



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
REED NARROWS BRIDGE REHABILITATION
HIGHWAY 71, TOWNSHIP OF SIOUX NARROWS-NESTOR FALLS
DISTRICT OF KENORA, ONTARIO
W.P. No. 6808-14-03, SITE No. 41S-002**

LATITUDE: 49.432946°, LONGITUDE: -94.013724°

GEOCRES Number: 52E-070

Report

to

McIntosh Perry

Date: December 13, 2018
File: 18879



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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained during a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed rehabilitation of the Reed Narrows Bridge on Highway 71, located in the Township of Sioux Narrows-Nestor Falls, District of Kenora, Ontario.

Thurber previously completed a preliminary foundation investigation and design report, dated December 12, 2018, which presented a description of the subsurface conditions anticipated at the bridge based on existing GEOCRES information, and providing preliminary geotechnical recommendations to assist selection and preliminary design of a foundation system for the possible replacement of the bridge.

The purpose of this investigation was to explore the subsurface conditions at the bridge 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 was retained to carry out the foundation investigation by McIntosh Perry who are completing the detailed design of the bridge rehabilitation under the Ministry of Transportation Ontario (MTO) Agreement Number 6017-E-0001.

2. SITE DESCRIPTION

The Reed Narrows Bridge is located on Highway 71 approximately 6.5 km northeast of Sioux Narrows in the Township of Sioux Narrows-Nestor Falls, District of Kenora, Ontario. The existing bridge carries Highway 71 over Reed Narrows in a generally southwest to northeast direction (construction south to north). Reed Narrows connects Lobstick Bay and Long Bay of Lake of the Woods.



The existing bridge consists of a seven span, two lane structure with a total length of 164.6 m and width of 10.4 m. The span lengths are 24.4 m between piers and 21.3 m at the abutments. The bridge is designed to be supported on 610 mm diameter steel pipe piles at the piers, a concrete footing at the south abutment, and steel H-piles at the north abutment.

The Ontario Structure Inspection Manual (OSIM) report from August 2015 indicates that the structure is in overall good condition, with some areas of scaling, spalling, delamination, cracking and disintegration of concrete components.

Based on the General Arrangement drawing for the existing bridge, road grades on the bridge generally rise towards the south, from Elev. 331.1 m at the north abutment to Elev. 332.7 m at the first pier from the south abutment. On the draft General Arrangement drawing for the current rehabilitation, the water level in Reeds Narrows is reported as Elev. 322.6 m in September 2017.

Photographs of the bridge and surrounding area are presented in Appendix A. Rock fill was observed at the surface at both the north and south approaches. The existing approach embankments appear to be stable. The margins of the narrows are marshy and the adjacent lands are wooded. Bedrock outcrops are visible on the west side of the waterway. The general area of the bridge consists of rock outcrops, forests, swamps and lakes.

The geology of the area generally consists of a sandy till ground moraine with cobbles and boulders, overlying Precambrian bedrock. Glacio-lacustrine deposits comprising varved clays and fine sands occupy low valley areas, and organic deposits have developed in depressions. Based on local geological maps the bedrock in the area is identified as metasedimentary.

3. INVESTIGATION PROCEDURES

The site investigation and field testing program for this project was carried out on July 18 and 19, 2018, and consisted of drilling, sampling and coring of two boreholes, designated Boreholes RN-01 and RN-02, to depths of 7.7 and 18.2 m. Boreholes RN-01 and RN-02 were drilled from the existing road adjacent to the south and north abutments, respectively.

The borehole locations and depths are summarized in Table 3.1. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata drawing in Appendix F. The locations were established in the field relative to site features, and the ground elevations at the boreholes have been interpreted from topographic and cross-section drawings provided by McIntosh Perry. An accuracy of 0.1 m is inferred.



Table 3.1 – Borehole Details

Foundation Unit	Borehole No.	Ground Elevation (m)	Borehole Depth (m)
South Abutment	RN-01	332.7	7.7
North Abutment	RN-02	330.9	18.2

A truck mounted drill rig was used to advance the boreholes using NW casing and wash boring techniques. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Bedrock core samples were recovered in both boreholes using an NQ size diamond drill core barrel.

The field investigation was supervised on a full-time basis by a member of Thurber's technical staff who marked/staked the boreholes in the field, arranged for the clearance of subsurface utilities, directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing. All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions were observed throughout the drilling operations and in the open boreholes upon completion of drilling. The boreholes were backfilled upon completion in general accordance with Ontario Regulation 903 as amended.

4. LABORATORY TESTING

Routine laboratory testing was carried out at Thurber's laboratory. 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 analysis and Atterberg Limits testing. Point Load Testing was carried out on selected rock cores for estimating the unconfined compressive strength of the intact rock. Results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix B and presented on the figures included in Appendix C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix B. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawing included in Appendix F. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. 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 must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered in the boreholes consists of an asphalt layer and approach slab overlying fill comprising gravelly sand, sandy gravel, sand, and rock fill, underlain by bedrock at the west abutment, and by silty clay, sand, and then bedrock at the east abutment. Further descriptions of the individual strata are presented below.

5.1 Asphalt and Concrete

An asphalt surface was encountered in both boreholes and was approximately 125 to 150 mm thick. The underlying approach slab was approximately 225 and 425 mm thick in Boreholes RN-01 and RN-02, respectively.

5.2 Embankment Fill

Fill was encountered below the approach slab at both abutments. At the south approach (Borehole RN-01), the fill consisted of gravelly sand to sandy gravel, with a 1.1 m thick layer of rock fill between depths of 2.7 and 3.8 m. At the north approach (Borehole RN-02), the fill consisted of gravelly sand over a 2.4 m thick layer of rock fill between 3.7 and 6.1 m depth, underlain by sand with some gravel and silt. Cobbles were locally present within the fill.

The fill was underlain by bedrock at 4.5 m depth (Elev. 328.2 m) at the south approach, and by native silty clay at 8.7 m depth (Elev. 322.2 m) at the north approach.

SPT 'N' values in the sand to sandy gravel fill generally ranged from 11 to 41 blows per 0.3 m penetration, indicating a compact to dense condition. One 'N' value of 3 blows per 0.3 m was recorded at the base of the fill in Borehole RN-01, possibly reflecting a very loose condition in the rock fill above the bedrock. Measured moisture contents in the fill ranged from 6 to 12 percent.

The results of grain size distribution analyses conducted on samples of the sand to gravelly sand fill are provided on the Record of Borehole sheets in Appendix B, and illustrated in Figure C1 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	15 to 20
Sand	65 to 70
Silt and Clay	15



5.3 Silty Clay

Silt clay was encountered beneath the sand fill at the north approach (Borehole RN-02) at a depth of 8.7 m (Elev. 322.2 m). The silty clay layer was approximately 1.5 m thick and extended to a depth of 10.2 m (Elev. 320.7 m).

An SPT 'N' value of 10 blows per 0.3 m penetration was recorded in the silty clay, indicating a stiff consistency. A moisture content of 34 percent was measured.

The results of a grain size analysis and Atterberg limits test conducted on a sample of the silty clay are provided on the Record of Borehole sheets in Appendix B, and illustrated in Figures C2 and C4 of Appendix C. The grain size results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	26
Clay	74

The results of Atterberg Limits testing are summarized below:

Index Property	Percentage (%)
Plastic Limit	30
Liquid Limit	72
Plasticity Index	42

The results of the Atterberg Limits test indicate the layer to be of high plasticity with a group symbol of CH.

5.4 Sand

Sand containing some silt and trace gravel was encountered below the clay in Borehole RN-02 at a depth of 10.2 m (Elev. 320.7 m). The sand layer was 4.5 m thick and extended to bedrock at a depth of 14.7 m (Elev. 316.2 m).

SPT 'N' values of 53 and 55 blows per 0.3 m penetration were recorded in the sand, indicating a very dense condition. Measured moisture contents varied from 7 to 17 percent.



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

Soil Particle	Percentage (%)
Gravel	2
Sand	81
Silt and Clay	17

5.5 Bedrock

Bedrock was proven by coring in both boreholes. The table below summarizes depths and elevations to the top of bedrock.

Table 5.1 - Depths and Elevations of Top of Bedrock

Borehole	Location	Top of Bedrock	
		Depth (m)	Elevation (m)
RN-01	South Abutment	4.5	328.2
RN-02	North Abutment	14.7	316.2

The bedrock recovered in the cores was described as slightly weathered, grey to dark grey schist with horizontal, sub-horizontal, and vertical fractures. Total Core Recovery (TCR) in the bedrock was 100 percent and the Solid Core Recovery (SCR) ranged from 89 to 98 percent. The Rock Quality Designation (RQD) determined from the recovered cores ranged from 24 to 73 percent, indicating poor to fair rock quality. Photographs of the recovered rock cores are presented in Appendix D.

Average unconfined compressive strengths (UCS) of the rock ranged between 128 and 190 MPa, indicating a rock strength classification of very strong. The estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes.

5.6 Groundwater Conditions

The groundwater conditions in the open boreholes were observed during and upon completion of drilling operations. Water was not observed in Borehole RN-01 during drilling. In Borehole RN-02, wet conditions were noted during sampling below 9.1 m depth (Elev. 321.8 m), however the borehole sidewalls caved to 1.5 m depth upon completion.



The use of rotary coring techniques introduces water into the boreholes, which impacts the observation of groundwater levels. In general, the stabilized water level at the site is expected to be approximately coincident with the water level in Reed Narrows, reported to be at Elev. 322.6 m in September 2017.

Seasonal fluctuations of the lake and groundwater levels should be expected. In particular, the groundwater and lake water levels may be at a higher elevation after periods of significant or prolonged precipitation, or after snowmelt.

6. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by McIntosh Perry.

George Downing Estate Drilling Ltd. of Ottawa, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. Ryan McCourt, P.Geo. of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory.

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



Thurber Engineering Ltd.



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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This section of the report presents interpretation of the subsurface data in the factual report and presents preliminary foundation recommendations concerning the proposed rehabilitation of the Reed Narrows Bridge located on Highway 71 in the Township of Sioux Narrows-Nestor Falls, District of Kenora.

The existing bridge consists of a seven span, two lane structure with a total length of 164.6 m and width of 10.4 m. The bridge was designed to be supported on 610 mm diameter steel pipe piles at the piers, a concrete footing at the west abutment, and steel H-piles at the east abutment.

We understand that the proposed rehabilitation of the bridge will include conversion of the abutments to a semi-integral configuration. This section of the report addresses the foundation aspects of excavation and temporary roadway protection required to accommodate the semi-integral conversion.

The discussions and recommendations presented in this report are based on the information provided by McIntosh Perry and on the factual data obtained during the investigation.

This foundation design report with the interpretation and recommendations are intended for the use of the McIntosh Perry and Ministry of Transportation of Ontario (MTO), and shall not be used or relied upon for any other purposes or by any other parties including the construction contractor. The contractor must make their own interpretation based on the factual data in the foundation investigation 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.



8. EXCAVATION AND TEMPORARY PROTECTION SYSTEMS

It is understood that conversion of the abutments to a semi-integral design will require excavation to a depth in the order of 2.5 m within the approach embankments adjacent to the abutments. Temporary roadway protection will be required to maintain a single lane of traffic at all times during construction.

All excavation must be carried out in accordance with OPSS 902 and the Occupational Health and Safety Act (OHSA). For the purposes of assessing excavation slope requirements in compliance with the OHSA, the gravely sand to sandy gravel fill within the anticipated excavation depth is classified as a Type 3 soil. Rock fill, if encountered, should also be considered a Type 3 soil. The excavation is expected to remain above the water level in Reed Narrows.

Roadway protection will be required to maintain traffic during abutment construction. Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 and designed for Performance Level 2 (maximum 25 mm horizontal deflection) provided that the existing adjacent roadway can tolerate this magnitude of deflection.

Use of a soldier pile and lagging system may be considered for the roadway protection at this site. Rock fill has been identified in the fill at both abutments, and driving of H-piles is expected to encounter refusal at varying depths in the rock fill as well as on possible cobbles in the granular fill. Predrilling, coring or other means may be required to achieve an adequate depth of embedment to develop the required lateral resistance for the protection system. At the south abutment, the soldier piles will need to be socketed by coring into the underlying very strong bedrock encountered at 4.5 m depth.

Driving or vibrating of steel sheet piles within the rock fill is not expected to be feasible, and the use of sheet pile shoring is not recommended at this site.

The soil parameters in Table 8.1 may apply for design of the temporary roadway protection system with horizontal backfill. The actual pressure distribution acting on the shoring systems is a function of the construction sequence and relative flexibility of the wall and these factors must be considered when designing the shoring system.



Table 8.1 – Soil Parameters for Design of Temporary Protection Systems

Soil Parameter	Existing Embankment Fill
Unit weight, γ	21 kN/m ³
K_a	0.31
K_p	3.3

Partial removal of the protection systems and dewatering measures shall be in accordance with OPSS.PROV 539.

The selection and design of the temporary protection systems and dewatering procedures are the responsibility of the contractor. The roadway protection system should be designed by a licensed Professional Engineer experienced in design of shoring with consideration of adjacent traffic loads, construction operations, and any sloping retained surfaces.

9. ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the structure elements (new abutments) should consist of rock backfill or free-draining granular material conforming to OPS Granular A or B Type II specifications. Rock backfill must be restricted to a maximum dimension of 250 mm. The rock backfill and granular material should be placed to the extents shown in OPSD 3101.200 or 3121.150. Compaction should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501.

Earth pressures acting on the structure may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2014 but generally are given by the expression:

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

where

$$p_h = \text{horizontal pressure on the wall at depth } h \text{ (kPa)}$$

$$K = \text{earth pressure coefficient (see table below)}$$

$$\gamma = \text{bulk unit weight of retained soil (see table below)}$$

$$h = \text{depth below top of fill where pressure is computed (m)}$$

$$q = \text{value of any surcharge (kPa)}$$



The earth pressure coefficients are dependent on the material used as backfill. Recommended unfactored values are shown in Table 9.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for any wingwalls or unrestrained walls.

Table 9.1 – Lateral Earth Pressure Coefficients

Loading Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		Rock Backfill $\phi = 42^\circ, \gamma = 19 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.39*	0.20	0.25*
At-rest (Restrained Wall)	0.43	-	0.33	-
Passive	3.7	-	5.0	-

* For wing walls.

The parameters in the table correspond to full mobilization of active and passive earth pressures, and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.16 of the Commentary to the CHBDC 2014.

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

The design of the abutment walls must incorporate measures such as weep holes and/or subdrains to permit drainage of the backfill and avoid the potential build-up of hydrostatic pressures behind the walls.

10. EMBANKMENT RESTORATION

In general, the existing approach embankments comprise rock fill, sand and gravel and appear to be performing satisfactorily without evidence of instability. Where required, it is recommended that rock fill be used as embankment reconstruction material. After completion of the rehabilitation, the existing embankments should be restored to the existing inclination, but no steeper than 1.25H:1V, in accordance with OPSS.PROV 206.

Embankment slopes comprising exposed granular material must be provided with erosion protection in accordance with OPSS.PROV 804. Typically, rock protection should be provided



over all surfaces with which lake water is likely to be in contact. Rock fill or a vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion.

The embankment slopes should be regularly inspected and any areas of material loss potentially impacting the highway platform should be repaired with rock fill.

11. CONSTRUCTION CONCERNS

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

- Rock fill is present within the existing approach embankments, and cobbles or boulders may be encountered in the granular fill. Equipment capable of excavating the rock fill and handling large boulders will be required for excavation. The rock fill thickness and rock size will vary with location.
- Driving of soldier piles for installation of roadway protections systems may be difficult within the existing approach fill, and predrilling or other means may be required to advance the piles to adequate depth. Use of sheet piles is not recommended.
- The bedrock surface is expected to vary along the length of the roadway protection system, and may be contacted at different elevations between and beyond the borehole locations. Variations in the bedrock surface should be anticipated during shoring installation.
- The bedrock is classified as very strong. Equipment that can penetrate hard rock will be required to construct soldier pile sockets.

Suggested wording for an NSSP alerting the Contractor to these concerns is provided in Appendix E.



12. CLOSURE

Engineering analysis and preparation of this report was carried out by Mr. Cory Zanatta, P.Eng and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



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Review Principal, Designated MTO Contact



Appendix A

Site Photographs



Reed Narrows Bridge Rehabilitation
Site Photographs



Photograph # 1 – West Side of Bridge looking north (July 2018)



Reed Narrows Bridge Rehabilitation
Site Photographs



Photograph # 2 –South Approach looking south (July 2018)



Reed Narrows Bridge Rehabilitation
Site Photographs



Photograph # 3 – North Embankment, East Side (from OSIM August 2015)



Reed Narrows Bridge Rehabilitation Site Photographs



Photograph # 4 – North Approach, looking south (July 2018)



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


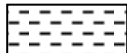



$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 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.

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	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	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
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 RN-01

1 OF 1

METRIC

W.P. 6818-14-03 LOCATION Reed Narrows Bridge, MTM Zone 16: N 5 477 692.1 E 231 197.4 ORIGINATED BY BRM
DIST Kenora HWY 71 BOREHOLE TYPE HW/NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.07.19 - 2018.07.19 LATITUDE 49.432653 LONGITUDE -94.014815 CHECKED BY CZ

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			20 40 60 80 100	W _P W W _L	20 40 60					
332.7	GROUND SURFACE														
0.0	ASPHALT (125mm)														
332.3	CONCRETE (225mm)														
0.4	Gravelly SAND, some silt Compact Brown Moist (FILL)		1	SS	13										
			2	SS	16										
331.1															
1.6	Sandy GRAVEL Compact to Dense Dark Grey Moist (FILL)		3	SS	19										
			4	SS	31										
330.0															
2.7	ROCK FILL														
328.9															
3.8	Sandy GRAVEL Compact to Dense Dark Grey Moist (FILL)		5	SS	3										
328.2															
4.5	BEDROCK (Schist) slightly weathered, strong, grey														
	Sub horizontal fractures at 4.6m, 4.7m, 4.8m, 5.2m, 5.3m, 5.4m, 5.6m, 5.9m, 6.0m and 6.2m		1	RUN											
	Sub vertical fracture (100mm) at 4.7m, 5.0m, 5.4m and 6.1m														
	Vertical fracture at (100mm) at 4.8m														
	Mechanical fracture at 5.6m														
	Sub horizontal fractures at 6.4m, 6.5m, 6.8m, 7.0m, 7.1m, 7.2m and 7.6m		2	RUN											
	Sub vertical fracture (125mm) at 6.5m														
	Horizontal fracture at 6.7m														
325.0															
7.7	END OF BOREHOLE AT 7.7m. BOREHOLE DRY UPON COMPLETION. BOREHOLE CAVED TO 3.9m, THEN BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, SAND TO 0.2m, THEN ASPHALT TO SURFACE.														

ONTMT452 MTO-18879.GPJ 2017TEMPLATE(MTO).GDT 9/27/18

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

RECORD OF BOREHOLE No RN-02

1 OF 2

METRIC

W.P. 6818-14-03 LOCATION Reed Narrows Bridge, MTM Zone 16: N 5 477 750.6 E 231 358.1 ORIGINATED BY BRM
DIST Kenora HWY 71 BOREHOLE TYPE HW/NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.07.18 - 2018.07.18 LATITUDE 49.433199 LONGITUDE -94.012611 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
330.9	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (150mm)							20	40	60	80	100					
0.2	CONCRETE (425mm)							20	40	60	80	100					
330.3								20	40	60	80	100					
0.6	Gravelly SAND, trace silt, with cobbles Compact Brown Moist (FILL)		1	SS	15		330										
			2	SS	11												
							329										
	Wet		3	SS	12												
			4	SS	16		328										
327.2																	
3.7	ROCK FILL						327										
							326										
							325										
324.8																	
6.1	SAND, some gravel, some silt Dense to Compact Brown Moist (FILL)		5	SS	41		324										
			6	SS	23		323										
322.2							322										
8.7	Silty CLAY Stiff Grey Wet (CH)		7	SS	10												
							321										

Continued Next Page

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

RECORD OF BOREHOLE No RN-02

2 OF 2

METRIC

W.P. 6818-14-03 LOCATION Reed Narrows Bridge, MTM Zone 16: N 5 477 750.6 E 231 358.1 ORIGINATED BY BRM
DIST Kenora HWY 71 BOREHOLE TYPE HW/NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.07.18 - 2018.07.18 LATITUDE 49.433199 LONGITUDE -94.012611 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	Continued From Previous Page							20	40	60	80	100				
								20	40	60	80	100				
320.7																
10.2	SAND , some silt, trace gravel Very Dense Grey Wet		8	AS	-		320									
							319									
			9	SS	55		318									2 81 17 (SI+CL)
							317									
			10	SS	53		316									
316.2																
14.7	BEDROCK (Schist) slightly weathered, dark grey Sub vertical fracture at 14.8m, 14.9m, 15.1m, (150mm) at 15.7m, (75mm) at 15.9m and (150mm) at 16.0m Sub horizontal fractures at 15.0m, 15.7m, 15.9m and 16.0m Sub horizontal fracture at 16.1m, 16.2m, 16.3m, 16.4m, 16.5m, 16.6m, 16.7m, 16.9m, 17.1m, 17.4m, 17.6m, 17.7m, 17.8m and 18.1m Vertical fracture (75mm) at 16.3m		1	RUN			316									RUN #1 TCR=100% SCR=98% RQD=52% UCS=179MPa
							315									
			2	RUN			314									RUN #2 TCR=100% SCR=89% RQD=24% UCS=188MPa (Average)
							313									
312.7																
18.2	END OF BOREHOLE AT 18.2m. BOREHOLE CAVED TO 1.5m, THEN BACKFILLED WITH SAND TO 0.2m, THEN ASPHALT TO SURFACE.															

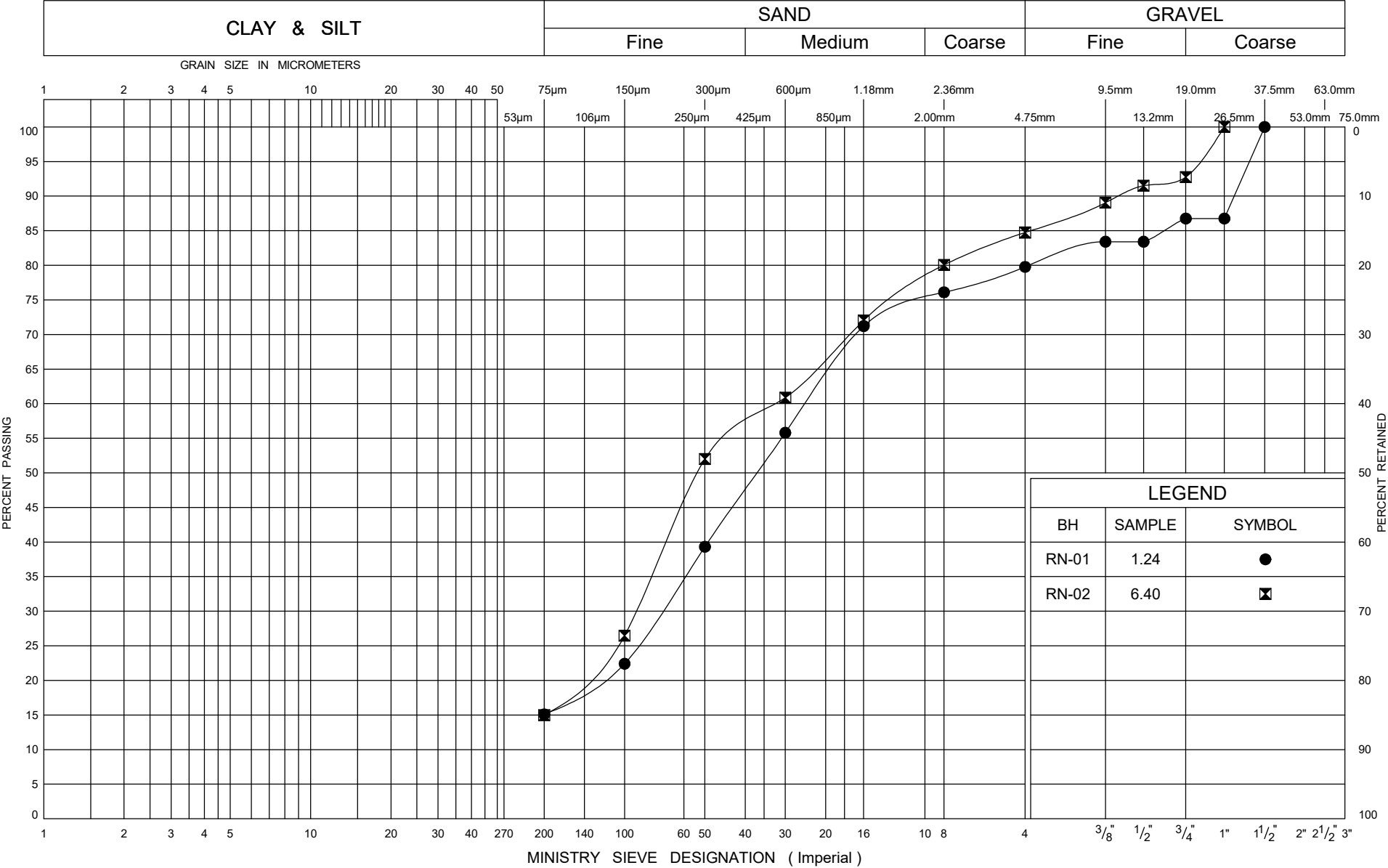
+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 0 (%) STRAIN AT FAILURE



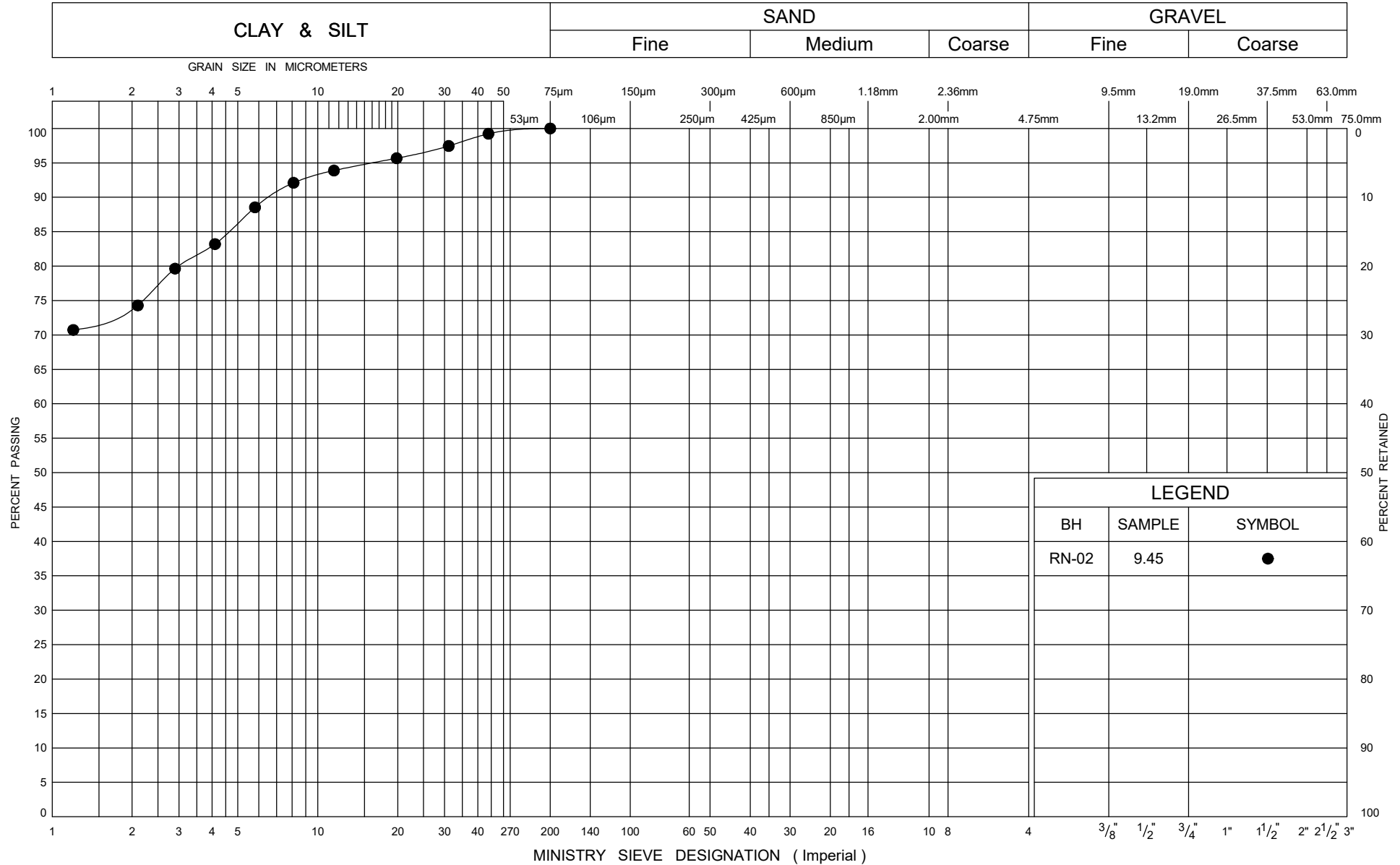
Appendix C

Geotechnical Laboratory Test Results

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

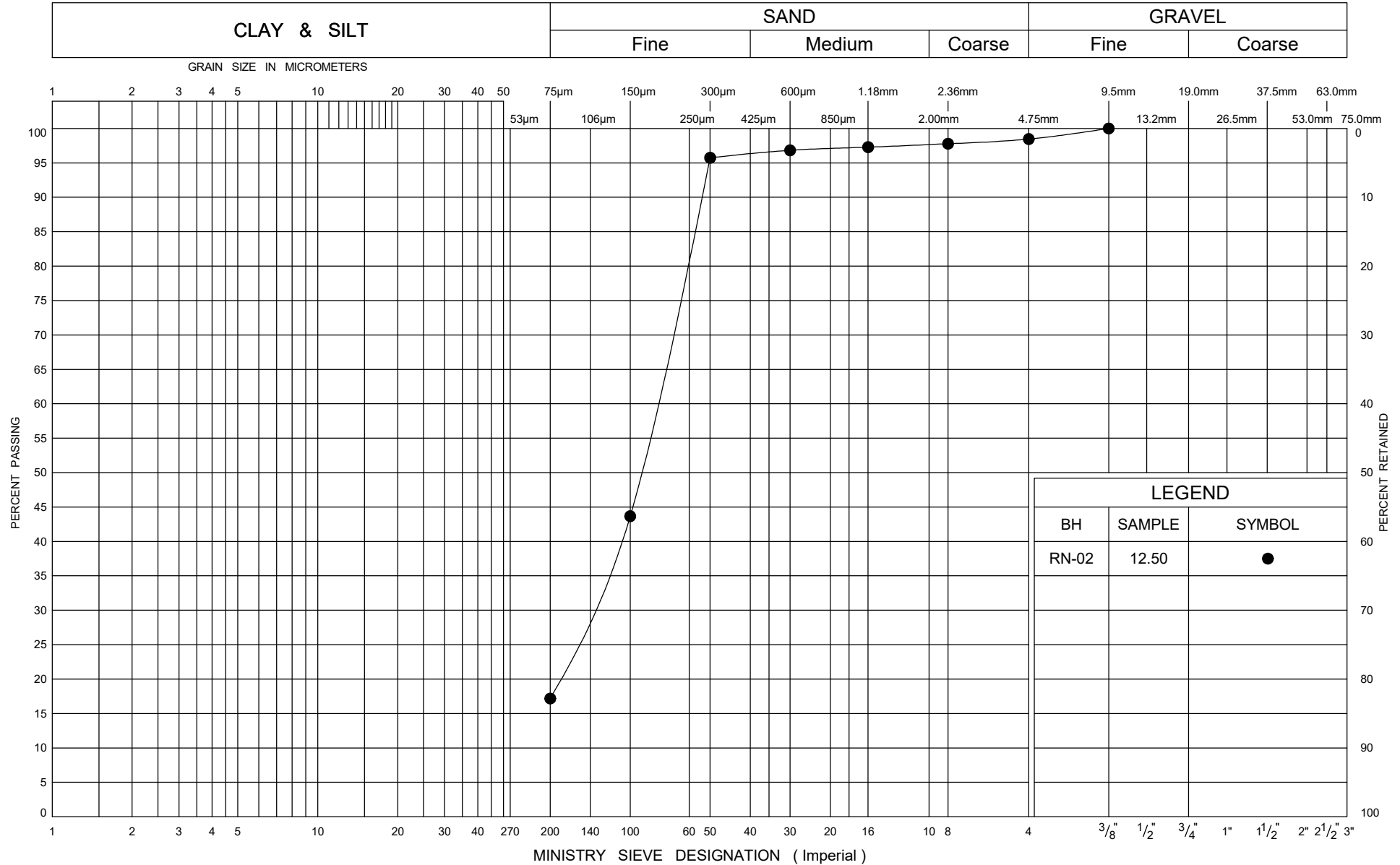
Silty CLAY

FIG No C2

W P 6818-14-03

Reed Narrows Bridge

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

SAND

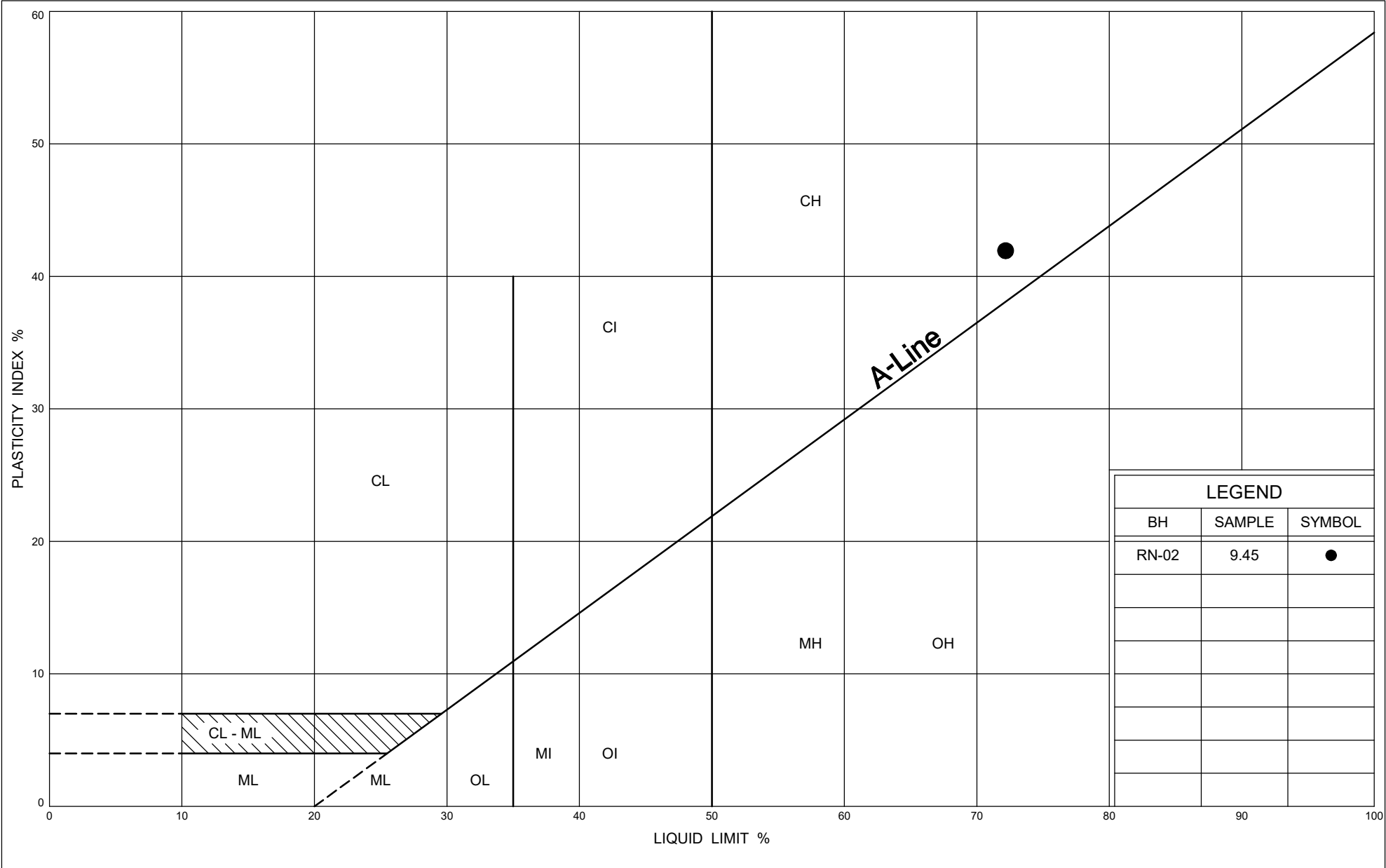
FIG No C3

W P 6818-14-03

Reed Narrows Bridge

ONTARIO MOT PLASTICITY CHART MTO-18879.GPJ ONTARIO MOT.GDT 9/10/18

Oct 75, FF - S - 21





ASTM D5731-08

Date Drilled:	19-Jul-18
Date Tested:	26-Jul-18
Tester:	KF
Reviewed by:	CZ

[illegible]



ASTM D5731-08

Date Drilled:	18-Jul-18
Date Tested:	26-Jul-18
Tester:	KF
Reviewed by:	CZ

[illegible]



Appendix D

Photographs of Rock Core



Reed Narrows Bridge Rehabilitation

Photographs of Bedrock Core

Borehole RN-01, Runs 1 and 2



Borehole RN-02, Runs 1 and 2





Appendix E

OPSS and OPSD References



1. List of OPSS and OPSD Documents Referenced in this Report

- OPSS.PROV 206 (Construction Specification for Grading)
- OPSS.PROV 501 (Construction Specification for Compacting)
- OPSS.PROV 539 (Construction Specification for Temporary Protection Systems)
- OPSS.PROV 804 (Construction Specification for Seed and Cover)
- OPSS.902 (Construction Specification for Excavating and Backfilling – Structures)
- OPSD 3101.150 (Walls, Abutment, Backfill, Minimum Granular Requirement)
- OPSD 3101.200 (Walls, Abutment, Backfill, Rock)

2. Suggested Text for NSSP on “Excavation and Installation of Roadway Protection”

The Contractor is advised of the following site conditions:

- Rock fill is present within the existing approach embankments, and cobbles or boulders may be encountered in the granular fill. Equipment capable of excavating the rock fill and handling large boulders will be required for excavation. The rock fill thickness and rock size will vary with location.
- Driving of soldier piles for installation of roadway protections systems may be difficult within the existing approach fill, and predrilling or other means may be required to advance the piles to adequate depth. Use of sheet piles is not recommended.
- The bedrock surface is expected to vary along the length of the roadway protection system, and may be contacted at different elevations between and beyond the borehole locations. Variations in the bedrock surface should be anticipated during shoring installation.
- The bedrock is classified as very strong. Equipment that can penetrate hard rock will be required to construct soldier pile sockets.



Appendix F

Borehole Locations and Soil Strata Drawing

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



CONT No
WP No 6818-14-03

HIGHWAY 71
REED NARROWS BRIDGE
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

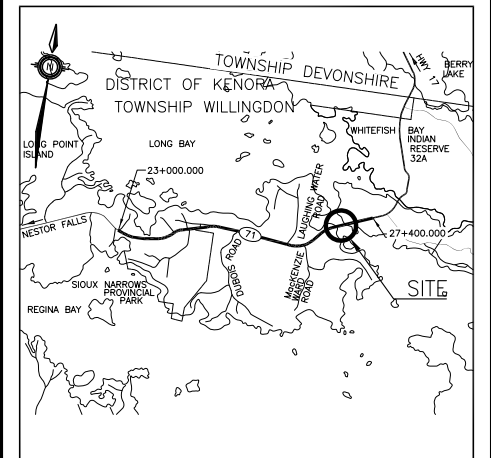


SHEET

McINTOSH PERRY



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

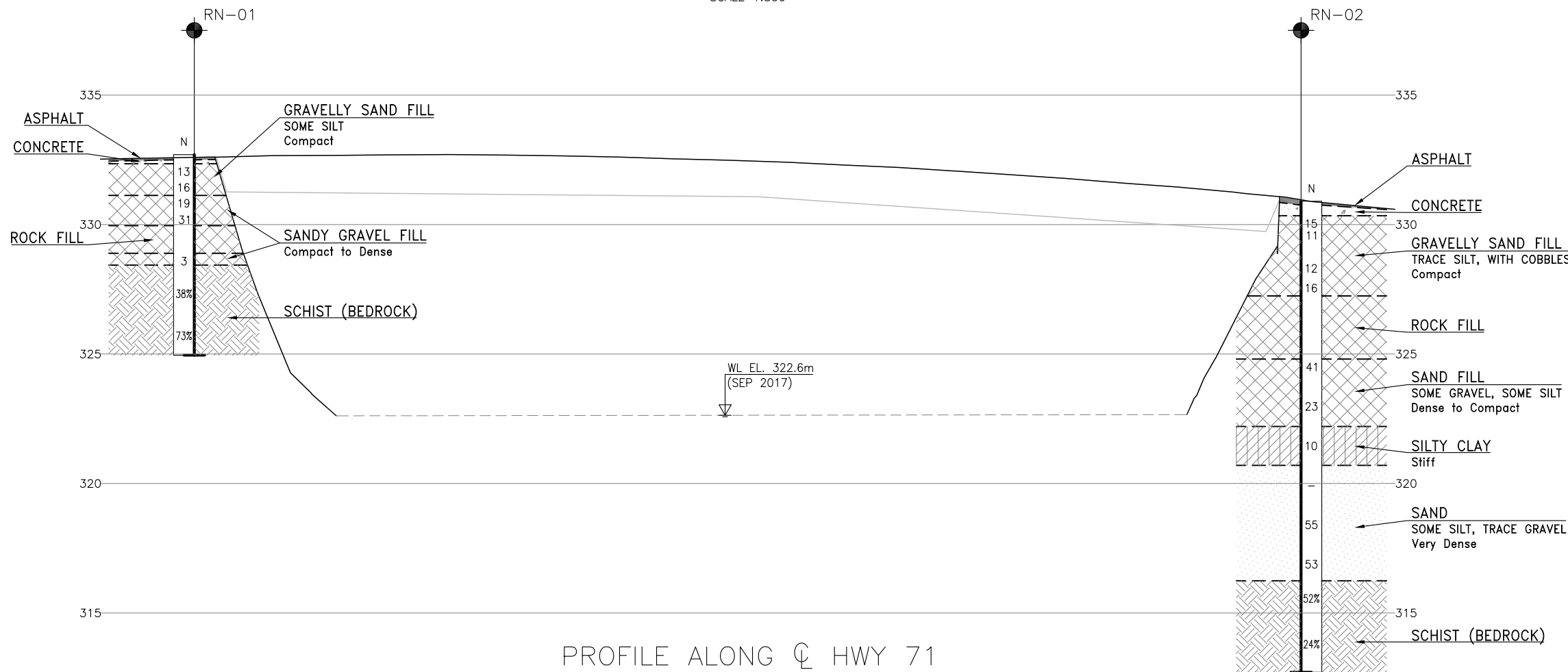
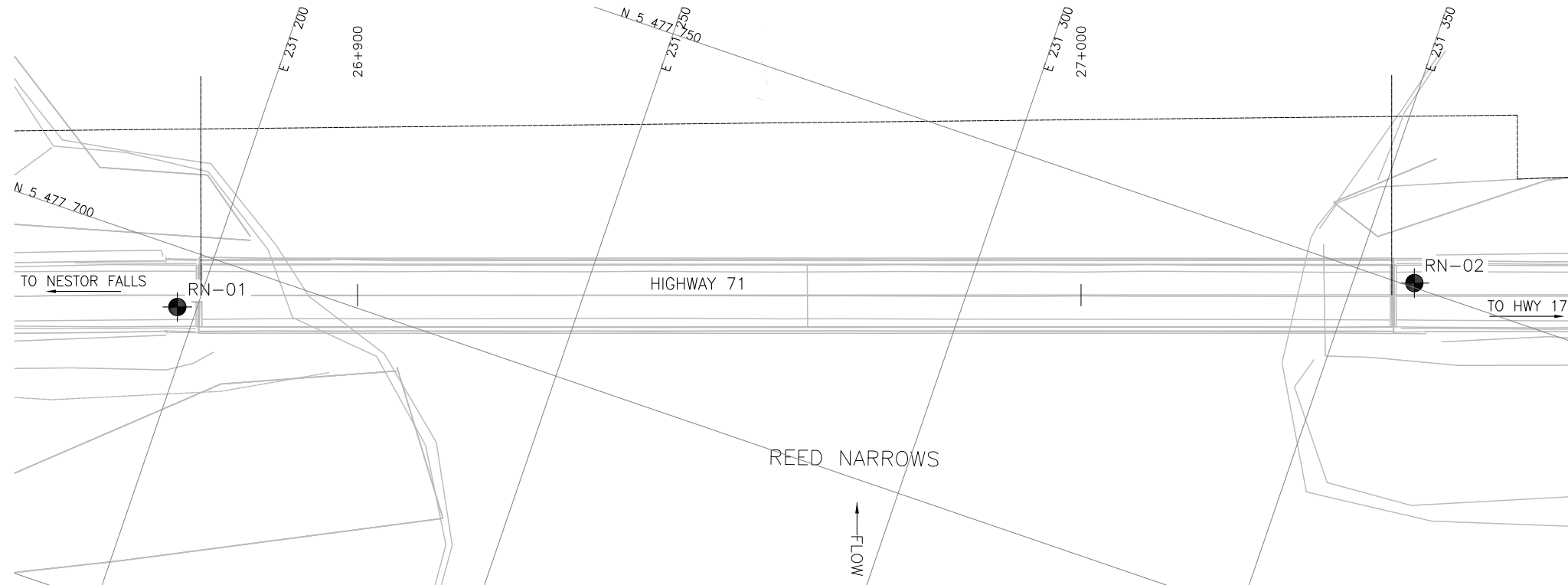
NO	ELEVATION	NORTHING	EASTING
RN-01	332.7	5 477 692.1	231 197.4
RN-02	330.9	5 477 750.6	231 358.1

-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 16.

GEOCRES No. 52E-070

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CZ	CHK MRA	CODE
DRAWN	MFA	CHK CZ	SITE
			LOAD
			DATE DEC 2018
			STRUCT
			DWG 1



PROFILE ALONG \varnothing HWY 71

