(1,2,3)</sup>	0.8	93.4	Shale bedrock proven by coring
South side	4 <sup>(1,2,3)</sup>	0.8	92.9	Shale bedrock proven by coring

<sup>(1)</sup> The actual locations of these boreholes cannot be confirmed due to incomplete information.

<sup>(2)</sup> All depths were converted from Imperial Units and relative to the ground surface prior to construction of the existing culvert.

<sup>(3)</sup> It is unknown how the elevations are related to the Canadian Geodetic Datum currently in use.

<sup>(4)</sup> Borehole drilled during the present investigation (September 2022).

It is noted that the soil and rock conditions reported on the previous boreholes, particularly within the upper portion, may have been modified by the original construction.

During the present investigation, one run of bedrock core was recovered using HQ size coring equipment. Total Core Recovery (TCR) in the bedrock was 22 percent in Run 1.

A RQD value of 0 (zero) was recorded indicating very poor rock quality. Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 4 to greater than 10.

Unconfined compressive strengths (UCS) interpreted from point load tests conducted on selected shale cores were 19.6 MPa and 15.8 MPa. The results indicate a generally very weak rock. Results of point load tests are included in Appendix B.

It must be noted, however, that point load tests were possible only on less weathered shale. Typical weathered shale cores tended to be not suitable for point load testing. Broken (rubble) zones were observed within the cores at several depths.

#### **5.4 Groundwater Conditions**

Water was used for rock coring and, therefore, the water level in the borehole upon completion of drilling is not considered representative of the groundwater level during the present field work.

Groundwater level was measured at 1.0 m depth (Elevation 92.7) in Borehole 4 drilled during the previous investigation. The preliminary GA drawing dated August 2022 indicated that the high water level (HWL) at Grindstone Creek was at Elevation 94.5 in June 1956.



## 5.5 Corrosivity and Sulphate Test Results

Selected soil samples were submitted for analytical testing of corrosivity parameters including sulphate content. The results of the analytical tests are shown in Table 5.2. The laboratory certificates of analysis are presented in Appendix B.

**Table 5.2 – Analytical Corrosivity Test Results**

Sample ID	Depth (m)	Soil Sample Description	Sulphide (percent)	Chloride (µg/g)	Sulphate (µg/g)	pH	Resistivity (ohm.cm)	Redox Potential (mV)	Electrical Conductivity (µS/cm)
GS-01 SS#3	1.7 to 2.3	Silty clay fill	< 0.04	1,100	110	8.58	587	273	1700
GS-01 SS#12	13.7 to 14.3	Silty sand fill	< 0.04	300	23	7.94	2,020	224	496

## 6.0 MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole in the field, and obtained the borehole coordinates and ground surface elevation.

Elements GEO of Hamilton, Ontario supplied and operated the drilling and sampling equipment for the field program.

Full time supervision of the field activities was carried out by Mr. Felipe Kozminski of Thurber. Overall supervision of the field program was performed by Mr. Stephane Loranger, C.E.T. and Ms. Rocio Palomeque Reyna, P.Eng., of Thurber.

Interpretation of the field data and preparation of the report were carried out by Ms. Rocio Palomeque Reyna, P.Eng. and Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**7.0 GENERAL**

This report presents interpretation of the geotechnical data in the factual report and provides preliminary foundation recommendations in support of preliminary design of the proposed culvert rehabilitation at the crossing of Grindstone Creek under Highway 403 located in Hamilton, Ontario.

A preliminary GA drawing provided by AECOM dated August 2022 indicates that the proposed culvert rehabilitation program involves installation of Retained Soil Systems (RSS) and barrier walls above the culvert. The RSS walls will be located just below the crest of and parallel to the Highway 403 embankment, one near each end (north and south) of the culvert. Both RSS walls will have a retained height of up to about 2 m. The proposed lengths of the north and south walls are about 23.3 m and 23.9 m, respectively. Erosion protection systems will be installed at the northeast, southeast and southwest quadrants of the culvert. The preliminary GA drawing also indicates that one additional travel lane and shoulder are proposed for each of the Highway 403 EBL and WBL directions.

As part of the rehabilitation program, delaminated and deteriorated concrete will be removed from the interior of the arch culvert and subsequently repaired. Waterproofing will be placed in areas where the soil cover above the culvert is less than 1.0 m.



The discussion and recommendations presented in this report are based on preliminary design information provided by AECOM and on factual data available to date.

## **8.0 FOUNDATION ALTERNATIVES**

Consideration was given to carrying out the rehabilitation program using the following foundation types:

- Retaining walls on bedrock
- Retained Soil Systems (RSS) walls on embankment fill

### Retaining Walls on Bedrock

New retaining walls have been considered at all four corners of the existing culvert. Given the shallow bedrock at the site, these walls may be supported on spread footings founded on bedrock. Temporary protection and dewatering will likely be required close to or within the creek channel during foundation construction.

### RSS Walls on Embankment Fill

Two sections of RSS walls, each to be located near the crest on both sides of the Highway 403 embankment, are being considered. It is anticipated that the retained height would be up to 2 m. According to GA drawing The RSS wall will be embedded for about 1.5 m to 2.0 m into the embankment fill. Some excavation into the existing fill will be required to facilitate installation of the reinforcing strips and compaction of the wall fill.

AECOM advised that the RSS option will reduce environmental impacts and eliminate in-water operation in the creek.

Rock fill has not been considered to date since reconfiguration of the existing embankments will likely be required.

### Recommended Foundations

From a foundation technical and cost effectiveness perspective, and taking into consideration the environmental concerns relating to working in the creek, the RSS wall option founded in the embankment fill is currently being considered in the design.



## 9.0 RETAINED SOIL SYSTEMS (RSS) WALL

According to the preliminary GA drawing, the base of the RSS walls will be founded at or below approximate Elevation 104. Based on our current investigation, the fill on the north embankment (Highway 403 WBL) at or below Elevation 104 consists of compact to very dense sand and silt to silty sand overlying shale bedrock. A borehole drilled in November 2022 for the nearby Hidden Valley Culvert also revealed similar conditions on the south embankment (Highway 403 EBL). Further details of the proposed RSS wall were not provided.

For preliminary design of RSS mass founded on the compact to very dense cohesionless fill at or below Elevation 104, it is assessed that a factored geotechnical resistance at Ultimate Limit States (ULS) of 150 kPa and a geotechnical resistance at Serviceability Limit State (SLS) of 100 kPa (corresponding up to 25 mm settlement) be used.

The RSS mass should be founded on a minimum 0.3 m thick engineered fill consisting of OPSS.PROV 1010 Granular A or Granular B Type 2 compacted to 100 percent of its Standard Proctor Maximum Dry Density (SPMDD) at a moisture content within 2 percent of optimum. The engineered pad must laterally extend at least 500 mm beyond the footprint of the RSS mass and levelling strips.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall may be estimated using an ultimate friction coefficient of 0.55 for an engineered granular fill subgrade.

RSS walls used on this project must be specified to be “High Performance” and “High Appearance”. The RSS supplier/designer may specify more stringent criteria or other requirements related to this particular design. The internal stability of the RSS wall should be analyzed by the supplier/designer of the proprietary product selected for this site.

RSS walls should be designed with reference to the latest version of the MTO RSS Design Guidelines published by the Engineering Standards Branch.

Construction of RSS walls will require excavations upslope for reinforcing strip installation and backfill placement. Up to the order of 0.7 to 1.0 times the RSS block height, or about 1.8 m to 2.5m, of excavation in plan is anticipated. Temporary protection (shoring) will likely be required during construction.

The preliminary GA drawing shows that the overall embankment slope in the vicinity of the wall is at an approximate 2H : 1V inclination or flatter. Based on this design configuration and the soil



and bedrock conditions encountered during the present investigation, no global slope stability concerns are anticipated. During detail design, global stability of the overall embankment and upper slope with an RSS wall, as well as settlement analysis due to additional fill loading, should be carried out. The designers should also assess the implication and effect of additional loading on the existing culvert.

## **10.0 EMBANKMENT DESIGN AND CONSTRUCTION**

Reference 2 recommended that the design of the approach and side slopes be at inclination of 2H : 1V. The existing Highway 403 embankments are up to the order of 15 m in height in the vicinities of the culvert inlet and outlet. According to the available preliminary GA drawing, these embankment slopes are at an inclination of 2H : 1V or flatter

Preliminary GA drawing indicates the proposed addition of one travel lane on each of the EBL and WBL. Embankment widening and grade raise in the order of 0.5 m at the Highway 403 EBL will be required.

The new slopes should be designed to match the existing slope configuration with an inclination of 2H : 1V or flatter. Where applicable, benching of the existing earth slope surface should be carried out as per OPSD 208.010 in order to enhance the keying in of the new fill.

Based on typical MTO practice, earth fill embankments higher than 8 m should be incorporated with mid-height berms at each 8 m vertical interval. The berms should:

- extend for the length through which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2 percent positive grade to shed run-off water.

It is noted that the existing highway embankments in the vicinity of Grindstone Creek do not have mid-height benches, despite their heights. The designers should confirm with MTO that this can remain to be the case.

The subgrade for new fill (where required) is expected to be existing fill or weathered shale. No global stability issues are anticipated for the slopes at this site provided the approved new fill is placed and compacted in accordance with OPSS.PROV 206 and OPSS.PROV 501, and provided that all surficial vegetation, organics and topsoil, soft/loosened or wet soils and debris are removed from the proposed embankment areas prior to fill placement.





It is recommended that all exposed slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804. Erosion protection measures must be provided for lower portions of the slopes with which potential creek water can be in contact.

Drainage measures at the top of the embankment should be designed to minimize surface runoff and precipitation from flowing perpendicularly down the slope. This occurrence could increase surficial erosion on the embankment face.

Foundation settlement of the soil subgrade due to the new fill and construction of RSS wall will be analyzed and preliminary estimates provided in detail design.

## 11.0 LATERAL EARTH PRESSURES

Earth pressures acting on the culvert walls may be assumed to impose 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)
	$\gamma$	=	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 are dependent on the material used as backfill. Recommended unfactored values are shown in the following Table 11.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for unrestrained walls.

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



**Table 11.1 - Earth Pressure Coefficients (K)**

Loading Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		Embankment Fill $\phi = 30^\circ, \gamma = 20.0 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H : 1V)	Horizontal Backfill	Sloping Backfill (2H : 1V)
Active (Unrestrained Wall)	0.27	0.40	0.33	0.48
At-rest (Restrained Wall)	0.43	0.62	0.50	0.72
Passive	3.7	-	3.0	-

## 12.0 EXCAVATION AND GROUNDWATER CONTROL

All excavations must be carried out in accordance with OPSS.PROV 902 and the Occupational Health and Safety Act (OHSA). For the purposes of assessing excavation slope and temporary support requirements in compliance with the OHSA, the embankment fill and weathered shale are classified as Type 3 soils. Sound shale may be considered as Type 1 material.

The anticipated excavations for construction of the new RSS walls will be carried out within the existing embankment fill and will not extend below the groundwater level. However, seepage or perched water from the embankment fill is to be expected.

The Contractor should be prepared to pump from properly filtered sumps to remove any perched seepage water or surface water collecting in an excavation. Unwatering must remain operational and effective until the excavation is backfilled.

The design of any dewatering system that may be required is the responsibility of the Contractor.

Where required, construction will need to be carried out in conjunction with temporary protection.

## 13.0 EROSION CONTROL

The preliminary GA drawing indicates that erosion protection systems will be placed at the northeast, southeast and southwest corners of the culvert.

Design of erosion and scour protection measures must consider hydrologic and hydraulic issues and should be carried out by specialists experienced in this field.



Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

#### **14.0 TEMPORARY PROTECTION SYSTEMS**

Temporary protection (shoring) systems will likely be required for construction of the new retaining walls in general accordance with OPSS.PROV 539. It is recommended that Performance Level 2 be specified. The use of temporary protection to retain the embankment slope will be required where any excavation is cut into the existing embankment fill.

The selection and design of suitable temporary protection systems are the responsibilities of the Contractor. All shoring systems must be designed by a Professional Engineer experienced in such designs.

#### **15.0 ADJACENT STRUCTURES AND BURIED UTILITIES**

It is recommended that the exact locations of any existing utilities and drainage pipes that are present in the vicinity of the work areas be established by the designer and compared with the extent of the potential work zones related to the proposed construction.

The utilities and drainage pipes should not be undermined or damaged during construction of the new retaining walls, and probable demolition of the existing walls. Relocation of, and/or special protective measures for, some or all of these affected utilities may be required.

#### **16.0 SOIL CORROSION POTENTIAL**

The results of corrosivity and sulphate analytical tests conducted on samples of the silty clay and sand fill during the current investigation are included in Appendix B. Based on the test results, the following statements can be made:

- The potential for sulphate attack on concrete from silty clay fill and silty sand fill is considered negligible due to the low concentration of sulphate and slightly alkaline pH values.
- Test results of one sample of the silty clay fill from 1.7 m to 2.3 m depth (about Elevation 106.5) in Borehole GS-01 indicate a very severe potential of corrosivity on metals. One sample of the silty sand fill from 13.7 m to 14.3 m depth (about Elevation 94.5) in



Borehole GS-01 indicate a moderate potential of corrosivity on metals. More testing will be required in the fill during detail design for confirmation.

- The effects of road de-icing salts should also be considered when selecting the class of concrete and corrosion mitigation measures.

## **17.0 INVESTIGATION FOR DETAIL DESIGN**

References 2 and 3 are available from the GEOCREST library for this site. As discussed previously, these reports were prepared in the early 1960's prior to construction of the existing culvert. The locations and elevations of the boreholes cannot be confirmed. There is also lack of information on the characteristics of the shale bedrock.

The subsurface conditions depicted by the one borehole of this preliminary investigation is insufficient to be used for detail design of the new works. It will be necessary to carry out additional site investigation and field testing to support the preparation of foundation design recommendations for detail design of the proposed RSS walls and for assessing the embankment stability.

For detail design, it is recommended that Guidelines for MTO Foundation Engineering Services (Version 3.0 April 2022) be followed. For RSS wall design and construction, the minimum requirements are summarized as follows:

- One (1) borehole shall be advanced at each end of a retaining wall and at a maximum longitudinal spacing of 50 m. Boreholes shall be advanced to 3 m into a competent stratum or 10 m below the base of the wall, whichever is less. If bedrock is encountered, bedrock shall be cored for a minimum depth of 3 m.
- Additional requirements for RSS wall include boreholes behind and in front of the wall facing; minimum depth of boreholes along wall facing and retained zone area shall be 2H or 10 m below the base of RSS, minimum depth of H for boreholes along the fore-slope area, where H is the proposed height of the RSS block.

## **18.0 CLOSURE**

Engineering analysis and preparation of the foundation design report were carried out by Rocio Reyna, P.Eng. The report was reviewed by Sydney Pang, P.Eng. and P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.



Rocío Palomeque Reyna, P.Eng.  
Senior Geotechnical Engineer



Sydney Pang, P.Eng.  
Senior Associate, Senior Foundation Engineer



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

## 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.



## **Appendix A**

### **Record of Borehole Sheet (Present Investigation)**

## 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 <sup>(1)</sup> '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


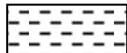



- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous 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 <sub>L</sub> < 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 <sub>L</sub> < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W <sub>L</sub> < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W <sub>L</sub> > 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			

## EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
<b>Fresh (FR)</b>	No visible signs of weathering.		
<b>Fresh Jointed (FJ)</b>	Weathering limited to the surface of major discontinuities.		CLAYSTONE
<b>Slightly Weathered (SW)</b>	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
<b>Moderately Weathered (MW)</b>	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
<b>Highly Weathered (HW)</b>	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
<b>Completely Weathered (CW)</b>	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

<u>TERMS</u>	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

# RECORD OF BOREHOLE No GS-01

1 OF 2

METRIC

W.P. W.O. 16-20004 LOCATION Grindstone Creek Culvert; MTM NAD83-10: N 4 796 396.1 E 275 019.1 ORIGINATED BY FK  
 DIST Central HWY 403 BOREHOLE TYPE Solid Stem Augers/HQ Coring COMPILED BY MC  
 DATUM Geodetic DATE 2022.09.26 - 2022.09.27 LATITUDE 43.306856 LONGITUDE -79.867094 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
108.2	GROUND SURFACE												
0.0 107.9	ASPHALT: (250mm)												
0.3 107.0	SAND and GRAVEL, trace to some silt and clay Very Dense to Compact Grey Moist (FILL) Occasional asphalt fragments, occasional cobbles		1	SS	52								
1.2 107.0			2	SS	19								
	Silty CLAY, sandy, trace gravel Stiff Reddish Brown Moist (FILL)		3	SS	12								
105.8			4	SS	5								
2.4	SAND and SILT, trace clay Loose Reddish Brown to Brown Moist to Wet (FILL)  <												

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

[illegible]

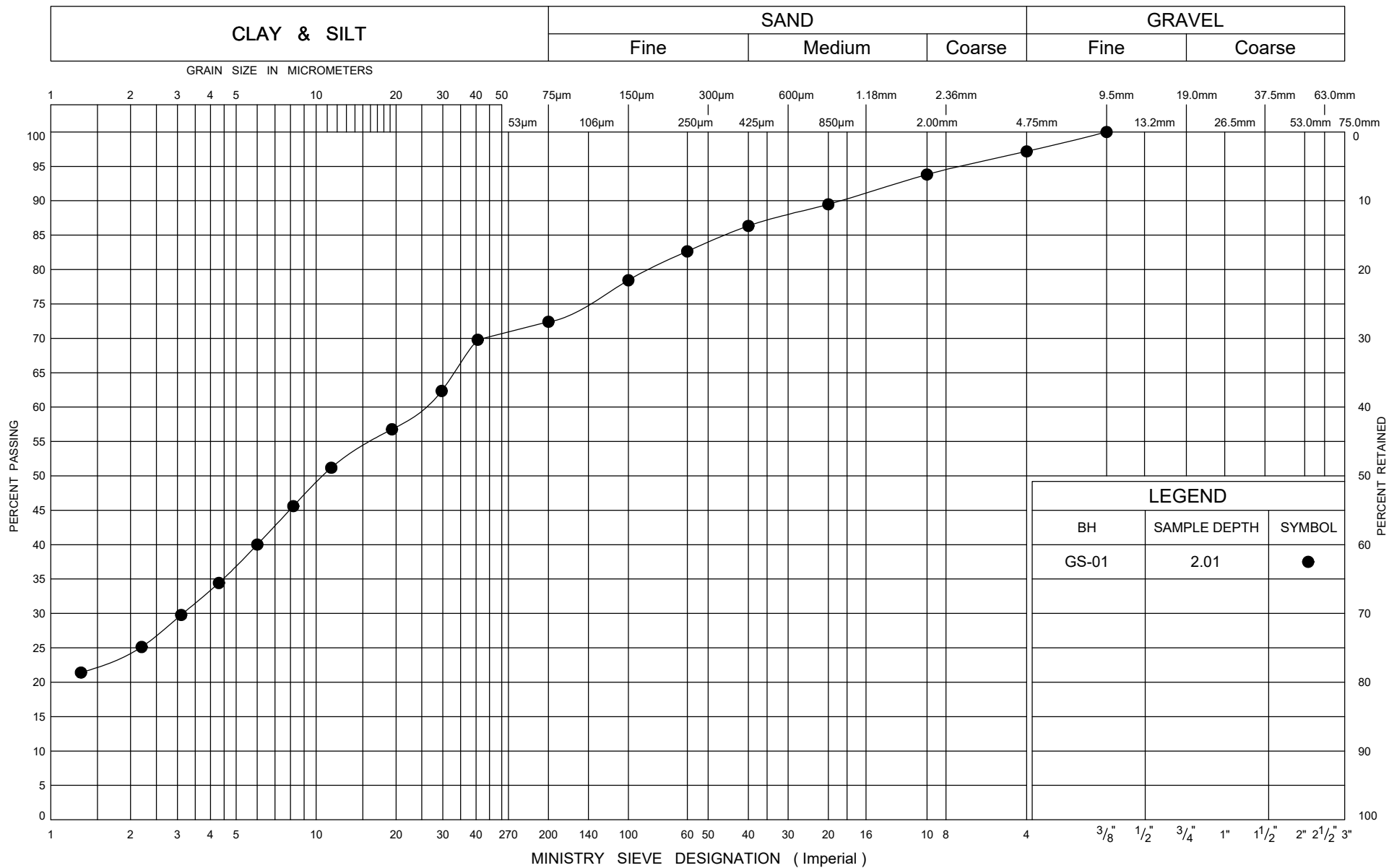
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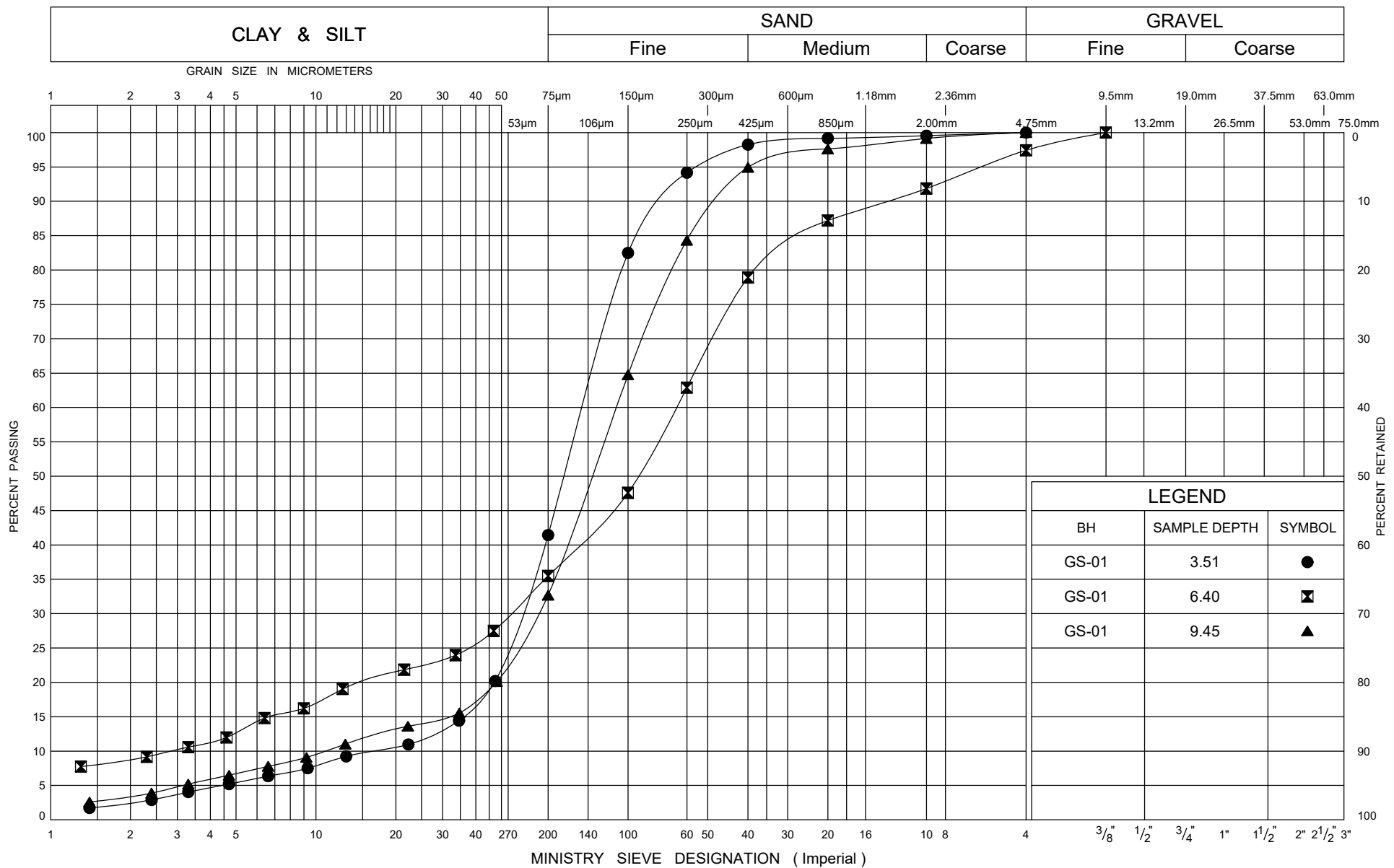
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

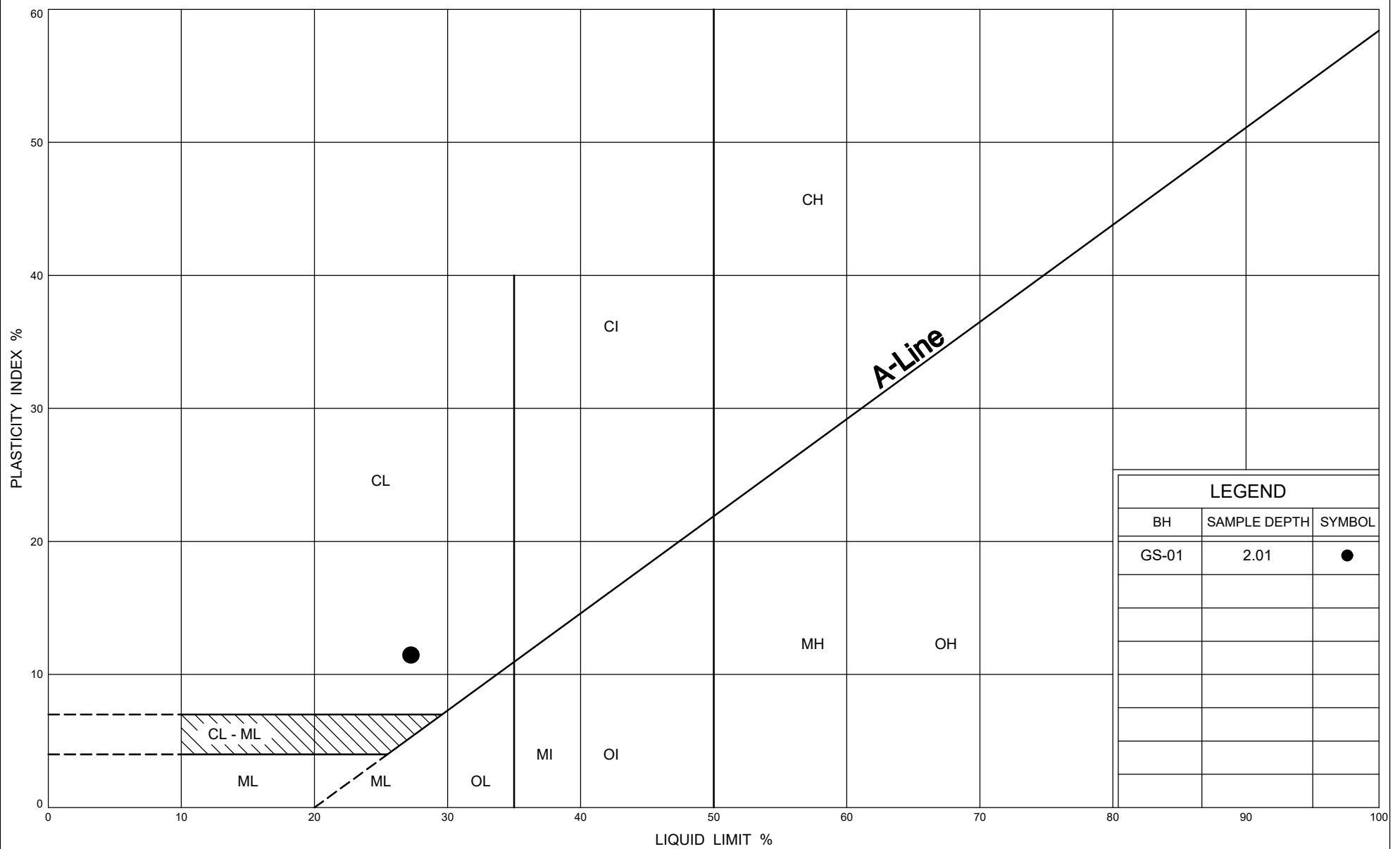


## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results (Present Investigation)**







Ministry of  
Transportation

## PLASTICITY CHART

Silty CLAY FILL

FIG No B3

W.P. W.O. 16-20004

Grindstone Creek Culvert





THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET  
ASTM D5731-08

Job No: 25963 - Phase 2  
Project Name: Hwy 403 & Hwy 6 - Grindstone Creek Culvert  
Core Size: HQ BH No : GS-01

Date Drilled: 27-Sep-22  
Date Tested: 30-Sep-22  
Tester: BS  
Client: AECOM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	Run 1	17.0	A	3.0	55.8	54.3	0.8	19.6	Shale	Weak
2	Run 1	17.2	A	2.6	58.6	55.6	0.7	15.8	Shale	Weak
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
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32										
33										
34										

- \* It is ideal to perform axial test on core specimens with D/L ratio of  $1.1 \pm 0.1$
- Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- \* Diametral Test should have  $0.7 \times D$  on either side of test point.
- \* Correlation factor to obtain UCS values is 24.



## FINAL REPORT

CA40389-SEP22 R1

25963, Hwy 403 & Grinstone Creek C, Burlington/Hamilton, ON

Prepared for

**Thurber Engineering Ltd.**

## First Page

### CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7, Canada

Contact Rocio Reyna

Telephone 905-829-8666 x 263

Facsimile

Email rreyna@thurber.ca

Project 25963, Hwy 403 & Grinstone Creek C, Burlington/Hamilton, ON

Order Number

Samples Soil (2)

### LABORATORY DETAILS

Project Specialist Maarit Wolfe, Hon.B.Sc

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2000

Facsimile 705-652-6365

Email Maarit.Wolfe@sgs.com

SGS Reference CA40389-SEP22

Received 09/30/2022

Approved 10/21/2022

Report Number CA40389-SEP22 R1

Date Reported 10/21/2022

### COMMENTS

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: n/a

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

### SIGNATORIES

Maarit Wolfe, Hon.B.Sc

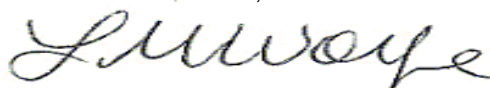




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# FINAL REPORT

CA40389-SEP22 R1

**Client:** Thurber Engineering Ltd.

**Project:** 25963, Hwy 403 & Grinstone Creek C, Burlington/Hamilton, ON

**Project Manager:** Rocío Reyna

**Samplers:** FK

MATRIX: SOIL

<b>Sample Number</b>	5	6
<b>Sample Name</b>	BH GS01, SS#3, 5.5'-7.5'	BH GS-01, SS#12 45-47'
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	26/09/2022	26/09/2022

Parameter	Units	RL		Result	Result
<b>Corrosivity Index</b>					
Corrosivity Index	none	1		14	3
Soil Redox Potential	mV	no		273	224
Sulphide (Na <sub>2</sub> CO <sub>3</sub> )	%	0.04		< 0.04	< 0.04
pH	pH Units	0.05		8.58	7.94
Resistivity (calculated)	ohms.cm	-9999		587	2020
<b>General Chemistry</b>					
Conductivity	uS/cm	2		1700	496
<b>Metals and Inorganics</b>					
Moisture Content	%	0.1		15.9	14.7
Sulphate	µg/g	0.4		110	23
<b>Other (ORP)</b>					
Chloride	µg/g	0.4		1100	300



FINAL REPORT

CA40389-SEP22 R1

QC SUMMARY

Anions by IC  
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0055-OCT22	µg/g	0.4	<0.4	1	35	103	80	120	ND	75	125
Sulphate	DIO0055-OCT22	µg/g	0.4	<0.4	0	35	94	80	120	97	75	125

Carbon/Sulphur  
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0012-OCT22	%	0.04	< 0.04	ND	20	116	80	120			

Conductivity  
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0017-OCT22	uS/cm	2	< 2	4	20	99	90	110	NA		



QC SUMMARY

pH  
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0017-OCT22	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

**Multielement Scan Qualifier:** as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

**Duplicate Qualifier:** for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

**Matrix Spike Qualifier:** for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

## LEGEND

### FOOTNOTES

**NSS** Insufficient sample for analysis.

**RL** Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

**NA** The sample was not analysed for this analyte

**ND** Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at [http://www.sgs.com/terms\\_and\\_conditions.htm](http://www.sgs.com/terms_and_conditions.htm).

The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. Reproduction of this analytical report in full or in part is prohibited.

This report supersedes all previous versions.

-- End of Analytical Report --



## Request for Laboratory Services and Chain of Custody

## Environment, Health & Safety

- Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: [www.sgs.com/environment](http://www.sgs.com/environment)  
 - London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

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Page 1 of 1

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Revision #: 1.1

Date of Issue: 04 April 2018



## **Appendix C**

### **Record of Borehole Sheets and Borehole Plan (Geocres/Previous investigation)**



Order No.: 5502-505/55/T-93 RACEY, MacCALLUM AND ASSOCIATES  
LIMITEDM. CHEVRIER  
DrillerHole Begun 11/6/55

Foundation Engineering Division

Hole Ended 11/6/55Engineering Data Sheet for Borehole: N<sup>o</sup> 2

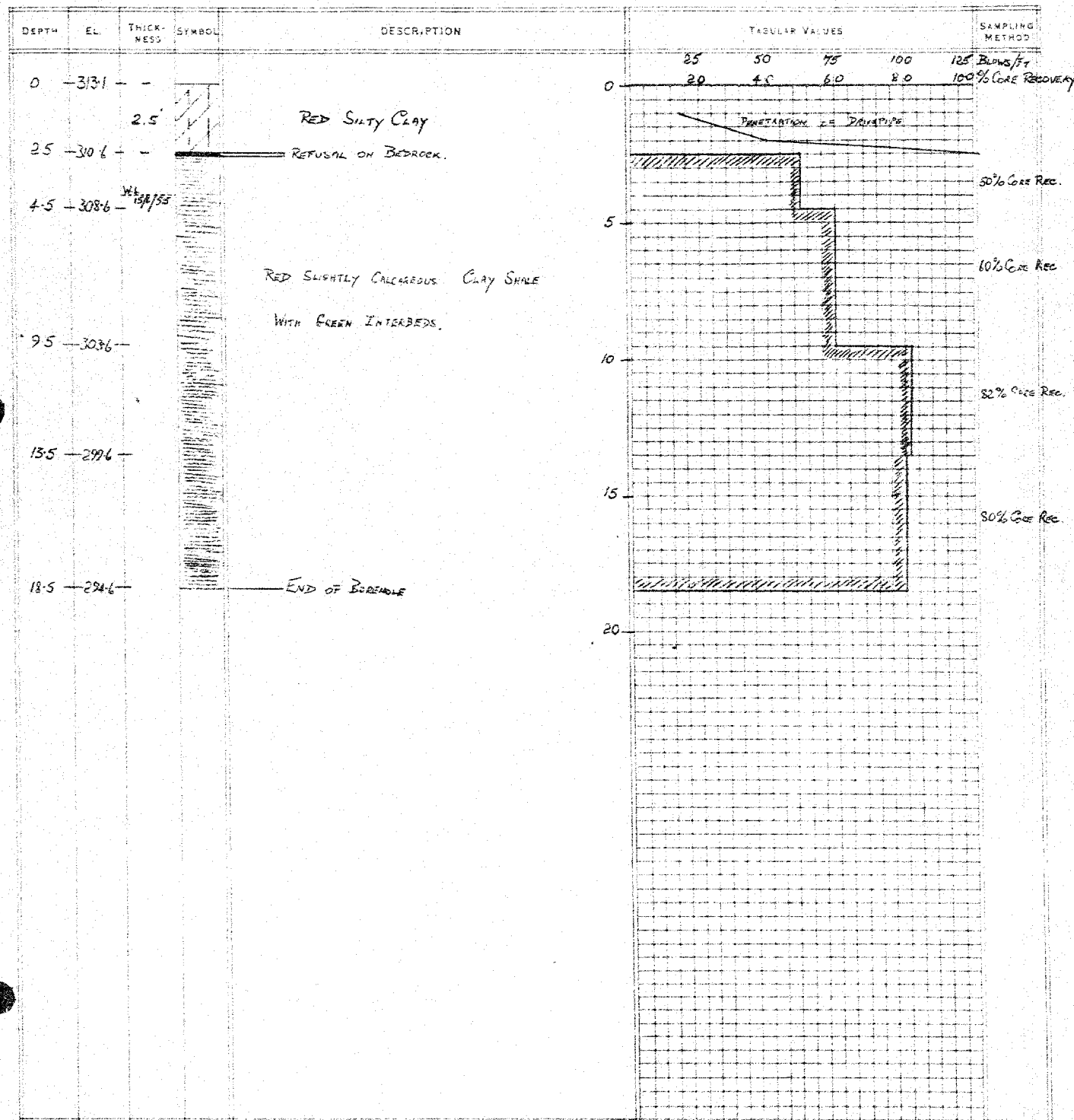
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: AS SHOWN ON ATTACHED SKETCH PLANHole Elevation: 313.1 Datum:11 7 55  
Day Month Year

Order No. 5-500-503/55/T-93 RACEY, MACCALLUM AND ASSOCIATES

LIMITED

M. CHEVRIER  
DrillerHole Begun 13/6/55

Foundation Engineering Division

Hole Ended 13/6/55Engineering Data Sheet for Borehole: 1125

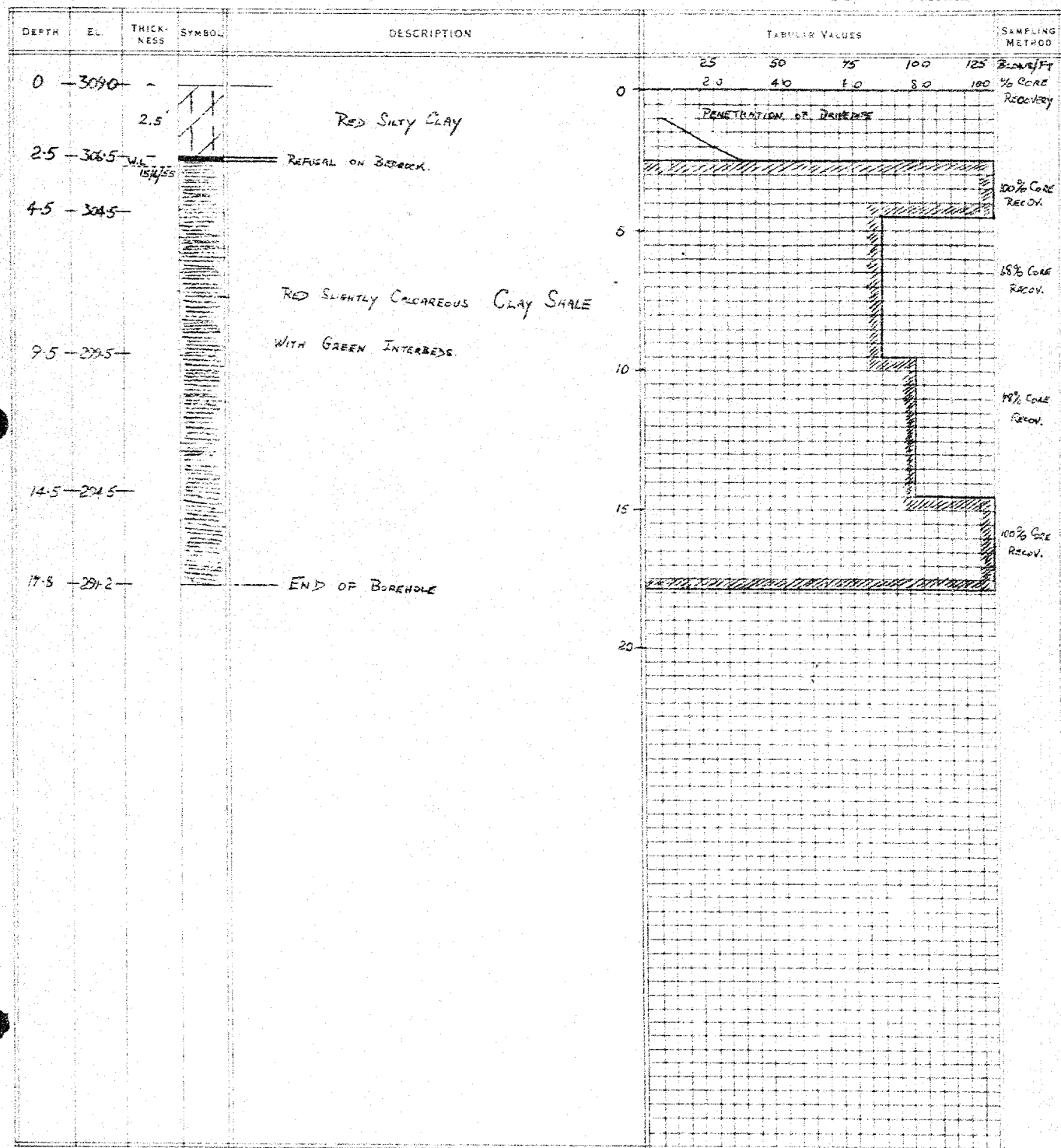
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: As SHOWN ON ATTACHED SKETCH PLAN.Hole Elevation: 302.0 Datum:11 7 55  
Day Month Year

Order No. S-500-505/5/T-93 RACEY, MacCALLUM AND ASSOCIATES  
LIMITEDM. CHEVRIER  
DrillerHole Begun 13/4/55

Foundation Engineering Division

Hole Ended 14/4/55Engineering Data Sheet for Borehole: N<sup>o</sup> 4

Helper

Job Name:

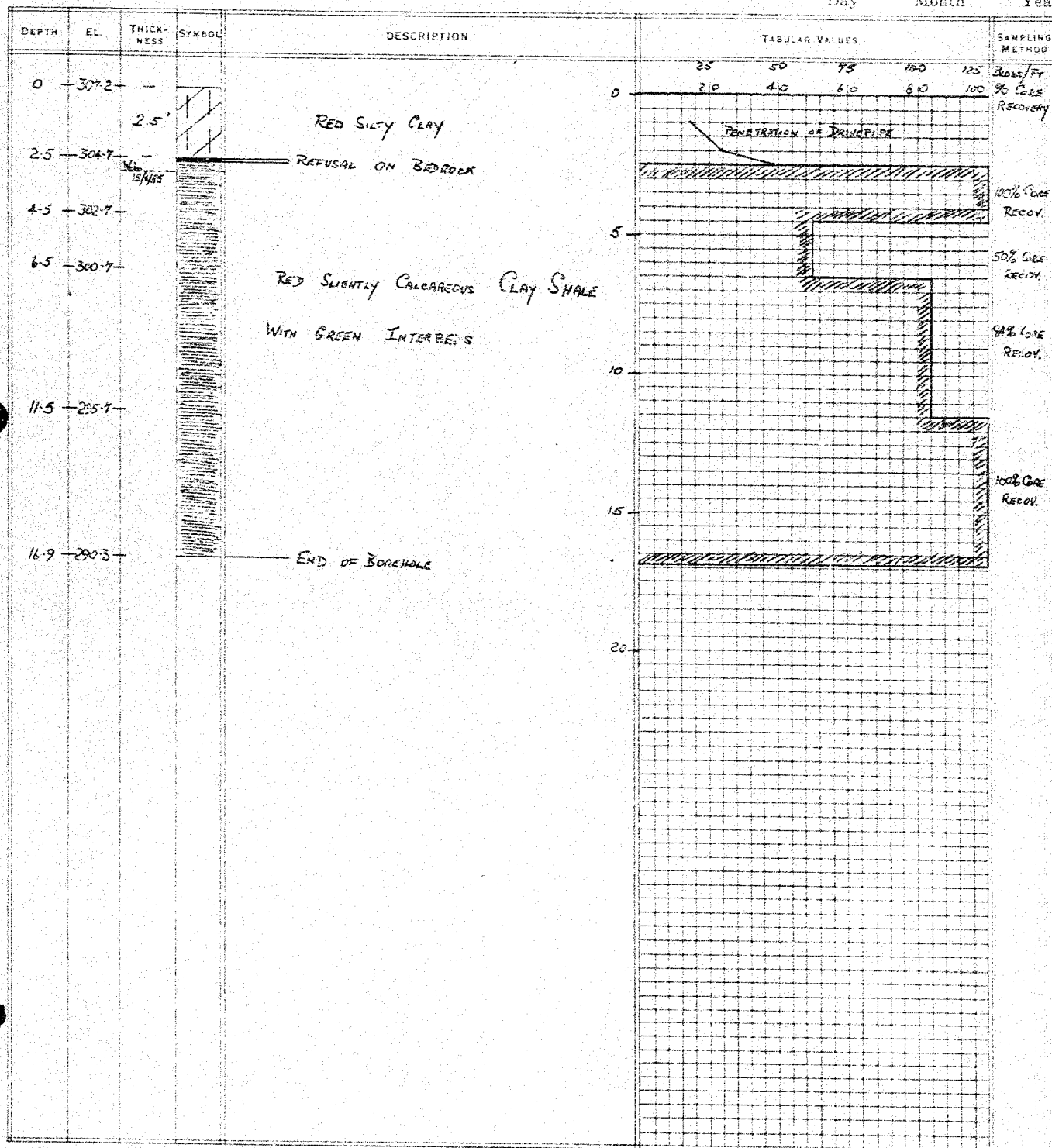
P.E.M.M.

Job Located:

Checked by

Hole Located: As show on ATTACHED SKETCH PLANHole Elevation: 307.2 Datum:

11 Day 7 Month 55 Year



Order No. 5-506-SU/55/T-93 RACEY, MACCALLUM AND ASSOCIATES

LIMITED

M. CHEVRIER  
DrillerHole Begun 14/6/55

Foundation Engineering Division

Hole Ended 14/6/55Engineering Data Sheet for Borehole: N° 5

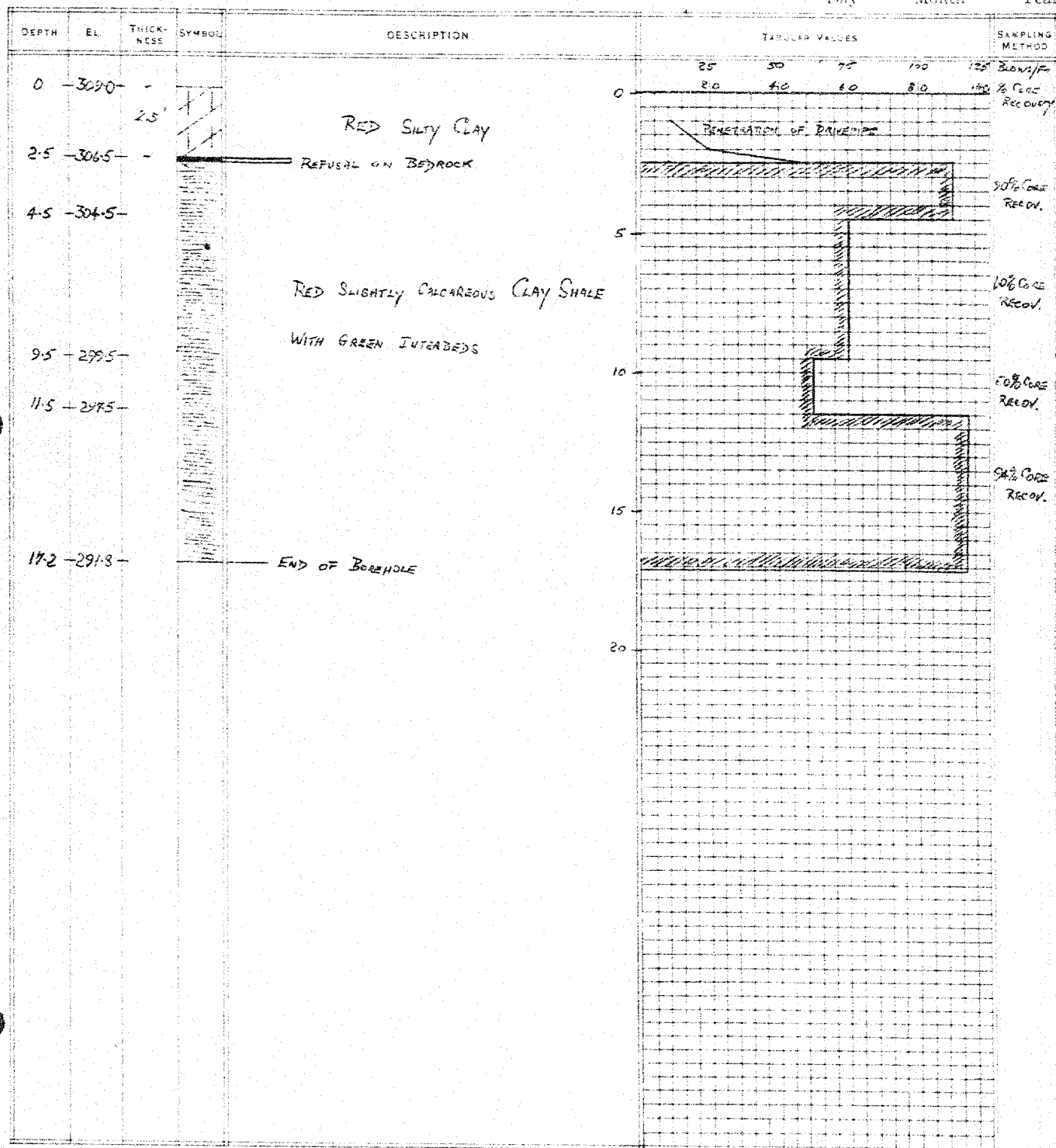
Helper

Job Name:

P.E.M.M.

Job Located:

Checked by

Hole Located: As shown on attached sketch planHole Elevation: 302.0 Datum:12  
Day7  
Month55  
Year

Order No.: S-500-505/55/T-93 RACEY, MACCALLUM AND ASSOCIATES  
LIMITEDM. C. NEYRER  
DrillerHole Begun 12/4/55

Foundation Engineering Division

Hole Ended 15/4/55Engineering Data Sheet for Borehole: NB 6

Helper

Job Name:

Job Located:

Hole Located: As shown on attached sketch planHole Elevation: 309.5 Datum:P.E.M.M.  
Checked by

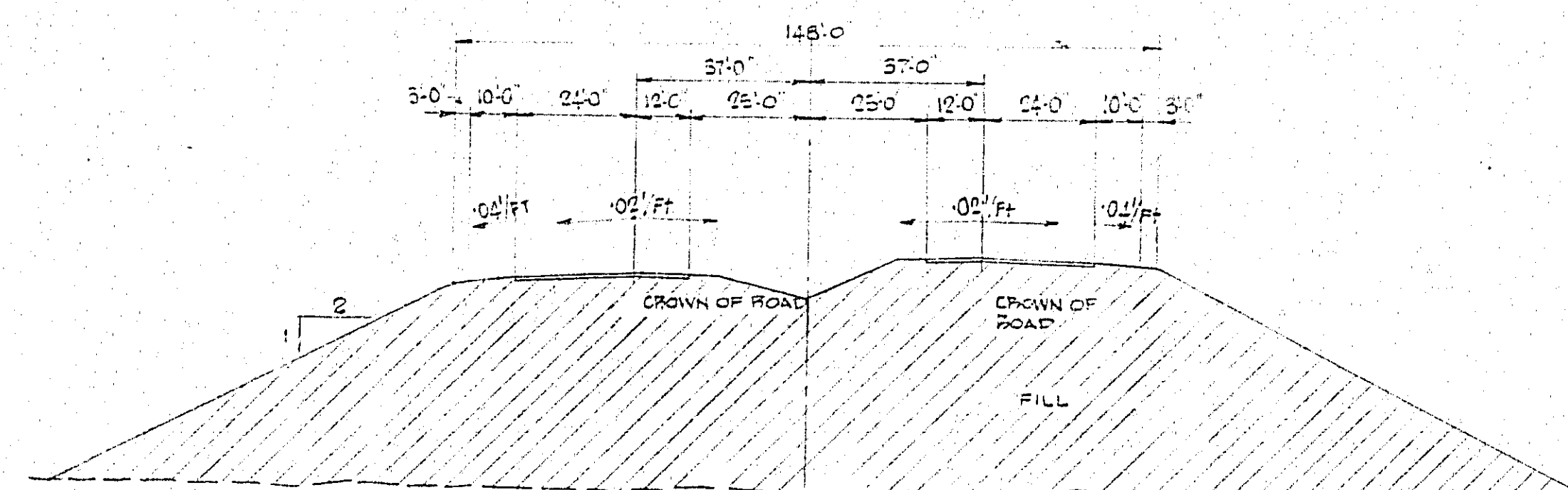
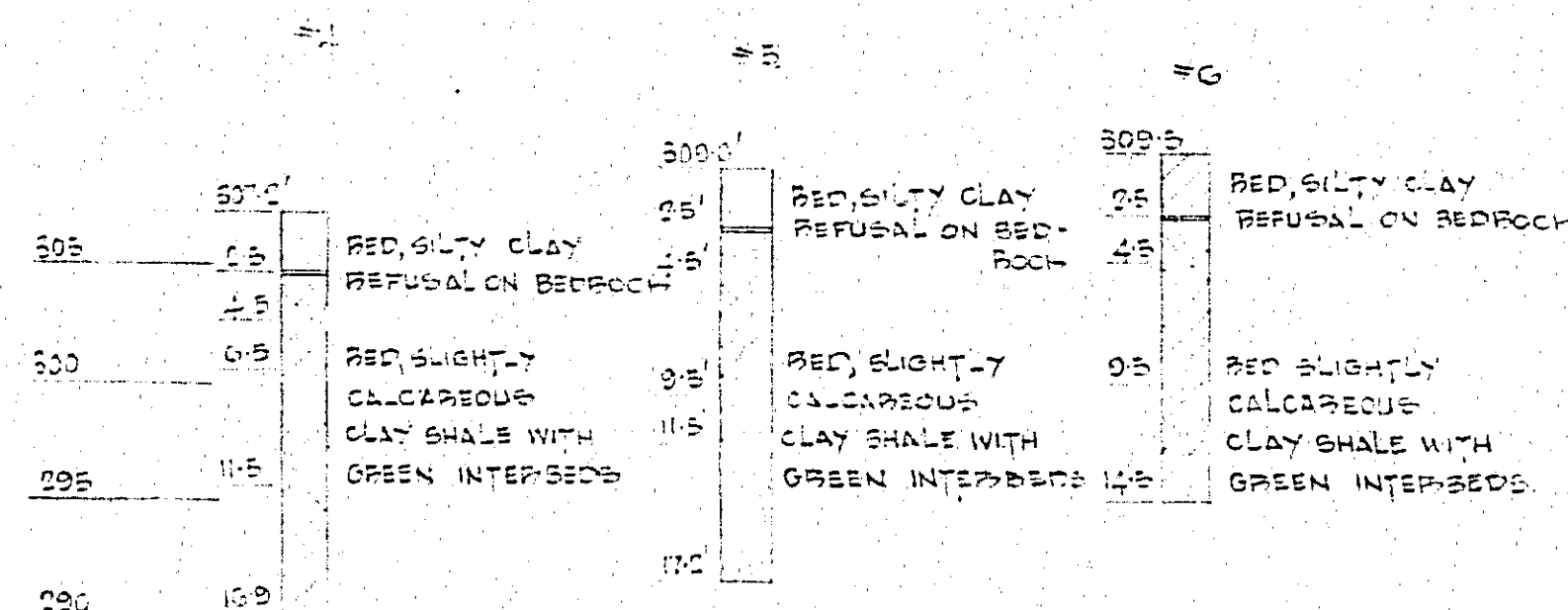
12 Day 7 Month 55 Year

DEPTH	EL.	THICK- NESS	SYMBOL	DESCRIPTION	TABULAR VALUES	SAMPLING METHOD
0	309.5	-			25 50 75 100 125 150 175 200	17.5' BRAND/FI 100% CORE RECOVERED
2.5	307.0	2.5		RED Silty Clay	20 40 60 80 100 120 140 160 180 200	
4.5	305.0	-		REFUSAL OF BED ROCK		42% CORE RECOVERED
9.5	300.0	-		RED SLIGHTLY CALCAREOUS CLAY SHALE WITH GREEN INTERBEDS		16.5% CORE RECOVERED
14.5	295.0	-		END OF BOREHOLE		40.5% CORE RECOVERED



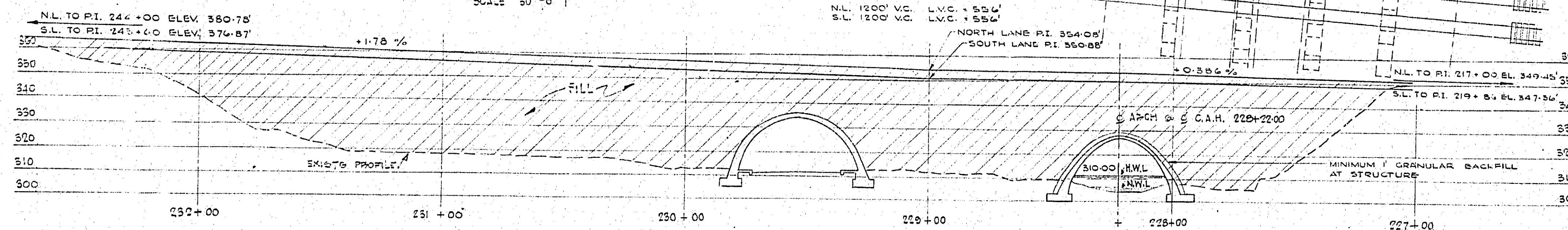
ENGINEERS ARE: EAGER, MACGILLIVRAY & ASSOCIATES LTD - JUNE 1988  
ENGINEERS ARE FOR GENERAL INFORMATION ONLY, AND ARE NOT  
GUARANTEED BY THE DEPARTMENT. THE COMPLETE SOIL INVESTIGATION  
REPORT NR BA-42 MAY BE SEEN AT THE BRIDGE OFFICE DOWNSVIEW.  
THE DEPARTMENT DOES NOT GUARANTEE THE ACCURACY OF THIS  
REPORT NOR THE ABRIDGED VERSION SHOWN HERE.  
LEVEL OF EXISTING GROUND & PROFILE OF CONTROLLED ACCESS.  
HIGHWAY TAKEN FROM D.H.O. PLAN E-2395-1, DATED AUGUST 5, 1980.  
MAXIMUM ALLOWABLE SOIL PRESSURE FOR FOOTINGS =  $\frac{1}{4}$  TONS/50 sq. ft.

#1	#2	#3
310	305	3000
305	300	2950
300	295	2900
295	290	2850
290	285	2800
285	280	2750
280	275	2700
275	270	2650
270	265	2600
265	260	2550
260	255	2500
255	250	2450
250	245	2400
245	240	2350
240	235	2300
235	230	2250
230	225	2200
225	220	2150
220	215	2100
215	210	2050
210	205	2000
205	200	1950
200	195	1900
195	190	1850
190	185	1800
185	180	1750
180	175	1700
175	170	1650
170	165	1600
165	160	1550
160	155	1500
155	150	1450
150	145	1400
145	140	1350
140	135	1300
135	130	1250
130	125	1200
125	120	1150
120	115	1100
115	110	1050
110	105	1000
105	100	950
100	95	900
95	90	850
90	85	800
85	80	750
80	75	700
75	70	650
70	65	600
65	60	550
60	55	500
55	50	450
50	45	400
45	40	350
40	35	300
35	30	250
30	25	200
25	20	150
20	15	100
15	10	50
10	5	0

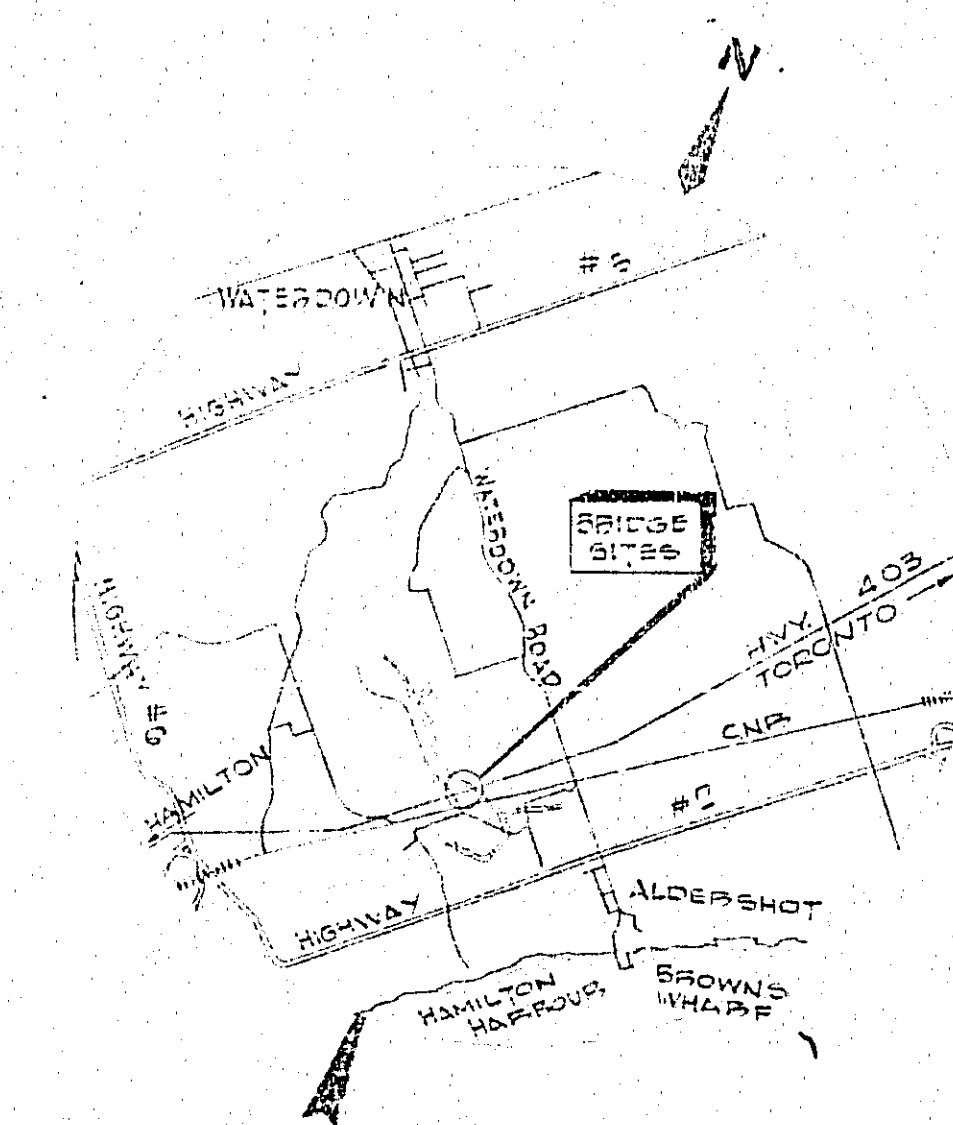
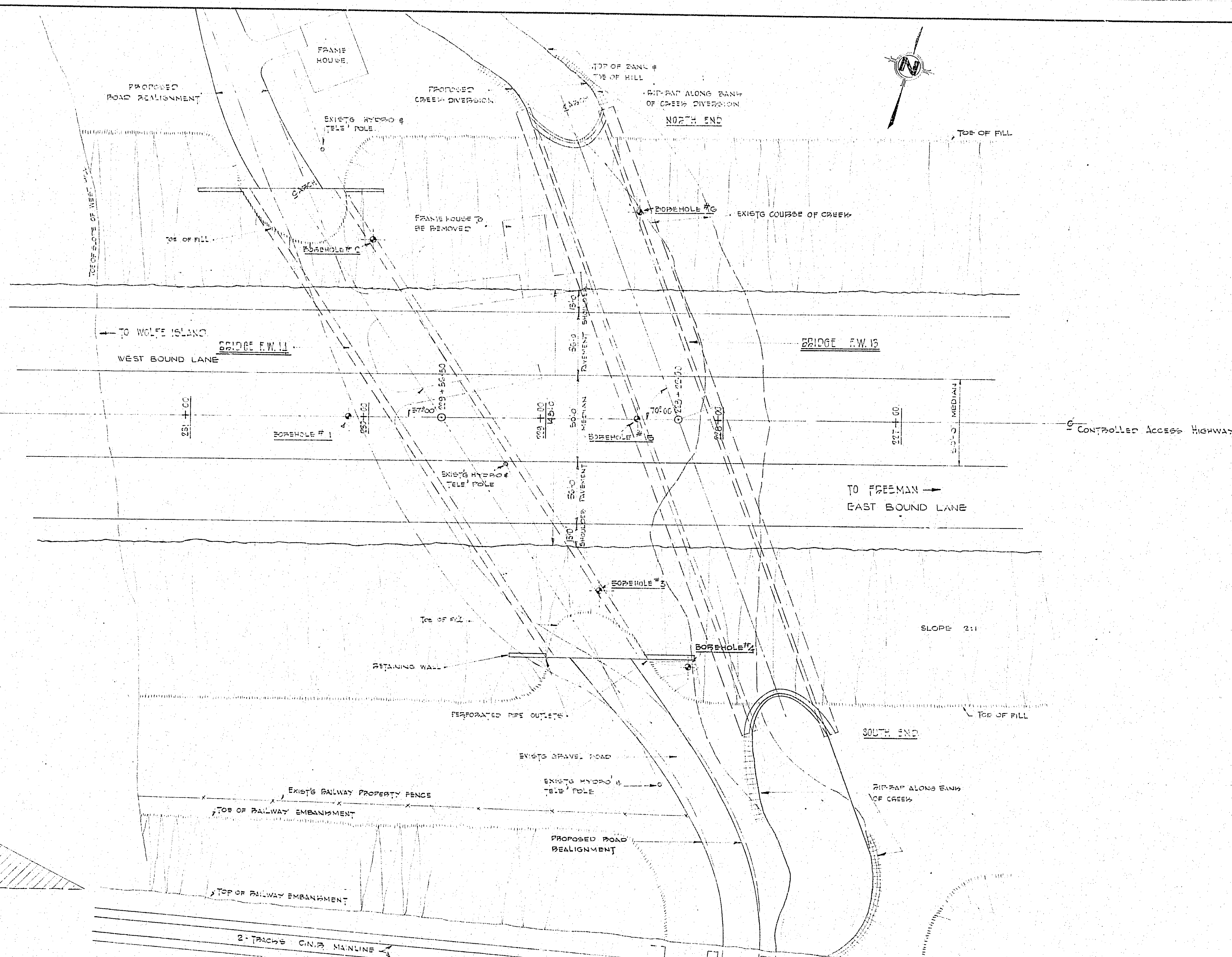


TYPICAL CROSS-SECTION  
THROUGH FILL NEAR STRUCTURE  
SCALE 30' TO 1"

D-3636-1 SITE PLAN  
D-3636-2 PLAN, SECTION & MISC. DETAIL  
D-3636-3 FTS. PLAN, REINF. & MISC. DETAIL  
D-3636-4 PANEL 'A' INTRADOS REINF.  
D-3636-5 PANEL 'X' EXTRADOS REINF.-PANEL 'C' EXTRADOS & INTRADOS, REINF.  
D-3636-6 REINFORCING STEEL SCHEDULE  
D-3636-7 REINFORCING STEEL SCHEDULE  
D-3636-8 REINFORCING STEEL SCHEDULE  
D-3636-9 REINFORCING STEEL SCHEDULE.



PROFILE ON CONTROLLED ACCESS HIGHWAY  
HORIZ: 80' TO 1" SCALE  
0.75' BELOW CROWN OF PAVEMENT VERT: 30' TO 1"



KEY PLAN  
SCALE: 1 IN. = 1 MI.

NOTE TO DISTRICT ENGINEER - CONCRETE WORK ON THIS STRUCTURE MUST NOT BE COMMENCED UNTIL MONUMENTS TO FIX CONTROL POINTS HAVE BEEN ERECTED & CHECKED BY THE DISTRICT ENGINEER.

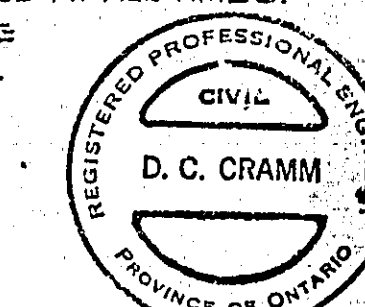
NOTE TO CONTRACTOR - STRUCTURE TO BE BUILT IN ACCORDANCE WITH SPECIFICATIONS FOR STRUCTURES, D.M.O. FORM NO 9, AND THE SPECIAL PROVISIONS, EXTRA COPIES OF WHICH MAY BE OBTAINED FROM THE DISTRICT ENGINEER.

CONCRETE MIX - ALL CONCRETE IN STRUCTURE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 3000 P.S.I. AT 28 DAYS. APPROVED ADMIXTURE SUPPLIED BY CONTRACTOR AND ADDED TO CONCRETE AS DIRECTED BY ENGINEER.

REINFORCING STEEL - CLEAR COVER IN FOOTINGS - 3" CLEAR COVER IN ALL CONCRETE IN CONTACT WITH EARTH OR ROCK - 3" CLEAR COVER IN ALL REMAINING CONC' IN STRUCTURE - 2" EXCEPT WHERE OTHERWISE NOTED. ALL BAR SPLICES TO BE LAPPED 35 DIAMETERS EXCEPT WHERE OTHERWISE NOTED.

CONSTRUCTION NOTES:

1. FOUNDATIONS: FOOTINGS DESIGNED FOR A MAXIMUM ALLOWABLE SOIL PRESSURE OF TONS PER SQ. FT. EXCAVATIONS FOR FOOTINGS TO BE CUT AS NEARLY AS POSSIBLE AND COMPLETELY FILLED WITH CONCRETE.
2. CONSTRUCTION JOINTS SHALL BE MADE ONLY WHERE LOCATED ON THE DRAWINGS UNLESS OTHERWISE APPROVED BY THE ENGINEER. EACH ARCH SECTION MUST BE PLACED CONTINUOUSLY IN ONE POUR.
3. ARCH CHOKING MUST NOT BE STRUCK UNTIL CONCRETE HAS REACHED ITS DESIGN STRENGTH, AND IN ANY CASE NOT LESS THAN 14 DAYS AFTER CONCRETE HAS BEEN PLACED. THE ENGINEER MUST GIVE WRITTEN PERMISSION BEFORE REMOVAL IS BEGUN.
4. FILL OVER ARCH TO BE PLACED EVENLY & SIMULTANEOUSLY ON BOTH SIDES AND FOR THE FULL LENGTH.
5. FILL AGAINST ARCH SHALL BE COMPACTED IN 6" LAYERS.
6. FALSEWORK AT CENTRE OF ARCH TO BE REMOVED FIRST THEN WORKING EACH WAY FROM THE SIDES. THE REMAINING FALSEWORK SHALL BE REMOVED SO THAT THE ARCH SUPPORT IS EQUALLY BALANCED AT ALL TIMES.
7. PROVISION FOR THE DEFLECTION OF FALSEWORK WILL BE MADE BY THE CONTRACTOR IN ADDITION TO THE D.L. DEFLECTION.



W.F. 16-56

SIN	0.939693
COS	0.342020
TAN	2.747477

SIN	0.838071
COS	0.544639
TAN	1.539805

C. C. PARKER AND ASSOCIATES LIMITED  
HAMILTON CONSULTING ENGINEERS. ONTARIO

DEPARTMENT OF HIGHWAYS:-ONTARIO-  
BRIDGE OFFICE:-TORONTO

GRINDSTONE CREEK  
EAST FLAMBOROUGH TOWNSHIP.

BRIDGE FW-13

THE KING'S HIGHWAY No. 403 DIST. No. 4

CO. HALTON

TWP. EAST FLAMBOURGH LOT 8 CON. I

# SITE PLAN

APPROVED

\_\_\_\_\_  
BRIDGE ENGINEER

\_\_\_\_\_  
DESIGN ENGINEER

DESIGN	V. B. A	CHECK	J. A. B	CONTRACT NUMBERS			GENERAL
DRAWING	G. S. N	CHECK	J. A. B				161-227

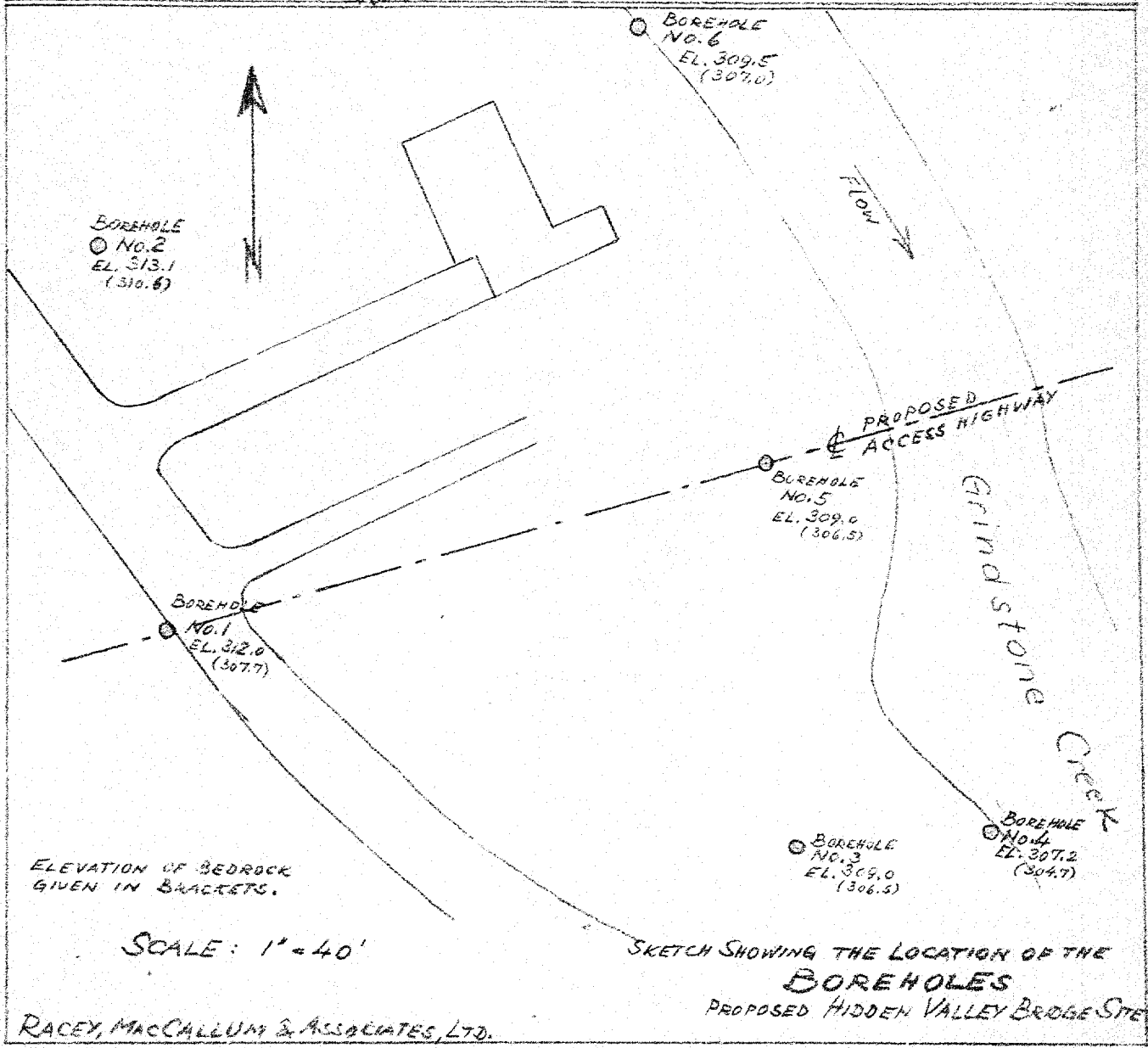
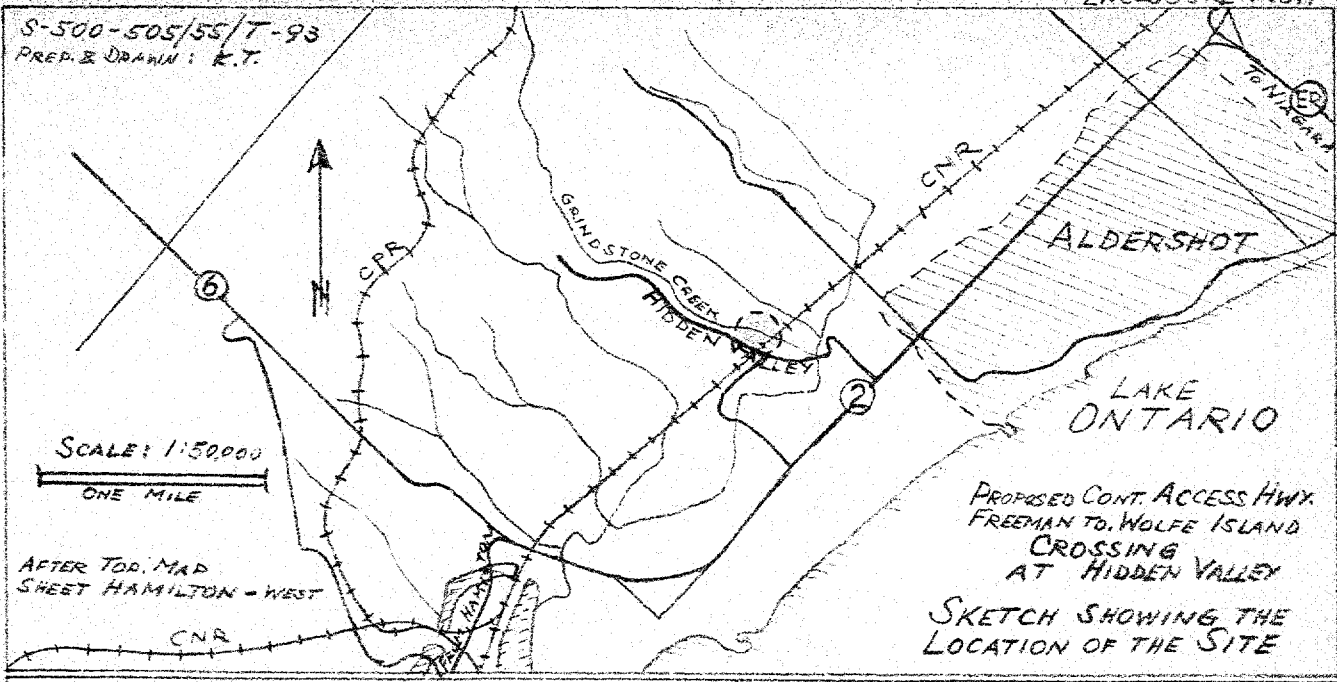
TRACING	F.H.Y	CHECK	D.C.C	LOADING	DRAWING NUMBER
DATE JUNE 29, 1956				H20-51G	D-9553 +

Twp #1337-193-1-A 337-50

~~1-10-193~~

~~D36,6~~  
~~1 to 9~~

S-500-505/55/T-93  
PREP. & DRAWN: K.T.





## **Appendix D**

### **Rock Core Photographs (Present Investigation)**



**PHOTOGRAPHS OF ROCK CORES - BOREHOLE GS-01**

**RUN 1**

Run 1



**TOP**

**Date Drilled: September 27, 2022**

**BOTTOM**

Run #	Depth (ft)	Depth (m)
1	(55'7" – 57')	(16.94 – 17.37)



## **Appendix E**

### **Borehole Location and Soil Strata Drawing**

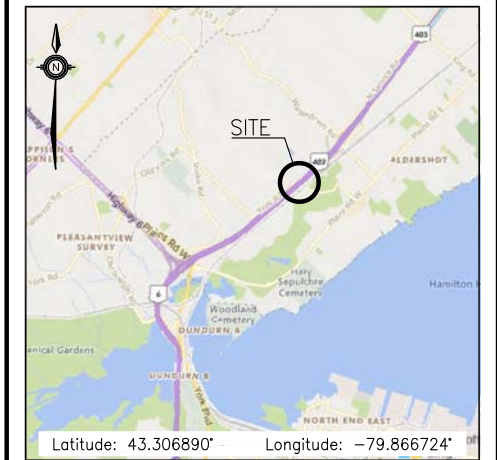
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WO No 16-20004

HIGHWAY 403  
GRINDSTONE CREEK  
CULVERT REHABILITATION  
BOREHOLE LOCATIONS PLAN

AECOM

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole
⊙	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
≡	Water Level
≡	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
1	95.1	4 796 360.5	275 006.9
2	95.4	4 796 385.0	274 988.9
3	94.2	4 796 369.2	275 058.4
4	93.6	4 796 370.4	275 078.3
5	94.2	4 796 394.7	275 042.7
6	94.3	4 796 420.4	275 018.3
GS-01	108.2	4 796 396.1	275 019.1
HV-01	107.3	4 796 352.0	275 027.7

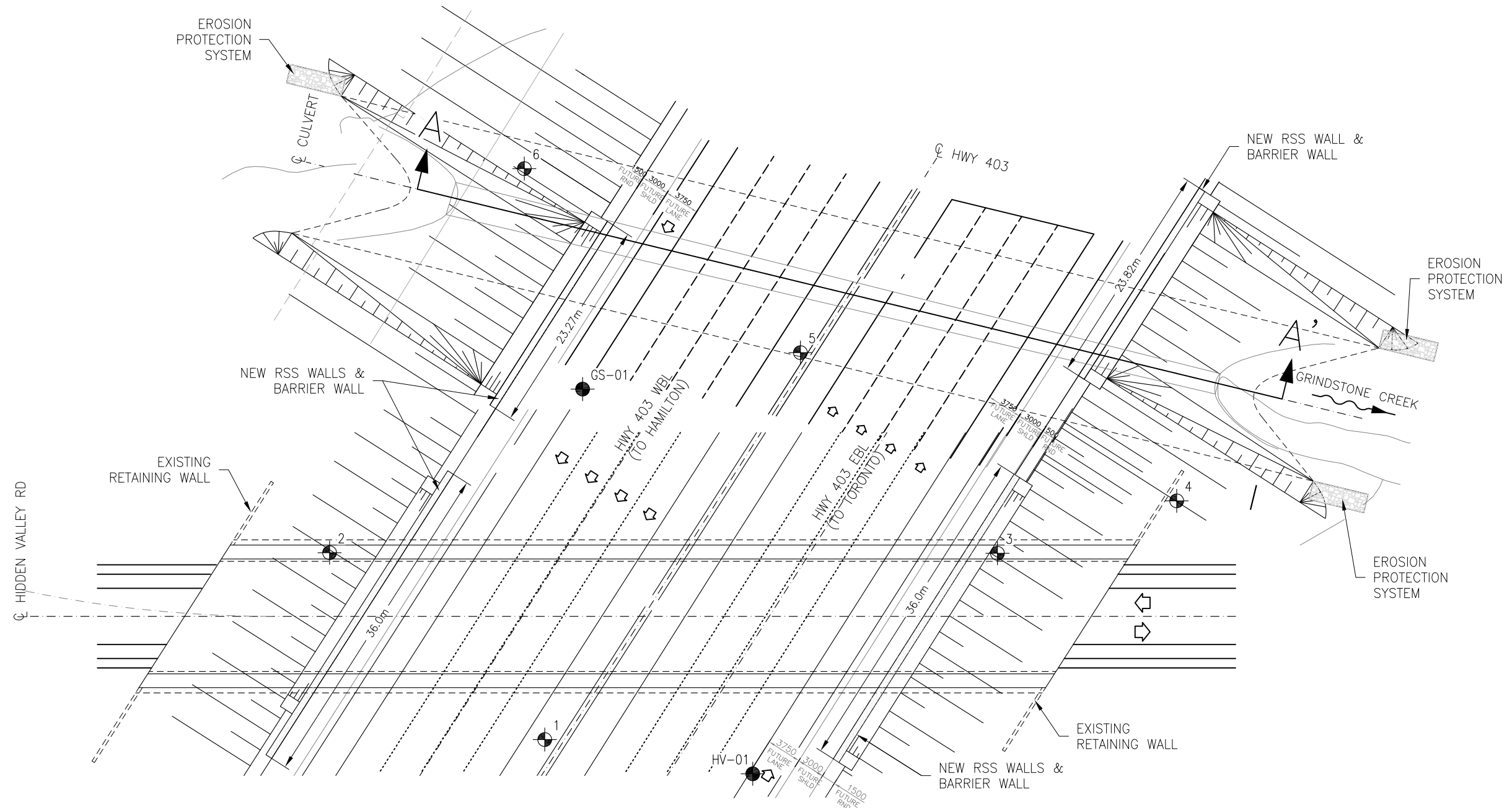
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 30M5-357

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP	CODE
DRAWN	AN	CHK RPR	SITE 10-193/C/STRUCT
			LOAD
			DATE NOV 2023
			DWG 1

FILENAME: H:\Drafting\25000\25963\1ED-25963-FLPR-GS-HV.dwg  
PLOTDATE: 11/7/2023 8:22 AM



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

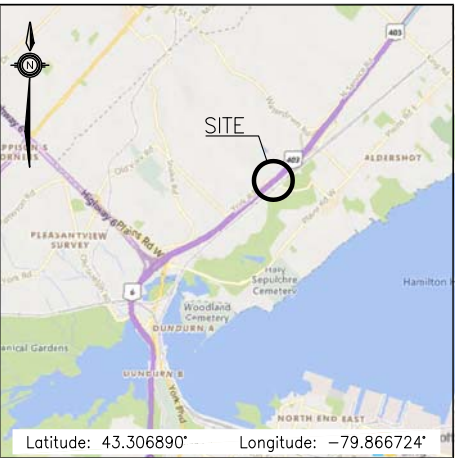
CONT No  
WO No 16-20004

HIGHWAY 403  
GRINDSTONE CREEK  
CULVERT REHABILITATION  
BOREHOLE SOIL STRATA

SHEET

AECOM

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

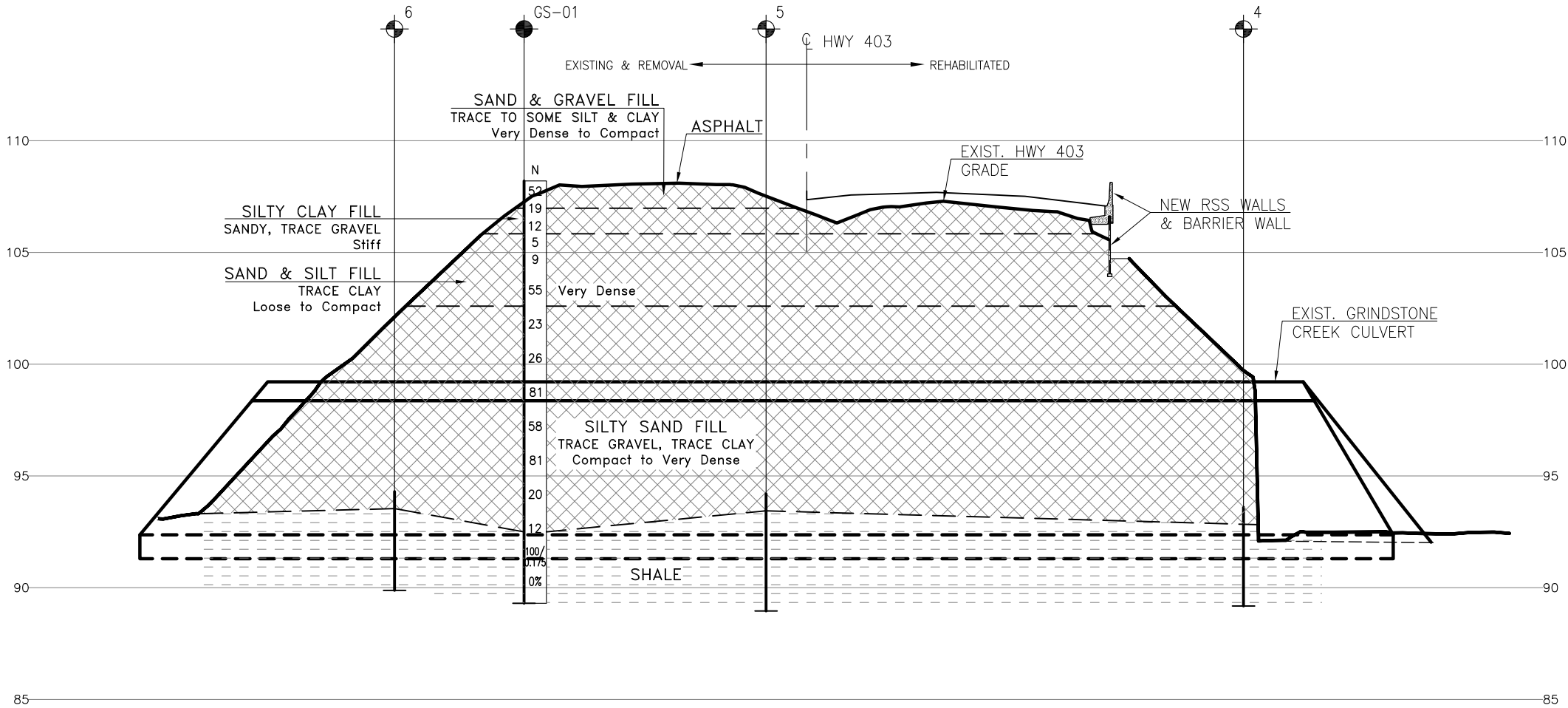
	Borehole
	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
4	93.6	4 796 370.4	275 078.3
5	94.2	4 796 394.7	275 042.7
6	94.3	4 796 420.4	275 018.3
GS-01	108.2	4 796 396.1	275 019.1

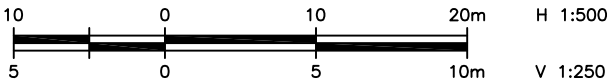
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 30M5-357



PROFILE ALONG GRINDSTONE CREEK CULVERT (A-A')



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP	CODE
DRAWN	AN	CHK RPR	SITE 10-193/C/STRUCT
			LOAD
			DATE NOV 2023
			DWG 2