December 12, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

HIGHWAY 60 MADAWASKA RIVER BRIDGE SIDEWALK
SITE #43-150, WHITNEY, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5198-10-00, WP 5359-11-01

Submitted to:
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GEOCRES NO.: 31E-341

REPORT

Report Number: 13-1191-0003-R04

Distribution:

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Golder Associates

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PART A

FOUNDATION INVESTIGATION REPORT

HIGHWAY 60 MADAWASKA RIVER BRIDGE SIDEWALK

SITE #43-150, WHITNEY, ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5198-10-00, WP 5359-11-01

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Limited (LEA) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed sidewalk along the south side of the Madawaska River Bridge as part of the rehabilitation of the Bridge on Highway 60, in Whitney, Ontario. The location of the bridge is shown on the Key Plan on Drawing 1.

The Terms of Reference and Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal, dated January 2013. Golder's proposal for foundation engineering services associated with the bridge rehabilitation is contained in Section 6.8 of LEA's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project dated May 10, 2013.

The purpose of this investigation is to establish the subsurface conditions for the proposed sidewalk by methods of borehole drilling, in situ testing and laboratory testing on selected soil samples.

2.0 SITE DESCRIPTION

The Madawaska River Bridge is located on the existing Highway 60 alignment in Whitney. The river banks adjacent to the existing bridge are approximately 5 m high and inclined between about 1 Horizontal and 1 Vertical (1H:1V) and 2H:1V, and are vegetated with grass and small shrubs and trees. The river flows to the north east and is about 20 m wide at the existing bridge location. The existing earth-filled reinforced concrete arch structure has a 30.2 m span and was constructed in 1941. The structure is supported on shallow foundations bearing on bedrock. The Madawaska River water level at the bridge was measured at Elevation 386.7 m on July 30, 2013. Photographs taken at the site are included following the text of this report.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation was carried out on September 8 and 9, 2014, during which time a total of four (4) boreholes were advanced at the site. The locations of the boreholes are shown on Drawing 1.

The boreholes were advanced using a CME-55 track-mounted drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec. The boreholes were advanced to depths to refusal using 108 mm inside diameter hollow stem augers. In general, soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer and performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). The open boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The groundwater conditions in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A. Groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

The fieldwork was observed by a member of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes and examined and cared for the soil samples. The soil samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. Classification testing (water content and grain size distribution) was carried out on selected soil samples.

The as-drilled borehole locations and ground surface elevations were referenced to the existing bridge deck and the locations were subsequently converted into MTM NAD 83 coordinates in AutoCAD. The borehole locations given on the Record of Borehole sheets in Appendix A and shown on Drawings 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

Borehole	MTM NAD 83 Coordinates (m)		Ground Surface Elevation (m)	Borehole Depth m)
	Northing	Easting		
MA1	5 040 127.4	403 340.9	392.9	5.9
MA2	5 040 133.3	403 343.7	392.9	6.8
MA3	5 040 153.4	403 316.4	393.1	6.8
MA4	5 040 157.1	403 320.6	393.1	6.7

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on NOEGTS[1] mapping, the subsoils at the bridge site consists of bedrock outcrops separated by organic deposits and glaciofluvial deposits.

Published literature indicates that the bedrock in the area typically consists of migmatic rocks and gneisses within the Central Gneiss Belt, a subdivision of the Grenville Structural Province (OGS, 1991)[2].

4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets and on Figure A1, respectively, in Appendix A. Stratigraphic profiles of the subsurface conditions along the south (sidewalk) and north (parapet wall) sides of the bridge are presented on Drawings 1 and 2, respectively. The stratigraphic boundaries shown on the Record of Borehole sheets and on Drawings 1 and 2 are inferred from non-continuous sampling, observations of drilling progress and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

1 Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping.

2 Ontario Geological Survey, 1991. Geology of Ontario, Special Volume 4, Part 1. Eds P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott, Ministry of Northern Development and Mines, Ontario.

Detailed descriptions of the subsurface conditions are provided in the following sections.

Embankment Fill

Boreholes MA1 to MA4 were advanced through the existing roadway and encountered a 100 mm thick layer of asphalt with the roadway surface ranging from Elevations 393.1 m to 392.9 m. Below the asphalt, between 5.8 m and 6.7 m of embankment fill consisting of sand to sand and gravel was encountered.

The SPT 'N'-values measured within the fill range between 2 blows and 45 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The grain size distribution of eight samples of the fill are shown on Figure A1.

The natural water content measured on the samples of the fill is between 2 and 6 per cent.

Refusal

Auger refusal was encountered in each of the boreholes at depths ranging from 5.9 m to 6.8 m below ground surface, corresponding to between Elevations 387.0 m and 386.1 m.

Groundwater Conditions

Borehole MA1 was noted to be dry upon completion of drilling. In Boreholes MA2 to MA4, the water level was measured at depths of 5.9 m and 6.0 m below ground surface upon completion of drilling corresponding to between Elevations 387.2 m and 386.9 m. The river water level measured in July 2013 is Elevation 386.7 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events and the adjacent river water level.

5.0 CLOSURE

The drilling program was supervised by Matt Thibeault and this report was prepared by Tibor Berecz. The technical aspects were reviewed by André Bom, P.Eng., and Jorge M. A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this project, carried out a quality control review of the report.

Report Signature Page

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PART B

FOUNDATION DESIGN REPORT

HIGHWAY 60 MADAWASKA RIVER BRIDGE SIDEWALK

SITE #43-150, WHITNEY, ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5198-10-00, WP 5359-11-01

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides an interpretation of the factual geotechnical data obtained during the subsurface investigation and recommendations on the foundation aspects of design of the proposed works. The recommendations provided are intended for the guidance of the design engineer. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the subsurface information provided as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

6.1 General

Golder has been retained by LEA to provide foundation design recommendations for the replacement of the south sidewalk, south and north barrier walls and curbs as part of the rehabilitation for the Madawaska River Bridge on Highway 60, in Whitney, Ontario.

Based on design drawings dated June 1941, the arch structure is supported on shallow footings founded on bedrock at about Elevation 385.7 m. The existing arch bridge deck is at about Elevation 393 m and the river water level is at about Elevation 386.7 m (July 2013).

At midspan, the concrete deck is supported directly on the concrete arch for a distance of 11.6 m and on granular/earth fill beyond the arch to the east and west abutments. The existing south sidewalk is constructed of timber and was installed structurally connected to the bridge as part of the rehabilitation of the bridge in 1966.

Based on information provided by LEA, we understand that the new concrete sidewalk within the deck portion of the arch will be dowelled into the south end of the deck. Beyond the deck portion of the arch, the 1.80 m wide cantilever sidewalk platform overhang will be counterbalanced by a 2.75 m wide longitudinal (strip) footing founded at a depth of 1 m depth below the pavement surface to anchor the sidewalk, the new railing and barrier curb. The existing north curb and barrier wall will be replaced by a new parapet wall supported on a 3.00 m wide longitudinal (strip) footing also founded at a depth of 1 m below the pavement surface, similar to that proposed for the south side sidewalk. Temporary roadway protection will be required to facilitate excavations within the footprint of the arch. The geotechnical axial resistances and geotechnical reactions and lateral resistance recommended for structural design of the gravity based cantilever elements are given in Section 6.3 and 6.4 respectively.

The current foundation investigation and design is limited to the gravity-based cantilever sidewalk and barrier walls. Based on grading sections provided by LEA, a minor volume of new rock fill (up to about 1 m thick) will be placed at the approaches to the sidewalk and to fill shallow depressions in some areas of the abutment side slopes. Given the limited volume of fill to be placed for grading purposes, embankment stability and settlement is not a concern. However, if a greater volume of fill is required for the approaches and for the slopes adjacent to the river than currently shown on the grading sections, foundation investigation and design should be completed for these areas.

6.2 Frost Protection

The estimated frost penetration depth for the Whitney area is 1.8 m, as per OPSD 3090.101 (Foundation, Frost Penetration Depths for Southern Ontario). However, as the strip footings for the cantilever sidewalk platform and parapet wall will be founded on existing free draining granular fill and the depth to the groundwater level is relatively great (i.e., at/near the bottom of the boreholes, about 6 m below the roadway surface near the existing river water level), additional soil cover or insulation for frost protection for the footings is not required.

6.3 Geotechnical Resistance

The proposed 2.75 m wide footing of the gravity-based cantilever sidewalk platform along the south side of the bridge is to be founded at a depth 1 m below the pavement surface, supported on the very loose to compact existing granular fill deposit. Similarly, the 3.00 m wide footing for the proposed parapet wall along the north side of the bridge is to be founded at a depth of 1 m below the pavement surface, supported on the very loose to dense existing granular fill deposit. The recommended factored geotechnical axial resistance at Ultimate Limit States (ULS) for a 2 m to 3 m wide footing constructed on a properly prepared subgrade is 200 kPa. The geotechnical axial reaction at Serviceability Limit States (SLS) for 25 mm settlement for design of this footing is 75 kPa. The geotechnical resistances provided are for loads applied perpendicular to the surface of the footing. Where loads are not applied perpendicular to the base of the footing, inclination of the loads should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the Canadian Highway Bridge Design Code (CHBDC, 2006) and its Commentary.

Should greater ULS resistance or SLS reaction than that provided above be required to accommodate the design of the sidewall/parapet wall, the deep foundation system would likely have to extend to bedrock, the presence of which would have to be confirmed.

6.4 Resistance to Lateral Loads/Sliding Resistance

Resistance to lateral forces/sliding resistance between the base of the concrete footing and the existing granular fill should be calculated in accordance with Section 6.7.5 of the CHBDC. For cast-in-place concrete constructed directly on the granular fill, the coefficient of friction, tan δ, can be taken as 0.50 (NAVFAC, 1982). This value is unfactored.

6.5 Construction Considerations

All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended). The fill is considered to be Type 3 soil and open cut (unsupported) excavation should be made with side slopes no steeper than 1H:1V. Provisions for traffic control measures should be included in the Contract Documents to maintain the safe operation of Highway 60 during the excavation and backfilling operations. Provision of protection of the existing pavement structure may be required in accordance with MTO's OPSS 539 (Temporary Protection Systems), designed to meet Performance Level 2.

All loose, softened or disturbed subgrade soil should be removed immediately prior to placement of concrete. Construction and inspection of the footings should be carried out in accordance with OPSS 902 (Excavating and Backfilling – Structures).

The excavation above and surrounding the sidewalk and parapet wall footings should be backfilled with Granular ‘A’ or Granular ‘B’ Type II meeting the requirements in OPSS.PROV1010 (Aggregates) and the new fill should be compacted to 100 per cent of the SPMDD. Inspection and field density testing should be carried out by qualified personnel during fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

At the approaches to the sidewalk, new fill should be keyed into the existing embankment side slope or cut slopes as per the requirements of OPSD 208.010 (Benching of Earth Slopes) to minimize differential settlement between the existing embankment slopes and the newly placed embankment fill.

7.0 CLOSURE

This report was prepared by André Bom. Mr. Jorge M. A. Costa, P.Eng., Golder’s Designated MTO Contact for this project and a Principal with Golder, reviewed the technical aspects of and conducted an independent quality control review of the report.

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REFERENCES

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping.

Ontario Geological Survey, 1991. Geology of Ontario, Special Volume 4, Part 1. Eds P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott, Ministry of Northern Development and Mines, Ontario.

Unified Facilities Criteria, U.S. Navy. 1982. NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures. Alexandria, Virginia.

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

Ontario Occupational Health and Safety Act:

Ontario Regulation 213	Construction Projects (as amended)

Ontario Provincial Standard Drawings:

OPSD 208.010	Benching of Earth Slopes
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specification:

OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 902	Construction Specification for Excavating and Backfilling – Structures
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Water Resources Act:

Regulation 903	Wells (as amended)

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5359-11-01

SHEET

HIGHWAY 60
MADAWASKA RIVER BRIDGE SIDEWALK
BOREHOLE LOCATIONS AND SOIL STRATA

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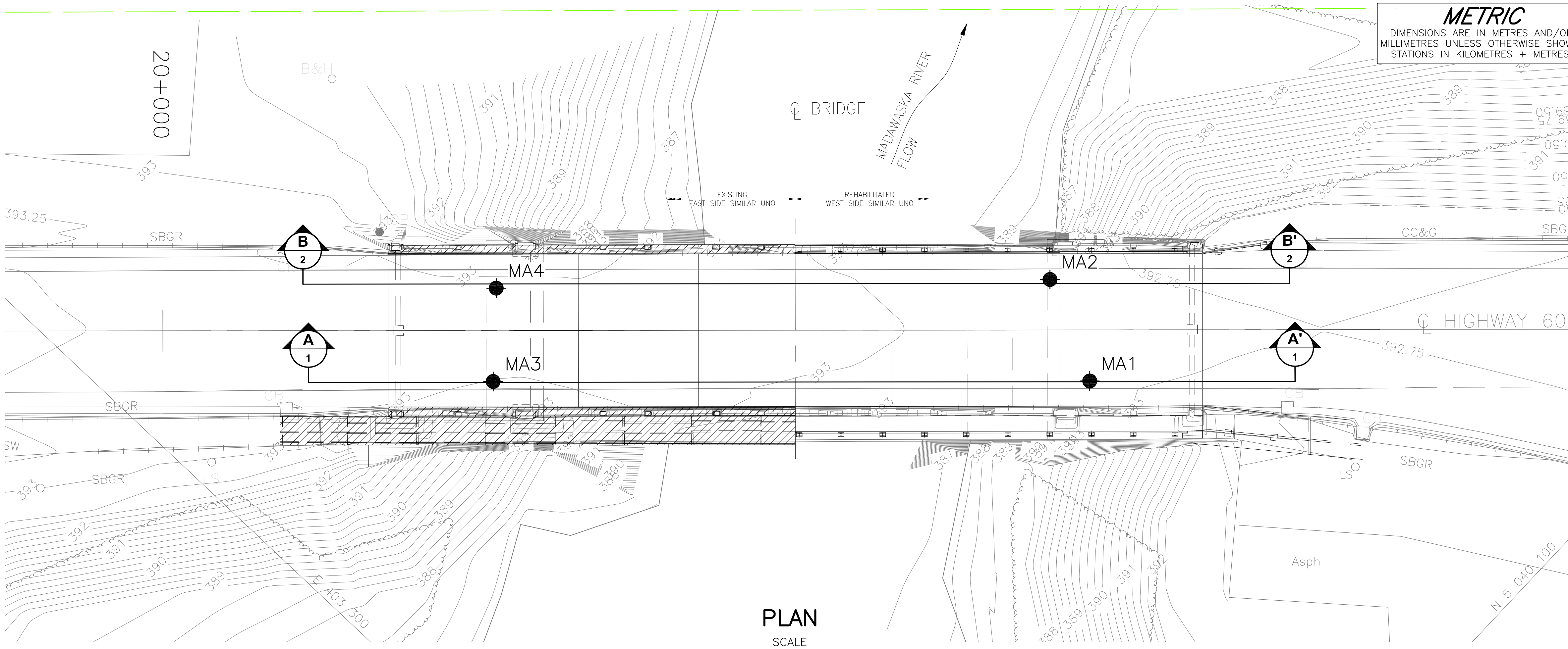
Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



PLAN
SCALE
3 0 3 6 m

KEY PLAN
12 0 12 km

LEGEND

- ● Borehole
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ⊽ WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
MA1	392.9	5040127.4	403340.9
MA2	392.9	5040133.3	403343.7
MA3	393.1	5040153.4	403316.4
MA4	393.1	5040157.1	403320.6

NOTES

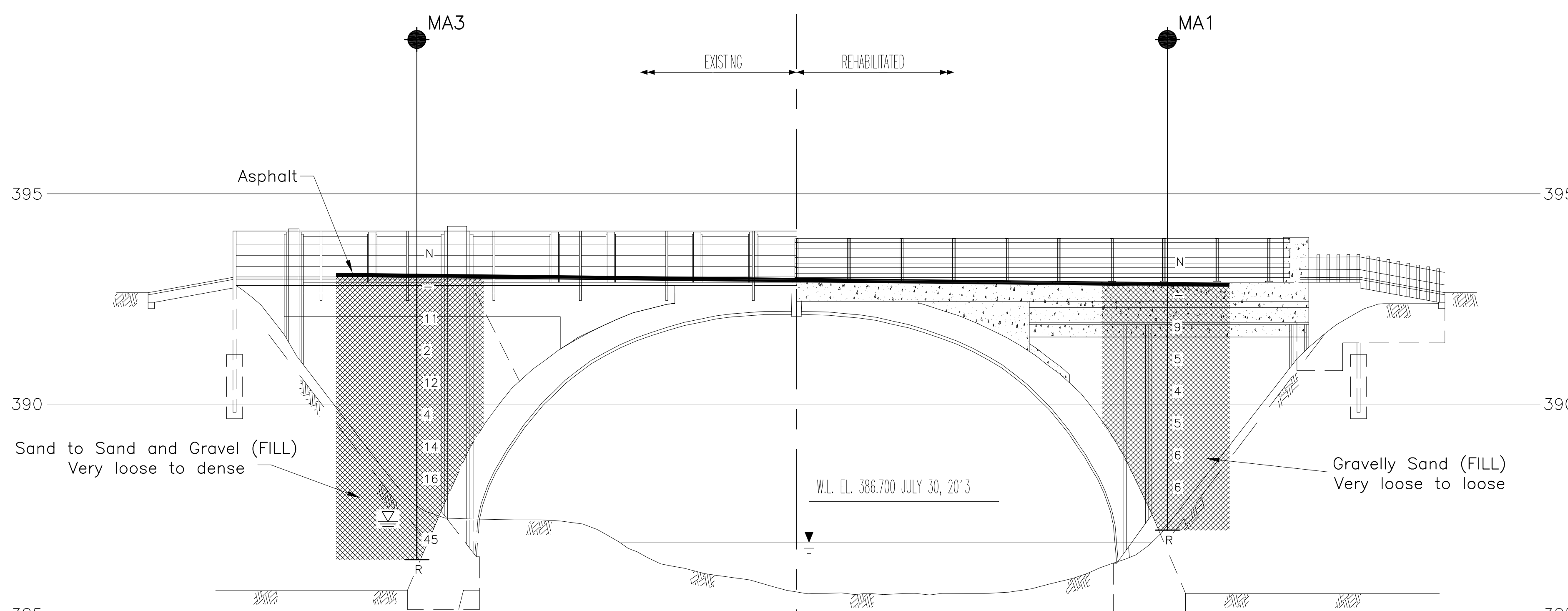
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by LEA, drawing file nos. x9255 Madawaskwa base.dwg, x9255 Madawaskwa contour.dwg and 9255-madawaska-S01.dwg, received SEP 8, 2014.



A-A' 1 PROFILE HIGHWAY 60
HORIZONTAL SCALE
3 0 3 6 m
1.5 0 1.5 3 m
VERTICAL SCALE

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LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA DEC 12, 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31E-341

HWY. 60	PROJECT NO. 13-1191-0003		DIST.
SUBM'D. AB	CHKD.	DATE: DEC 2014	SITE: 43-150
DRAWN: TB	CHKD. AB	APPD. JMAC	DWG. 1

PLOT DATE: December 12, 2014
FILENAME: \\golder.gds\gal\Sudbury\CAD-GIS\CAD\Projects\2013\13-1191-0003 - LEA Hwy 60-35-118\Madawaska\13119100003 Madawaska.dwg

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5359-11-01

SHEET

HIGHWAY 60

MADAWASKA RIVER BRIDGE SIDEWALK

SOIL STRATA

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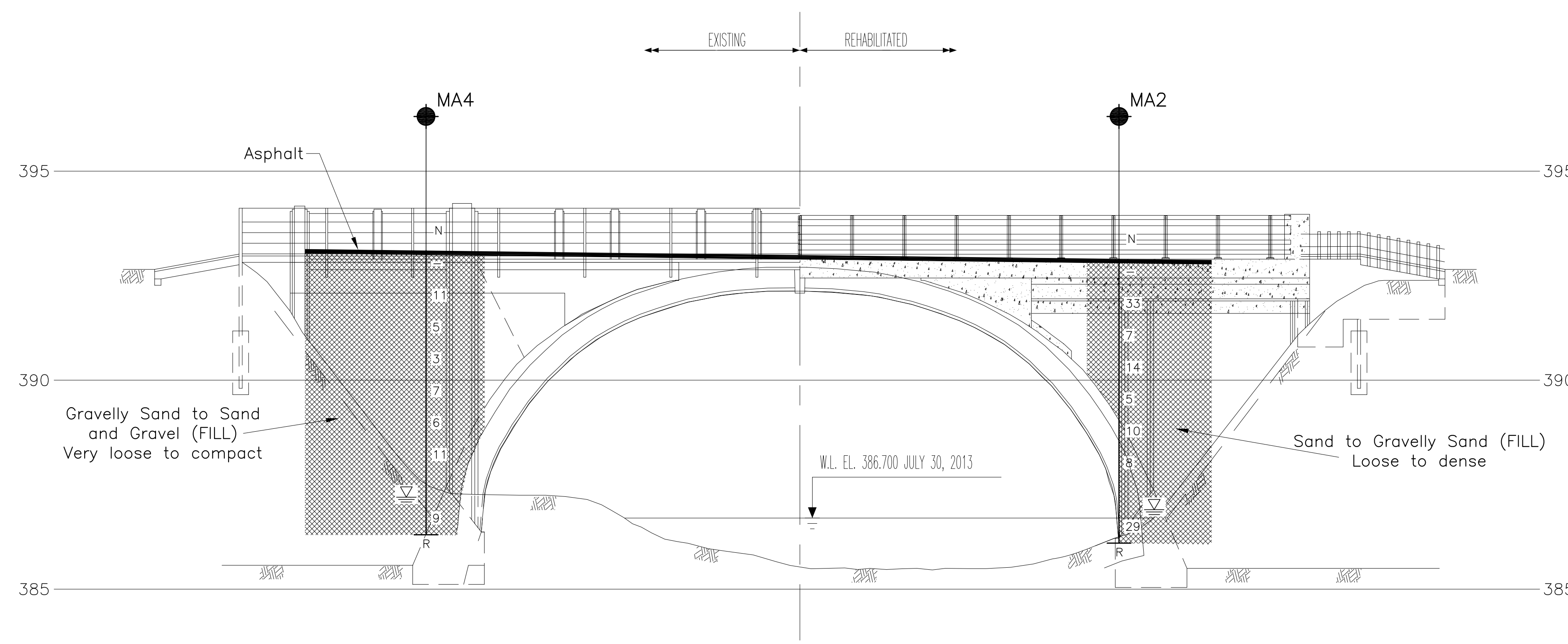
SUDBURY, ONTARIO, CANADA



B-B' 1 PROFILE HIGHWAY 60

HORIZONTAL SCALE 3 0 3 6 m
1.5 0 1.5 3 m VERTICAL SCALE

LEGEND

- Borehole
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- R — Refusal

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
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LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA DEC 12, 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31E-341

HWY. 60	PROJECT NO. 13-1191-0003		DIST.
SUBM'D. AB	CHKD.	DATE: DEC 2014	SITE: 43-150
DRAWN: TB	CHKD. AB	APPD. JMAC	DWG. 2

Photograph 1: Looking West from East Side Of Bridge (April 2014)

Photograph 2: Looking East on Bridge (September 2014)

APPENDIX A

Record of Borehole and Laboratory Test Results

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1. $\tau = c' + \sigma' \tan\phi'$
2. shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to “A” size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index Relative Density	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils
Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

RECORD OF BOREHOLE No MA1

 METRIC

PROJECT 13-1191-0003
G.W.P. 5198-10-00
DIST HWY 60
DATUM GEODETIC
LOCATION N 5040127.4; E 403340.9
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE September 8, 2014
ORIGINATED BY MT
COMPILED BY TB
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
392.9	GROUND SURFACE												
0.0	ASPHALT (100 mm)												
0.1	Gravelly sand, some silt (FILL) Very loose to loose Brown Moist		1	AS	-								
			2	SS	9		392						
			3	SS	5		391	○		26	65	(9)	
			4	SS	4		390						
			5	SS	5		389						
			6	SS	6			○		21	73	(6)	
			7	SS	6		388						
387.0 / 5.9	END OF BOREHOLE AUGER REFUSAL						387						

Note:

1. Borehole dry upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%): 20 40 60
REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No MA2

 METRIC

PROJECT 13-1191-0003
G.W.P. 5198-10-00
LOCATION N 5040133.3; E 403343.7
ORIGINATED BY MT
DIST ____ HWY 60
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
COMPILED BY TB
DATUM GEODETIC
DATE September 9, 2014
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
392.9	GROUND SURFACE									
0.0 / 0.1	ASPHALT (100 mm)									
	Sand, some gravel to gravelly sand, some silt (FILL) Loose to dense Brown Moist		1	AS	-					
			2	SS	33		392			
			3	SS	7		391	○		20 65 (15)
			4	SS	14		390			
			5	SS	5			○		19 72 (9)
			6	SS	10		389			
			7	SS	8		388			
						∇	387			
	Wet (Sample 8)		8	SS	39/0.2					
386.1 / 6.8	END OF BOREHOLE AUGER REFUSAL									

Note:

1. Water level at a depth of 6.0 m below ground surface (Elev. 386.9 m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No MA3

 METRIC

PROJECT 13-1191-0003
G.W.P. 5198-10-00 LOCATION N 5040153.4; E 403316.4 ORIGINATED BY MT
DIST HWY 60 BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers COMPILED BY TB
DATUM GEODETIC DATE September 8, 2014 CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
393.1	GROUND SURFACE								
0.0	ASPHALT (100 mm)						393		
0.1	Sand, some gravel to sand and gravel, trace silt (FILL) Very loose to dense Brown Moist		1	AS	-				
			2	SS	11		392		
			3	SS	2		391	○	15 82 (3)
			4	SS	12		390		
			5	SS	4				
			6	SS	14		389		
			7	SS	16		388	○	34 61 (5)
						▽	387		
	Wet (Sample 8)		8	SS	45				
386.3 / 6.8	END OF BOREHOLE AUGER REFUSAL								

Note:

1. Water level at a depth of 5.9 m below ground surface (Elev. 387.2 m) upon completion of drilling.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No MA4

 METRIC

PROJECT 13-1191-0003
G.W.P. 5198-10-00
DIST ___ HWY 60
DATUM GEODETIC

LOCATION N 5040157.1; E 403320.6
BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers
DATE September 8, 2014

ORIGINATED BY MT
COMPILED BY TB
CHECKED BY AB

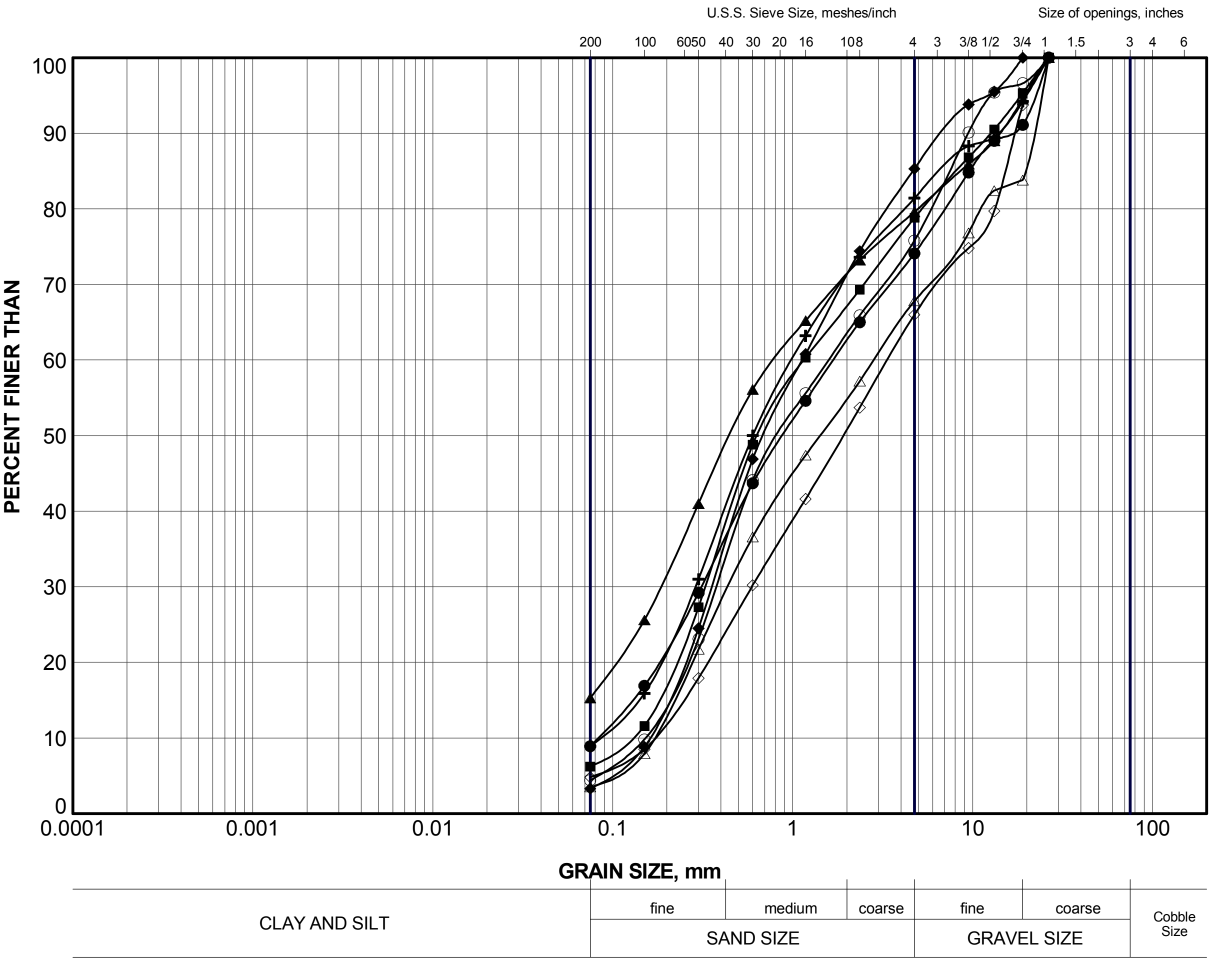
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
393.1	GROUND SURFACE											
0.0	ASPHALT (100 mm)					393						
0.1	Gravelly sand to sand and gravel, some silt (FILL) Very loose to compact Brown Moist	1	AS	-								
		2	SS	11		392						
		3	SS	5		391	○		24	72	(4)	
		4	SS	3		390						
		5	SS	7								
		6	SS	6		389	○		32	64	(4)	
		7	SS	11		388						
					∇	387						
	Wet (Sample 8)	8	SS	9/0.2								
386.4 6.7	END OF BOREHOLE AUGER REFUSAL											

Note:

1. Water level at a depth of 5.9 m below ground surface (Elev. 387.2 m) inside casing.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MA1	3	391.1
■	MA1	6	388.8
▲	MA2	3	391.1
+	MA2	5	389.6
◆	MA3	3	391.3
◇	MA3	7	388.2
○	MA4	3	391.3
△	MA4	6	389.0

PROJECT

HIGHWAY 60
MADAWASKA RIVER BRIDGE

TITLE

GRAIN SIZE DISTRIBUTION

SAND to SAND and GRAVEL (FILL)

PROJECT No.		13-1191-0003	FILE No.	13-1191-0003.GPJ	
DRAWN	TB	Oct 2014	SCALE	N/A	REV.
CHECK	AB	Oct 2014	FIGURE A1		
APPR		Oct 2014			

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