



**FOUNDATION INVESTIGATION AND DESIGN REPORT
FOR
HOGG'S HOLLOW BRIDGE SINKHOLE REMEDIAL MEASURES
SW APPROACH EMBANKMENT
DON RIVER BRIDGE
HIGHWAY 401 EASTBOUND
TORONTO, ONTARIO**

**AGREEMENT NO. 2013-E-0039
TASK NO. 2013-E-0039-007A**

PREPARED FOR MINISTRY OF TRANSPORTATION OF ONTARIO

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PML Ref.: 14TF046A
Index No.: 016FIR and 017FDR
Geocres No.: 30M11-256
November 25, 2015



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FOUNDATION INVESTIGATION REPORT
for
HOGG'S HOLLOW BRIDGE SINKHOLE REMEDIAL MEASURES
SW APPROACH EMBANKMENT
DON RIVER BRIDGE
HIGHWAY 401 EB
City of Toronto, Ontario
Task No. 2013-E-0039-007A

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out to identify the cause and to develop remedial measures for the sinkhole encountered at Highway 401 eastbound collectors SW shoulder about 60 m west of the Hogg's Hollow Bridge south west abutment. The study was carried out by Peto MacCallum Ltd. (PML) for the Ministry of Transportation of Ontario (MTO).

2. BACKGROUND

A sinkhole occurred at the SW approach embankment to the Highway 401 Hogg's Hollow Bridge over the Don River and Yonge Street. The sinkhole issue was assigned for evaluation in November 2014 due to settlement of the utility cabinet located above the sinkhole area. After its discovery, the sinkhole was filled with Granular A material by MTO's maintenance subcontractor, However, the sinkhole continued to subside and moderate cracking of the pavement along the highway shoulder was noticed. The occurrence of sinkhole in close proximity to the highway shoulder and the existing noise barrier raised concerns about its impact on the performance of the highway embankment and the potential consequences to the performance of the adjacent highway lanes.

3. SITE DESCRIPTION

The geometry of the existing embankment that forms the south side slope to the SW Highway 401 approach embankment to the Don River Bridge is approximately 20 m high with an estimated inclination of 1.75 Horizontal to 1 Vertical (1.75H:1V). The toe of the slope is retained by a 1.5 to 2.0 m high toe wall located immediately adjacent to the Don Valley Golf Course property. Based



on visual observation, no obvious signs of global instability of the slope were noted at the time of the site inspection.

MTO advised that fill was placed in the sinkhole after the subsidence was noted. No evidence of fill placed on the existing slope was observed.

4. INVESTIGATION PROCEDURES

4.1 Phase 1

The initial phase of the investigation conducted from November 2014 to March 2015 included the following aspects:

- Site visits were conducted to investigate locations of drainage systems and outlets and to assess the extent and impacts of the sink hole.
- A ground-penetrating radar geophysical survey was conducted with the intention of investigating the integrity of the pipes connecting to the manholes and identifying the location of leakage.
- A CCTV survey of the drainage system under the Highway 401 EB collector lanes in close proximity to the sink hole was conducted to determine if these pipes were leaking.
- Manhole # 18, located behind the noise barrier wall and the traffic barrier was exposed to provide information on the location and flow pattern of the existing drainage system.

4.2 Phase 2

The second phase of the investigation was carried out in July and August 2015 and included excavating a test pit to locate Manhole # 19 and advancing boreholes for subsurface investigation of soil conditions at the sinkhole area.

A field investigation consisting of four boreholes was carried out on August 13 and 14, 2015. One borehole was drilled at bottom of the sinkhole cavity (Borehole No. 15-1), two boreholes were



drilled from the original ground level adjacent to the sinkhole (Boreholes No. 15-3 and 15-4) and one borehole (Borehole No. 15-2) was drilled adjacent to MH # 19. Borehole locations are shown on attached Borehole Location and Stratigraphical Profile Drawing.

The boreholes were advanced using continuous flight hollow stem augers, powered by a portable drill rig due to restricted access. The drill rig was supplied and operated by a specialist drilling contractor working under the full-time supervision of a PML field supervisor.

Soil samples were recovered at mostly 0.75 m depth intervals using the standard penetration test method. Standard penetration tests were conducted to assess the strength characteristics of the substrata. Soils were identified in accordance with the MTO soil classification manual procedures.

The groundwater conditions in the boreholes were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved. The groundwater levels in the boreholes following drilling were also obtained.

Piezometers consisting of 25 mm diameter PVC pipe slotted over the bottom 3.0 m and surrounded in filter sand were installed in Boreholes No. 15-3 and 15-4 to monitor groundwater conditions. The annular space around the pipe above the filter sand was backfilled with auger cuttings and a bentonite seal placed as illustrated on the respective borehole log. The water levels in the piezometers were measured at the time of installation and on September 18.

The boreholes and piezometers were backfilled with a bentonite/grout mixture where required in accordance with the MTO guidelines and MOE Reg. 903 for borehole abandonment.

The recovered soil samples were returned to our laboratory in Toronto for detailed visual examination, laboratory testing and classification. The laboratory testing program included the following tests:

- Natural moisture content determinations (20)
- Grain size distribution analyses (8)
- Atterberg Limit Test (1)



The results of the grain size distribution analyses are presented in Figures SH-GS-1 and SH-GS-2. The results of Atterberg Limit testing are presented in Figure SH-PC-1. All the test results are summarized on the Record of Borehole Sheets (attached).

A CCTV scan proposed as a contingency item by PML to assess the location and condition of the subdrain network was not approved by MTO. Consequently, the scope of this report is restricted to remedial measures to repair the existing leak and does not extend to an evaluation of the condition of the drainage system or recommendations for system replacement.

5. OBSERVATIONS AND SUMMARIZED SUBSURFACE CONDITIONS

5.1 Phase 1

Refer to the relevant photographs in Appendix FIR-A for site conditions observed.

An 8 m by 4 m oval-shaped depression about 1.5 m in depth was observed at the sinkhole location during the initial site inspection of November 5, 2014. The sinkhole is located at the east end of the existing highway noise barrier wall and was under a concrete footing pad supporting an existing utility cabinet. The utility cabinet and its concrete pad were tilted due to the loss of material that had occurred under the concrete pad.

The fill material under the highway pavement was exposed and was inspected by hand probe and found to be in very loose condition as evidenced by the ease with which a hand probe could be pushed about 600 mm into the fill material.

The Highway 401 approach embankment side slope was observed to be in stable condition at this time with minor localized areas of erosion but no obvious instabilities related to the sink hole. During the site inspection, several cracks were observed on the south shoulder of Highway 401 that are attributable to the loss and loosening of material related to the formation of the sink hole.

The results of the geophysical survey were inconclusive and are not included in this report.



The CCTV inspection of the sewer pipes under the Highway 401 EB Collector was performed on January 25, 2015 to identify any leaks that could have contributed to the formation of the sinkhole. This drainage system collects storm water from the Highway 401 EB collector lanes through catch basins and is connected to Manhole # 18, which is located behind the noise barrier wall and buried under about 1 m soil.

The drainage system was found to be in good condition except for the pipe that runs towards the south and connects to the MH # 18.

Water was backed up in MH # 18 indicating a blockage in its outlet pipe. Consequently, MH # 18 was located and exposed on March 3, 2015 and found to be full of water. MH # 18 is connected by 760 mm diameter corrugated steel pipe that runs parallel to the noise barrier to MH # 19. The sinkhole occurred about 28 m east side of MH # 18 and the water accumulated inside the manhole indicated that the blockage has taken place between MH # 18 and MH # 19.

5.2 Phase 2

A test hole to uncover MH # 19 in July, 2015, revealed that there was no flow from an inlet pipe connected to the west side of the manhole. However, water was leaking through a weep hole on the wing wall of the east abutment of the bridge flowing to the slope surface. Refer to the relevant photographs (Appendix FIR-A) for illustration of the site condition at the manhole at the time of the investigation.



5.2.1 Subsurface Conditions

Reference is made to the Record of Borehole logs and associated Borehole Location and Stratigraphical Profile Drawing (Appendix FIR-A) for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration tests, and groundwater observations. The results of laboratory particle size distributions, Atterberg Limit Testing and 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 stratigraphic boundaries are assumed and may vary.

Fill was encountered in all boreholes to their termination depth and consisted of generally loose to compact silty sand with occasional gravelly zones and occasional clayey silt zones. Refer to attached Figure SH-GS-1 for a grain size distribution envelope of the sandy silt fill and to Figure SH-GS-2 for a grain size distribution envelope of the clayey silt zones. Refer to attached Figure SH-PC-1 for a plasticity chart of the clayey silt zones.

Note that N-values of 1 were recorded on three consecutive samples below the inferred obvert of the sewer at the borehole advanced within the sinkhole (BH 15-1).

5.2.2 Groundwater Conditions

The free water observed in BH No. 15-1 likely originated from the damaged sewer pipe under the sinkhole. No water was observed in BH No. 15-2. Although the piezometers installed in BH's No. 15-3 and 15-4 were dry at the time of installation and remained dry at subsequent readings, water was detected at depths of 3.3 and 3.9 m (elevation 163.7 and 163.1) in BH's No. 15-3 and 15-4, respectively, during drilling and is considered to represent a perched water level that will vary with seasonal conditions and precipitation events and may be influenced by flows from the damage sewer pipe. The regional groundwater is inferred to be below the termination level of the boreholes.



6. CLOSURE

The field investigation was carried out by Mr. F. Portela under the supervision of Mr. M. Khorsand, BEng, EIT, and Mr. C. M. P. Nascimento, P. Eng., Project Manager. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This Foundation Investigation Report was prepared by Mr. M. Khorsand, BSc, EIT., and reviewed by Mr. David Dundas, P.Eng., Senior Engineer, Geotechnical Services. Mr. C. M. P. Nascimento, P. Eng., MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A blue ink signature of Mansoor Khorsand, written in a cursive style.

Mansoor Khorsand, BSc, EIT.
Project Supervisor, Geotechnical Services



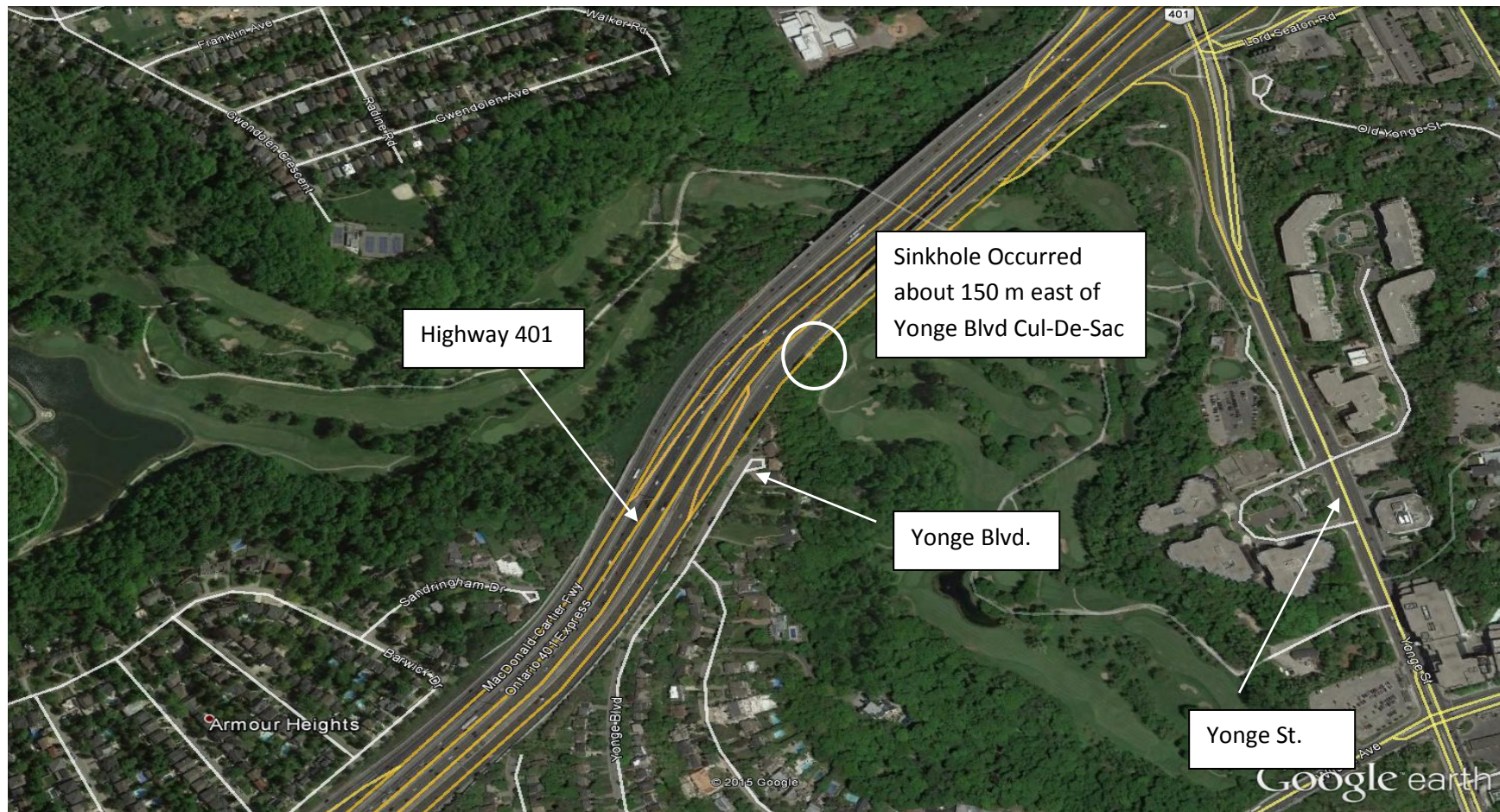
David Dundas, P.Eng.
Senior Engineer, Geotechnical Services

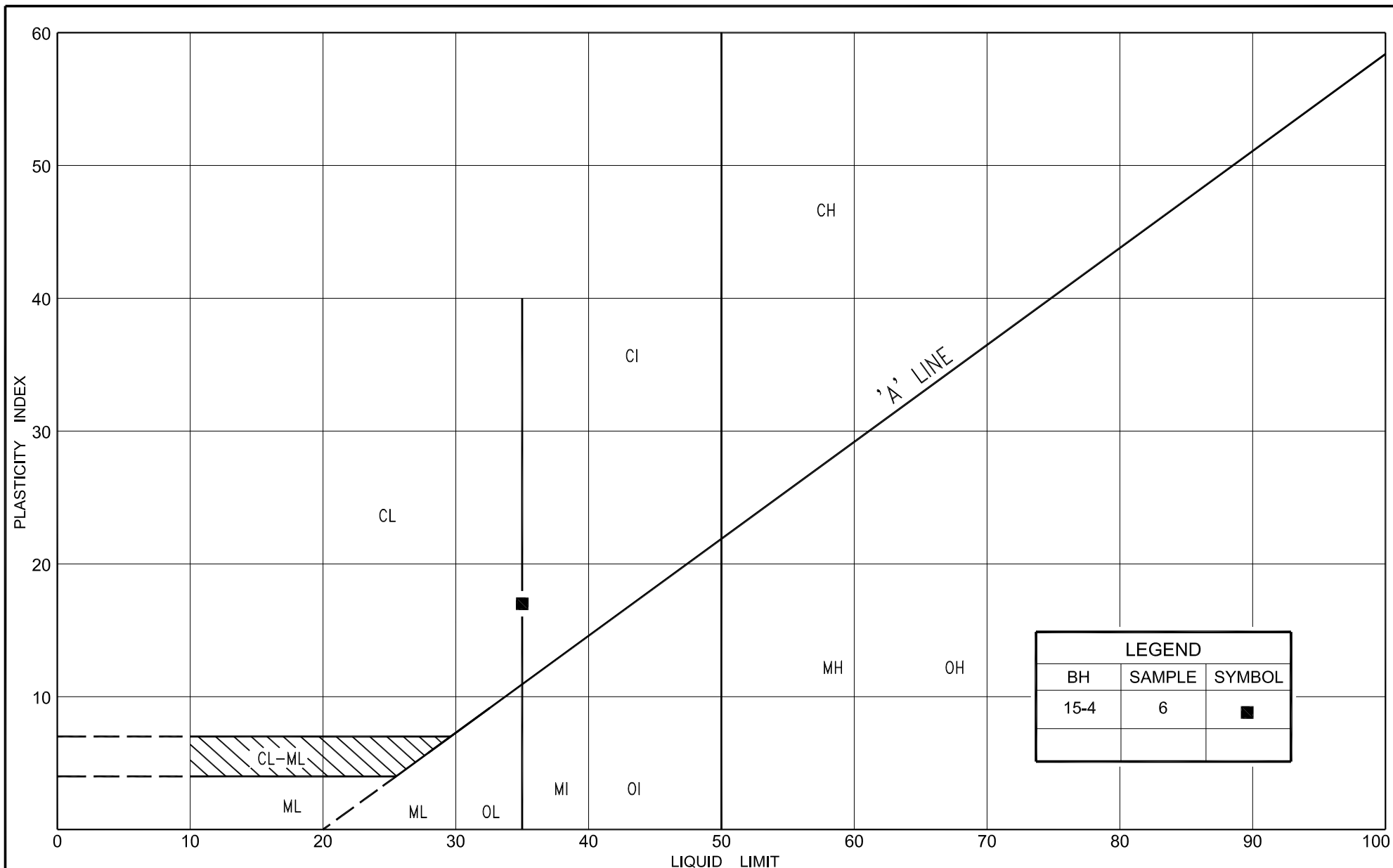


Carlos M.P. Nascimento, P. Eng.
Project Manager and
MTO Designated Principal Contact

MK/DD/CN:mk-js-jk

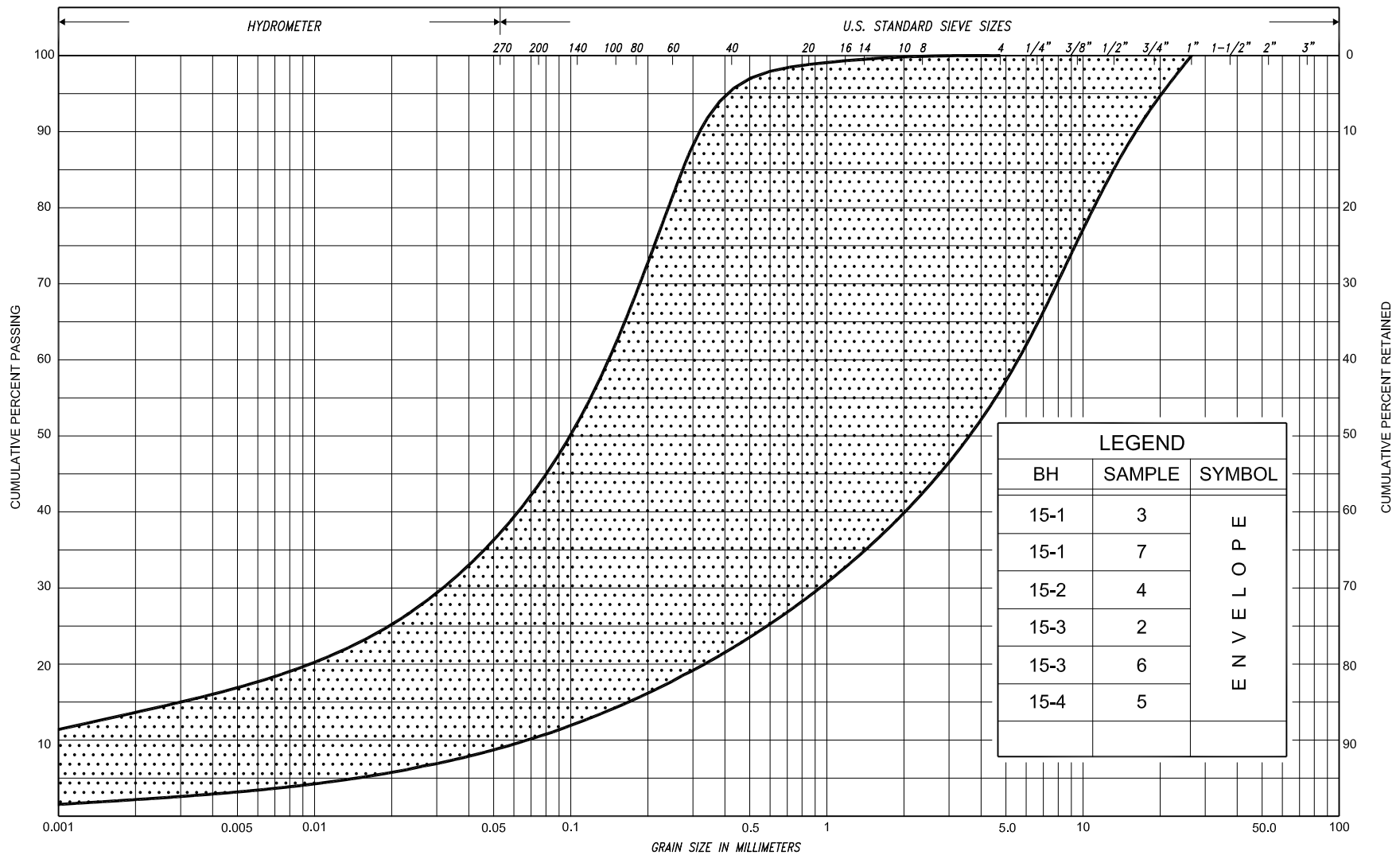
Figure 1 – Key Plan





PLASTICITY CHART
 CLAYEY SILT, some sand (CL)
 (FILL)

FIG No.	SH-PC-1
HWY:	401
TASK No.	2013-E-0039-007A



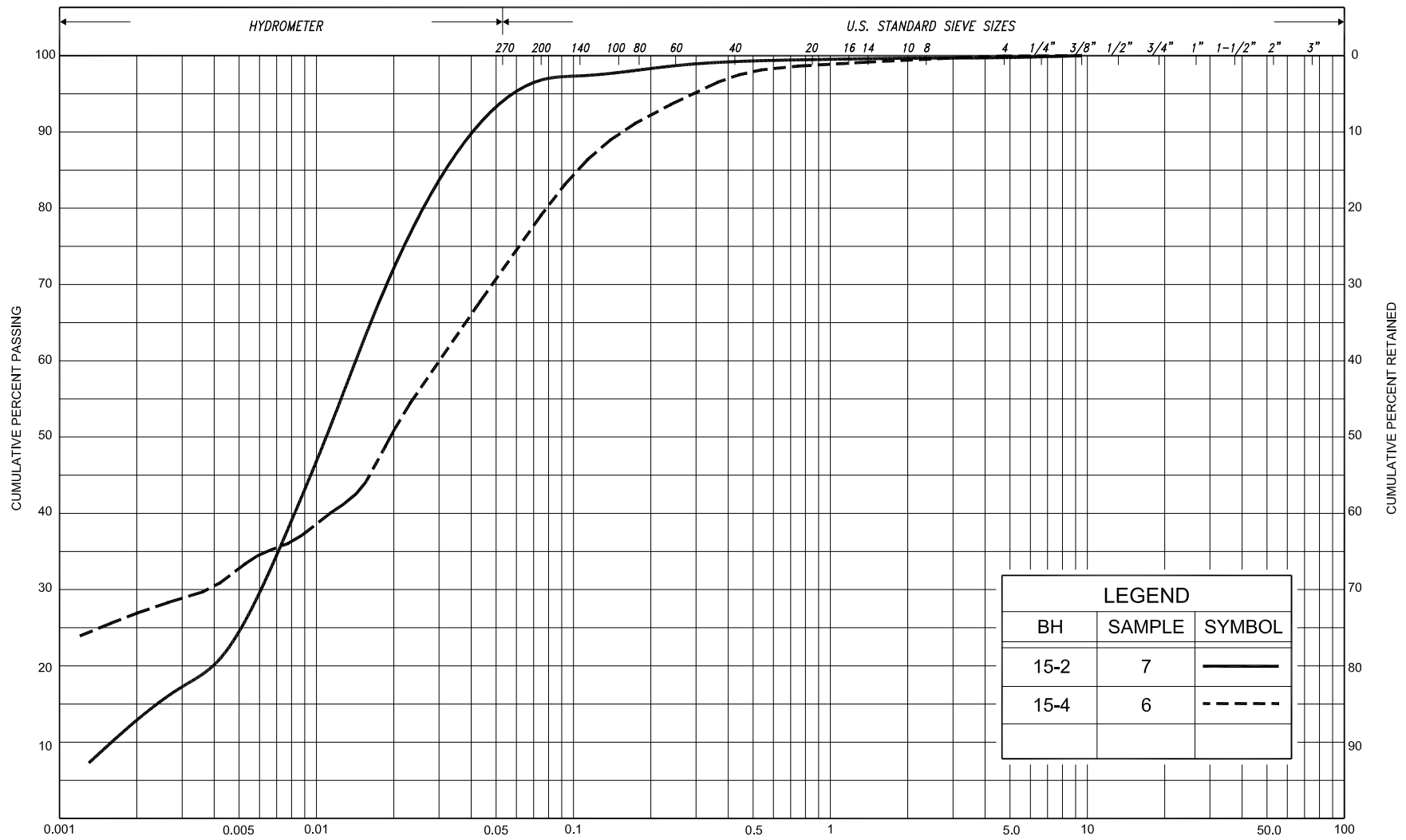
SILT & CLAY				FINE SAND			COARSE SAND	GRAVEL	COB BLES	UNIFIED
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL	COBBLES	M.I.T.	
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL	U.S. BUREAU	



GRAIN SIZE DISTRIBUTION

SILTY SAND, trace clay, trace gravel
(FILL)

FIG No.	SH-GS-1
HWY:	401
TASK No.	2013-E-0039-007A



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, some sand (CL) (FILL)

FIG No.	SH-GS-2
HWY:	401
TASK No.	2013-E-0039-007A

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm 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 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

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/0.3m)	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, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	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_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	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_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	e_{max}	1, %	VOID RATIO IN LOOSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	e_{min}	1, %	VOID RATIO IN DENSEST STATE
ρ_w	kg/m ³	DENSITY OF WATER	S_r	%	DEGREE OF SATURATION	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w	kN/m ³	UNIT WEIGHT OF WATER	w_L	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_p	%	PLASTIC LIMIT	D_n	mm	n PERCENT - DIAMETER
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_s	%	SHRINKAGE LIMIT	C_u	1	UNIFORMITY COEFFICIENT
ρ_d	kg/m ³	DENSITY OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m ³ /s	RATE OF DISCHARGE
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	j	kN/m ³	SEEPAGE FORCE
e	1, %	VOID RATIO						

RECORD OF BOREHOLE No 15-1

1 of 1

METRIC

G.W.P. 2013-E-0039-007A LOCATION Coords: 4 845 463.1 N; 311 715.7 E ORIGINATED BY F.P.
DIST Central HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.K.
DATUM Geodetic DATE August 13, 2015 CHECKED BY C.N.

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 kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE								● QUICK TRIAXIAL		× LAB VANE
165.5	Ground Surface						20	40	60	80	100						GR SA SI CL			
0.0	Silty sand occasional gravelly zones Loose to compact		1	SS	4															
	(FILL)		2	SS	6	▽* ▼*														
			3	SS	6												43 46 8 3			
			4	SS	4															
	asphaltic gravel inclusions		5	SS	1															
			6	SS	1															
			7	SS	1												17 46 28 9			
	clayey silt zone																			
	Very stiff		8	SS	28															
158.8	End of borehole																			
6.7																				
	* 2015 08 13																			
	▽ Water level observed during drilling																			
	▼ Water level measured after drilling																			

RECORD OF BOREHOLE No 15-2

1 of 1

METRIC

G.W.P. 2013-E-0039-007A LOCATION Coords: 4 845 478.2 N; 311 729.7 E ORIGINATED BY F.P.
DIST Central HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.K.
DATUM Geodetic DATE August 13 & 14, 2015 CHECKED BY C.N.

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												
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
160.4	Ground Surface						20	40	60	80	100									
0.0	Silty sand occasional gravelly zones Loose to dense (FILL)		1	SS	7		160							○					7 58 30 5	
			2	SS	12		159								○					
			3	SS	11		158								○					
			4	SS	28		157								○					
			5	SS	41		156								○					
			6	SS	59															
	clayey silt zones		7	SS	51										○					0 3 84 13
155.3	Hard																			
5.1	End of borehole																			

RECORD OF BOREHOLE No 15-3

1 of 1

METRIC

G.W.P. 2013-E-0039-007A	LOCATION	Coords: 4 845 457.8 N; 311 712.1 E	ORIGINATED BY F.P.
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DIST Central HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.K.

DATUM Geodetic DATE August 14, 2015 CHECKED BY C.N.

[illegible]

RECORD OF BOREHOLE No 15-4

1 of 1

METRIC

G.W.P. 2013-E-0039-007A	LOCATION	Coords: 4 845 462.3 N; 311 716.3 E	ORIGINATED BY F.P.
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DIST Central HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.K.

DATUM Geodetic DATE August 14, 2015 CHECKED BY C.N.

[illegible]

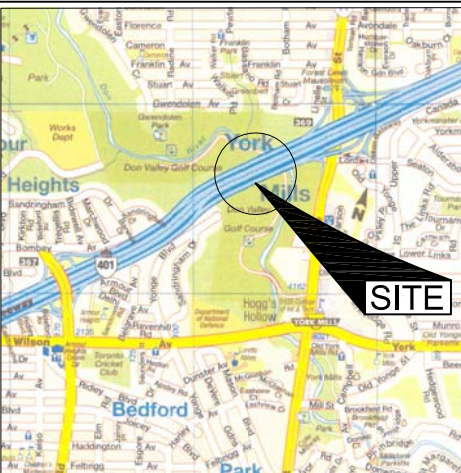
CONT No
TASK No 2013-E-0039-007A
WP No 2013-E-0039



HOGG'S HOLLOW BRIDGE SINKHOLE INVESTIGATION
HIGHWAY 401
BOREHOLE LOCATION AND SOIL STRATA

SHEET

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS



KEY PLAN
SCALE
250m 0 250m 500m

LEGEND

- Borehole
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- WL at time of investigation (August 2015)
- MH Manhole
- Piezometer

BH No	ELEVATION	NORTHINGS	EASTINGS
15-1	165.5	4 845 463.1	311 715.7
15-2	160.4	4 845 478.2	311 729.7
15-3	167.0	4 845 457.8	311 712.1
15-4	167.0	4 845 462.3	311 716.3

COORDINATES ESTIMATED

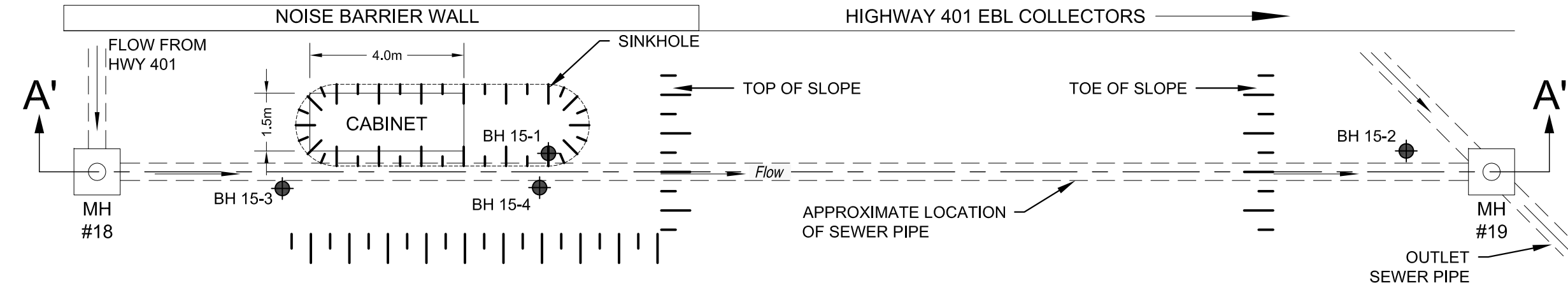
NOTE

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

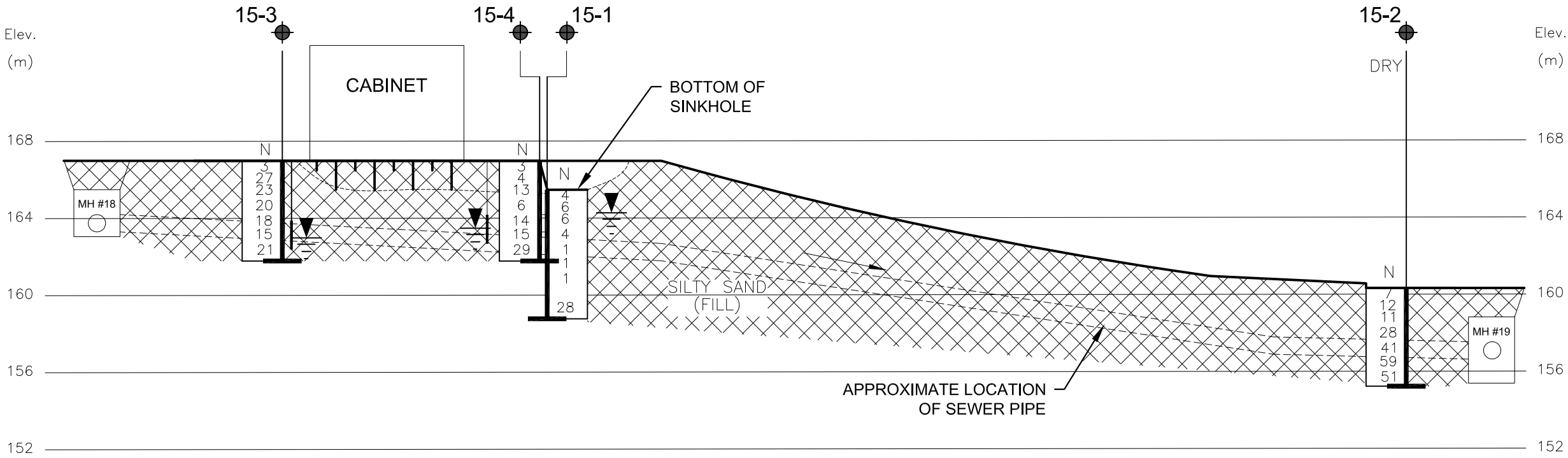
REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 30M11-256

HWY No	401	DIST	Central
SUBM'D	N.A.	CHECKED	M.Kh.
DRAWN	N.L.	CHECKED	D.D.
DATE	NOV. 25, 2015	APPROVED	C.N.
SITE		DWG	HH-1



PLAN
N.T.S.



PROFILE A'-A' ALONG STORM SEWER PIPE
N.T.S.

- NOTES:
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
 - REFERENCE DRAWINGS WERE NOT AVAILABLE AT THE TIME OF THIS REPORT.

Foundation Investigation Report

Hogg's Hollow Bridge Sinkhole Remedial Measures, SW Approach Embankment, Don River Bridge
Highway 401 EB, Agreement No. 2013-E-0039, Task No. 2013-E-0039-007A, Index No.:016FIR

PML Ref.: 14TF046A, November 25, 2015



APPENDIX FIR-A

Site Photographs from Field Reconnaissance



Photograph 1: Looking at the sinkhole toward Hwy 401. The fill material under the barrier wall and highway pavement caved into the sinkhole. (November 2014)



Photograph 2: Several cracks were observed during a site visit on the right shoulder of collector lanes likely resulted by loss of material under the pavement. (November 2014)



Photograph 3: Manhole # 18 was uncovered under about 1.5 m of frozen fill layer. (March 2015)



Photograph 4: The manhole #18 was full of water and the inlet and outlet pipes were placed under water suggesting a blockage downstream. (March 2015)



Photograph 5: Surface soil was very soft and swampy, silty sand layer was saturated by water leaking from a retaining wall weep hole and stormwater ponding. (July 2015)



Photograph 6: Showing the weeping hole source of water possibly from highway catch basins. Water collects in the MH # 19 surrounding area. (July 2015)



Photograph 7: The MH # 19 was found under about 1 m of fill. Several utility cables pass adjacent to the manhole. (July 2015)



Photograph 8: View inside the MH # 19. Two pipes are connected to the manhole. The west wall inlet pipe originates from MH # 18 and the bottom pipe runs from the highway toward the Don River. (July 2015)



Photograph 9: The inlet pipe to MH # 19 inspected visually. A soil pile was observed in the inlet pipe and a small amount of water flow. (July 2015)



Photograph 10: View inside the pipe connected to the bottom level of MH # 19 running toward north to the highway. A small water flow was noted. (July 2015)



**FOUNDATION DESIGN REPORT
FOR
HOGG'S HOLLOW BRIDGE SINKHOLE REMEDIAL MEASURES
SW APPROACH EMBANKMENT
DON RIVER BRIDGE
HIGHWAY 401 EASTBOUND
TORONTO, ONTARIO**

**AGREEMENT NO. 2013-E-0039
TASK NO. 2013-E-0039-007A**

PREPARED FOR MINISTRY OF TRANSPORTATION OF ONTARIO

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
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1 cc: PML Toronto

PML Ref.: 14TF046A
Index No.: 017FDR
Geocres No.: 30M11-256
November 25, 2015



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Removal, Grading Paving & Drainage, West of Hogg's Hollow Structure

Appendix FDR-B – OPSS 410 Construction Specification for Pipe Sewer Installation in Open Cut

**FOUNDATION DESIGN REPORT
for
HOGG'S HOLLOW BRIDGE SINKHOLE REMEDIAL MEASURES
SW APPROACH EMBANKMENT
DON RIVER BRIDGE
HIGHWAY 401 EB
City of Toronto, Ontario
Task No. 2013-E-0039-007A**

7. FOUNDATION RECOMMENDATIONS

7.1 Cause of Sinkhole and Evaluation of Remedial Alternatives

It is inferred from the results of the investigations that the sinkhole was caused by water erosion from a broken sewer pipe that is located along the Highway 401 SW approach embankment. The sinkhole is about 150 m to the east side of the Yonge Blvd. cul-de-sac and extends to the south of the Highway 401 Noise Barrier walls and traffic barriers under the location of the utility cabinets.

The following alternatives could be considered for remediation of the cause of the sink hole.

1. Repair of existing pipe
2. Replacement with a new pipe

The complete recommendations for the pipe replacement are beyond the scope of the existing assignment.



The following table compares the advantages, disadvantages, risks / consequences and relative costs of each alternative from the foundation perspective:

Sinkhole Remediation Alternatives	Advantages	Disadvantages	Risks/ Consequences	Relative Costs
Option 1. Rehabilitation of existing pipe - This rehabilitation could include inserting liner inside the existing pipe, or more conventionally, replacing the damaged part	- Relatively short time required for construction than for Option 2 - The localized repairs required excavation and roadway protection systems will be limited in relation to Option 2	- A repair strategy including installation of a liner has experienced problems on the NW approach embankment of Don River Bridge and failed - The drainage capacity could be impacted by a constricted pipe diameter from a liner - The existing damage type could occur on other parts of the pipe later	- This is a viable and typical fix for a sewer pipe break but does not address the long range problem of general deterioration of an old pipe	- Relatively lower cost than Option 2 - Cost to vacuum soil debris within broken pipe should be considered - Cost of shoring and excavation protection should be considered - Cost of removal and re-establishing noise barriers and traffic barriers should be considered - Cost of lane closure for construction access should be considered
Option 2. Installation of new pipe	- More reliable performance and longer service life than fixing the pipe break	- Requires massive construction operation - Temporary shoring and roadway protection systems would be more extensive than Option 1 - Longer restricted access highway shoulder and lane closure required than for Option 1	- Slope destabilization during construction	- Higher cost than Option 1 - Consider also the higher costs for shoring, traffic barriers and lane closures than identified for Option 1

Based on this evaluation, Option 1 is recommended for immediate remedial measure with Option 2 recommended for consideration for future work. Option 1 should be implemented as soon as possible and before significant periods of precipitation and runoff that can be expected to occur after mid-November 2015 to mitigate the risks of further damage to the pavement structure of Hwy 401 and of potential extensive erosion and destabilization of the south side slope.



7.1.1. Rehabilitation of existing pipe

Refer to Appendix FDR-A for the plan and section details that were provided by MTO for the drainage system at this location.

Rehabilitation of the existing pipe is a less complex construction operation than pipe replacement. The repair would be standard sewer construction work and involve excavating to 1 m below the base of the broken pipe, re-establishing the bedding with granular materials in conformance with OPSS 410 (Construction Specification for Pipe Sewer Installation in Open Cut) replacing the damaged and leaking portion of the pipe and reinstating the backfill. Refer to Appendix FDR-B for OPSS 410. The operations would require partial removal of the existing noise and traffic barriers and closure of the most southerly lane during the construction. A vacuum truck could be used to assist in excavation. The excavated area should be supported by roadway protection and excavation shoring. A temporary drainage system by-passing the damaged section should be installed during the repairs at the site by blocking the MH # 18 outlet (sand bag or plywood) and installation of a sump pump to drain the water directly to MH # 19.

7.1.2. Installation of new pipe

New pipe installation has more reliable performance and longer service life than rehabilitating the existing pipe, but should only be considered as a long term measure after the existing sewer break is repaired due to the urgency of fixing the destabilizing leak. The new pipe could be installed along the existing alignment and would be constructed in conformance with OPSS 410. The installation of a temporary drainage system along the slope would be required during the construction operation. Roadway protection and lane closures would be required during construction operations.

8. **EXCAVATION AND DEWATERING**

For construction in-the-dry, the prevailing groundwater level should be lowered a minimum of 0.5 m below the base of excavations. Since the sewer is perched within a fill, it is anticipated that gravity drainage supplemented where necessary by sump pumping will suffice.



Excavations will be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO regulations. The existing cohesionless fill soils are generally classified as Type 3 soils. Refer to the OHSA for permitted slope geometries.

Where the OHSA requirements cannot be met due to space constraints, shoring will be required.

Temporary roadway protection, where required, should be constructed in accordance with OPSS 539 (Temporary Protection Systems). A minimum performance level of 2, according to OPSS 539 will be assumed. Consideration could be given to the use of soldier pile shoring systems or trench box shoring systems. These systems should be selected and designed by the contractor.

The following table provide parameters for shoring design.

Parameters	Silty Sand Fill
Internal Friction Angle, ϕ (degrees)	30
Unit weight, γ (kN/m ³)	20.0
Coefficient of Active Earth Pressure, K_a	0.33
Coefficient of Earth Pressure At Rest, K_o	0.50
Coefficient of Passive Earth Pressure, K_p	2.99



9. CLOSURE

This Foundation Design Report was prepared by Mr. M. Khorsand, BSc, EIT, and reviewed by Mr. D. Dundas, P.Eng., Geotechnical Services. Senior Engineer. Mr. C. M. P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A handwritten signature in blue ink, likely belonging to Mansoor Khorsand, is located to the left of his name and title.

Mansoor Khorsand, BSc, EIT.
Project Supervisor, Geotechnical Services



David Dundas, P.Eng.
Senior Engineer, Geotechnical Services



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



APPENDIX FDR-A

Drainage Profiles, West of Hogg's Hollow

Removal, Grading Paving & Drainage, West of Hogg's Hollow Structure

COUNTY OF YORK TWP. OF NORTH YORK

LOT 13
CON. I W.Y.S.CONTRACT No. 65-131
W.P. No. 252-61-1 & 2

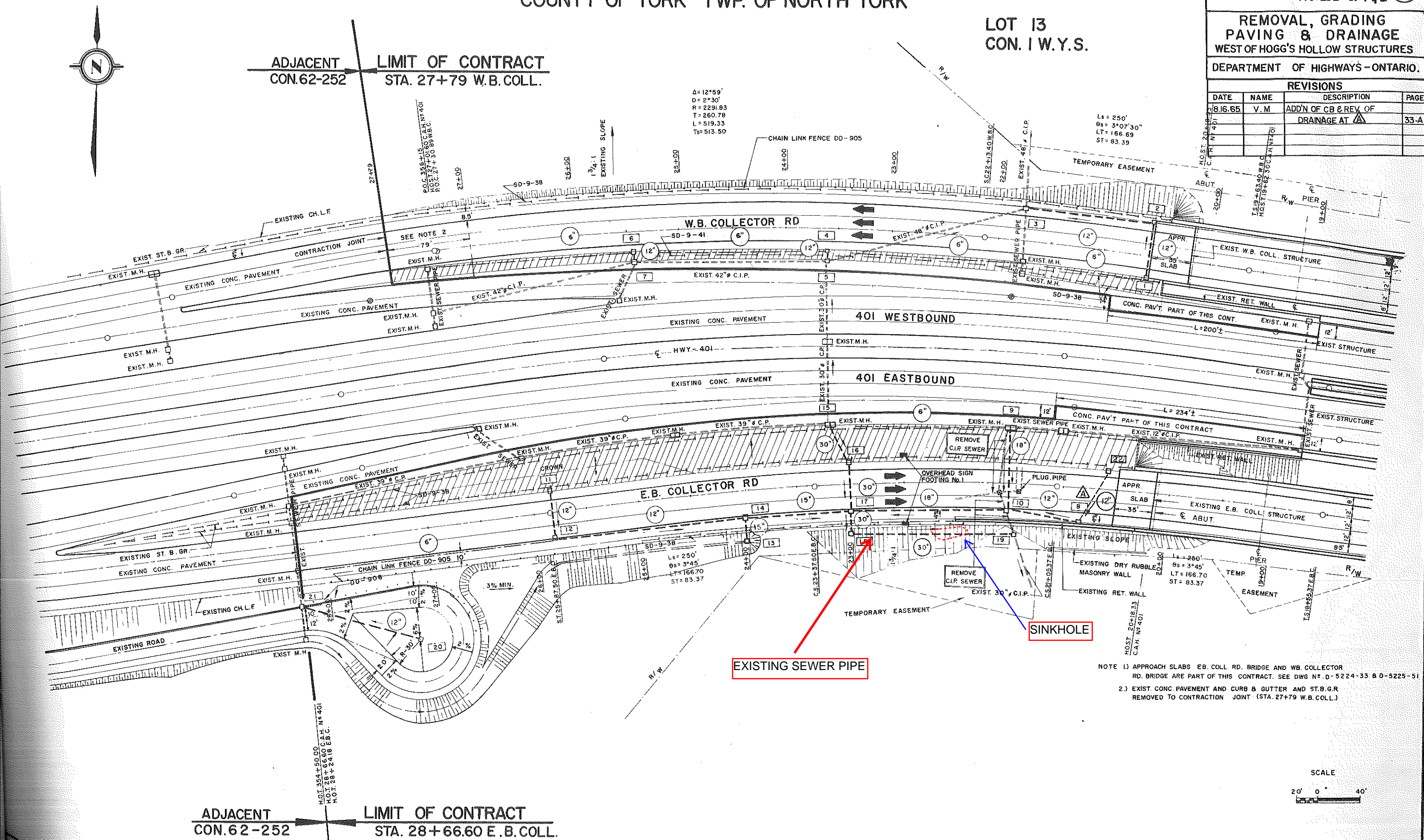
33-A

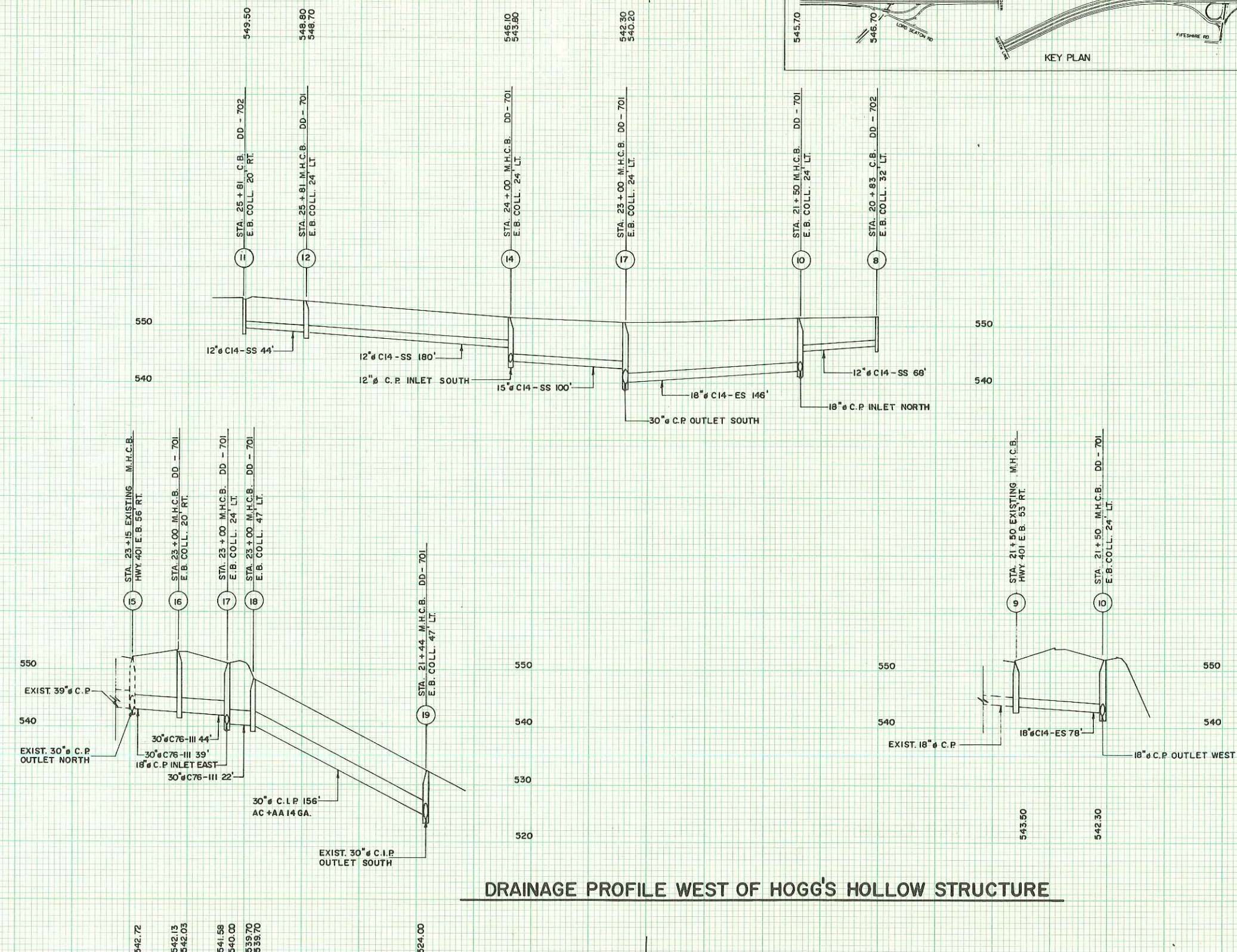
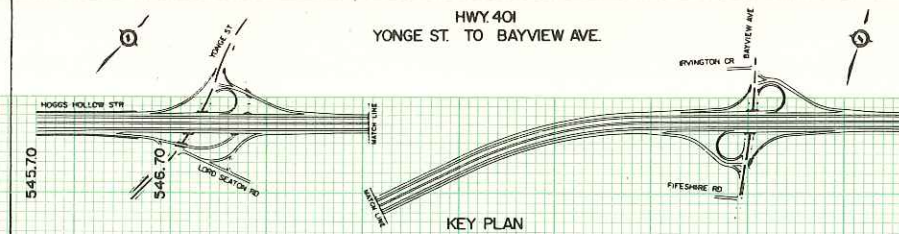
REMOVAL, GRADING
PAVING & DRAINAGE
WEST OF HOGG'S HOLLOW STRUCTURES

DEPARTMENT OF HIGHWAYS - ONTARIO.

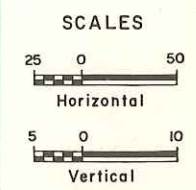
REVISIONS

DATE	NAME	DESCRIPTION	PAGE
8.16.65	V.M.	ADD'N OF CB & REV. OF DRAINAGE AT A	33-A





DRAINAGE PROFILE WEST OF HOGG'S HOLLOW STRUCTURE



Totals		Earth Cut
		Sub-Excavation
		Stripping
		Ditching
		Muskeg Excav.
		Earth Fill
		Rock Cut
		Shatter
		Rock Fill
		Muskeg Backfill



APPENDIX FDR-B

OPSS 410 Construction Specification for Pipe Sewer Installation in Open Cut



CONSTRUCTION SPECIFICATION FOR PIPE SEWER INSTALLATION IN OPEN CUT

TABLE OF CONTENTS

410.01	SCOPE
410.02	REFERENCES
410.03	DEFINITIONS
410.04	DESIGN AND SUBMISSION REQUIREMENTS - Not Used
410.05	MATERIALS
410.06	EQUIPMENT - Not Used
410.07	CONSTRUCTION
410.08	QUALITY ASSURANCE - Not Used
410.09	MEASUREMENT FOR PAYMENT
410.10	BASIS OF PAYMENT

APPENDICES

410-A	Commentary
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410.01 SCOPE

This specification covers the requirements for the installation of storm and sanitary pipe sewers, laterals, service connections, and concrete appurtenances in open cut.

410.01.01 Specification Significance and Use

This specification has been developed for use in provincial- and municipal-oriented Contracts. The administration, testing, and payment policies, procedures, and practices reflected in this specification correspond to those used by many municipalities and the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

410.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

410.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

When the Contract Documents indicate that municipal-oriented specifications are to be used and there is a municipal-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.MUNI, unless use of a provincial-oriented specification is specified in the Contract Documents. When there is not a corresponding municipal-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a provincial-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 206	Grading
OPSS 401	Trenching, Backfilling, and Compacting
OPSS 404	Support Systems
OPSS 407	Maintenance Hole, Catch Basin, Ditch Inlet, and Valve Chamber Installation
OPSS 409	Closed-Circuit Television Inspection of Pipelines
OPSS 490	Site Preparation for Pipelines, Utilities, and Associated Structures
OPSS 491	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 492	Site Restoration Following Installation of Pipelines, Utilities, and Associated Structures
OPSS 510	Removal
OPSS 517	Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 539	Temporary Protection Systems
OPSS 904	Concrete Structures
OPSS 905	Steel Reinforcement for Concrete

Ontario Provincial Standard Specifications, Material

OPSS 1004	Aggregates - Miscellaneous
OPSS 1205	Clay Seal
OPSS 1301	Cementing Materials

OPSS 1302	Water
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1801	Corrugated Steel Pipe Products
OPSS 1820	Circular Concrete Pipe
OPSS 1840	Non-Pressure Polyethylene Plastic Pipe Products
OPSS 1841	Non-Pressure Polyvinyl Chloride (PVC) Pipe Products
OPSS 1843	Non-Pressure Polypropylene (PP) Plastic Pipe Products
OPSS 1860	Geotextiles

CSA Standards

B182.1-11	Plastic Drain and Sewer Pipe and Pipe Fittings [Part of B1800-11, Plastic Non-Pressure Pipe Compendium]
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ASTM International

C 507-12	Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
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410.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Backfilling means the operation of filling the trench with bedding, cover, and backfill material or embedment and backfill material.

Concrete Appurtenances means concrete head walls, cut-off walls, stiffeners, aprons, collars, and any other concrete fixtures associated with the pipe sewer, excluding concrete bedding or concrete structures specified in the Contract Documents.

Dimension Ratio means the average specified outside diameter of a pipe divided by the minimum specified wall thickness.

Drainage Structure means a maintenance hole, catch basin, or ditch inlet.

Excavation, Earth and Rock means the excavation classified as earth and rock according to OPSS 206.

Flexible Pipe means pipe that can deflect 2% or more without cracking, such as polyvinyl chloride or polyethylene or steel pipe.

Pipe Class means a pipe's physical material specification, such as load and pressure ratings, wall thickness, protective coatings, corrugation profiles, ring stiffness constants, and reinforcement.

Pipe Run means a section of a pipe sewer between two drainage structures or between a drainage structure and an outlet.

Pipe Sewer means an installation designed for the conveyance of sanitary sewage or storm water using preformed or precast pipe sections, circular or non-circular in cross-section, laid end to end using suitable jointing material and connected by maintenance holes for sanitary pipe sewers and by maintenance holes, catch basins, ditch inlets, or concrete appurtenances for storm pipe sewers.

Pipe Type means a pipe's inner wall design, which can be smooth or corrugated.

Polypropylene Plastic means a material made with virgin polymers in which propylene is essentially the sole monomer.

Service Connection means the pipe used to convey sanitary sewage or storm water from the property line to the main sanitary or storm pipe sewer respectively.

410.05 MATERIALS

410.05.01 Pipe Materials

410.05.01.01 General

Pipe sewer size, type, and class shall be as specified in the Contract Documents.

Pipe sewer size and class shall be consistent throughout a pipe run as specified in the Contract Documents. Pipe type shall be consistent throughout a pipe sewer as specified in the Contract Documents.

Fittings shall be suitable for and compatible with the pipe type and class for which they will be used.

410.05.01.02 Concrete Pipe

Circular concrete pipe and joints shall be according to OPSS 1820.

Elliptical concrete pipe and joints shall be according to ASTM C 507.

410.05.01.03 Corrugated Steel Pipe Products

Corrugated steel pipe products shall be according to OPSS 1801.

410.05.01.04 Polyethylene Pipe Products

Polyethylene pipe products shall be according to OPSS 1840.

410.05.01.05 Polyvinyl Chloride Pipe Products

Polyvinyl chloride pipe products shall be according to OPSS 1841.

Polyvinyl chloride service connection pipe shall be according to CSA B182.1 and shall have bell and spigot joints with elastomeric gaskets.

410.05.01.06 Polypropylene Plastic Pipe Products

Polypropylene plastic pipe products shall be according to OPSS 1843.

410.05.02 Mortar

Mortar for joints shall be composed of one part normal Portland cement and two parts mortar sand, wetted with only sufficient water to make the mixture plastic. The mortar sand shall be according to OPSS 1004, the normal Portland cement shall be according to OPSS 1301, and the water shall be according to OPSS 1302.

410.05.03 Clay Seal

Clay seal material shall be according to OPSS 1205.

410.05.04 Concrete

Concrete for concrete appurtenances shall be according to OPSS 1350 with a nominal minimum 28-Day compressive strength of 30 MPa.

410.05.05 Steel Reinforcement

Steel reinforcement shall be of the size and grade specified in the Contract Documents and shall be according to OPSS 1440.

410.05.06 Geotextile

Geotextile shall be according to OPSS 1860.

410.07 CONSTRUCTION

410.07.01 Site Preparation

Site preparation shall be according to OPSS 490.

410.07.02 Removals

Removals shall be according to OPSS 510.

410.07.03 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

410.07.04 Protection Against Floatation

Damage to the pipeline due to floatation shall be prevented during construction and until completion of the work.

410.07.05 Cold Weather Work

All work shall be protected from freezing. Pipes and bedding material shall not be placed on frozen ground.

410.07.06 Transporting, Unloading, Storing, and Handling Pipe

Manufacturer's recommendations for transporting, unloading, storing, and handling of pipe shall be followed.

All pipes, fittings, and gaskets that are unsound or damaged shall be rejected.

410.07.07 Excavation

Excavation for the placement of pipe sewers shall be according to OPSS 401.

410.07.08 Support Systems

Support systems shall be according to OPSS 404.

410.07.09 Dewatering

Dewatering shall be according to OPSS 517.

410.07.10 Protection Systems

The construction of all protection systems shall be according to OPSS 539. When the stability, safety, or function of an existing roadway, railway, other works, or proposed works may be impaired due to the method of operation, such protection as may be required shall be provided. Protection may include sheathing, shoring, and the driving of piles, when necessary, to prevent damage to such works or proposed works.

410.07.11 Backfilling and Compacting

Backfilling and compacting shall be according to OPSS 401.

410.07.12 Pipe Installation

410.07.12.01 General

If a universal dimple coupler or any other coupler does not follow the contour of the flexible pipe sections to be joined, polyethylene gaskets shall then be installed at all joints when such couplers are used. Polyethylene gaskets shall be installed symmetrically about the pipe joint, between the coupler and the pipe, and shall be of sufficient length to equal the circumference of the pipe plus a minimum overlap of 300 mm.

Pipe shall be laid within the alignment and grade tolerances specified in the Contract Documents. When bell and spigot pipe is laid, the bell end of the pipe shall be laid upgrade.

Pipe shall be kept clean and dry as work progresses. The trench shall be kept dry. A removable watertight bulkhead shall be installed at the open end of the last pipe laid whenever work is suspended.

Pipe shall not be laid until the preceding pipe joint has been completed and the pipe is carefully embedded and secured in place.

When the Owner raises or lowers the invert of a pipe sewer by 150 mm or less, it shall not constitute a Change in the Work and no adjustment shall be made to the payment. When the invert of a pipe sewer is raised or lowered by more than 150 mm, it shall constitute a Change in the Work for the full extent of the change from the original grade.

When installing gaskets, all pipe ends shall be thoroughly cleaned. For gaskets requiring field lubrication, a lubricant recommended by the pipe manufacturer shall be used.

When gaskets have been affixed, the pipe shall be handled in a way so that the gasket is not damaged, displaced, or contaminated with foreign matter. Any gasket displaced or contaminated shall be removed, cleaned, and lubricated, if required, and reinstalled before closure of the joint is attempted. When specified in the Contract Documents, nitrile gaskets shall be used.

The pipe shall be properly positioned by means of an appropriate mechanism. Sufficient pressure shall be applied in making the joint to ensure that the joint is in position. Sufficient restraint shall be applied to the line to ensure that joints are held in this position.

Once the pipe has been jointed, a test shall be made with a feeler gauge at intervals around the joint to ensure that the gasket has not been displaced from the spigot groove. If the gasket is found out of position, the joint shall be opened and the gasket placed in its proper position. If necessary, a new gasket shall be installed.

410.07.12.02 Circular Concrete Pipe

All circular concrete pipe joints shall have elastomeric gaskets.

410.07.12.03 Non-Circular Concrete Pipe

Elliptical concrete pipes and joints shall be used for storm pipe sewers only.

All non-circular concrete pipe joints shall be according to the procedures recommended by the manufacturer.

410.07.12.04 Corrugated Steel Pipe Products

Corrugated steel pipe products shall be used for storm pipe sewers only.

Helical corrugated steel pipe without rerolled ends shall be installed so that the helix angle is constant for the total length of the installation. Each pipe section shall be installed next to the previous section so that the lockseam forms a continuous helix. For rerolled ends, the correct fit of the coupling system does not depend on the location of the helical lockseam and corrugation.

Corrugated steel pipe sections shall be joined by means of steel couplers. The couplers shall be installed to lap approximately equal portions of the pipes being connected so that the corrugations or projections of the coupler properly engage the pipe corrugations. As the coupler is being tightened, it shall be tapped with a mallet to take up the slack.

When joint seals are specified in the Contract Documents, they shall be installed immediately prior to the installation of steel couplers.

410.07.12.05 Polyethylene Pipe

Polyethylene pipe shall be jointed by one of the following methods, as recommended by the manufacturer:

- a) Bell and Spigot
- b) Welded Joint
- c) Thermal Fusion Joint
- d) Screw-on Coupler
- e) Split Coupler
- f) Threaded Joint

410.07.12.06 Polyvinyl Chloride Pipe

Polyvinyl chloride pipe shall be jointed, as recommended by the manufacturer, using a bell and spigot joint with an elastomeric gasket.

At the end of a day's work, the last pipe shall be blocked as may be required to prevent movement.

410.07.12.07 Polypropylene Pipe

Polypropylene pipe shall be jointed by means of a bell and spigot joint with elastomeric gasket or a coupler joint as recommended by the manufacturer to satisfy the pipe joint specification.

410.07.13 Service Connections

Service connections to the main pipe sewer shall be made using factory made tees or wyes, strap-on-saddles, or other approved saddles. Factory made tees or wyes shall be used for all service connections when the diameter of the main pipe sewer is:

- a) less than 450 mm; or
- b) less than twice the diameter of the service connection.

Strap-on-saddles shall be installed before laying the pipe.

Holes in the main pipe sewer shall be cut with approved cutters and shall be the minimum diameter required to accept the service connection saddle. If mortar-on saddles are used, the inside of the pipe shall be mortared at the connection.

Service connections shall be plugged at the property line with watertight caps or plugs. Plugs or caps shall be braced sufficiently to withstand test pressures.

When existing service connections shall be connected to new pipe sewers or service connections, proper jointing procedures shall be used.

410.07.14 Marking and Recording Service Connections

A painted temporary location marker consisting of a 50 x 75 mm stake or two short sections of lumber connected by a piece of heavy gauge wire shall be placed at the end of the plugged or capped service connection. The marker shall be placed from 300 mm below the finished grade to a point 300 mm above the plugged end of the service pipe.

A painted surface stake, 50 x 75 x 450 mm long, shall be placed after trench restoration.

Service connections shall not be backfilled until they have been inspected and measurements of location have been taken by the Contract Administrator.

410.07.15 Breaking into Maintenance Holes, Catch Basins, Ditch Inlets, Pipe Culverts, and Pipe Sewers

Openings shall be made as necessary in an existing maintenance hole, catch basin, ditch inlet, pipe culvert, or pipe sewer to install the new pipe sewer and connect it to the structure according to OPSS 407. Benching in existing maintenance holes shall be altered to accommodate the flow in the new pipe sewer system.

When specified in the Contract Documents, the opening for the connection of a subdrain outlet shall be formed by coring. The subdrain outlet pipe shall be sealed into place using non-shrink grout. When specified in the Contract Documents, a 50 mm diameter weep hole shall be cored into the same wall as the subdrain connection and at the same invert elevation.

410.07.16 Field Testing

410.07.16.01 General

Field tests described in this subsection shall be conducted when specified in the Contract Documents and applied to sanitary and storm pipe sewers. All tests shall be carried out in the presence of and accepted by the Contract Administrator.

When specified in the Contract Documents, leakage tests shall be carried out on completed pipe sewers 1,200 mm in diameter and smaller. There shall be no visible leakage for pipe sewers larger than 1,200 mm diameter.

Testing shall be carried out from maintenance hole to maintenance hole, including house service connections as work progresses.

The construction of new mainline pipe sewers shall not proceed when three previously placed sections of the pipe sewer have not been tested or have been tested and are unsatisfactory.

Leakage up to 25% in excess of the calculated limits shall be approved in any test section provided that the excess is offset by lower leakage measurements in adjacent sections so that the total leakage is within the allowable limits for the combined sections.

Pipe sewers shall be repaired and retested, as required, until the test results are within the limits specified in this specification. Visible leaks shall be repaired regardless of the test results.

No part of the work shall be accepted until the pipe sewers are satisfactorily tested following completion of installation of service connections and backfilling.

410.07.16.02 Prequalification Leakage Tests

Prequalification leakage tests shall be carried out as either infiltration or exfiltration tests, as required.

The test shall be performed on the first section of the pipe sewer of each size, not less than 100 m in length, installed by each crew in order to prequalify the crew and the material. Tests may be carried out prior to service connections being installed in the section being tested.

When tests are unsatisfactory, the test section shall be repaired and retested until satisfactory results are obtained.

410.07.16.03 Infiltration Test

Dewatering operations shall be discontinued at least three days prior to conducting the test and allow for the groundwater level to stabilize. Infiltration tests shall be conducted when the groundwater level at the time of testing is 600 mm or more above the crown of the pipe for the entire length of the test section. The test section is normally between adjacent maintenance holes.

A watertight bulkhead shall be constructed at the upstream end of the test section. All service laterals, stubs, and fittings shall be plugged or capped to prevent water entering at these locations. A V-notch weir or other suitable measuring device shall be installed at the downstream end of the test section. Infiltrating water shall be allowed to build up behind the weir until the flow through the V-notch has stabilized. The rate of flow shall then be measured. The rate of flow shall not exceed the maximum allowable infiltration calculated for the test section. Allowable infiltration shall be calculated as 0.075 litres/millimetre diameter/100 metres of pipe sewer/hour.

410.07.16.04 Exfiltration Test

410.07.16.04.01 General

Exfiltration tests shall be conducted when the groundwater level is lower than 600 mm above the crown of the pipe or the highest point of the highest service connection included in the test section.

The test section is normally between adjacent maintenance holes. The test section of the pipe sewer shall be isolated by temporarily plugging the downstream end and all incoming pipes of the upstream maintenance hole. All service laterals, stubs, and fittings are plugged or capped to prevent water entering at these locations.

410.07.16.04.02 Testing With Water

The test section shall be slowly filled with water ensuring that all air is removed from the line. A period of 24 hours for absorption or expansion shall be allowed prior to starting the test, except if exfiltration requirements are met by a test carried out during the absorption period.

Water shall be added to the pipeline prior to testing until there is a head in the upstream maintenance hole of 600 mm minimum over the crown of the pipe or at least 600 mm above the existing groundwater level, whichever is greater. The maximum limit of the net internal head on the line is 8 m. In calculating the net internal head, allowance for groundwater head, if any, shall be made.

The distance from the maintenance hole frame to the surface of the water shall be measured. After allowing the water to stand for one hour, the distance from the frame to the surface of the water shall again be measured. The leakage shall be calculated using volumes.

The leakage at the end of the test period shall not exceed the maximum allowable calculated for the test section. Allowable leakage shall be calculated as 0.075 litres/millimetre diameter/100 metres of pipe sewer/hour.

An allowance of 3.0 litres per hour per metre of head above the invert for each maintenance hole included in the test section shall be made.

Maintenance holes shall be tested separately, if the test section fails.

410.07.16.04.03 Low Pressure Air Testing

The Contract Administrator may allow or require testing by use of air when water is not readily available or the differential head in the test section is greater than 8 m or freezing temperatures exist.

Air control equipment that includes a shut off valve, safety valve, pressure regulating valve, pressure reduction valve and monitoring pressure gauge with pressure range from 0 to 35 kPa with minimum divisions of 0.5 kPa and accuracy of approximately 0.25 kPa shall be provided.

Tests shall be conducted between two consecutive maintenance holes. The test section shall be plugged at each end. One plug shall be equipped with an air inlet connection to fill the pipe sewer system with air.

The test section shall be filled slowly until a constant pressure of 24 kPa is maintained. If the groundwater is above the pipe sewer being tested, the air pressure shall be increased by 3.0 kPa for each 300 mm that the groundwater level is above the invert of the pipe.

The air pressure shall be stabilized for five minutes and then regulated to maintain it to 20.5 kPa plus the allowance for groundwater, if any. After the stabilization period, the time taken for a pressure loss of 3.5 kPa shall be recorded.

The time taken for a pressure drop of 3.5 kPa shall not be less than the times shown in Table 1.

If the length of the test section is greater than the length for minimum time, the new testing time shall be a product of the length of test section multiplied by the time shown in Table 1 for the appropriate size pipe.

If the results of an air test are marginal, the Contract Administrator may require the section to be retested using water.

410.07.16.05 Deflection Testing of Pipe Sewers

Ring deflection testing shall be performed on all pipe sewers constructed using flexible pipe. The allowable deflected pipe diameter is calculated as:

Pipes 100 to 750 mm:	7.5% of the Base Inside Diameter of the Pipe
Pipes Greater Than 750 mm:	5.0% of the Base Inside Diameter of the Pipe

Where:

Base Inside Diameter is defined in the CSA or ASTM standard to which the pipe is manufactured.

A suitably designed device as defined below shall be pulled through the pipe sewer to demonstrate that the pipe deflection does not exceed the allowable deflected pipe diameter. The device shall be pulled manually through the pipe not sooner than 30 Days after the completion of backfilling and installation of service connections.

The suitably designed device shall be a mandrel, cylindrical in shape, and constructed with an odd number of evenly spaced arms or prongs, minimum 9 in number. The minimum diameter of the circle scribed around the outside of the mandrel arms shall be equal to the allowable deflected pipe diameter ± 1 mm. The contact length of the mandrel shall be measured between the points of contact on the mandrel arm or between sets of prongs. This length shall not be less than that shown in Table 2.

The mandrel shall be checked with a go-no-go proving ring. The proving ring shall have a diameter equal to the allowable deflected pipe diameter ± 0.1 mm. An acceptable mandrel shall not pass through the proving ring. The proving ring shall be fabricated from steel a minimum of 6 mm thick.

Any section of pipe that does not allow the mandrel to pass shall be considered to have failed the deflection test.

All sections of pipe that fail the deflection test shall be repaired and retested.

410.07.16.06 Closed-Circuit Television (CCTV) Inspection

Pipe sewers shall be inspected using CCTV equipment. CCTV inspection of pipe sewers shall be according to OPSS 409.

410.07.17 Cleaning and Flushing of Pipe Sewers

When specified in the Contract Documents, all pipe sewers shall be cleaned and flushed immediately prior to inspection and acceptance.

410.07.18 Clay Seals

Clay seals shall be placed as specified in the Contract Documents and compacted to 95% of the maximum dry density.

410.07.19 Concrete Appurtenances

Concrete appurtenances shall be constructed as specified in the Contract Documents. Concrete in concrete appurtenances shall be placed according to OPSS 904. Steel reinforcement shall be placed according to OPSS 905. Steel grating shall be installed when specified in the Contract Documents.

410.07.20 Site Restoration

Site restoration shall be according to OPSS 492.

410.07.21 Management of Excess Material

Management of excess material shall be as specified in the Contract Documents.

410.09 MEASUREMENT FOR PAYMENT

410.09.01 Actual Measurement

410.09.01.01 Pipe Sewers

Measurement of pipe sewers shall be by length in metres along the horizontal centreline length of the pipe from the centre of one drainage structure to the centre of another drainage structure or outlet end of the pipe sewer. When the grade of the pipe sewer is 10% or greater, the above measurement is then of the slope length.

410.09.01.02 Service Connections

Measurement of the service connections shall be by length in metres along its horizontal centreline from the centreline of the main pipe sewer to the end of the service connection.

410.09.01.03 Breaking into Maintenance Holes, Catch Basins, Ditch Inlets, Pipe Culverts, and Pipe Sewers

For measurement purposes, a count shall be made of the number of openings made in maintenance holes, catch basins, ditch inlets, pipe culverts and pipe sewers.

410.09.01.04 Concrete Appurtenances

Measurement for concrete appurtenances shall be by volume in cubic metres for the volume of concrete placed. Alternatively, concrete appurtenances may be a lump sum item.

410.09.01.05 Clay Seal

Measurement for clay seal shall be by volume in cubic metres for the volume of clay placed. Alternatively, clay seal may be a lump sum item.

410.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clauses under Actual Measurement.

410.10 BASIS OF PAYMENT

410.10.01 *"size, type, class"* Pipe Sewers - Item
Service Connections - Item
Breaking into Maintenance Holes, Catch Basins, Ditch Inlets, Culverts and
Sewers - Item
Concrete Appurtenances - Item
Clay Seal - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

410.10.02 Closed-Circuit Television (CCTV) Inspection

When a CCTV inspection of pipe sewers is specified in the Contract Documents, payment for CCTV inspection shall be according to OPSS 409.

TABLE 1
Exfiltration Test - Low Pressure Air Testing

NominalPipe Size mm	MinimumTime min:sec	Length for Minimum Time m	Time For Longer Length sec
100	1:53	182	0.623
150	2:50	121	1.140
200	3:47	91	2.493
250	4:43	73	3.893
300	5:40	61	5.606
375	7:05	48	8.761
450	8:30	41	12.615
525	9:55	35	17.171
600	11:20	30	22.425
675	12:45	27	28.382
750	14:10	24	35.040
825	15:35	22	42.397
900	17:00	20	50.450

TABLE 2
Deflection Testing of Pipe Sewers

Nominal Pipe Size mm	Mandrel Contact Length mm
150	100
200	150
250	200
300	250
350	300
375	300
400	300
450	350
500	400
525	450
600	500
675	575
750	675
900	750
1050	900
1200	1050

Appendix 410-A, November 2013
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

The designer should specify the following in the Contract Documents:

- Pipe sewer size, type, and class. (410.05.01.01)
- Pipe size. (410.05.01.01)
- Size and grade of steel reinforcement. (410.05.05)
- Alignment and grade tolerances for the pipe installation. (410.07.12.01)
- Placement of clay seals. (410.07.18)
- Requirements to construct concrete appurtenances. (410.07.19)
- Depth of backfill over the pipe sewer. (410.07.20)

The designer should determine if the following are required and, if so, add the requirement in the Contract Documents:

- Use of nitrile gaskets. (410.07.12.01)
- Use of joint seals with corrugated steel pipe products. (410.07.12.04)
- Coring for the installation of subdrain. (410.07.15)
- Coring of a 50 mm diameter weep hole. (410.07.15)
- Field tests. (410.07.16.01)
- Cleaning and flushing prior to inspection and acceptance. (410.07.17)
- Use of steel grating. (410.07.19)
- Payment of concrete appurtenances by volume or lump sum. (410.09.01.04)

The tender item description for pipe sewer should include reference to one or more of the attributes shown, i.e., *size, type, class*. (410.10.01)

The designer should ensure that the General Conditions of Contract and the 100 Series General Specifications are included in the Contract Documents.

Appendix 410-A

Related Ontario Provincial Standard Drawings

OPSD 708.010	Catch Basin Connection for Rigid Main Pipe Sewer
OPSD 708.020	Support for Pipe at Catch Basin or Maintenance Hole
OPSD 708.030	Catch Basin Connection for Flexible Main Pipe Sewer
OPSD 802.010	Flexible Pipe Embedment and Backfill Earth Excavation
OPSD 802.013	Flexible Pipe Embedment and Backfill Rock Excavation
OPSD 802.014	Flexible Pipe Embedment in Embankment Original Ground: Earth or Rock
OPSD 802.020	Flexible Pipe Arch Embedment and Backfill Earth Excavation
OPSD 802.023	Flexible Pipe Arch Embedment and Backfill Rock Excavation
OPSD 802.024	Flexible Pipe Arch Embedment in Embankment Original Ground: Earth or Rock
OPSD 802.030	Rigid Pipe Bedding, Cover, and Backfill, Type 1 or 2 Soil - Earth Excavation
OPSD 802.031	Rigid Pipe Bedding, Cover, and Backfill, Type 3 Soil - Earth Excavation
OPSD 802.032	Rigid Pipe Bedding, Cover, and Backfill, Type 4 Soil - Earth Excavation
OPSD 802.033	Rigid Pipe Bedding, Cover, and Backfill, Rock Excavation
OPSD 802.034	Rigid Pipe Bedding and Cover in Embankment, Original Ground: Earth or Rock
OPSD 802.050	Horizontal Elliptical Rigid Pipe Bedding, Cover, and Backfill, Type 1 or 2 Soil - Earth Excavation
OPSD 802.051	Horizontal Elliptical Rigid Pipe Bedding, Cover, and Backfill, Type 3 Soil - Earth Excavation
OPSD 802.052	Horizontal Elliptical Rigid Pipe Bedding, Cover, and Backfill, Type 4 Soil - Earth Excavation
OPSD 802.053	Horizontal Elliptical Rigid Pipe Bedding, Cover, and Backfill, Rock Excavation
OPSD 802.054	Horizontal Elliptical Rigid Pipe Bedding and Cover in Embankment, Original Ground: Earth or Rock
OPSD 802.095	Clay Seal for Pipe Trenches
OPSD 804.030	Concrete Headwall for Pipe Less Than 900 mm Diameter
OPSD 804.040	Concrete Headwall for Sewer or Culvert Pipe
OPSD 804.050	Grating for Concrete Endwall
OPSD 805.010	Height of Fill Table, Round Corrugated Steel Pipe and Structural Plate Corrugated Steel Pipe
OPSD 805.020	Height of Fill Table, Corrugated Steel Pipe Arch and Structural Plate Corrugated Steel Pipe Arch
OPSD 805.030	Height of Fill Table, Spiral Rib Round Pipe
OPSD 805.040	Height of Fill Table, Spiral Rib Pipe Arch
OPSD 806.020	Height of Fill Table, Dual Wall Corrugated Polyethylene Gravity Sewer Pipe, 210 and 320 kPa
OPSD 806.021	Height of Fill Table, Closed Profile Wall Polyethylene Pipe, RSC 160 and 250
OPSD 806.022	Height of Fill Table, Dual Wall Corrugated Polyethylene Gravity Sewer Pipe, RSC 100 and RSC 160
OPSD 806.030	Height of Fill Table, Dual and Triple Wall Corrugated Polypropylene Gravity Sewer Pipe, 320 kPa
OPSD 806.040	Height of Fill Table, Polyvinyl Chloride Gravity Sewer Pipe, 210, 320, and 625 kPa
OPSD 806.060	Height of Fill Table, Polyvinyl Chloride Pressure Pipe for Different Dimension Ratios
OPSD 807.010	Height of Fill Table, Reinforced Concrete Pipe - Confined Trench Class 50-D, 65-D, 100-D, and 140-D
OPSD 807.030	Height of Fill Table, Reinforced Concrete Pipe - Embankment Class 50-D, 65-D, 100-D, and 140-D
OPSD 807.040	Height of Fill Table - Nonreinforced Concrete Pipe Class 3
OPSD 807.050	Height of Fill Table, Horizontal Elliptical Concrete Pipe Class HE-A, HE-I, HE-II, HE-III, and HE-IV
OPSD 1006.010	Sewer Service Connections for Rigid Main Pipe Sewer
OPSD 1006.020	Sewer Service Connections for Flexible Main Pipe Sewer