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MEMO

To: Primo Scalzo, M.Sc., P.Eng., Cook Engineering
From: Murray Anderson, P.Eng.
P.K. Chatterji, P.Eng.
Copy:
Date: May 24, 2011
Our File: 19-4078-4
Subject: Rehabilitation of Black River Bridge
Highway 17, Marathon
W.P. 134-97-00

This memorandum presents the factual information obtained from a foundation investigation conducted at the existing bridge carrying Highway 17 over Black River just east of Marathon, Ontario. It also provides an assessment of the geotechnical resistance of the pile foundations supporting the existing bridge, as well as recommendations regarding design of pile foundations to support a temporary detour bridge adjacent to this structure.

The existing Black River bridge is a three-span structure consisting of two large steel girders with crossbeams and a concrete deck, supported on driven pipe pile foundations. Replacement of the superstructure with precast concrete box girders is planned.

Description of Subsurface Conditions

Four boreholes were drilled at the site during the period November 25 to December 4, 2009. One borehole was drilled adjacent to each pier and abutment; the locations are shown on the Borehole Locations and Soil Strata Drawing, appended. The boreholes were terminated at depths of 34.5 to 45.0 m after recovery of approximately 3 m of bedrock core.

In general, the soil stratigraphy consisted of a pavement structure and sand/gravel fill layer (at the abutments) overlying very loose to compact sand to sand and silt (on the west side of the river) and loose to compact silt, underlain by soft to very stiff silty clay. The clay is underlain by a thin layer of gravel and granitic bedrock.

Descriptions of the individual strata are presented below.

Pavement Structure and Sand/Gravel Fill

Boreholes 09-1 and 09-4 were drilled through the existing approach fill. These boreholes encountered a 65 mm thick asphalt layer overlying granular fill comprising sand and gravel to sand, some gravel. The fill extended to depths of 5.5 and 4.0 m (Elev. 235.4 and 237.7 m) in Boreholes 09-1 and 09-4, respectively.

Sand and gravel fill was also encountered in Borehole 09-3 drilled through the bridge deck. The fill layer was 3.1 m thick with a lower boundary at 11.9 m below the bridge deck (Elev. 229.5 m).

SPT N-values recorded in the fill generally ranged from 13 to 44 blows/0.3 m, indicating a compact to dense condition. Moisture contents ranged from 2 to 14%.

Sand and Silt

Deposits typically consisting of sand and silt, grading from sand to silt, were encountered below the fill in Borehole 09-1 drilled at the west abutment and at the river bottom in Borehole 09-2 drilled at the west pier. The sand/silt deposits were 11.3 and 7.7 m thick, with a lower boundary at depths of 16.8 and 17.9 m below existing road grade (Elev. 224.1 and 223.2 m).

SPT N-values obtained in the sand/silt ranged from 2 to 28 blows/0.3 m, indicating a very loose to compact condition. Moisture contents varied from 12 to 46%, typically from 18 to 25%.

The results of grain size distribution analyses conducted on samples of the sand and silt are presented on Figure 1, appended. The results are summarized as follows:

Gravel %	0
Sand %	43 to 76
Silt %	21 to 53
Clay %	3 to 4

Silt

Silt was encountered below the sand/silt in Boreholes 09-1 and 09-2, and below the fill in Boreholes 09-3 and 09-4. The thickness of the silt stratum varied from 6.0 to 25.0 m. The lower boundary was at depths of 23.9 to 29.0 m (Elev. 217.2 to 212.7 m).

SPT N-values obtained in the silt ranged from 8 to 27 blows/0.3 m, indicating a loose to compact condition. Moisture contents varied from 17 to 40%, typically from 20 to 25%.

The results of grain size distribution analyses conducted on samples of the silt are presented on Figures 2 and 3, appended. The results are summarized as follows:

Gravel %	0
Sand %	0 to 6
Silt %	82 to 89
Clay %	8 to 18

A second layer of silt was encountered below the silty clay in Borehole 09-2. This localized deposit was compact and 3.1 m thick.

Silty Clay

Silty clay was encountered below the silt in all boreholes. The clay layer ranged in thickness from 2.5 to 14.0 m, and the lower boundary was encountered at depths of 31.5 to 39.9 m (Elev. 210.2 to 200.9 m).

SPT N-values obtained in the silty clay ranged from 2 to 17 blows/0.3 m, indicating a soft to very stiff consistency. Undrained shear strengths measured by in situ vane testing ranged from 60 to 85 kPa. Moisture contents varied from 22 to 40%.

The results of grain size distribution analyses conducted on samples of the silty clay are presented on Figures 4 and 5, appended. The results of Atterberg Limits tests are shown on Figure 6. The results are summarized as follows:

Gravel %	0
Sand %	0
Silt %	13 to 77
Clay %	23 to 87
Liquid Limit	24 to 44
Plastic Limit	18 to 22

The results indicate that the silty clay is of low to medium plasticity with group symbols of CL to CI.

Gravel

A 0.6 to 2.1 m thick layer of gravel was encountered below the silty clay in Boreholes 09-1 to 09-3. The gravel contains trace sand and possible cobbles. The

gravel is very dense, as evidenced by N-values of 74 blows/0.3 m to 50 blows/0.125 m. Moisture contents of 10 and 18% were measured.

Bedrock

Granitic bedrock was proved by coring in all four boreholes. The depth to bedrock below existing road grade and the elevation of the bedrock surface encountered in the boreholes are summarized as follows:

Foundation Unit	Borehole	Depth to Bedrock Below Road Grade (m)	Bedrock Elevation (m)
West Abutment	09-1	42.0	198.9
West Pier	09-2	35.7	205.4
East Pier	09-3	40.0	201.4
East Abutment	09-4	31.5	210.2

The granite is described as grey, fresh and strong to very strong. Total Core Recovery (TCR) was 100% and Solid Core Recovery (SCR) ranged from 79 to 100%. The measured Rock Quality Designation (RQD) ranged from 70 to 100%, indicating a fair to excellent quality rock.

Water Levels

The water levels measured in the open boreholes upon completion of drilling and subsequently in piezometers installed in Boreholes 09-1 and 09-4 were as follows:

Borehole	Date	Water Level		Remark
		Depth (m)	Elevation (m)	
09-1	Nov 28, 2009	7.0	233.9	In open borehole
	Nov 30, 2009	8.0	232.9	In piezometer
	Dec 2, 2009	8.2	232.7	In piezometer
	Dec 4, 2009	8.7	232.2	In piezometer
09-2	Nov 29, 2009	10.0	231.1	In open borehole
09-3	Dec 4, 2009	9.9	231.5	In open borehole
09-4	Dec 1, 2009	9.1	232.6	In open borehole
	Dec 2, 2009	9.2	232.5	In piezometer
	Dec 4, 2009	9.9	231.8	In piezometer

The measured water levels are short-term readings and in some cases may reflect residual water from rock coring operations. The water levels may be at higher levels after the spring snowmelt or after rainy periods, and are likely to vary in conjunction with the water level in Black River.

Assessed Resistance of Existing Pile Foundations

Contract Drawings for the existing bridge structure (General Plan, Contract 57-83) indicate that the existing bridge is supported on tube piles driven to a “safe super imposed load of 30 Tons” (allowable load of 267 kN). The specified pile section has a diameter of 311 mm and wall thickness of 5.2 mm. The design pile length and estimated tip elevation are as follows:

Foundation Unit	Top of Pile Cap Elevation (m)	Specified Pile Length (m)	Estimated Pile Tip Elevation (m)
West Abutment	235.6	22.9	211.8
West Pier	226.8	22.6	203.0
East Pier	227.1	21.3	204.7
East Abutment	236.4	16.8	218.8

** Note that the contract drawings were partially illegible in some cases, and information summarized here should be considered approximate.*

The pile length data summarized in the above table indicates that the piles were terminated in soft silty clay at the west abutment, bedrock at the west pier, stiff silty clay at the east pier, and compact silt at the east abutment. Pile driving records were not available to confirm the pile tip depths however, and verification of the pile lengths is not possible.

Considering the subsurface conditions, the inferred pile lengths, and the associated uncertainty with regards to the actual pile lengths, it is recommended that assessment of the existing foundation system to support the new deck loads be carried out using a factored axial resistance at ULS of 800 kN/pile and an axial resistance at SLS of 600 kN/pile. The structural resistance of the pile must be checked by the structural designer.

Temporary Detour Bridge - Piers

We understand that installation of a temporary three-span, single lane modular bridge is planned to divert traffic during deck replacement. Each pier of the temporary structure will be supported on a foundation system comprising six or eight HP 310x110 steel piles. The required resistance per pile will range from 287 to 383 kN at factored ULS and 185 to 247 kN at SLS.

Analysis of the pile resistance indicates that the foundation loads can be carried on friction piles developing shaft and point resistance in the loose to compact silt to silt and sand underlying the site. The pile tip elevation and pile length recommended to achieve the required resistance values are summarized below.

Foundation Unit	Option	Pile Cut-off Elevation (m)	Required Resistance (kN)		Recommended Elevation of Pile Tip (m)	Length of Pile below Cut-off (m)
			Factored ULS	SLS		
East Pier	8-piles	235.56	287	185	222	13.6
	6-piles	235.56	383	247	219	16.6
West Pier	8-piles	234.17	287	185	220	14.2
	6-piles	234.17	383	247	217	17.2

From a geotechnical perspective, the eight-pile option is preferred as the shorter pile length will maintain a greater separation between the pile tips and the soft to very stiff silty clay underlying the silt.

Pile installation must be in accordance with OPSS 903. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an Ultimate Geotechnical Resistance of kN per pile but not below El..... without approval of the Engineer", where the Ultimate Geotechnical Resistance is twice the maximum factored design load at ULS and the Elevation is the recommended elevation of pile tip indicated in the table above.

Monitoring with the Hiley Formula should commence approximately 2 m above the recommended pile tip elevation. If the required resistance is not achieved upon reaching the recommended elevation, pile driving should be terminated for at least 24 hours and the pile should then be retapped to reassess the resistance after possible setup. If the specified resistance is still not achieved, the designer should be contacted.

The new piles will be positioned as close as 7 m from the existing bridge pier foundations and about 9 m from the existing abutments. The existing piles supporting the piers extend approximately 14 to 17 m below the pile tip elevations recommended above, and are not expected to be impacted by installation of the new piles. The piles at the east and west abutments may extend up to 3.0 and 8.0 m, respectively, below the new pile tips in an eight-pile option.

Vibration monitoring and settlement monitoring of the existing bridge foundations should be carried out during pile driving to confirm that the existing foundations are not detrimentally affected. In this regard, it is recommended that the vibration level (peak particle velocity) measured at the existing bridge foundations be limited to a maximum value of 11 mm/sec during driving. If this threshold value is exceeded, it may be necessary to modify pile driving operations to reduce the vibrations reaching the existing foundations.

The monitoring program should require the contractor to establish a reference point over each abutment and each pier of the existing structure, and to monitor movement of these points relative to known, fixed reference points on a regular basis. The suggested frequency of readings is as follows:

- Three readings on separate days prior to construction to establish a baseline.
- Twice daily while any foundation construction or other subsurface construction is in progress.
- Daily for one week after completion of foundation construction.

Readings should be taken at the same time each day. The vertical and horizontal accuracy of readings should be 2 mm. All readings must be reported to the contract administrator within 24 hours and immediately if any movement exceeds limits set by the structural designers. The contract administrator must be advised of the importance of monitoring and be required to advise the Ministry immediately if the vertical or horizontal movement exceeds the specified limits.

Visual examination and settlement monitoring of the riverbank slope should also be carried in the vicinity of the pier foundations to identify any surficial instability caused by the pile driving vibrations and assess the need for further driving restrictions and/or other measures to improve stability.

Temporary Detour Bridge - Abutments

We understand that the abutments for the temporary bridge will consist of a steel pad constructed from three H-piles placed under each of the two trusses of the modular bridge. The bearing pads will be 0.9 by 2.2 m in plan and support a factored live load of 937 kN and factored dead load of 167 kN at ULS. The temporary bridge abutments will be located approximately 14.5 m beyond the existing bridge abutments (further away from the river).

To support the abutment loads, it is recommended that the steel pads be placed on a minimum 1.8 m thick pad of engineered fill constructed over the native soils. The engineered fill must consist of OPSS Granular "A" placed in 150 mm lifts and compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content. The fill pad should extend at least 1 m beyond the edge of the steel pads.

The abutment design should include provision for shimming to re-establish the bridge level in the event that settlement of the foundation subgrade occurs. Assessment of the need for shimming should be carried out as a routine maintenance check.

The impact of the temporary abutment loads on the stability of the existing embankments was assessed by conducting limit equilibrium analyses using a commercially available slope stability program (GSLOPE by Mitre Software Inc.). The Bishop's simplified method was employed. The results of these analyses indicate that the minimum factor of safety against instability of the slope incorporating the abutment load will be in the order of 1.45. This value exceeds the normally accepted value of 1.3 for this type of analysis, and therefore the temporary abutment loads are not expected to impact the stability of the embankments.

Closure

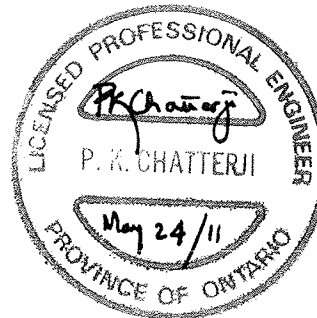
Engineering analysis and preparation of this memorandum were carried out by Mr. Alastair Gorman, P.Eng. and Mr. Murray Anderson, P.Eng. The memorandum was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects.

Thurber Engineering Ltd.

Murray R. Anderson, P.Eng., M.Eng.
Senior Foundations Engineer



P.K. Chatterji, P.Eng., Ph.D.
Review Principal



SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

RECORD OF BOREHOLE No 09-1

1 OF 5

METRIC

W.P. 134-97-00 LOCATION Black River Bridge ORIGINATED BY GA
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2009.11.25 - 2009.11.28 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								○ UNCONFINED		+ FIELD VANE				
								● QUICK TRIAXIAL		X LAB VANE				
240.9						20	40	60	80	100	PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
0.7	ASPHALT: (65mm)		1	SS	38									
240.1	SAND and GRAVEL Dense Brown (FILL)													
0.8	SAND, some gravel, trace silt, occasional cobbles Compact to Very Dense Brown (FILL)		2	SS	50/ .150									
			3	SS	44									
			4	SS	22									
			5	SS	22									
			6	SS	13									
235.4														
5.5	SAND and SILT, trace clay Very Loose to Loose Brown Damp		7	SS	8									
			8	SS	2									
231.7														
9.1	SAND, fine to medium grained Loose Grey/Brown Wet		9	SS	4									
231.0														

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+³ X³: Numbers refer to
Sensitivity

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15 10 5
10 (%) STRAIN AT FAILURE

METRIC

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METRIC

ELEV. DEPTH	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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					
								SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
								20 40 60 80 100					
									WATER CONTENT (%)				
									20 40 60				
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RECORD OF BOREHOLE No 09-2

3 OF 4

METRIC

W.P. 134-97-00 LOCATION Black River Bridge ORIGINATED BY GA
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2009.11.28 - 2009.11.29 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W _P W W _L					
	Continued From Previous Page							20 40 60 80 100		20 40 60				
217.2 23.9	SILT, some clay, trace sand Compact Grey Wet Occasional clay seams		9	SS	12		221					○		
							220							
			10	SS	10						○			
							219							
			11	SS	13		218					○		
		Silty CLAY Soft to Stiff Grey (CL)						217					○	
	12			SS	10							○		
							216							
	13			SS	3		215					○		
							214						○	
			14	SS	4		213							
						212					○			
			15	SS	2						○			

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Sensitivity

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10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 09-3

1 OF 5

METRIC

W.P. 134-97-00 LOCATION Black River Bridge ORIGINATED BY GA
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2009.12.02 - 2009.12.04 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L				
241.4														
0.0	ASPHALT: (75mm)													
0.1														
241.1	CONCRETE, (bridge deck): (230mm)													
0.3														
							241							
							240							
							239							
							238							
							237							
							236							
							235							
							234							
							233							
232.6							232							
8.8	SAND and GRAVEL, trace silt Compact Brown Damp to Wet (FILL)		1	SS	13									

ONTMT4S 0784.GPJ 3/31/11

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RECORD OF BOREHOLE No 09-3

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METRIC

W.P. 134-97-00 LOCATION Black River Bridge ORIGINATED BY GA
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2009.12.02 - 2009.12.04 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
Continued From Previous Page							20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	WATER CONTENT (%)		
	Silty CLAY Firm to Very Stiff Grey (Cl)		16	SS	17		211	1.9					
							210	1.8					
			17	SS	5		209						0 0 13 87
							208	2.3					
			2	SH			207						
							206						
			18	SS	8		205						
							204						
203.3							203						
38.1	GRAVEL, possible cobble, no recovery		19	SS	50/ .200		202						
201.4	Began coring at 40.0m.												

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Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 09-3

5 OF 5

METRIC

W.P. 134-97-00 LOCATION Black River Bridge ORIGINATED BY GA
HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
DATUM Geodetic DATE 2009.12.02 - 2009.12.04 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
	Continued From Previous Page							20 40 60 80 100							
								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL × LAB VANE							
									WATER CONTENT (%)						
								20 40 60 80 100							
									PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT				
									W _P	W	W _L				
40.0	GRANITE, fresh, strong, grey Occasional mechanical breaks. Highly fractured zones at 40.0 to 40.1 and 41.4 to 41.5m. Sub-horizontal joint at 40.0m.		1	RUN			201							>5	RUN 1# TCR=100%, SCR=79%, RQD=79%
														1	
														0	
														0	
														0	
														3	
	Vertical joint at 41.5 to 41.6m		2	RUN			200						1	RUN 2# TCR=100%, SCR=100%, RQD=100%	
													0		
													0		
													0		
198.6							199						0		
42.8	END OF BOREHOLE AT 42.8m. BOREHOLE OPEN TO 42.8m AND WATER LEVEL AT 9.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH GROUT TO 10.1m, AND HOLEPLUG TO 8.8m. DECK PLUGGED WITH CONCRETE TO 0.2m, AND ASPHALT TO SURFACE.														

ONTM14S 0784.GPJ 3/31/11

+ 3, X 3; Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 09-4

1 OF 4

METRIC

W.P. 134-97-00 LOCATION Black River Bridge ORIGINATED BY GA
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2009.11.30 - 2009.12.01 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE				
241.7							20	40	60	80	100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
0.0	ASPHALT: (65mm)		1	SS	34										
0.1	SAND and GRAVEL, occasional cobbles, trace silt Compact to Dense Brown (FILL)		2	SS	30										
			3	SS	27										
			4	SS	20										
			5	SS	22										
237.7															
4.0	SILT, trace clay, trace sand Compact Brown Wet		6	SS	16										
			7	SS	11										
			8	SS	26										
			9	SS	16										
							</								

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

ONTMT4S 0784.GPJ 4/29/11

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 09-4

3 OF 4

METRIC

W.P. 134-97-00 LOCATION Black River Bridge ORIGINATED BY GA
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2009.11.30 - 2009.12.01 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _P W W _L				
Continued From Previous Page														
	SILT, some clay Compact Grey Wet		16	SS	13		221							
							220							
							219							
				17	SS	17		218						
							217							
							216							
			18	SS	14		215							
							214							
							213							
212.7	Silty CLAY Very Stiff Grey (CL-ML)						212							
29.0			19	SS	16									

ONTMT4S 0784.GPJ 4/29/11

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 09-4

4 OF 4

METRIC

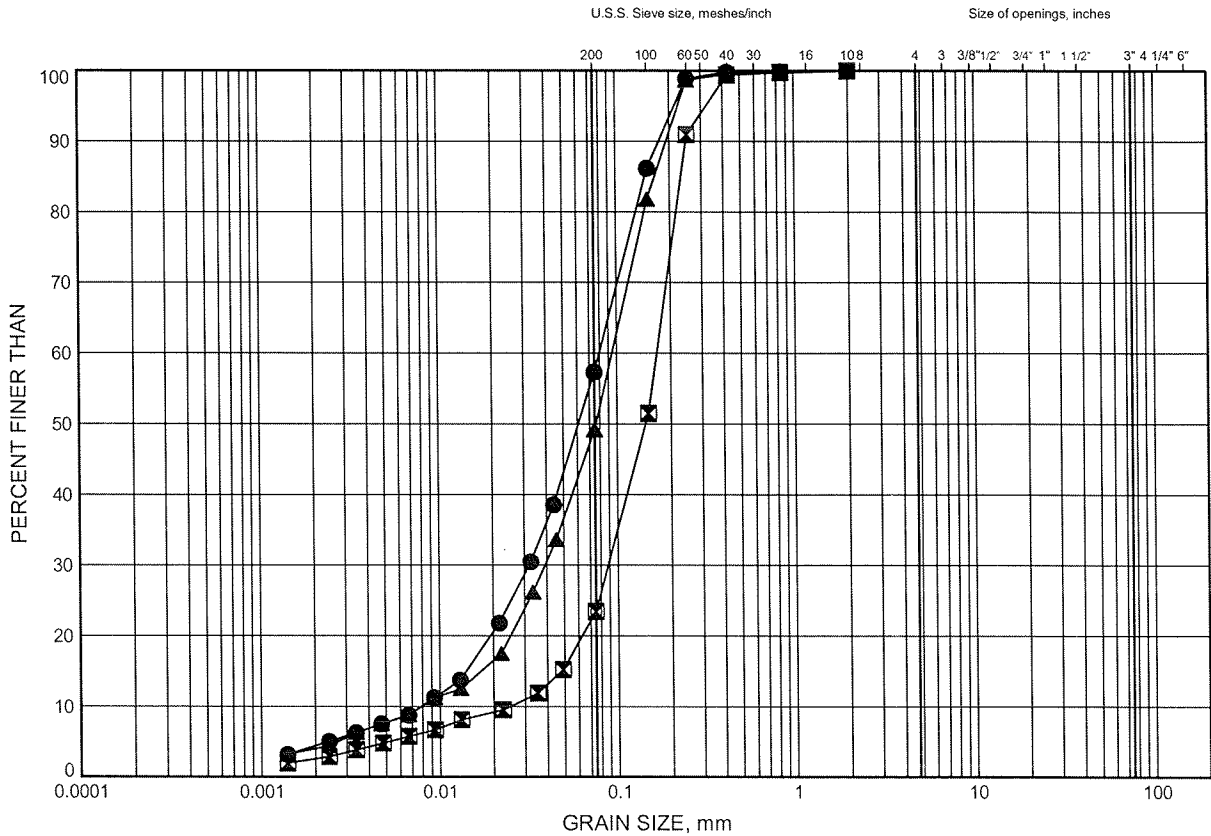
W.P. 134-97-00 LOCATION Black River Bridge ORIGINATED BY GA
HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
DATUM Geodetic DATE 2009.11.30 - 2009.12.01 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _P	W	W _L		
	Continued From Previous Page							20 40 60 80 100									
210.2	Silty CLAY Very Stiff Grey						211										
31.5	Began coring at 31.5m.																
	GRANITE, fresh, greenish grey, strong to very strong Highly broken zone at 31.5 to 31.6m.		1	RUN			210										RUN #1 TCR=100% SCR=93% RQD=93%
							209										RUN #2 TCR=100% SCR=100% RQD=100%
207.2			2	RUN			208										
34.5	END OF BOREHOLE AT 34.5m. BOREHOLE OPEN TO 34.5m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2009.12.01 9.1 232.6 2009.12.02 9.2 232.5 2009.12.04 9.9 231.8																

Black River Bridge GRAIN SIZE DISTRIBUTION

FIGURE 1

SILTY SAND / SAND AND SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-1	7.92	232.95
⊠	09-1	14.02	226.85
▲	09-2	13.26	227.84

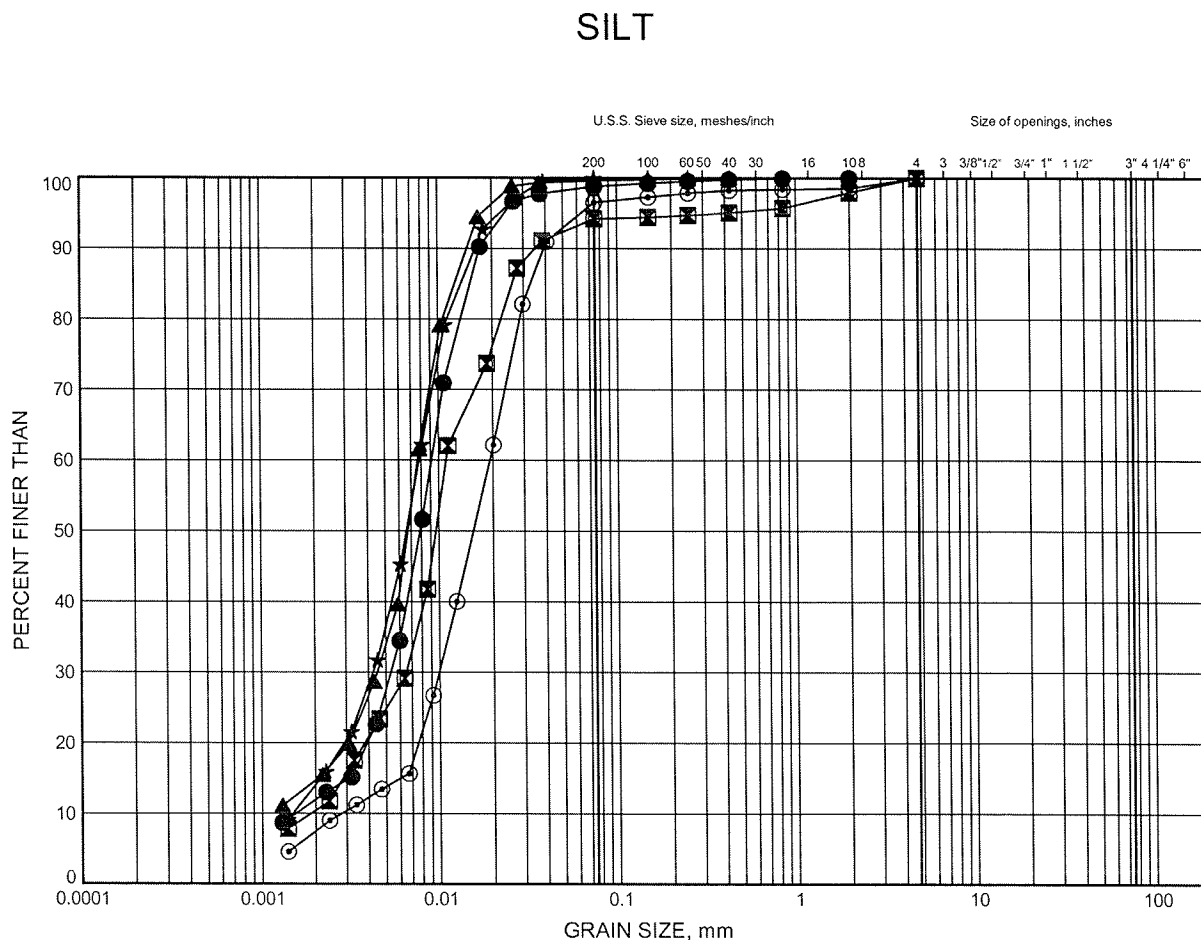
GRAIN SIZE DISTRIBUTION - THURBER 0784.GPJ 3/31/11

W.P.# 134-97-00
Prepared By MFA
Checked By MRA



Black River Bridge GRAIN SIZE DISTRIBUTION

FIGURE 2



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-2	18.59	222.51
⊠	09-3	12.50	228.90
▲	09-3	18.59	222.81
★	09-3	24.69	216.71
⊙	09-4	4.88	236.82

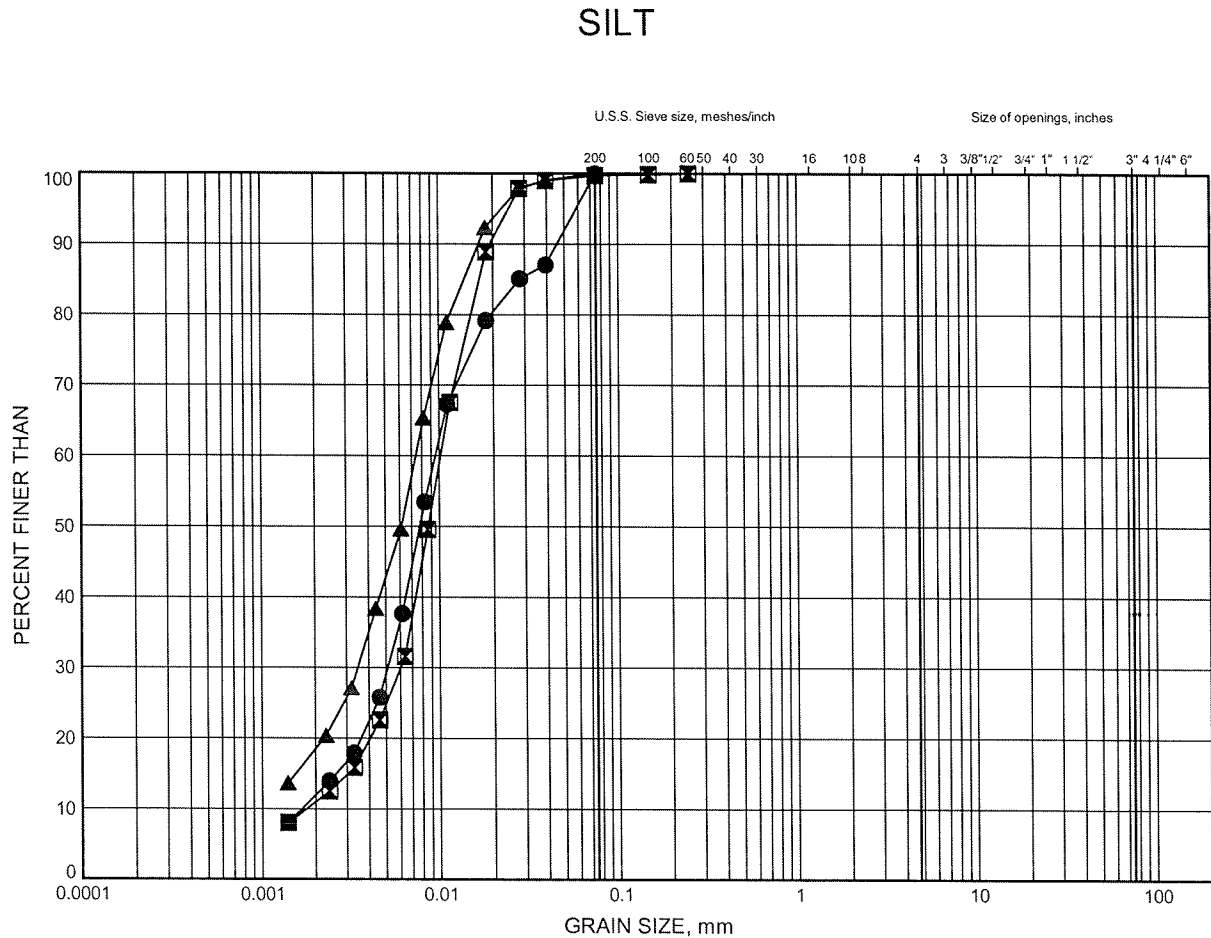
GRAIN SIZE DISTRIBUTION - THURBER 0784.GPJ 3/31/11

W.P.# 134-97-00
Prepared By MFA
Checked By MRA



Black River Bridge GRAIN SIZE DISTRIBUTION

FIGURE 3



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

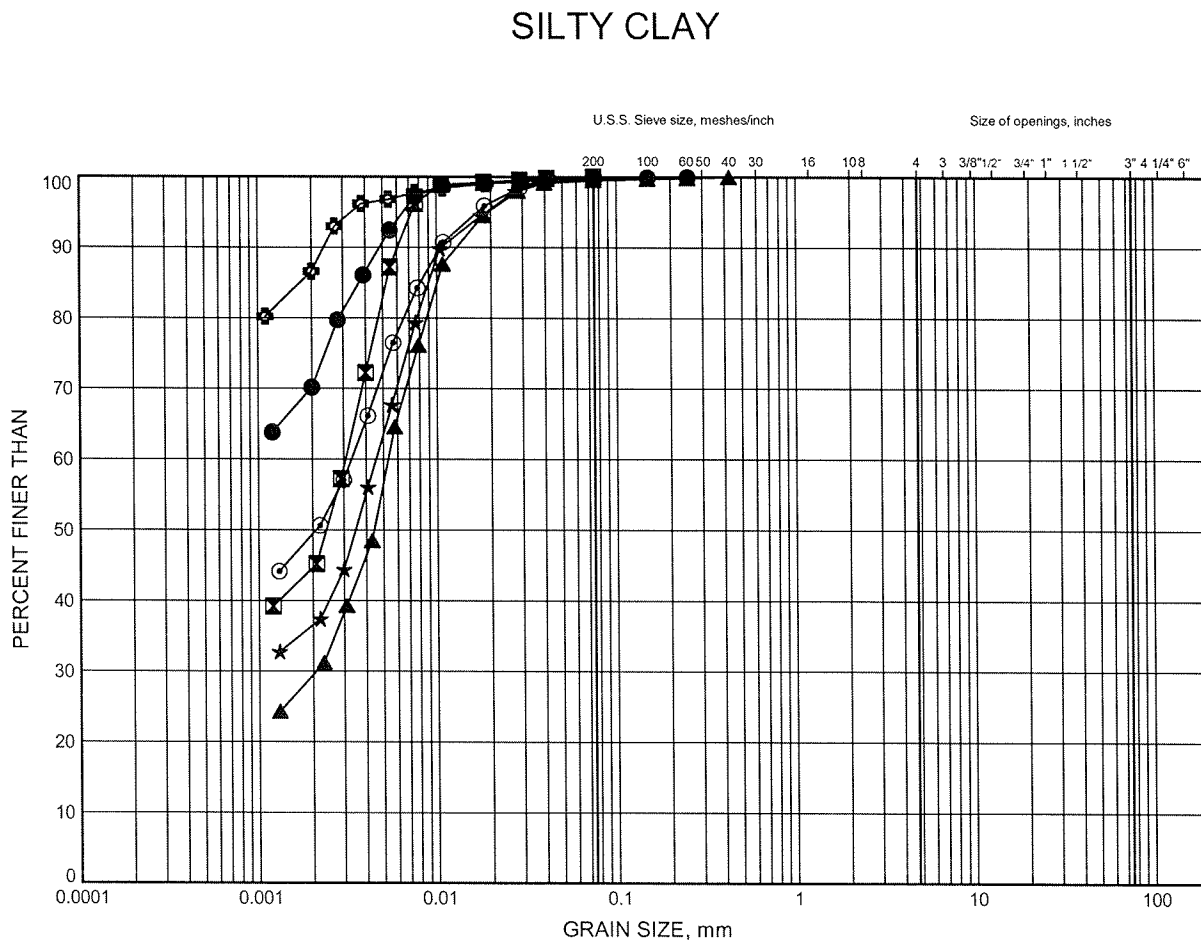
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-4	10.97	230.73
⊠	09-4	17.07	224.63
▲	09-4	26.21	215.49



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Black River Bridge GRAIN SIZE DISTRIBUTION

FIGURE 4



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-1	29.26	211.61
⊠	09-1	38.40	202.47
▲	09-2	24.69	216.41
★	09-2	29.26	211.84
⊙	09-3	29.26	212.14
⊕	09-3	32.31	209.09

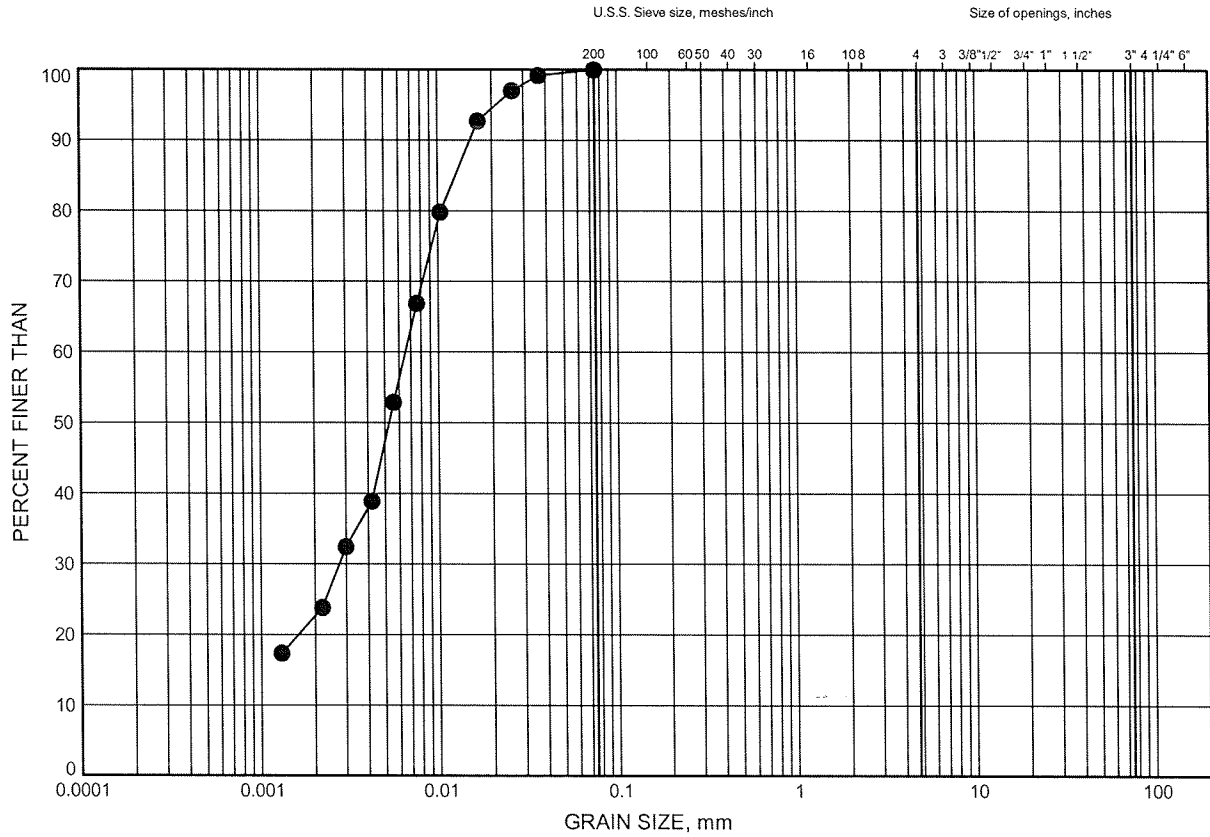


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Prepared By ..MFA.....
Checked By ..MRA.....

Black River Bridge GRAIN SIZE DISTRIBUTION

FIGURE 5

SILTY CLAY



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	09-4	29.26	212.44

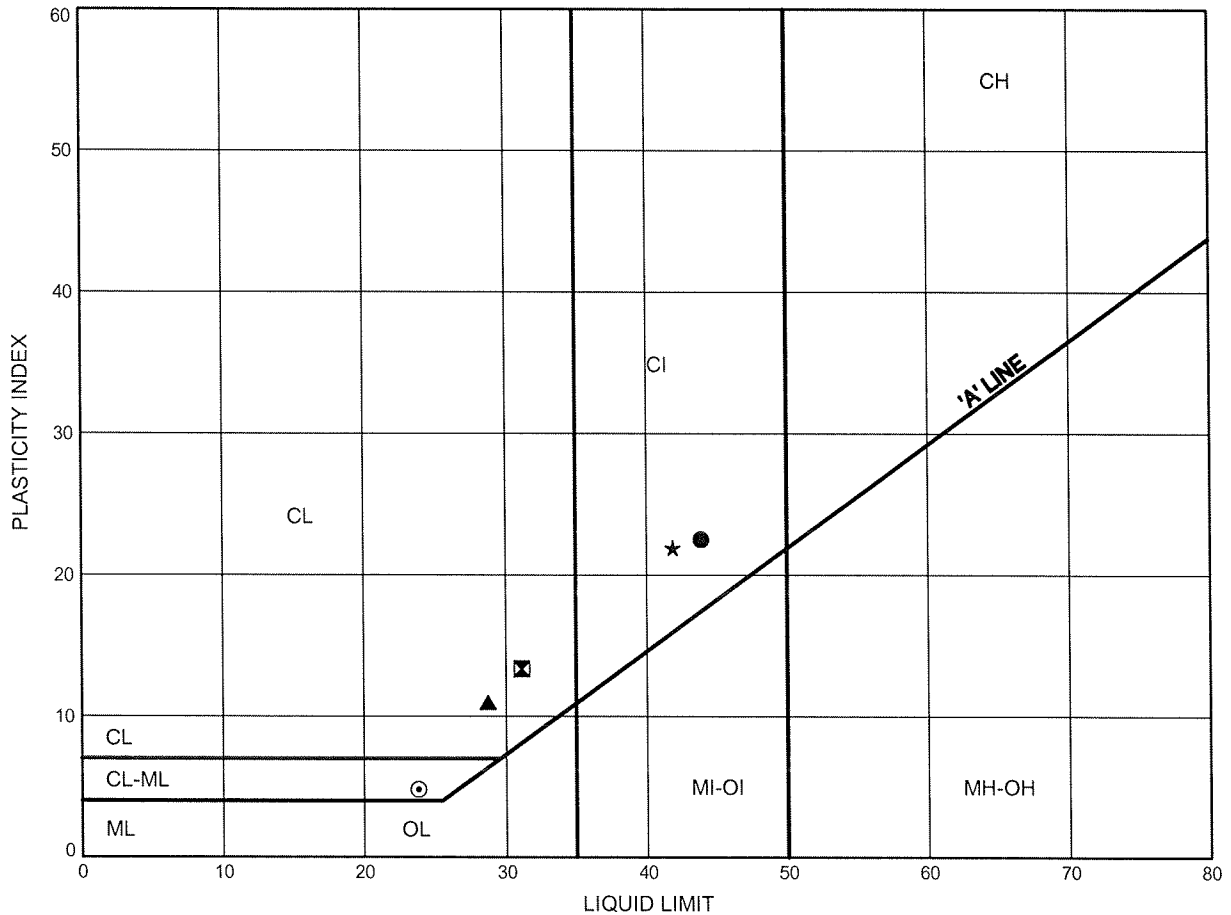


W.P.# 134-97-00
Prepared By MFA
Checked By MRA

Black River Bridge ATTERBERG LIMITS TEST RESULTS

FIGURE 6

SILTY CLAY

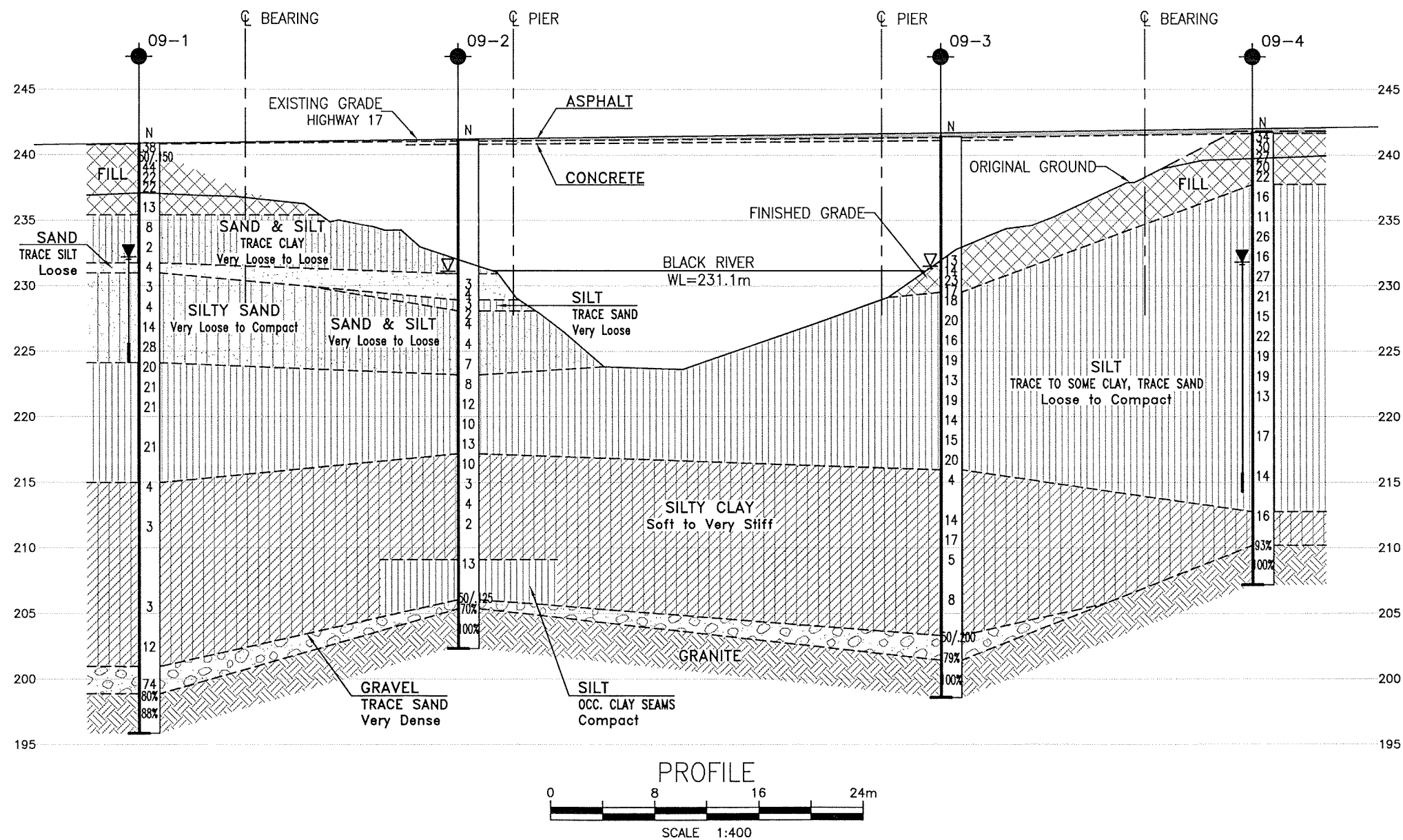
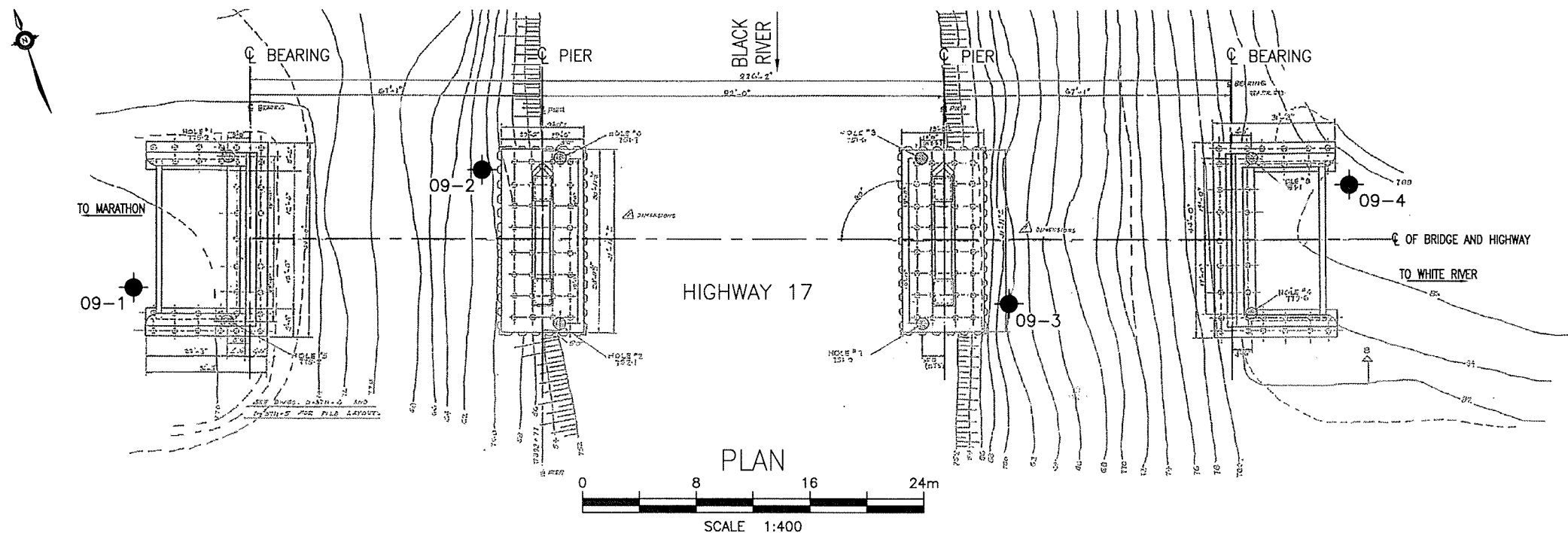


SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	09-1	29.26	211.61
⊠	09-2	29.26	211.84
▲	09-3	29.26	212.14
★	09-3	32.31	209.09
⊙	09-4	29.26	212.44

Date March 2011
 Project 134-97-00



Prep'd MFA
 Chkd. MRA



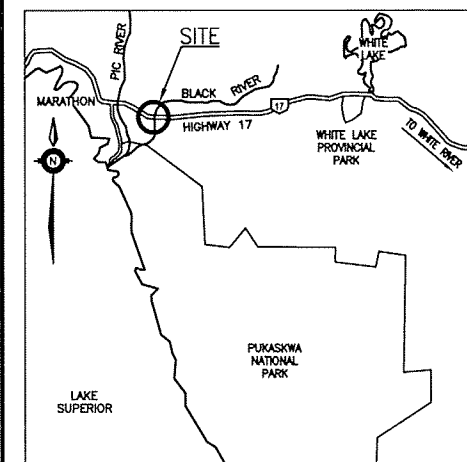
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No 2011-6008
WP No 134-97-00

HIGHWAY 17
BLACK RIVER BRIDGE
MARATHON - WHITE RIVER
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
8

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



LEGEND

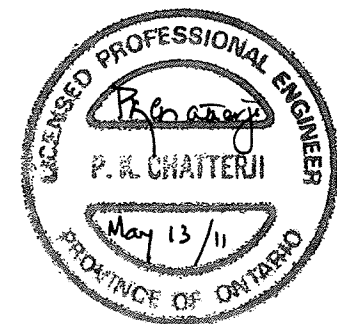
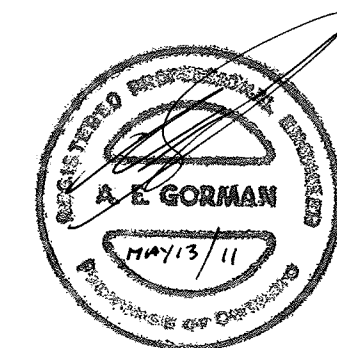
- ◆ Borehole
- ◆ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
09-1	240.9	—	—
09-2	241.1	—	—
09-3	241.4	—	—
09-4	241.7	—	—

-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.

GEOCRES No.



REVISIONS	DATE	BY	DESCRIPTION
DESIGN TJH	CHK AEG	CODE	LOAD
DRAWN MFA	CHK PKC	SITE 48E-26	STRUCT DWG 2