



**FOUNDATION INVESTIGATION AND DESIGN REPORT
for
LONGWOOD CHANNEL REHABILITATION, SECTION 3
HIGHWAY 403
GWP 2054-14-00
TASK NO. 2054-14-00-001
HAMILTON, ONTARIO**

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PML Ref.: 16TF023A-1
Index No.: 027FIR and 028FDR
GEOCRES No.: 30M5-324
March 20, 2017



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TABLE OF CONTENTS

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION	1
2. SITE DESCRIPTION AND GEOLOGY	1
3. INVESTIGATION PROCEDURES	2
4. SUMMARISED SUBSURFACE CONDITIONS.....	3
4.1 Topsoil.....	3
4.2 Fill.....	4
4.3 Clayey Silt and Sand	4
4.4 Silty Clay	4
4.5 Silty Clay Till	5
4.6 Groundwater	5
5. CLOSURE.....	6

Appendix FIR-A – Borehole Logs and Borehole Location Plan from Geocres No. 30M5-322

Appendix FIR-B – Locations and Directions of Photographs

Site Photographs

Appendix FIR-C – Plasticity Chart and Results of Grain Size Distribution Analyses

FOUNDATION INVESTIGATION REPORT
for
Longwood Channel Rehabilitation, Section 3
Highway 403, GWP 2054-14-00
Hamilton, Ontario

1. INTRODUCTION

This report summarises the results of a foundation investigation carried out for rehabilitation of Section 3 of the Longwood Drainage Channel in Hamilton, Ontario. The study was conducted for AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation of Ontario (MTO).

This report provides subsurface information pertaining to the proposed rehabilitation of Section 3 of the Longwood Drainage Channel.

2. SITE DESCRIPTION AND GEOLOGY

The Longwood Drainage Channel is a trapezoidal open channel with concrete lining that was constructed in 1964. It runs along Highway 403 from Station 11+606 to 13+323, Highway 403 chainage (ref. Contract Drawings 'Highway 403 – Longwood Channel and Lower Princess Falls (Upper Cascade) Outfall'). Section 3 of the channel is located on the south side of the highway between approximate Station 12+480 and 12+630 on a curved alignment and has a total length of about 160 m. The Chedoke East storm sewer outlet structure feeds into the Longwood Channel within this section.

The site of Section 3 of the Longwood Drainage Channel is situated south of Highway 403 between Aberdeen Avenue and Longwood Road South in the City of Hamilton. The channel is bounded by a grassed slope to the south that abuts the McMaster Innovation Park on the table lands at the top of the slope. Highway 403 follows the alignment of the former Chedoke Creek ravine and runs approximately in the west-east direction at the site. Land use above the north side of the ravine generally comprises a mix of residential subdivisions and commercial development.

Stormwater run-off from the Chedoke East catchment above the Niagara Escarpment is captured and conveyed by a storm sewer pipe terminating at the Longwood Drainage Channel with a



“Y” connection at an angle of about 45°. After the conjunction point, the Longwood Channel bottom width increases from 2.4 to 4.8 m.

The study area lies in the physiographic region known as the Iroquois Plain and is characterised by glaciolacustrine sands and silts discontinuously underlain by glacial till deposits overlying shale bedrock of the Queenston Formation (L.J. Chapman and D.F. Putnam, *The Physiography of Southern Ontario*, 3rd Edition, 1984). There is shallow overburden at this site due to the proximity of the Niagara Escarpment, with evidence of ongoing erosion.

3. INVESTIGATION PROCEDURES

The scope of work for the current investigation included a site visit to review the conditions of Section 3 of the Longwood Channel with no requirement for soil sampling or borehole drilling.

A review of the preliminary foundation investigation and design report ‘Longwood Channel Rehabilitation’ (Geocres No. 30M5-322) available for the existing channel was carried out. The subsurface information from boreholes 15-04 and 15-05 advanced as part of the preliminary investigation is considered to be relevant for Section 3 of the channel. The previous borehole logs are given in Appendix FIR-A of this report.

The field work for the available preliminary investigation report was carried out in July 2015. Boreholes 15-04 and 15-05 were both advanced to a depth of 9.8 m. The approximate locations of the boreholes are indicated on the Thurber drawing included in Appendix FIR-A.

Peto MacCallum Ltd. undertook a visit to the site of Section 3 of the Longwood Drainage Channel on September 14, 2016. The purpose of the site visit was to investigate the sidewalls of the channel, determine existing backfill conditions, assess requirements for slab subgrade preparation and evaluate potential construction issues. Site photographs are shown in Appendix FIR-B.

Two grab soil samples from the gully on the north side of the channel (Photo 11 in Appendix FIR-B) were also recovered during the site visit. Soils were identified in the field in



accordance with the MTO Soil Classification procedures. Recovered soil samples were returned to our laboratory for detailed visual examination and classification. Atterberg limits testing (2) and grain size distribution analyses (2) were conducted on the soil samples. The laboratory test results are presented in Appendix FIR-C.

4. SUMMARISED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, boundary elevations, standard penetration test data and groundwater observations. The results of laboratory Atterberg limits testing, grain size distribution analyses and natural moisture content determinations are also shown on the Record of Borehole sheets.

The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised surficial topsoil and/or fill overlying a cohesive deposit of silty clay underlain by the glacial till. The groundwater was at depths of 3.3 to 3.7 m (elevation 78.4 to 78.8 m).

The strata encountered are summarised below.

4.1 Topsoil

Surficial topsoil was identified in borehole 15-05. The topsoil was about 100 mm thick and penetrated at elevation 82.0 m.



4.2 Fill

Surficial fill was present in borehole 15-04 and below the topsoil at 0.1 m depth (elevation 82.0 m) in borehole 15-05. The fill was composed of silty clay in both boreholes, with occasional cobbles encountered in borehole 15-04. The fill was stiff to hard in consistency and 9 to 24% in moisture content. The fill had a thickness of 3.0 m in borehole 15-04 and 2.1 m in borehole 15-05 and was penetrated at respective depths of 3.0 and 2.2 m (elevation 79.1 and 79.0 m).

The results of Atterberg limits testing and grain size distribution analyses conducted by Peto MacCallum Ltd. on two cohesive samples of the fill recovered during the site visit are presented in respective Figures LC-PC-1 and LC-GS-1 (Appendix FIR-C). The clayey silt fill had liquid limits of 22 and 26, plastic limits of 16 and 17, its plasticity index being 6 and 9.

4.3 Clayey Silt and Sand

Directly beneath the fill at 2.2 m depth (elevation 79.9 m) in borehole 15-05 was clayey silt and sand. This unit was very stiff in consistency and had a moisture content of about 24%. The clayey silt and sand was 600 mm thick and penetrated at a depth of 2.8 m (elevation 79.3 m).

4.4 Silty Clay

Overlain by the fill at 3.0 m depth (elevation 79.1 m) in borehole 15-04 or by the clayey silt and sand at a depth of 2.8 m (elevation 79.3 m) in borehole 15-05 was a cohesive deposit of silty clay. This deposit was firm to very stiff in consistency and 28 to 34% in moisture content. The silty clay had a thickness of 5.7 m in borehole 15-04 and 3.1 m in borehole 15-05 and was penetrated at respective depths of 8.7 and 5.9 m (elevation 73.4 and 76.2 m).



4.5 Silty Clay Till

Underlying the silty clay at 8.7 m depth (elevation 73.4 m) in borehole 15-04 and a depth of 5.9 m (elevation 76.2 m) in borehole 15-05 was a cohesive deposit of silty clay till. This deposit was very stiff to hard in consistency and had a moisture content of 18 to 30%. The silty clay till was not penetrated upon termination of drilling at 9.8 m depth (elevation 72.3 m) in both boreholes.

4.6 Groundwater

The water level measured in piezometers installed in boreholes 15-04 and 15-05 was at respective depths of 3.7 and 3.3 m (elevation 78.4 and 78.8 m) on October 6, 2015.

The groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns.



5. CLOSURE

The field work was carried out by Mr. M. Khorsand, EIT, under the supervision of Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer. The laboratory testing of selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. C.M.P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact.

Yours very truly,

Peto MacCallum Ltd.



Grigory O. Degil, PhD, P.Eng.
Senior Foundation Engineer



Carlos M.P. Nascimento, P.Eng.
Project Manager
MTO Designated Principal Contact



APPENDIX FIR-A

Borehole Logs and Borehole Location Plan from Geocres No. 30M5-322

RECORD OF BOREHOLE No 15-04

1 OF 2

METRIC

W.P. 2054-14-00 LOCATION N 4 790 862.1 E 272 079.8 ORIGINATED BY AHF
 HWY 403 BOREHOLE TYPE Tripod/NW Wash Boring COMPILED BY AN
 DATUM Geodetic DATE 2015.07.02 - 2015.07.02 CHECKED BY MRA

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 kPa						
							20 40 60 80 100	20 40 60 80 100	20 40 60					
82.1	GROUND SURFACE													
0.0	Silty CLAY , some topsoil, trace to some sand, occasional cobble, occasional roots and rootlets Stiff to Hard Brown to Reddish Brown Moist (FILL)		1	SS	10									
			2	SS	30									
			3	SS	36									
			4	SS	40									
79.1														
3.0	Silty CLAY , trace sand Stiff Grey		5	SS	14									
			6	SS	11									0 10 50 40
			7	SS	8									
			8	SS	14									0 4 40 56
	Very Stiff													
			9	SS	18									
73.4														
8.7	Silty CLAY , trace sand, trace gravel Very Stiff Grey (TILL)		10	SS	25									
72.3														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

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

RECORD OF BOREHOLE No 15-04

2 OF 2

METRIC

W.P. 2054-14-00 LOCATION N 4 790 862.1 E 272 079.8 ORIGINATED BY AHF
 HWY 403 BOREHOLE TYPE Tripod/NW Wash Boring COMPILED BY AN
 DATUM Geodetic DATE 2015.07.02 - 2015.07.02 CHECKED BY MRA

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 (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2015.07.07 0.5 81.6 2015.10.06 3.7 78.4																

RECORD OF BOREHOLE No 15-05

1 OF 2

METRIC

W.P. 2054-14-00 LOCATION N 4 790 819.6 E 272 029.4 ORIGINATED BY AHF
 HWY 403 BOREHOLE TYPE Tripod/NW Wash Boring COMPILED BY AN
 DATUM Geodetic DATE 2015.07.06 - 2015.07.07 CHECKED BY MRA

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							
82.1	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>							
0.0	TOPSOIL: (100mm)							<div><div>204060</div><div>W P W W L</div><div>PLASTIC NATURAL LIQUID</div><div>LIMIT MOISTURE LIMIT</div><div>CONTENT</div></div>							
0.1	Silty CLAY , trace sand and gravel, roots and rootlets Stiff to Hard Reddish Brown Dry to Moist (FILL)		1	SS	11		82								
			2	SS	42		81								
			3	SS	38		80								
79.9							79								
2.2	Clayey SILT and SAND , trace gravel Very Stiff Grey Moist		4	SS	24		78								
79.3							77								
2.8	Silty CLAY , trace sand Firm Grey		5	SS	6		76								
			6	SS	7		75								
							74								
76.2							73								
5.9	Silty CLAY , some sand to sandy, trace gravel Hard Grey Moist (TILL)		7	SS	51		72								
							71								
			8	SS	28		70								
	Very Stiff						69								
							68								
	Some sand and gravel		9	SS	16		67								
72.3							66								
9.8	END OF BOREHOLE AT 9.8m.						65								

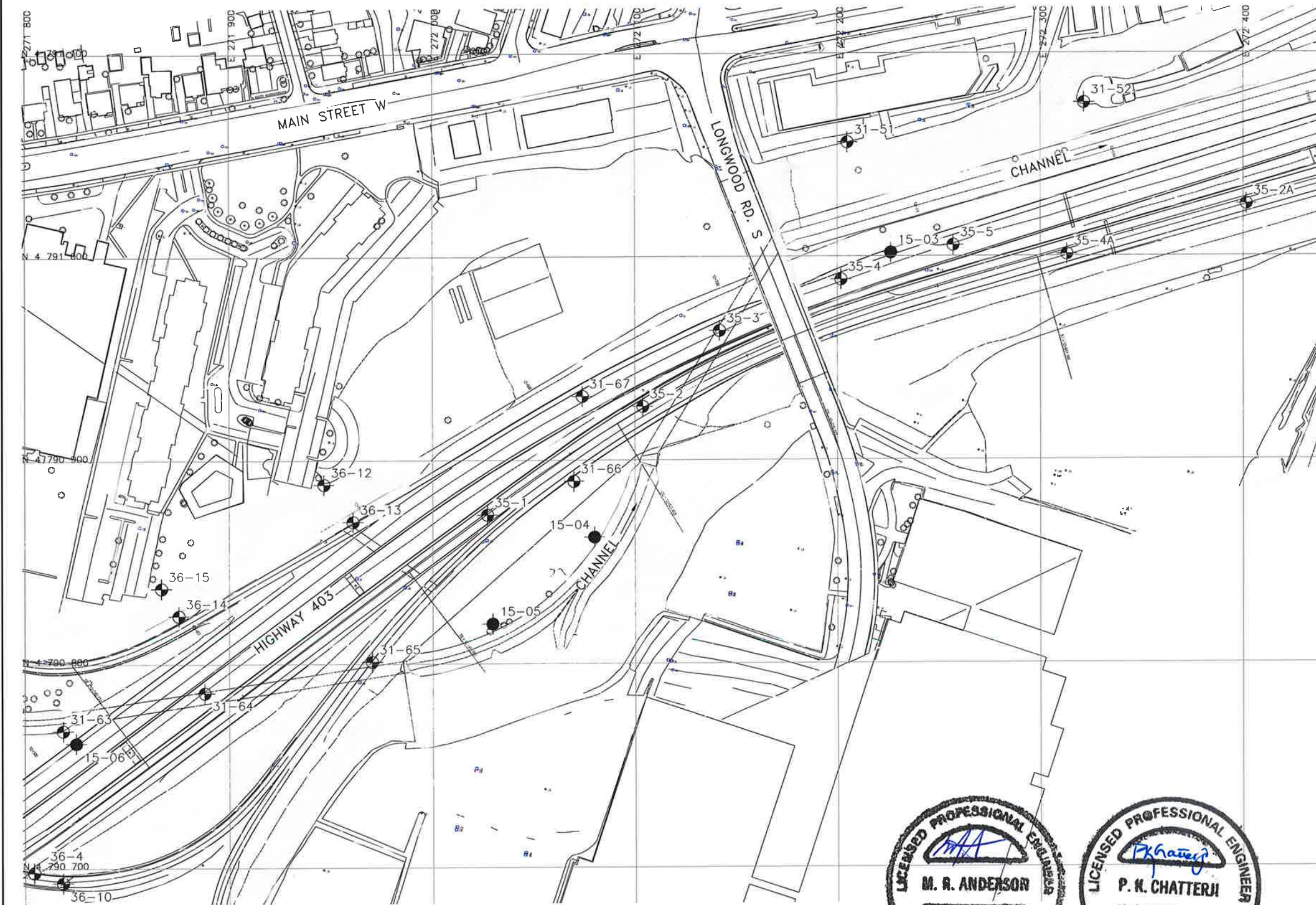
Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]



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

CONT No
WP No

HIGHWAY 403
LONGWOOD ROAD
AND UPPER CASCADE
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN
LEGEND

- Borehole from Current Investigation
- ◐ Borehole from Geocres Files
(ie, BH 35-2 from Geocres No. 30M5-35)

NO	ELEVATION	NORTHING	EASTING
15-03	85.6	4 791 001.8	272 226.3
15-04	82.1	4 790 862.1	272 079.8
15-05	82.1	4 790 819.6	272 029.4
15-06	84.9	4 790 761.2	271 825.0
31-51	0.0	4 791 056.1	272 204.9
31-52	0.0	4 791 075.5	272 321.6
31-63	0.0	4 790 767.4	271 818.5
31-64	0.0	4 790 785.8	271 887.8
31-65	0.0	4 790 801.0	271 970.1
31-66	0.0	4 790 889.6	272 069.6
31-67	0.0	4 790 931.4	272 073.8
35-1	0.0	4 790 873.1	272 026.9
35-2	0.0	4 790 926.4	272 103.9
35-2A	0.0	4 791 025.5	272 401.6
35-3	0.0	4 790 963.6	272 141.7
35-4	0.0	4 790 988.6	272 201.8
35-4A	0.0	4 791 000.9	272 313.2
35-5	0.0	4 791 005.4	272 256.9
36-4	0.0	4 790 697.9	271 804.4
36-10	0.0	4 790 692.9	271 818.4
36-12	0.0	4 790 888.1	271 946.5
36-13	0.0	4 790 869.8	271 960.8
36-14	0.0	4 790 823.6	271 875.1
36-15	0.0	4 790 837.1	271 866.7

GEOCRES No. 30M5-322



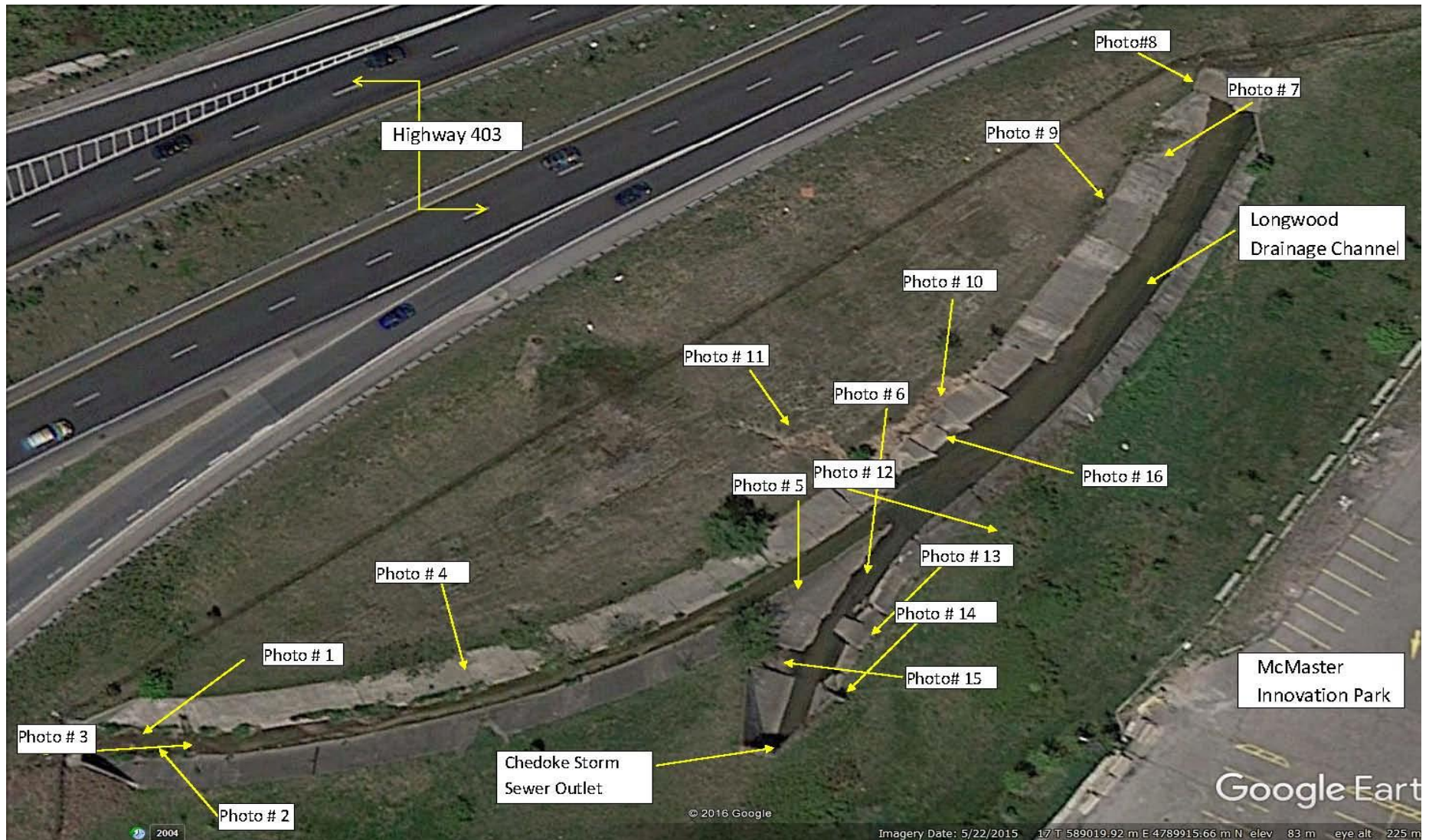
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MRA	CHK PKC	CODE
DRAWN	MFA	CHK MRA	SITE
LOAD			
STRUCT			
DWG	2		
DATE	APR 2016		



APPENDIX FIR-B

Locations and Directions of Photographs
Site Photographs

Locations and Directions of Photographs





Photograph No.1: Looking west to Longwood Channel Section 3 outlet. Grass grows on the side slope and base of channel. Cracks are observed on south channel wall (September 14, 2016).



Photograph No. 2: Looking northwest to Longwood Channel outlet. Slight movement is visible on south side wall (September 14, 2016).



Photograph No. 3: Looking east to Longwood Channel from outlet. Grass grows on side wall surface and toe. Cracks are visible on channel wall (September 14, 2016).



Photograph No. 4: Looking south to the beveled section at south side wall. Concrete deterioration and map cracks are observed on channel wall. Wall base rotated and upper section moved down (September 14, 2016).



Photograph No. 5: Looking south to Chedoke storm sewer outlet. Side walls slipped over and fell in channel. Concrete wall at divider section is undermined and cracked section visible (September 14, 2016).



Photograph No. 6: Looking south to south wall at Chedoke storm sewer outlet. Wall almost completely deteriorated and the concrete slab turned apart. Wall is undermined and backfill material washed out. Wall slid to channel base (September 14, 2016).



Photograph No. 7: Looking west to north wall at east inlet. Wall is undermined and the base slab separated from walls (September 14, 2016).



Photograph No. 8: Looking east to inlet wing wall. Wall rotated slightly and backfill material washed out (September 14, 2016).



Photograph No. 9: Backfill material washed out and the wall has lost the support. (September 14, 2016).



Photograph No. 10: The north section of wall located at the middle of channel totally moved from its place and backfill material washed out (September 14, 2016).



Photograph No. 11: The soil was washed out and the gully created by surface water runoff on north crest of channel (September 14, 2016).



Photograph No. 12: Looking south to channel south wall. Concrete totally cracked and plants grew on the surface (September 14, 2016).



Photograph No. 13: Looking west to Chedoke storm sewer outlet and divider section. Concrete slab cracked and subgrade soils are washed out (September 14, 2016).



Photograph No. 14: Looking west to Chedoke storm sewer outlet. Concrete slab cracked and slid to the channel and subgrade soils are washed out (September 14, 2016).



Photograph No. 15: Looking northwest to the north wall of divider section. Concrete slab is missing and subgrade soils are washed out (September 14, 2016).

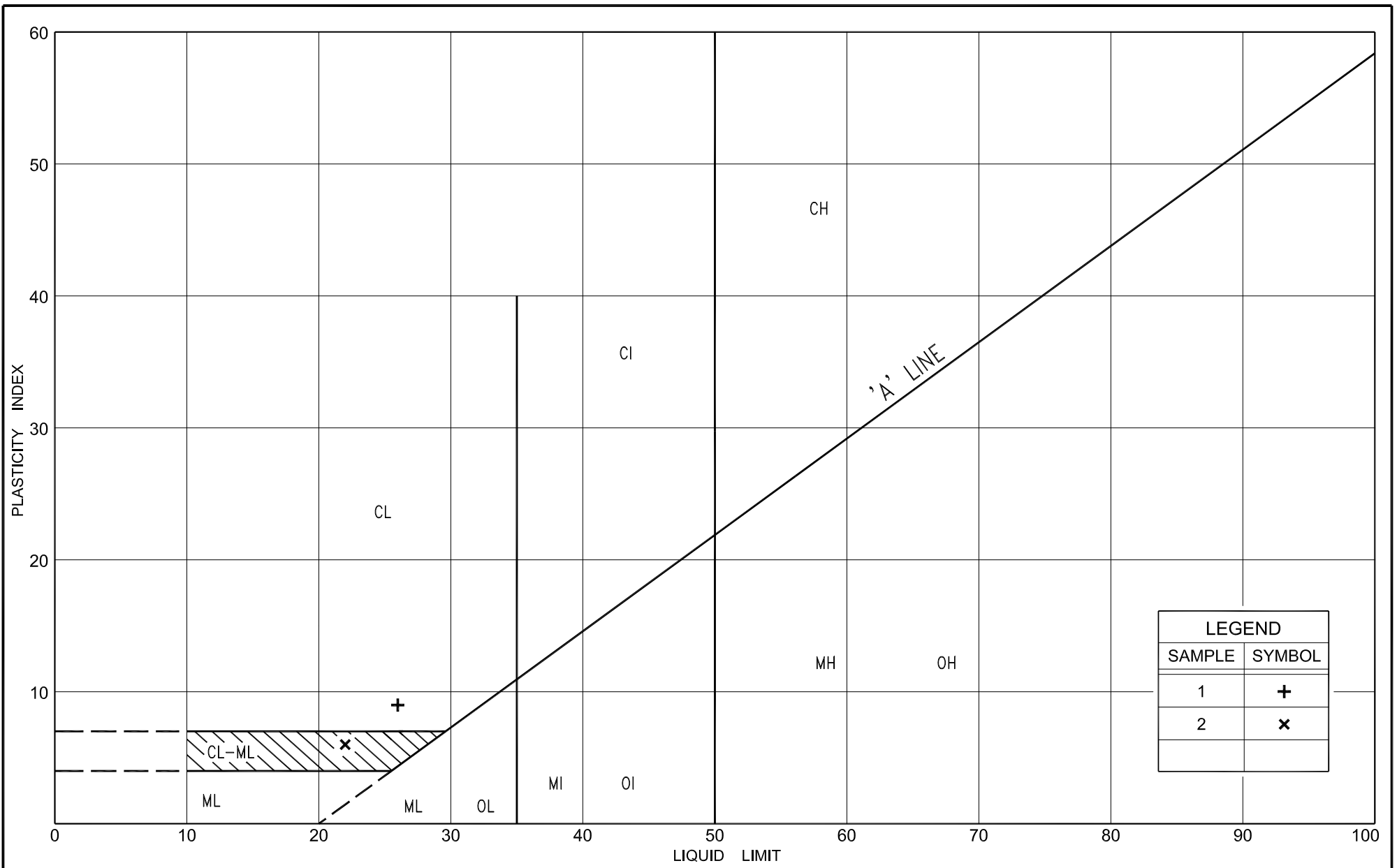


Photograph No. 16: Looking north to channel north wall. Concrete slabs slid to the channel and subgrade soils are washed out (September 14, 2016).



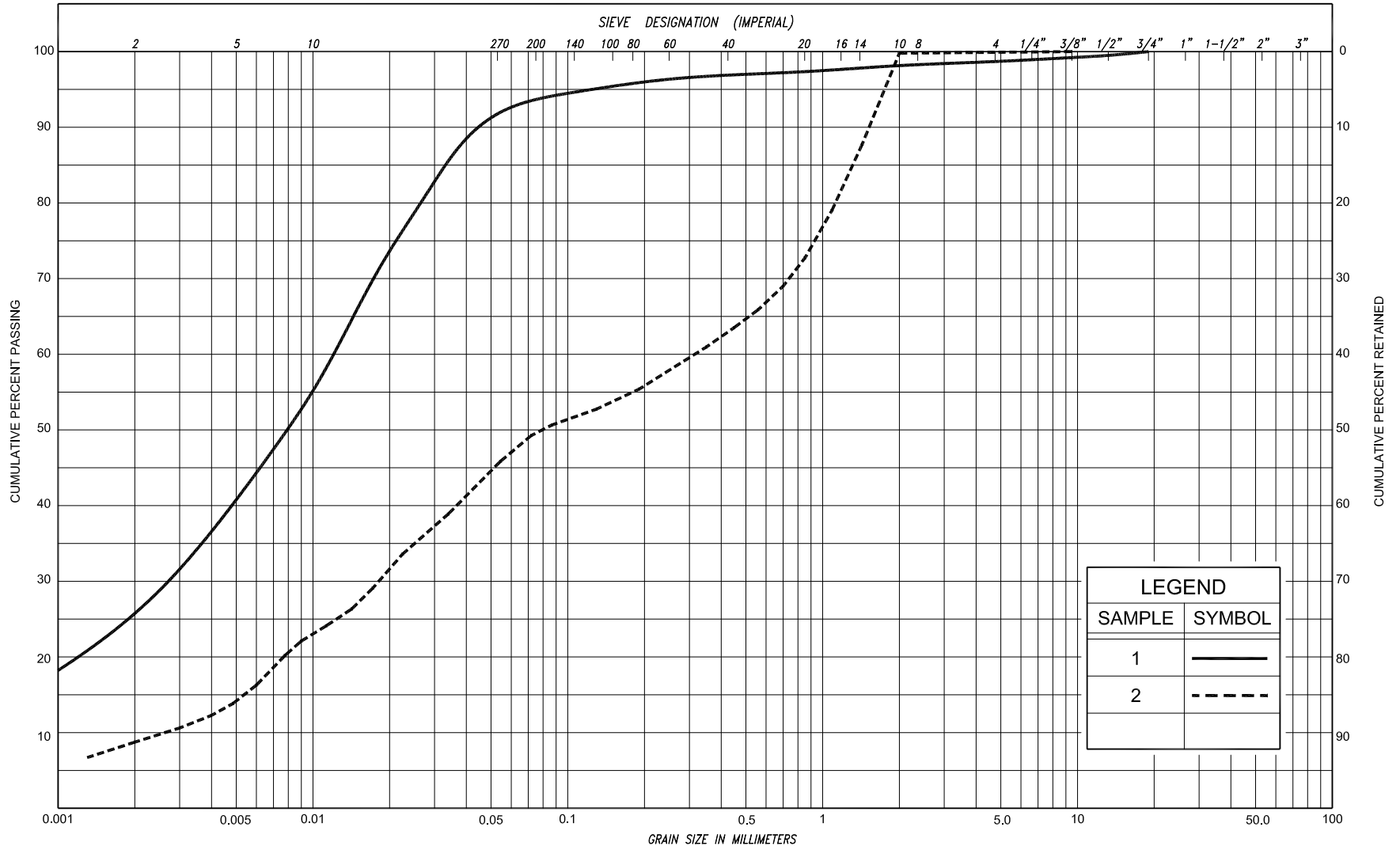
APPENDIX FIR-C

Plasticity Chart and Results of Grain Size Distribution Analyses



PLASTICITY CHART
 CLAYEY SILT, trace sand to sandy, trace gravel (CL / CL-ML)
 (FILL)

FIG No.	LC-PC-1
HWY	403
G.W.P.	2054-14-00



LEGEND	
SAMPLE	SYMBOL
1	—
2	- - -

SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED		
				SAND											
CLAY	FINE		MEDIUM	COARSE	FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT														
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL						U.S. BUREAU
					SAND										



GRAIN SIZE DISTRIBUTION
 CLAYEY SILT, trace sand to sandy, trace gravel (CL / CL-ML)
 (FILL)

FIG No.	LC-GS-1
HWY	403
G.W.P.	2054-14-00



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TASK NO. 2054-14-00-001
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TABLE OF CONTENTS

FOUNDATION DESIGN REPORT

6. INTRODUCTION.....	7
7. FOUNDATION CONSIDERATIONS.....	8
8. REHABILITATION CONSIDERATIONS.....	8
8.1 General.....	8
8.2 Slope Stability.....	8
8.3 Seepage	9
8.4 Lining Failure	9
9. LATERAL EARTH PRESSURE	10
10. BACKFILL AND EROSION CONTROL	11
11. CONSTRUCTION CONSIDERATIONS	11
11.1 Excavation	11
11.2 Groundwater Control	12
12. CLOSURE	13

Appendix FDR-A – List of Standard Specifications and Special Provision Referenced in Report

FOUNDATION DESIGN REPORT
for
Longwood Channel Rehabilitation, Section 3
Highway 403, GWP 2054-14-00
Hamilton, Ontario

6. INTRODUCTION

This report provides foundation engineering recommendations and comments regarding the proposed rehabilitation of Section 3 of the Longwood Drainage Channel in Hamilton, Ontario.

Section 3 of the Longwood Drainage Channel is located on the south side of Highway 403 between Aberdeen Avenue and Longwood Road South. The Chedoke East storm sewer outlet structure feeds into the Longwood Channel within this section. Constructed in 1964, the Longwood Drainage Channel is a trapezoidal open channel with concrete lining.

Most of the Longwood Channel structure is proposed for rehabilitation. However, an approximate 90 m long segment at the conjunction point with the Chedoke East storm sewer requires full replacement as it has experienced extensive concrete plate deterioration, cracking and toe erosion. Severe displacement or collapse of the concrete lining has occurred where the channel is joined by the municipal drain. Photographs showing the condition of the channel are presented in Appendix FIR-B.

Rehabilitation of Section 3 of the Longwood Channel is envisaged to include repair of damaged or replacement of collapsed plates of the concrete lining. The recommendations given in this report are based on the information available from the preliminary investigation and observations made during the site visit.

The scope of work does not include providing recommendations for modification of the Chedoke East storm sewer outlet or replacement of an energy dissipation structure at the confluence of the Chedoke storm sewer and the Longwood Channel.



7. FOUNDATION CONSIDERATIONS

The concrete base of the Longwood Drainage Channel in Section 3 is founded on native clayey deposits. The invert level of the channel adjacent to the locations of boreholes 15-04 and 15-05 is at approximate elevation 78.9 and 79.5 m respectively. The two existing boreholes indicate that the subgrade soils at the invert level comprise stiff silty clay in borehole 15-04 and very stiff clayey silt and sand over firm silty clay in borehole 15-05. It is assumed that the ground conditions are similar at the invert level for the extent of Section 3.

The native clayey deposits at the channel base are considered to be suitable for support of the concrete lining. Factored values of geotechnical resistance of 150 kPa at ULS and 100 kPa at SLS may be used in design of the concrete slabs along Section 3 of the Longwood Channel.

8. REHABILITATION CONSIDERATIONS

8.1 General

Based on visual observations, Section 3 of the Longwood Drainage Channel exhibits signs of significant deterioration, cracking, vegetation intrusion and possible undermining by erosion. Deterioration of the concrete lining is visible at the joint between the walls and base of the channel with vegetation growth and probable soil erosion along this joint. Areas of concrete lining collapse, water seepage and loss of ground were also present.

8.2 Slope Stability

There were no signs of slope instability on either the ravine slopes or the highway embankment during the site visit. It is noteworthy that the slopes were heavily vegetated so that close visual inspection was not possible. Taking into account the relatively low heights and competent ground conditions, the slopes with the current configuration are considered to be stable.

It is recommended that any rehabilitation work to be implemented along Section 3 of the Longwood Channel involve maintaining the existing slope inclinations. The current drainage conditions should



not be adversely affected by construction. The sequence of construction should be designed to avoid blocking potential seepage zones emanating on the slope face.

8.3 Seepage

Seepage on top of the culvert outlet at the west end of Section 3 of the Longwood Drainage Channel and wet ground behind its south wing wall were observed during the site visit. It was reported in 1965 that a crack appeared along the south wall of the channel between the culvert and the Chedoke East storm sewer outlet structure.

Drainage from behind the walls of the concrete lining is prevented by blockage of weep holes with vegetation. To relieve hydrostatic pressure on the walls, the drains should be re-established.

A layer of Granular B Type II should be provided behind any replacement panels of the lining. A subdrain system and weep holes should be installed to minimise the build-up of hydrostatic pressure behind the concrete lining. The subdrain tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system.

8.4 Lining Failure

Collapse of the lining has occurred in Section 3 of the Longwood Channel within an approximate 90 m long segment where the municipal drain joins the channel. Boreholes 15-04 and 15-05 put down on the north side of the channel indicate that the soils behind the lining and underneath the channel base comprise silty clay / clayey silt fill and native silty clay. Taking into account a relatively low sensitivity of these soils to erosion owing to high clay content and cohesiveness, the lining failure is likely due to high turbulence during periods of intensive flows.

Since there have been no capacity issues or flooding in Section 3 of the Longwood Channel, the channel lining repair or replacement is considered to be the preferred improvement solution. This method should include filling the scour holes, repairing the eroded concrete (cracks and toe erosion) and replacing the collapsed plates without changing the channel configuration. This approach has a relatively low capital cost while maintaining the existing hydraulic conditions of the drainage system.



On the north side of the channel opposite the Chedoke East storm sewer outlet, there is an erosion gulley formed due to surface water runoff and uncontrolled discharge into the channel. Surface water runoff should be directed to appropriately designed outlets to prevent erosion after the gulley has been rectified.

9. LATERAL EARTH PRESSURE

The walls should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure, p (kPa) may be computed using the equivalent fluid pressure diagrams presented in Section 6.9 of the Canadian Highway Bridge Design Code (CHBDC) 2014 Edition or employing the following equation, assuming a triangular pressure distribution:

$$p = K(\gamma h + q) + C_p + C_s$$

where K = coefficient of lateral earth pressure (dimensionless)
 γ = unit weight of free-draining granular material, kN/m^3
 h = depth below final grade, m
 q = surcharge load, kPa, if present
 C_p = compaction pressure, kPa (refer to clause 6.12.3 of CHBDC)
 C_s = earth pressure induced by seismic events, kPa (refer to clause 4.6.5 of CHBDC)
 where ϕ = angle of internal friction of retained soil
 δ = angle of friction between the soil and wall

Free-draining granular material should be used as backfill behind the wall. The following parameters are recommended for design:

Table 3 – Geotechnical Parameters for Granular Backfill

PARAMETERS	GRANULAR A / GRANULAR B TYPE II
Internal Friction Angle, ϕ (degrees)	35
Unit weight, γ (kN/m^3)	22.8
Coefficient of Active Earth Pressure, K_a	0.27
Coefficient of Earth Pressure At Rest, K_o	0.43
Coefficient of Passive Earth Pressure, K_p	3.69

The coefficient of earth pressure at-rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures. The active earth pressure condition can be assumed if the wall is permitted to move 0.2% of its height, which is probably the case except



where the wall abuts an unyielding structure. The earth pressure coefficients should be reviewed if the slope of the backfill exceeds 10° to the horizontal. Alternatively, the material above the top of the wall could be treated as a surcharge load (q in the preceding equation).

10. BACKFILL AND EROSION CONTROL

The backfill behind the repaired or replaced concrete plates of the channel lining should consist of suitable free draining granular materials such as Granular A or B conforming to the requirements of OPSS.PROV 1010. The backfill arrangements should be made as specified in OPSD 802 and OPSD 803 as appropriate.

Backfilling adjacent to the walls should be carried out with conformance to OPSS.PROV 501. Operation of compaction equipment at the walls should be restricted to limit the compaction pressure noted in clause 6.12.3 of the CHBDC. Refer to OPSS.PROV 501 for additional information in this regard.

Although the clayey deposits within Section 3 of the Longwood Drainage Channel generally have a relatively low susceptibility to erosion, discontinuous sandy layers present locally may possess a moderate to high potential of erodibility. Erosion protection should be provided to the design high water level over any unlined areas of the channel that are likely to be in direct contact with flowing water.

The earth fill slopes and other exposed earth surfaces should be protected against surface erosion by sodding and suitable vegetation. Refer to OPSS 803 and OPSS.PROV 804 for time constraints and the type of seed and mulch required.

11. CONSTRUCTION CONSIDERATIONS

11.1 Excavation

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.



Excavation for rehabilitation or replacement of concrete panels of the channel lining is expected to extend through the silty clay / clayey silt fill and native cohesive deposits.

The fill and typically stiff silty clay are classified as Type 3 soils according to Occupational Health and Safety Act (Ontario Regulation 213/91) criteria. Temporary cut slopes in earth over the full depth of excavation should therefore be inclined at an angle of 45° to the horizontal. Excavating flatter sideslopes may be needed if excessively soft/wet materials or concentrated seepage zones are encountered locally during construction.

11.2 Groundwater Control

The groundwater was at depths of 3.3 to 3.7 m (elevation 78.4 to 78.8 m) at the borehole locations. Water was running in the channel during the site visit on September 14, 2016. It is worth noting that groundwater levels at the site are subject to seasonal fluctuations and precipitation patterns, generally reflecting the water level in the Longwood Drainage Channel.

The groundwater level is expected to be at or slightly above the invert of the channel. It is considered that seepage from soil fissures or surface water run-off that enters the excavation should be done by means of stream diversion measures and conventional sump pumping techniques to ensure dewatering to at least 0.5 m depth below the base of excavation.

A Special Provision on dewatering structure excavations as an amendment to OPSS 902 included in Appendix FDR-A should be added to the Contract documentation. A designer should provide a design storm return period according to MTO Drainage Design Standard TW-1 as required in subsection 902.04.01.01 of the Special Provision.



12. CLOSURE

This report was prepared by Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. C.M.P. Nascimento, P.Eng., MTO Designated Principal Contact.

Yours very truly,

Peto MacCallum Ltd.



Grigory O. Degil, PhD, P.Eng.
Senior Foundation Engineer



Carlos M.P. Nascimento, P.Eng.
Project Manager
MTO Designated Principal Contact

GD/CN:nk



APPENDIX FDR-A

List of Standard Specifications and Special Provision Referenced in Report



TABLE 1
LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS.PROV 501	Construction Specification for Compacting
OPSS 803	Construction Specification for Sodding
OPSS 804	Construction Specification for Seed and Cover
OPSS 1860	Material Specification for Geotextiles
OPSD 3121.150	Minimum Granular Backfill Requirements – Retaining Walls
OPSD 3190.100	Retaining Wall and Abutment Wall Drain Detail

DEWATERING STRUCTURE EXCAVATIONS - Item No.

Special Provision

Amendment to OPSS 902, November 2010

902.02 REFERENCES

Section 902.02 of OPSS 902 is amended by the addition of the following:

Ontario Provincial Standard Specifications, Construction

OPSS 805 Temporary Erosion and Sediment Control Measures

902.03 DEFINITIONS

Section 903.03 of OPSS 902 is amended by the addition of the following:

Automatic Transfer Switch means an electrical device that transfers power supply to a backup power source when there is an outage of the primary power source.

Cofferdam means as defined in OPSS 539.

Cut-Off Wall means a below grade wall that restricts groundwater flow and/or supports excavations, typically using soil-bentonite or cement-bentonite.

Design Storm Return Period means the average number of years based upon probability, between the occurrences of a storm event of a certain severity or greater.

Dewatering System means the components required to control water to permit construction work to proceed under specified conditions, and may include a groundwater control system, impermeable barriers, pumps, and/or equipment to carry out unwatering.

Groundwater Control System means sump pumps, oversized excavations with perimeter ditches, deep wells or well points or other systems used to lower the groundwater table.

Plug means an impervious, natural, or constructed drainage work that blocks water.

Sediment means soil particles detached from an earth surface by erosion.

Sediment Control Measure means a measure to remove sediment from water prior to discharge to the natural environment and sewer systems.

Temporary Flow Control means temporary flow control devices, channels, pipes, and other materials used to convey or divert water past an area under construction.

Unwatering means the removal of ponded or flowing surface water.

Vegetated Discharge Area means a sloped, open area of land with existing vegetation suitable to prevent erosion.

Waterbody means as any permanent or intermittent, natural or constructed body of water including lakes, ponds, wetlands and watercourses, but does not include sewage works as defined in the Ontario Water Resources Act.

Watercourse means a stream, creek, river, or channel including ditches, in which the flow of water is permanent, intermittent, or temporary.

902.04 DESIGN AND SUBMISSION REQUIREMENTS

Subsections 902.04.01 and 902.04.02 of OPSS 902 are deleted in their entirety and replaced with the following:

902.04.01 Design Requirements

902.04.01.01 Dewatering

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work. The design of the system shall be sufficient to permit the work to be carried out as specified in the Contract Documents.

The design shall meet the requirements of the Contract Documents, and where a waterbody is present, shall include channel and inlet and outlet protection measures as required to protect the environment in the event of system failure or the design flow rate being exceeded.

The design shall not include the use of embankments and/or structures in public use, either existing or to be constructed as part of the Work, to control or stop water flow, unless approved by the Contract Administrator.

The design shall not result in displacement or damage to property, buildings, structures, utilities and other facilities adjacent to the Working Area, including from drawdown related settlement or other groundwater related effects.

The system shall be designed to prevent soil loss or erosion where water is removed, pumped, or discharged. The system shall be designed to prevent basal heave or instability.

Where the system involves the taking of water from a waterbody, the design shall maintain the flow of water and the natural functions of the waterbody upstream and downstream of the work area, and shall not interfere with other uses of the water.

When the system includes temporary flow control, the temporary flow control shall be designed, as a minimum, for a [* Designer Fill-In, See Notes to Designer] year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

Temporary flow control shall include provision for fish passage during low flows.

902.04.02

Submission Requirements

902.04.02.01

Working Drawings

Three (3) sets of Working Drawings for the dewatering system shall be submitted to the Contract Administrator at least 7 Days prior to commencement of the dewatering system installation, for information purposes only. Prior to submission of Working Drawings, the seals and signatures of a design Engineer and a design-checking Engineer shall be affixed on the Working Drawings verifying that the drawings are consistent with the Contract Documents.

One person shall not perform both the design Engineer and design-checking Engineer roles for a system.

Where multi-discipline engineering work is depicted on the same Working Drawing and the design or design-checking Engineer or both are unable to seal and sign the Working Drawing for all aspects of the work, the drawing shall be sealed and signed by as many additional design and design-checking Engineers as necessary.

The following information and details shall be shown on the Working Drawings, where applicable:

a) Plans, Elevations, and Details

- i. Type of system(s).
- ii. Design calculations demonstrating adequacy of the system and equipment.
- iii. Design flow rate(s).
- iv. Plan location, description, and dimensions of system components, including dams, cofferdams, cut-off walls, temporary channels, pipes, culverts, sewers, groundwater control systems employing wells and/or well points, sedimentation basins, tanks, pumps, power supply, and standby equipment.
- v. Method of management of pumped water and plan location of all dewatering discharge points.
- vi. Profile drawings shall extend through and immediately beyond the limits of the system.
- vii. Water elevations upstream and downstream of the system at design flow rate.
- viii. Dam height or crest elevation, cofferdam depth and tip elevation, cutoff wall depth or base elevation, pipe invert elevations, depths of wells and wellpoints, pump intake elevation, and sedimentation basin depth or base elevation.
- ix. Plan location, elevation, and dimensions of environmental protection measures.
- x. Pipe type, size, and length, pump capacity, and tank capacity.
- xi. Material and construction standards to be used for the work.
- xii. Method for establishing and monitoring construction site groundwater levels.
- xiii. Criteria and method of removal of the system.

b) Procedures for the system construction, operation, and maintenance, including daily start-up sequence where applicable, and operation shut down.

c) Procedures for the removal of the system, including the removal sequence, and well decommissioning.

d) Stand-by power or pumping system requirements and the use of automatic transfer switching, when required to protect the environment and the Work.

e) A copy of the Permit to Take Water issued by the Ministry of the Environment and Climate Change or confirmation of registration of water taking for construction dewatering, if a permit or registration is required by provincial regulation.

f) When applicable, a copy of the water taking report and discharge plan required by provincial regulation.

- g) A copy of any necessary permits for the discharge of water to a sanitary sewer, or stormwater sewer system, stormwater pond, or other facility.

902.04.02.02 Preconstruction Survey

When a groundwater control system by wells or a well point system will be used, a condition survey of property and structures that may be affected by the work shall be carried out. The condition survey shall include the location and condition of adjacent properties, buildings, underground structures, water wells, Utilities, and structures, within a distance of twice the depth of excavation or tunnelling from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website <https://www.ontario.ca/environment-and-energy/map-well-records> or its successor site.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

902.04.02.03 Milestone Inspections

The Quality Verification Engineer shall witness the following Interim Inspections of the work:

- a) Dewatering of excavation for structure.
- b) Completion of excavation for foundation.
- c) Excavation for backfill and frost tapers.
- d) Backfilling.

A copy of the written permission to proceed shall be submitted to the Contract Administrator prior to commencement of the successive operation.

902.07 CONSTRUCTION

Subsection 902.07.04 of OPSS 902 is deleted in its entirety and replaced with the following:

902.07.04 Dewatering Structure Excavation

902.07.04.01 General

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation of temporary flow control, if applicable, shall be as specified in the Contract Documents.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When temporary flow control is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the temporary flow control during the seasonal shutdown period.

Temporary erosion and sediment control measures, including to control the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow control shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

902.07.04.02 Discharge of Water

Water from dewatering and unwatering operations shall be directed to a sediment control measure and/or a vegetated discharge area 30 m away from waterbodies or as far away as practicable from the top of the bank of any waterbody, prior to discharge to the natural environment.

Equipment and materials shall not be used or stored in vegetated discharge areas.

The discharge of water to the natural environment shall not be directed across pavements, sidewalks, curb and gutter or similar hard surfaces except through appurtenances as specified in the Contract Documents.

902.07.04.03 Monitoring

The Contract Administrator shall be notified of any complaints and any action taken or proposed to be taken in response to complaints.

Daily external visual monitoring of the surrounding area and property and structures on the preconstruction survey, if applicable, for impacts such as settlement and erosion shall be completed. Any observed impacts shall be immediately reported to the Contract Administrator. When public safety, the environment, or property is impacted or potentially impacted, the design Engineer shall, without delay, make a full assessment and direct changes to the system to eliminate impacts or potential impacts. Any changes shall be documented according to the System Amendments subsection.

When a groundwater control system is observed to negatively impact water supplies obtained from any adequate sources that were in use prior to groundwater control system operation, then water shall be supplied to the affected water users. The water shall be equivalent in quantity and quality to the normal water takings of the users. Supply shall continue until the negative impacts on the water supplies are removed, or until Contract Completion, whichever occurs first.

902.07.04.04 System Amendments

When displacement or damage to embankments and/or structures, or property adjacent to the Working Area, occurs due to the operation of the system, or soil loss or erosion occurs where water is removed, pumped, or discharged, the dewatering system or temporary flow control shall be amended to stop the displacement, damage, soil loss, or erosion.

Amendments shall be submitted to the Contract Administrator within two Business Days of the system being amended, on revised Working Drawings bearing the seal and signature of the design Engineer and design-checking Engineer.

902.07.04.05 Removal

Dewatering system and temporary flow control components shall be removed when no longer required. Removal of system components shall be according to the procedures specified on the Working Drawings, where applicable, and as specified in the Contract Documents.

Deactivation of temporary flow control shall be as specified in the Contract Documents.

Removal of temporary drainage work shall be according to OPSS 510.

Environmental protection measures and cut-off walls shall be removed, unless approved otherwise by the Contract Administrator.

Sedimentation basins and other excavations shall be backfilled with the original soil excavated, unless approved otherwise by the Contract Administrator. All disturbed areas shall be restored to an equivalent or better condition than existed prior to the commencement of construction.

NOTES TO DESIGNER:

Designer Fill-Ins

- * Fill in the design storm return period according to MTO Drainage Design Standard TW-1.

WARRANT: Include with this item **only** on the recommendation of a foundation engineer.

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.