



**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
for
FEASIBILITY STUDY FOR THE REHABILITATION OR REPLACEMENT
OF THE HIGHWAY 3 BRIDGE OVER THE GRAND RIVER AT CAYUGA
GWP 3501-01-00, SITE 9-43
HIGHWAY 3, DISTRICT 31**

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PML Ref.: 04HF058A
Index No. 015FIR and 016FDR
Geocres No: 30L13-18
July 9, 2009



PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

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PRELIMINARY FOUNDATION INVESTIGATION REPORT

for
Feasibility Study for the Rehabilitation or Replacement
Of the Highway 3 Bridge Over the Grand River at Cayuga
GWP 3501-01-00, Site 9-43
Highway 3, District 31

1. INTRODUCTION

This report summarizes the results of the preliminary foundation investigation carried out for the proposed rehabilitation/replacement of the existing bridge on Highway 3 that crosses over the Grand River near the west limit of Cayuga, Ontario. The study was conducted for McCormick Rankin Corporation on behalf of the Ministry of Transportation of Ontario.

The existing structure is a five span steel through truss bridge; each span is approximately 37.7 m long. The roadway is approximately 7.0 m wide and accommodates two lanes of traffic. A concrete sidewalk is located on the north side of the structure. The bridge was originally constructed in 1924 and rehabilitated in 1976. Additional rehabilitation was undertaken in 2001 to repair corroded truss members.

The centre of the bridge is at Station 10+000, Highway 3 chainage, in the Township of North Cayuga (ref. Drawing No. E-003-CAY-3, River Crossing at the King's Highway 3 and Grand River prepared by MTO in December 2004).

The report provides preliminary information concerning the composition of the pier concrete as well as the material below the pier footings.

2. SITE DESCRIPTION

The Grand River bridge on Highway 3 is located on the west side of Cayuga. The surrounding lands to the east within Cayuga are developed for light industrial, commercial and residential purposes. Residential and agricultural development exists west of the bridge.



The river is about 180 m wide at the location of the existing structure. The water level, although subject to seasonal variations and weather dependent precipitation, is normally about elevation 176 (refer to drawing noted previously), corresponding to about a 2 to 3 m water depth. The top of the bridge deck is at about elevation 182.8, typically 7 m above normal river level.

The valley walls of the Grand River at the bridge site are up to 5 m high and relatively steep, near vertical at some locations. Vegetation along the shoreline mainly comprises grass and small shrubs, with occasional areas of thick vegetation and trees. No evidence of rock outcrops or rock remnants was noted during the site visit.

Selected photographs of the existing bridge taken in August 2004 are provided in Appendix A.

3. GEOLOGY

The soil at the site primarily comprises glaciolacustrine clays and silts deposited by glacial Lake Warren as well as river bottom sediments of sand and gravel.

In the immediate vicinity of the bridge site, a terrain evaluation study conducted by Peto MacCallum Ltd. in 1969 (PML Ref.: 69F214) revealed that the lacustrine deposit is primarily a silty clay with silt seams. This deposit is underlain by a very dense sandy silt till that is underlain by bedrock. Isolated deposits of Wentworth till (a late Wisconsinan gravelly silt till) exist as drumlins in the vicinity of the bridge on the west side of the river. Stream deposits, primarily silt and clay with some gravel and sand, exist within and adjacent to the river bed. Dense water bearing sand and gravel deposits overlying bedrock were identified in terraces adjacent to the river channel.

The underlying bedrock comprises bituminous dolostone, argillaceous limestone and argillaceous dolostone primarily of the Bertie Formation and argillaceous dolomite and shale with evaporites of the Salina Formation. Both of these formations are of Paleozoic origin.



4. INVESTIGATION PROCEDURES

The field investigation for this study was carried out during the period of September 12 to 15, 2005 and comprised four boreholes advanced at each of the bridge pier locations as shown on Drawing 1.

The borehole depths are presented in the following table:

Borehole No.	Depth⁽¹⁾ to Top of Pier (m)	Concrete Core⁽²⁾⁽³⁾ (m)	Sand and Gravel (m)	Rock Core⁽³⁾ (m)	Total (m)
1	1.1	8.8	0.2	3.2	13.3
2	1.2	8.3	1.2	2.7	13.4
3	1.1	7.8	2.2	3.8	14.9
4	1.1	8.9	1.6	4.8	16.4

(1) From existing bridge deck.

(2) Pier and footing.

(3) NQ rock coring equipment.

The locations of the boreholes were programmed and established in the field by Peto MacCallum Ltd. The surface elevation of the bridge deck at the boreholes was deduced from information shown on the "Plan" drawing of Highway No. 3, Town of Haldimand, Geographic Township of North Cayuga (Plan Drawing C-003-CAY-1, dated December 2004) provided by McCormick Rankin Corporation in an email dated October 21, 2005.

The boreholes were advanced using NQ rock coring equipment, powered by a truck-mounted CME-75 drillrig, supplied and operated by a specialist drilling contractor, working under the full time supervision of a member of our engineering staff.

The concrete and rock core samples were returned to our laboratory for detailed visual examination and laboratory testing. Observation of the groundwater conditions in the boreholes was not possible since water was used as a drilling fluid during coring and was continuously pumped into the boreholes during the coring operations.



The coreholes were backfilled with cement grout in accordance with MTO guidelines for borehole abandonment.

Unconfined compressive strength and density tests were conducted on eleven concrete samples and five rock core samples. The results are provided in Tables 1 and 2 respectively.

5. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including inferred stratigraphy and unconfined compressive strength test results conducted on the concrete and rock core.

The borehole locations are presented on Drawing 1.

The subsurface stratigraphy revealed in the boreholes generally comprised concrete (bridge deck slab, underlying pier and footing) overlying a sand and gravel layer underlain by dolostone bedrock.

The pier concrete and subsurface strata encountered are summarized below.

5.1 Pier Concrete

The length of concrete core extracted from each pier was as follows:

Pier No.	Borehole No.	Length of Concrete Core (m)
1	1	8.8
2	2	8.3
3	3	7.8
4	4	8.9

It is apparent from examination of the cores that the same type of concrete was used for the full height in each pier.



5.1.1 Horizontal Fractures

Each core had many horizontal fractures/core breaks over the total core length. Based on visual examination, it is considered that most of the fractures/breaks result from the drilling and sampling process and the size and quality of the coarse aggregate in the concrete. Construction/cold joints which would normally be expected in piers of this height were ruled out as a contributing cause as no visual indication of horizontal construction joints/cold joints was observed in any of the cores.

The upper 600 mm section of the core from Pier 3 was the only section in which other evidence of horizontal cracking or fracturing was noted. This section of core contained seven actual breaks and several other fracture lines/planes, although the core was still intact across these planes. This fracturing may be evidence of horizontal delamination that is often associated with freeze/thaw deterioration. This phenomenon is not present in Piers 1, 2 or 4.

Apart from the upper 600 mm of Core 3, all sections of core located between the core breaks were sound and unfractured with no evidence of honeycombing, significant porosity, voiding or microcracking.

5.1.2 Aggregate Quality

The coarse aggregate used in the concrete is considered to be poor to fair quality and consists mainly of crushed buff to brown coloured limestone particles and grey dolomite, appearing to have a maximum of size of 50 to 75 mm. In Pier 4 one large (approximate 300 mm in size) cobble sized piece of grey dolomite was noted.

The grey dolomite aggregate was generally hard and sound. The buff to brown limestone was softer and often quite porous.

Small pieces of chert were apparent throughout the concrete as well as infrequent deposits of gypsum in some of the voids in the concrete.

The finer aggregate and cement matrix of the cores was considered to be sound and of fairly good quality.



Photographs of the four cores are presented in Appendix B.

5.1.3 Compression and Density Test Specimens

Test specimens (100 mm long) were cut from various sections of each core to determine the unconfined compressive strength and density of the concrete. Due to the large size particles of the coarse aggregate in the concrete and in order to furnish compressive strength results that would be representative of the concrete, these test specimens were cut from sections of the core in which the coarse aggregate particles did not exceed 20 mm in size. The locations of each of these test specimens are noted on the Log of Borehole sheets and on the photographs of the concrete core (identified as 1-2, typical).

Eleven unconfined compressive strength tests were conducted on the pier concrete and the test results are presented in Table 1, ranged from 32.9 to 62.0 MPa, with an average strength of 45.6 MPa. The measured density of the test specimens are also provided in Table 1.

5.2 Sand and Gravel

Sand and gravel was identified below the pier foundation in all boreholes. This unit ranged in thickness from approximately 0.2 to 2.2 m generally increasing in thickness from west to east. The relative density of this unit was not determined since the holes were advanced by coring and conventional standard penetration testing was not conducted.

Based on the information provided on the structural drawing prepared for the existing bridge in July 1923 (Drawing No. 1160, Proposed Bridge over Grand River, Talbot Street, Village of Cayuga, County of Haldimand, Station 820+31.44 to 827+67.38 revised July 24, 1923) as well as resistance during coring, this deposit is judged to be dense to very dense.

5.3 Bedrock

Bedrock was contacted in all boreholes approximately 10.1 to 11.6 m below the bridge deck (elevation 171.2 to 172.7 m). The bedrock surface gently slopes down towards the east at about 1.5%.



The bedrock comprises very poor quality dolostone of the Bertie Formation.

The dolostone contains light brown to buff and dark grey 'layers'. The light brown to buff 'layers' are typically slightly to moderately weathered and of low to medium strength. Numerous 'fine' voids/vugs were observed in the rock core; large voids were identified in two cores (430 and 250 mm in Pier 1; 600 and 175 mm in Pier 4). The dark grey 'layers' are typically unweathered and of medium strength.

The measured rock core recovery varied from 37 to 100%, typically 60 to 83%. It was not possible to discern whether the recovery is indicative of open voids in the rock mass or very weak highly weathered rock that was washed away during the drilling operation. It is noted however, that the drill rig supervisor was able to detect the large voids in Piers 1 and 4 noted above. There is no discernible difference in the core recovery between the light brown to buff and dark grey 'layers' in the rock mass.

The Rock Quality Designation (RQD) determined from the recovered core indicates the rock is of very poor quality. The majority of the bedrock core was less than 50 mm long. The RQD in 10 of the 14 core runs was 0% and ranged from 7 to 19% in the other four core runs. There was no discernible difference in the RQD between the light brown to buff and dark grey 'layers' in the rock mass.

The unconfined compressive strength (UCCS) of the light brown to buff dolostone was typically 33 MPa while the dark grey dolostone was much stronger with both UCCS' ranging from 140 to 195 MPa. Refer to Table 2 for the test results.

The density of the light brown to buff dolostone was measured at 2473 and 2595 kg/m³ while the density of the stronger dark grey dolostone was 2624 to 2750 kg/m³

A detailed description of the bedrock is provided in Table 3.

5.4 Groundwater

The holes were advanced by coring and water was used as a drilling fluid. Hence observation of the groundwater level was not possible. Water loss was detected during coring operations but was difficult to quantify.

6. CLOSURE

The field work was carried out under the supervision of Mr. M. Rapsey and direction of Mr. P.A. Lyall, BEng. The equipment was supplied by Geo-Environmental Drilling Inc.

The concrete core was examined by Mr. G. Pacitti, P.Eng. The tests conducted on the concrete core samples were performed in the laboratory located in our Hamilton office. The tests conducted on the rock core samples were performed in our Toronto laboratory.

This report was prepared by Mr. P.A. Lyall, BEng., and Mr. G.O. Degil, Ph.D., P.Eng., Senior Foundation Engineer, and reviewed by Mr. D.W. Kerr, MEng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, MEng., P.Eng., MTO Designated Contact, carried out an independent review of the report.

Sincerely

Peto MacCallum Ltd.



Dennis W. Kerr, MEng., P.Eng.
Chief Foundation Engineer

PL/DWK:lad



Brian R. Gray, MEng, P.Eng.
MTO Designated Contact



Table 1

Unconfined Compressive Strength and Density Tests

Concrete Core

Pier Reference ⁽¹⁾	Borehole No.	Specimen No.	Depth to Core Specimen (m)	Unconfined Compressive Strength (MPa)	Average Unconfined Compressive Strength (MPa)	Density (kg/m ³)
1	1	1-1	1.8	57.9	58.0	2275
		1-2	5.1	54.0		2253
		1-3	8.1	62.0		2291
2	2	2-1	2.9	33.8	38.7	2214
		2-2	6.8	43.6		2192
		2-3	8.4	38.6		2273
3	3	3-1	5.2	48.6	40.8	2193
		3-2	7.4	32.9		2290
4	4	4-1	1.7	49.8	43.6	2254
		4-2	5.0	37.7		2228
		4-3	8.9	43.2		2255

(1) refer to Drawing 1 for pier location

Note: 1. All test specimens have a length:diameter ratio ranging from 2.06 to 2.17.
 2. Maximum size of coarse aggregate in test specimens < 20 mm.



Table 2

Unconfined Compressive Strength and Density Tests

Rock Core

Pier Reference	Borehole No.	Depth to Core ¹ Specimen (m)	Unconfined Compressive Strength (MPa)	Density (kg/m ³)
Light Brown to Buff Dolostone				
1	1	10.6	33.2	2595
3	3	11.5	33.5	2473
Dark Grey Dolostone				
1	1	13.0	195.1	2624
3	3	13.4	139.9	2642
4	4	14.9	154.7	2750

1. From Bridge Deck



Table 3-1
 Rock Core Description

Core Recovery					Core Description	
BH	RC	Depth (m)	Rec (%)	RQD (%)	Depth (m)	Description
1	7	10.3 – 11.8	61	0	10.3 – 12.7	DOLOSTONE: Light brown to buff, fine crystalline to aphanitic, numerous fine voids, with 430 mm void at 11.3 m depth, low to medium strength, slightly to moderately weathered, very close to close spaced bedding joints, smooth planar, oxidized to slightly altered, very poor quality.
	8	11.8 – 13.3	83	0		
					12.7 – 13.3	DOLOSTONE: Dark grey, laminated, shaley, fine crystalline to aphanitic, 250 mm void at 12.8 m depth, medium strength, unweathered, very close to close spaced flat bedding joints, smooth planar, tight, very poor quality.

RQD = Rock Quality Designation
 Drilled: September 15, 2005
 Logged: October 31, 2005



Table 3-2
 Rock Core Description

Core Recovery					Core Description	
BH	RC	Depth (m)	Rec (%)	RQD (%)	Depth (m)	Description
2	7	10.3 – 11.6	97	0	10.7 – 11.9	DOLOSTONE: Light brown to buff, aphanitic to cryptocrystalline, occasional layers with numerous fine voids, occasional layers with cross bedding, low to medium strength, slightly to moderately weathered, very close to close spaced flat bedding joints, smooth planar, oxidized to slightly altered, very poor quality.
	8	11.6 – 11.8	100	0		
	9	11.8 – 13.4	60	0		
					11.9 – 13.4	DOLOSTONE: Dark grey, shaley, fine crystalline to aphanitic, medium strength, unweathered, very close spaced flat bedding joints, smooth planar, tight, very poor quality.

RQD = Rock Quality Designation

Drilled: September 13, 2005

Logged: October 31, 2005

Borehole advanced by coring through concrete, sand and gravel and bedrock. Bedrock confirmed at 10.7 m; recovery and RQD values are for rock core only.



Table 3-3
 Rock Core Description

Core Recovery					Core Description	
BH	RC	Depth (m)	Rec (%)	RQD (%)	Depth (m)	Description
3	7	10.3 – 11.8	77	0	11.1 – 12.3	DOLOSTONE: Light brown to buff, fine crystalline to aphanitic, with numerous fine voids, occasional layers without voids, occasional black shaley partings, low to medium strength, slightly to moderately weathered, very close to close spaced flat to dipping bedding joints, smooth planar, oxidized to slightly altered, occasional with white scaling on surface, very poor quality.
	8	11.8 – 12.2	100	0		
	9	12.2 – 13.4	78	0		
	10	13.4 – 14.9	65	19		
					12.3 – 13.4	DOLOSTONE: Dark grey, shaley, fine crystalline to aphanitic, low strength, moderately weathered, very close spaced flat bedding joints, rough planar, up to 2 mm aperture with dark brown silty filling, very poor quality.
					13.4 – 14.9	DOLOSTONE: Light brown to buff, aphanitic, with occasional fine voids, occasional black shaley partings, medium strength, unweathered, very close to close spaced flat bedding joints, smooth planar, tight, very poor quality.

RQD = Rock Quality Designation

Drilled: September 14, 2005

Logged: October 31, 2005

Borehole advanced by coring through concrete, sand and gravel and bedrock. Bedrock confirmed at 11.1 m; recovery and RQD values are for rock core only.



Table 3-4
 Rock Core Description

Core Recovery					Core Description	
BH	RC	Depth (m)	Rec (%)	RQD (%)	Depth (m)	Description
4	7	10.2 – 11.8	23	0	11.6 – 14.6	DOLOSTONE: Light brown to buff, fine crystalline to aphanitic, numerous fine voids becoming less frequent at depth, occasionally to 2 mm, occasional vugs, with 600 mm void at 14.0 m depth, generally low to medium strength with occasional high strength layers, slightly to moderately weathered, very close to close spaced flat bedding joints, smooth planar, oxidized to slightly altered, occasional with black residue on parting, vertical cross joint, smooth planar, oxidized with minor white scale on parting, very poor quality
	8	11.8 – 12.9	73	13		
	9	12.9 – 13.4	37	0		
	10	13.4 – 14.9	63	7		
	11	14.9 – 16.4	76	9		
					14.6 – 15.4	DOLOSTONE: Dark grey, shaley, laminated with cross bedding, fine crystalline to aphanitic, medium to high strength, slightly weathered, close spaced flat bedding joints, smooth planar, tight, vertical cross joint, smooth planar, oxidized with minor white scaling on parting, very poor quality.
					15.4 16.4	DOLOSTONE: Light brown to buff, aphanitic, with numerous fine voids, 175 mm void at 16.0 m, low to medium strength, unweathered, very close spaced flat bedding joints, smooth planar, tight, very poor quality.

RQD = Rock Quality Designation

Drilled: September 12, 2005

Logged: October 31, 2005

Borehole advanced by coring through concrete, sand and gravel and bedrock. Bedrock confirmed at 11.6 m; recovery and RQD values are for rock core only.

TERMS USED IN REPORT



N Value: the standard penetration test (SPT) N value is the number of blows required to cause a standard 51 mm O.D. split barrel sampler to penetrate 0.3 m into undisturbed ground in a borehole when driven by a hammer with a mass of 63.5 kg. Falling freely a distance of 0.76 m. For penetrations of less than 0.3 m N values are indicated as the number of blows for the penetration achieved. Average N value is denoted thus N.

Dynamic cone penetration test: continuous penetration of a conical steel point (51 mm O.D. 60° cone angle) driven by 475 J impact energy on 'A' size drill rods. The resistance to cone penetration is measured as the number of blows for each 0.3 m advance of the conical point into the undisturbed ground.

Soils are described by their composition and consistency or denseness.

CONSISTENCY: Cohesive soils are described on the basis of their undrained shear strength (C_u) as follows:

C_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	Very Soft	Soft	Firm	Stiff	Very Stiff	Hard

DENSENESS: Cohesionless soils are described on the basis of denseness as indicated by SPT N values as follows:

N (Blows/0.3 m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	Very Loose	Loose	Compact	Dense	Very Dense

Rocks are described by their composition and structural features and/or strength.

RECOVERY: Sum of all recovered rock core pieces from a coring run expressed as a percent of the total length of the coring run.

MODIFIED RECOVERY: Sum of those intact core pieces, 100 mm + in length expressed as a percent of the length of the coring run. The rock quality designation (RQD), for modified recovery, is:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	Very Poor	Poor	Fair	Good	Excellent

JOINTING AND BEDDING:

Spacing	50 mm	50 - 300 mm	0.3 m - 1 m	1 m - 3 m	> 3 m
Jointing	Very Close	Close	Mod. Close	Wide	Very Wide
Bedding	Very Thin	Thin	Medium	Thick	Very Thick

ABBREVIATIONS AND SYMBOLS



FIELD SAMPLING

SS	Split Spoon	TP	Thinwall Piston
WS	Wash Sample	OS	Osterberg Sample
ST	Slotted Tube	RC	Rock Core
BS	Block Sample	PH	T W Advanced Hydraulically
CS	Chunk Sample	PM	T W Advanced Manually
TW	Thinwall Open	FS	Foil Sample

STRESS AND STRAIN

U_w	kPa	Pore Water Pressure
γ_u	1	Pore Pressure Ration
σ	kPa	Total Normal Stress
σ'	kPa	Effective Normal Stress
τ	kPa	Shear Stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal Stresses
e	%	Linear Strain
e_1, e_2, e_3	%	Principal Strain
ε	kPa	Modulus of Linear Deformation
G	kPa	Modulus of Shear Deformation
μ	1	Coefficient of Friction

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	Coefficient of Volume Change
C_c	1	Compression Index
C_s	1	Swelling Index
C_a	1	Rate of Secondary Consolidation
C_v	m ² /s	Coefficient of Consolidation
H	m	Drainage Path
α_v	1	Time Factor
u	%	Degree of Consolidation
σ'_{vo}	kPa	Effective Overburden Pressure
σ'_p	kPa	Preconsolidation Pressure
τ_f	kPa	Shear Strength
c'	kPa	Effective Cohesion Intercept
ϕ'	-°	Effective Angle of Internal Friction
c_u	kPa	Apparent Cohesion Intercept
ϕ_u	-°	Apparent Angle of Internal Friction
τ_R	kPa	Residual Shear Strength
τ_r	kPa	Remoulded Shear Strength
s_t	1	Sensitivity

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	Density of Solid Particles	w_p	%	Plastic Limit
γ_s	kN/m ³	Unit Weight of Solid Particles	w_s	%	Shrinkage Limit
ρ_w	kg/m ³	Density of Water	I_p	%	Plasticity Index = $w_L - w_p$
γ_w	kN/m ³	Unit Weight of Water	I_L	1	Liquidity Index = $\frac{w - w_p}{I_p}$
ρ	kg/m ³	Density of Soil	I_C	1	Consistency Index = $\frac{w_L - w}{I_p}$
γ	kN/m ³	Unit Weight of Soil	e_{max}	1, %	Void Ratio in Loosest State
ρ_d	kg/m ³	Density of Dry Soil	e_{min}	1, %	Void Ratio in Densest State
γ_d	kN/m ³	Unit Weight of Dry Soil	I_D	1	Density Index = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_{sat}	kg/m ³	Density of Saturated Soil	D	mm	Grain Diameter
γ_{sat}	kN/m ³	Unit Weight of Saturated Soil	D_n	mm	n Percent - Diameter
ρ'	kg/m ³	Density of Submerged Soil	C_u	1	Uniformity Coefficient
γ'	kN/m ³	Unit Weight of Submerged Soil	h	m	Hydraulic Head or Potential
e	1, %	Void Ratio	q	m	Rate of Discharge
n	1, %	Porosity	v	m/s	Discharge Velocity
w	1, %	Water Content	i	1	Hydraulic Gradient
s_r	%	Degree of Saturation	k	m/s	Hydraulic Conductivity
w_L	%	Liquid Limit	J	kN/m ³	Seepage Force

RECORD OF BOREHOLE No 1

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Co-ords: 4 756 616 N ; 275 260 E
 DIST 31 HWY 3 BOREHOLE TYPE Rock Coring
 DATUM Geodetic DATE September 15, 2005
 ORIGINATED BY MR
 COMPILED BY PL
 CHECKED BY DWK

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
182.8	Top of Bridge												
0.0	Bridge deck												
0.2	Space between Bridge Deck and Top of Pier												
181.7	Top of Pier												
1.1	Concrete												
			1	RC NQ								22.3	
			2	RC NQ									
			3	RC NQ								22.1	
			4	RC NQ									
			5	RC NQ								22.5	
			6	RC NQ									
172.9	Sand and gravel												
172.7	Dense to very dense ⁽¹⁾ Dolostone bedrock											25.5	
10.1	Light brown to buff Low to medium strength Slightly to moderately weathered Very poor quality 430 mm void at 11.3 m 250 mm void at 12.8 m		7	RC NQ									RQD 0%
	Dark grey		8	RC NQ									RQD 0%
169.5	Medium strength											25.7	
13.3	Unweathered												
	Very poor quality End of borehole. Core sample jammed in core barrel, borehole abandoned at 13.3 m. Interpreted from drilling resistance. Hole advanced by coring hence SPT not conducted.												

RECORD OF BOREHOLE No 2

1 of 1

METRIC

G.W.P. 3501-01-00 LOCATION Co-ords: 4 756 632 N ; 275 295 E ORIGINATED BY MR
DIST 31 HWY 3 BOREHOLE TYPE Rock Coring COMPILED BY PL
DATUM Geodetic DATE September 13, 2005 CHECKED BY DWK

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			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
182.8	Top of Bridge											
0.0	Bridge deck											
0.2	Space between Bridge Deck and Top of Pier											
181.6	Top of Pier											
1.2	Concrete		1	RC NQ	REC 100%							
			2	RC NQ	REC 100%							
			3	RC NQ	REC 100%							
			4	RC NQ	REC 100%							
			5	RC NQ	REC 98%							
173.3	Sand and gravel		6	RC NQ	REC 67%							
9.5	Dense to very dense ⁽²⁾											
172.1	Dolostone bedrock		7	RC NQ	REC 97%							
10.7	Light brown to buff											
	Low to medium strength											
	Slightly to moderately weathered		8	RC NQ	REC 100%							
	Very poor quality											
	Dark grey		9	RC NQ	REC 60%							
	Medium strength											
	Unweathered											
169.4	Very poor quality											
13.4	End of borehole. Pulled casing from borehole at 13.4m to retrieve core sample. Borehole abandoned due to cave-in at 10.1 m. Interpreted from drilling resistance. Hole advanced by coring hence SPT not conducted.											

RECORD OF BOREHOLE No 3

1 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Co-ords: 4 756 639 N ; 275 332 E ORIGINATED BY MR
 DIST 31 HWY 3 BOREHOLE TYPE Rock Coring COMPILED BY PL
 DATUM Geodetic DATE September 14, 2005 CHECKED BY DWK

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
182.8	Top of Bridge													
0.0	Bridge deck													
0.2	Space between Bridge Deck and Top of Pier													
181.7	Top of Pier													
1.1	Concrete													
			1	RC NQ	REC 97%									
			2	RC NQ	REC 97%									
			3	RC NQ	REC 100%									
			4	RC NQ	REC 100%									
			5	RC NQ	REC 97%									
173.9			6	RC NQ										
8.9	Sand and gravel Dense to very dense ⁽¹⁾		7	RC NQ	REC 77%									
171.7			8	RC NQ	REC 100%									
11.1	Dolostone bedrock Light brown to buff Low to medium strength Slightly to moderately weathered Very poor quality Dark grey Low strength Moderately weathered Very poor quality Light brown to buff Medium strength Unweathered Very poor quality		9	RC NQ	REC 78%									
			10	RC NQ	REC 65%									
167.3														

RECORD OF BOREHOLE No 3

2 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Co-ords: 4 756 639 N ; 275 332 E ORIGINATED BY MR
 DIST 31 HWY 3 BOREHOLE TYPE Rock Coring COMPILED BY PL
 DATUM Geodetic DATE September 14, 2005 CHECKED BY DWK

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 (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH MPa								WATER CONTENT (%)		
								20 40 60 80 100										
167.8																		
14.9	End of borehole																	
	(H) Interpreted from drilling resistance. Hole advanced by coring hence SPT not conducted.																	

METRIC

ORIGINATED BY MR

COMPILED BY PL

CHECKED BY DWK

ON MOT VER3 04HF058A.GPJ ON MOT.GDT 2/10/2006 11:53:50 AM

 $+^7, \times^5:$

Numbers refer to
Sensitivity

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

2 of 2

METRIC

G.W.P. 3501-01-00 LOCATION Co-ords: 4 756 656 N ; 275 367 E ORIGINATED BY MR
 DIST 31 HWY 3 BOREHOLE TYPE Rock Coring COMPILED BY PL
 DATUM Geodetic DATE September 12, 2005 CHECKED BY DWK

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH MPa								
167.8							20	40	60	80	100					
	Medium to high strength		11	RC NQ	REC 76%		167									
	Slightly weathered															
	Very poor quality															
166.4	Light brown to buff															RQD 9%
16.4	Low to medium strength															
	Unweathered															
	Very poor quality															
	175 mm void at 16.0 m															
	End of borehole															
	Interpreted from															
	drilling resistance. Hole															
	advanced by coring hence															
	SPT not conducted.															

METRIC

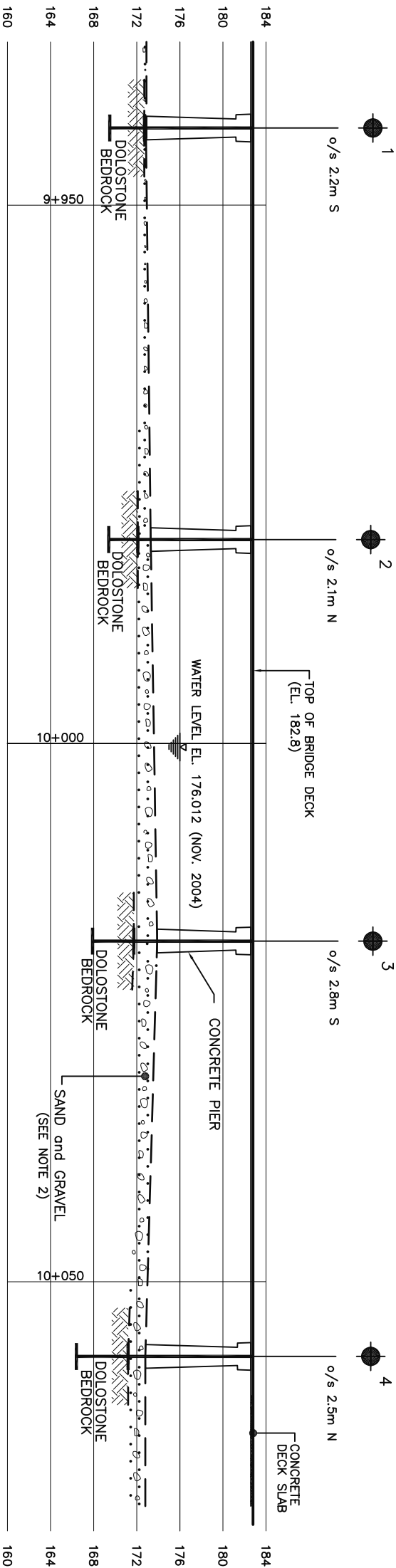
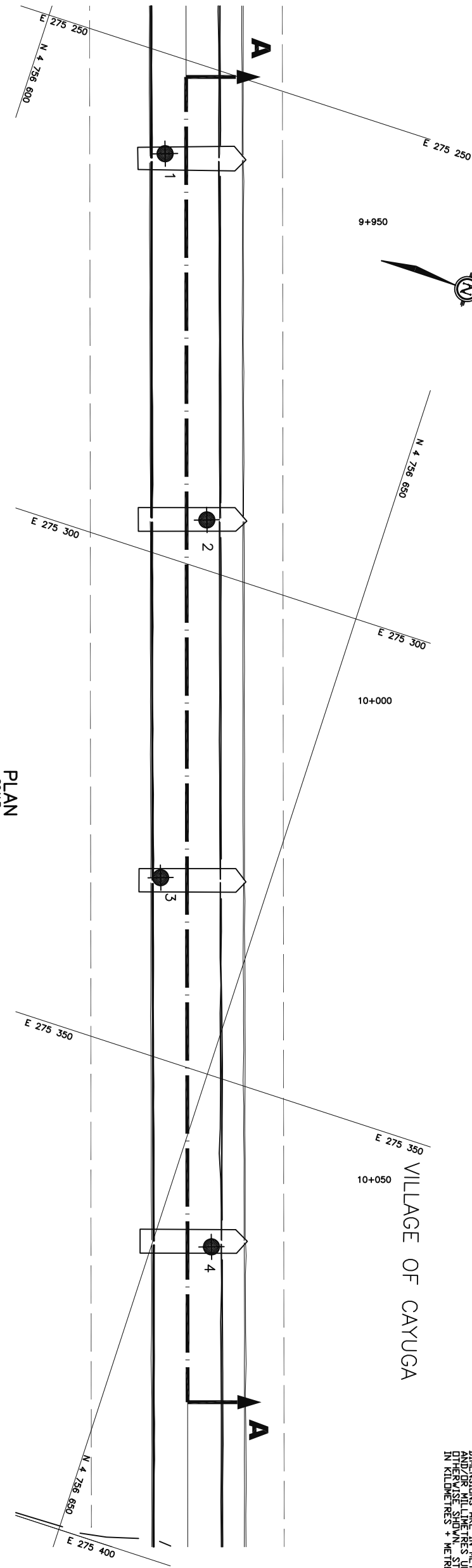
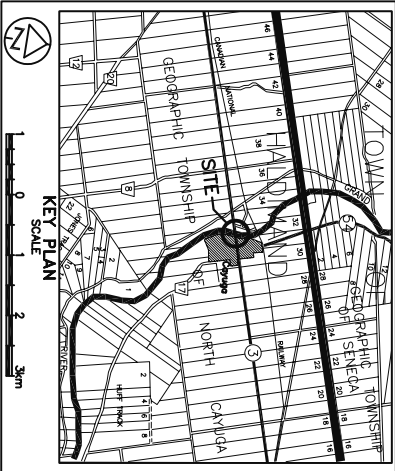
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SPECIFIED
IN KILOMETRES + METRES

CONT No
GWP No 3501-01-00
HIGHWAY 3-
GRAND RIVER BRIDGE
BOREHOLE LOCATIONS & SOIL STRATA



SHEET

PMI *Peto MacCallum Ltd*
CONSULTING ENGINEERS



NOTES:

- SECTIONS ARE PROVIDED SOLELY FOR ILLUSTRATIVE PURPOSES. REFER TO RECORD OF BOREHOLES FOR DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS, IN-SITU TEST DATA AND LABORATORY TEST RESULTS.
- BOREHOLE ADVANCED BY CORING. STANDARD PENETRATION TESTS NOT CONDUCTED, HENCE THE RELATIVE DENSITY OF THE SAND AND GRAVEL UNIT NOT DETERMINED. BASED ON INFORMATION PROVIDED ON THE STRUCTURAL DRAWING PREPARED FOR THE EXISTING STRUCTURE IN 1923 AND RESISTANCE DURING CORING, THE DEPOSIT IS JUDGED TO BE DENSE TO VERY DENSE.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

A-A
SECTION



REF No e003coy1.dwg Nov. 2005

LEGEND			
	Borehole		
	Dynamic Cone Penetration Test (Cone)		
	Borehole & Cone		
	Blows/0.3m (Std. Pen Test, 475 J / blow)		
	Blows/0.3m (60° Cone, 475 J / blow)		
	W L at time of investigation Sept. 2005		
	Head		
	ARTESIAN WATER		
	Encountered		
	PIEZOMETER		
BH No	ELEVATION	CO-ORDINATES	
1	182.8	4 756 616	275 260
2	182.8	4 756 632	275 295
3	182.8	4 756 639	275 332
4	182.8	4 756 656	275 367

— NOTE —

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

REVISIONS		REVISION NOTES		DIST o/s LONDON	
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Appendix A

Site Photographs



Photograph 1: View north from east side of Grand River (August 2004).



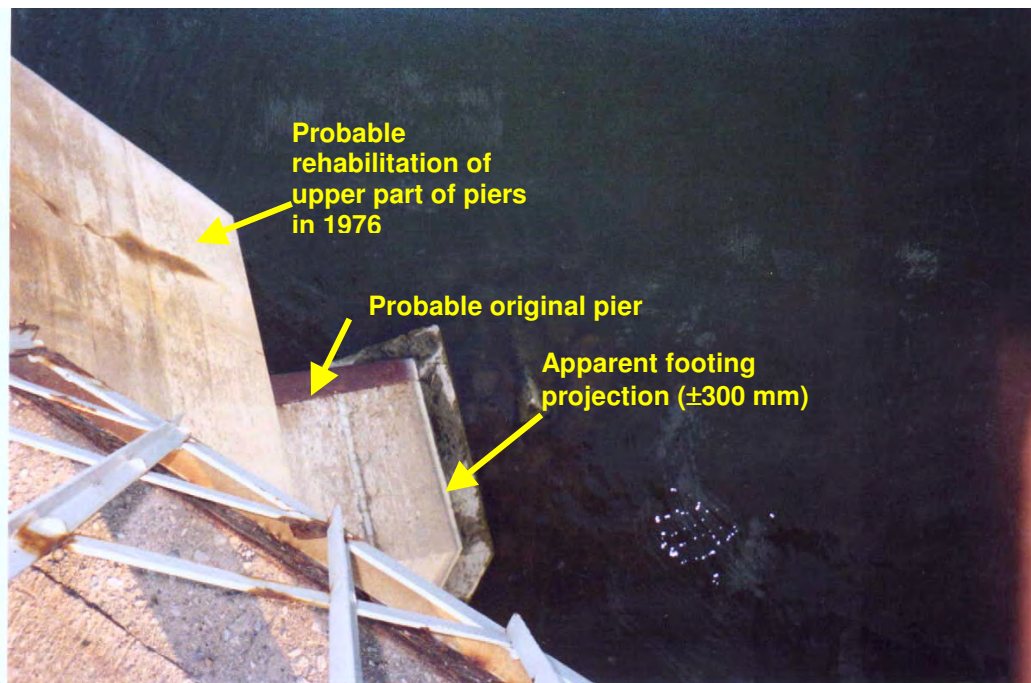
Photograph 2: View west along Highway 53 (August 2004).



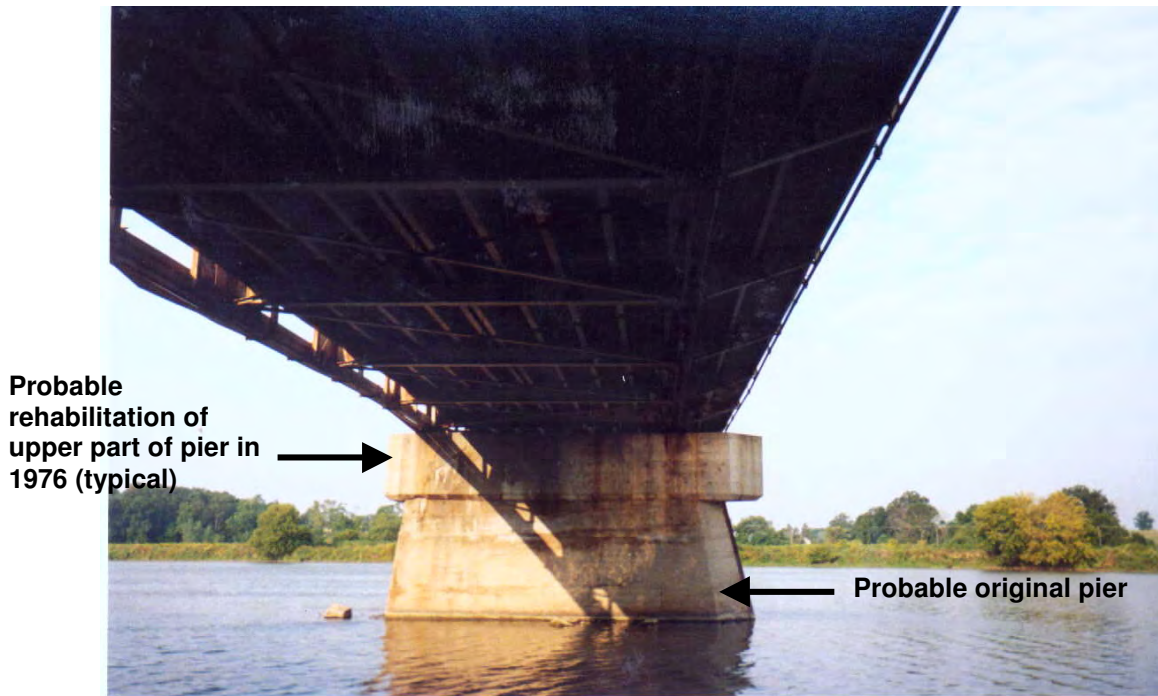
Photograph 3: View west from east side of Grand River along north side of bridge (August 2004).



Photograph 4: View west from east side of Grand River along south side of bridge (August 2004).



Photograph 5: View of typical pier. Note: footing projection; probable original pier; probable rehabilitation of upper part of pier in 1976. (August 2004).



Photograph 6: View west of east pier from east side of Grand River (August 2004).



Photograph 7: View east of east side of river south of bridge. Note: boat launch ramp (August 2004).



Photograph 8: View west of west side of river south side of bridge (August 2004).



Photograph 9: View west of west side of river north side of bridge (August 2004).



Photograph 10: View east of east side of river north side of bridge (August 2004).



Appendix B

Concrete Core Photographs



Core 1 - Borehole 1



Core 2 - Borehole 2



Core 3 - Borehole 3



Core 4 - Borehole 4



Appendix C

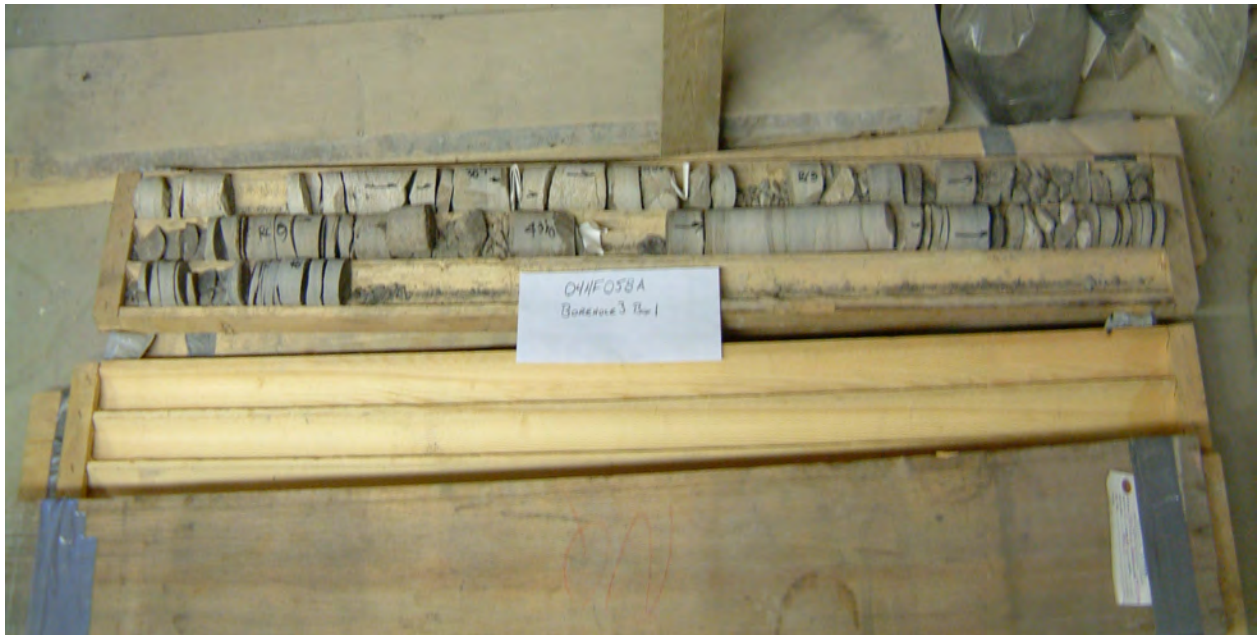
Rock Core Photographs



Borehole 1, Rock Cores 7 and 8



Borehole 2, Rock Cores 8 and 9



Borehole 3, Rock Cores 7, 8, 9 and 10



Borehole 4, Rock Cores 8, 9 and 10