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To:	Mike Trader	From:	Raymond Haché / Kevin Nelson
	Hamilton ON Office		Ottawa (Clyde Ave) ON Office
File:	165000801	Date:	May 19, 2016

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**Reference: Addendum to Foundation Report Prepared by Stantec, Dated December 2012  
West Abutment Pile Capacities  
Highway 9 - Holland Drainage Canal Bridge Replacement  
G.W.P. 2188-08-00**

Based on a review of the Contract Drawings for this project, the design pile tip elevation of 195 m may result in the piles at the west abutment penetrating into a silty sand stratum containing artesian groundwater conditions. Therefore, additional analyses have been carried out to further assess the pile capacities and required lengths of piles for the west abutment in order to optimize the design of these piles and confirm if slightly shorter piles can be utilized in order to reduce the potential for punching into the artesian layer.

This memorandum presents the results of further assessment of the pile capacities for the west abutment of the proposed replacement structure for the Holland Drainage Canal Bridge. Stantec provided foundation design recommendations for the above referenced project in our Report No. 165000801 titled "Preliminary Foundation Investigation Report – Highway 9 Holland Drainage Canal Bridge Replacement – Township of King – Site No. 37-030 – G.W.P. 2188-08-00 (Geocres No. 31D-553)" and dated December 2012. The contents of this memorandum should be read in conjunction with the foundation recommendations and guidance provided in the aforementioned report

The calculations of the pile capacities in the original Preliminary Foundation Investigation Report (PFIR) were based on the soil strength profile/characteristics encountered at boreholes advanced near the central pier and east abutment of the structure where a deep organic silt (muck) deposit is present above the inorganic overburden soils. However, as shown on the records of the deep boreholes advanced on the west side of the replacement structure (i.e. Borehole 12-1 from the current investigation and Borehole 2 from a 1965 investigation for the existing structure), the clayey silt deposit is considerably stiffer on the west side of the site than on east side of the structure (i.e. where the design soil model was developed). For reference, a borehole location plan and copies of borehole records for boreholes advanced on the west and east sides of the bridge have been included in Appendix A while the attached Figure 1 provides a comparison of the soil models on the west and east sides of bridge. Review of Figure 1 indicates that the undrained shear strengths measured within the clayey silt deposit are consistently higher on the west side of the bridge; likewise a review of the SPT values shown on boreholes BH12-1 and BH2 from the west abutment area are considerably higher than those shown on BH12-2 and BH12-3 from the east abutment area.

Figure 2 provides a new profile of the computed geotechnical axial resistance (in compression at Ultimate Limit States (ULS)) for the proposed 356 mm diameter pipe piles at the west abutment location. This profile incorporates a resistance factor of 0.4 applied to the calculated ultimate capacity. The contract drawings indicate that the required factored ULS axial capacity of the abutment piles is 525 kN. As indicated on this figure, the design axial capacity is expected to be achievable using 21 m long piles at the west abutment. The underside of the west abutment pile cap is understood to have an underside elevation of approximately 218.1 m. Accordingly, it is

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**West Abutment Pile Capacities**  
**Highway 9 - Holland Drainage Canal Bridge Replacement**  
**G.W.P. 2188-08-00**

recommended that the design pile tip elevations for piles at the west abutment location be revised to 197 m in order to reduce the potential for the piles penetrating into the underlying silty sand deposit. Piles should not be driven below the proposed tip elevation to avoid potential penetration into the underlying silty sand stratum which contains artesian groundwater conditions.

We also recommend that the nominal hammer energy should not exceed the industry standard or the recommendation in the Canadian Foundation Engineering Manual (maximum nominal rated hammer energy of 600 J/cm<sup>2</sup> of steel) to avoid damaging the piles. If high driving resistance occurs above the targeted tip elevation and it is determined that an energy level exceeding the maximum recommended value is required to further advance the piles, the pile capacity shall be determined using the Hiley Formula.

Due to the different targeted pile lengths for the west abutment, it is recommended that four additional PDA tests be carried out for this project. Therefore, during construction of the north portion of the bridge four PDA tests would be carried out at the west abutment and four separate PDA tests at the east abutment.

We trust the above provides sufficient information. If you have any questions or concerns, please do not hesitate to contact the undersigned.

**STANTEC CONSULTING LTD.**

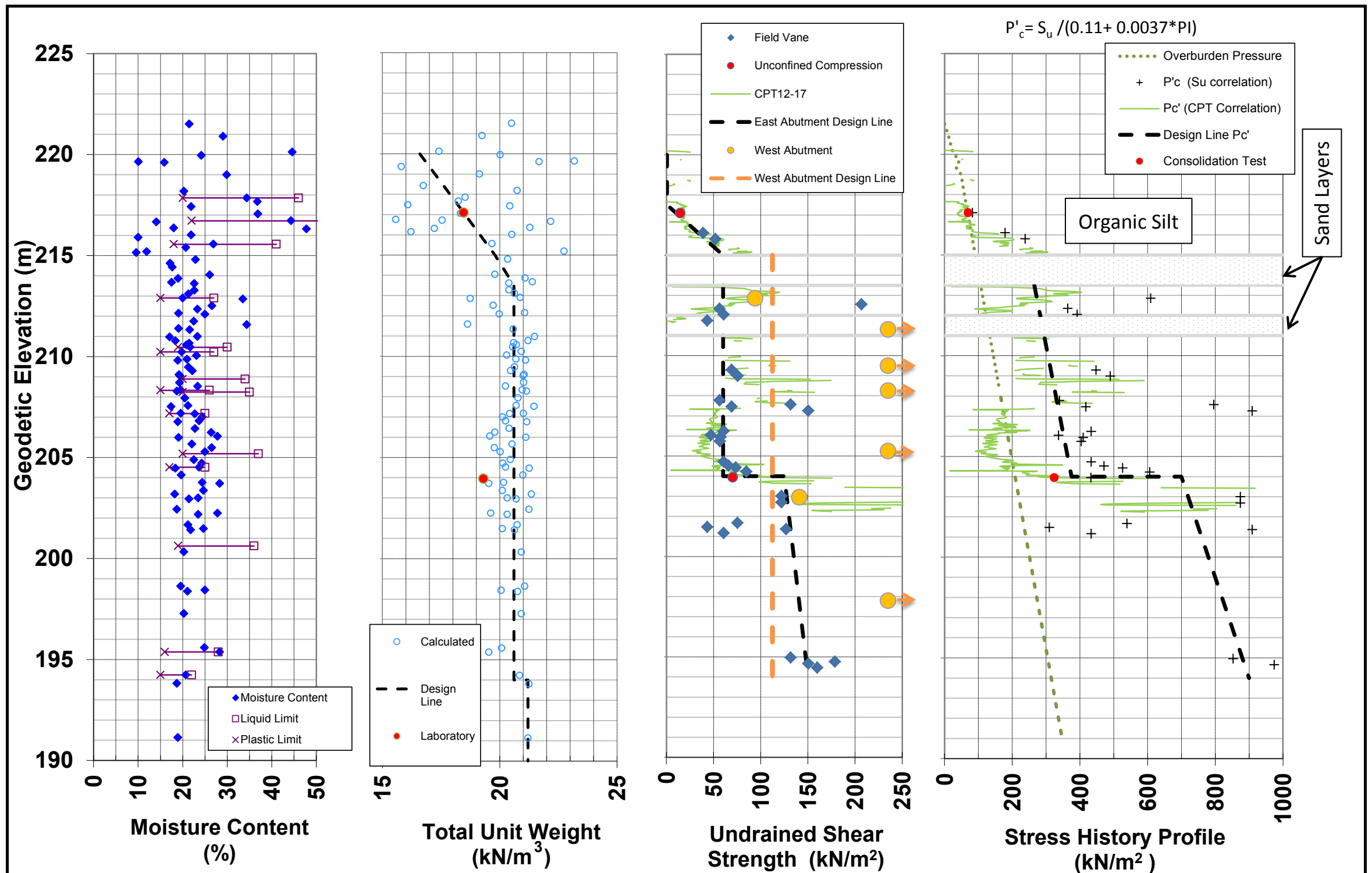


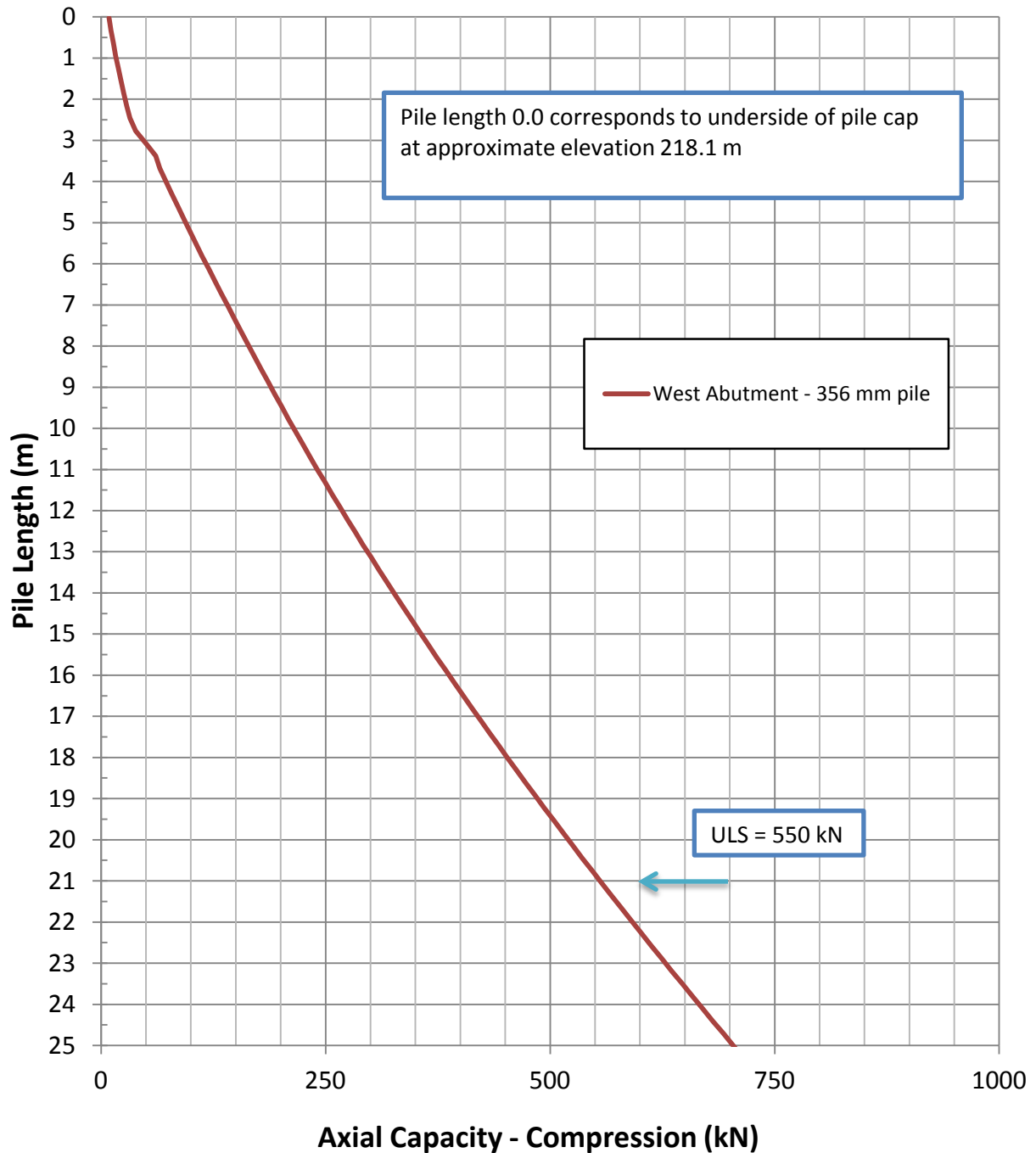
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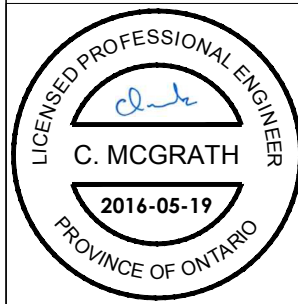






**Figure 2**  
**West Abutment**  
**Factored Axial Capacity (Compression) of Pipe Piles**

DRAWING NAME: 165000801\_P&XS\_2016.dwg  
CREATED BY: GBB  
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2016-05-19  
MODIFIED:  
Printed: May 19, 2016



PLAN — BRIDGE  
SCALE  
3 m 0 3 6 m

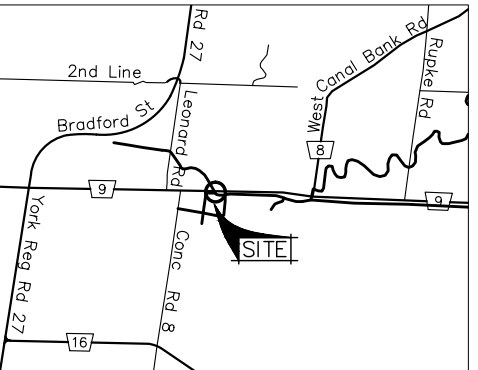
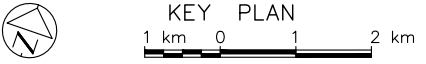
==NOTES==  
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.  
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS		DATE		BY	DESCRIPTION
GEOGRES No		31D-553			
HWY No		9		DIST	
SUBM'D SKG		CHECKED	DATE 2012-12-12		SITE 37-30
DRAWN GBB		CHECKED	APPROVED		DWG 2

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

- LEGEND
- Borehole
  - Borehole and Cone
  - Auger Hole
  - Cone Penetration Test
  - Blows/0.3m (Std Pen Test, 475 J/blow)
  - Inferred WL at time of investigation April 2012
  - WL at Time of Investigation, April 18, 2012
  - (m NORTH) Offset from Cross Section Line (m)
  - 1965 MTO Borehole (Job. No. 65-F-114)

No	ELEVATION	MTM ZONE 10 NORTH	COORDINATES EAST
12-1	219.7	4 875 305.0	292 810.3
12-2	219.9	4 875 312.0	292 843.3
12-3	220.1	4 875 314.6	292 852.5
12-4	220.3	4 875 310.2	292 806.5
12-5	221.8	4 875 322.5	292 845.4
12-6	219.8	4 875 299.4	292 800.2
12-7	220.4	4 875 320.8	292 873.3
12-8	221.2	4 875 327.3	292 863.2
12-9	219.9	4 875 304.7	292 789.3
12-16	219.0	4 875 308.1	292 839.9
12-17	220.2	4 875 316.4	292 851.8
1	219.8	4 875 306.4	292 841.9
2	221.3	4 875 301.2	292 826.0

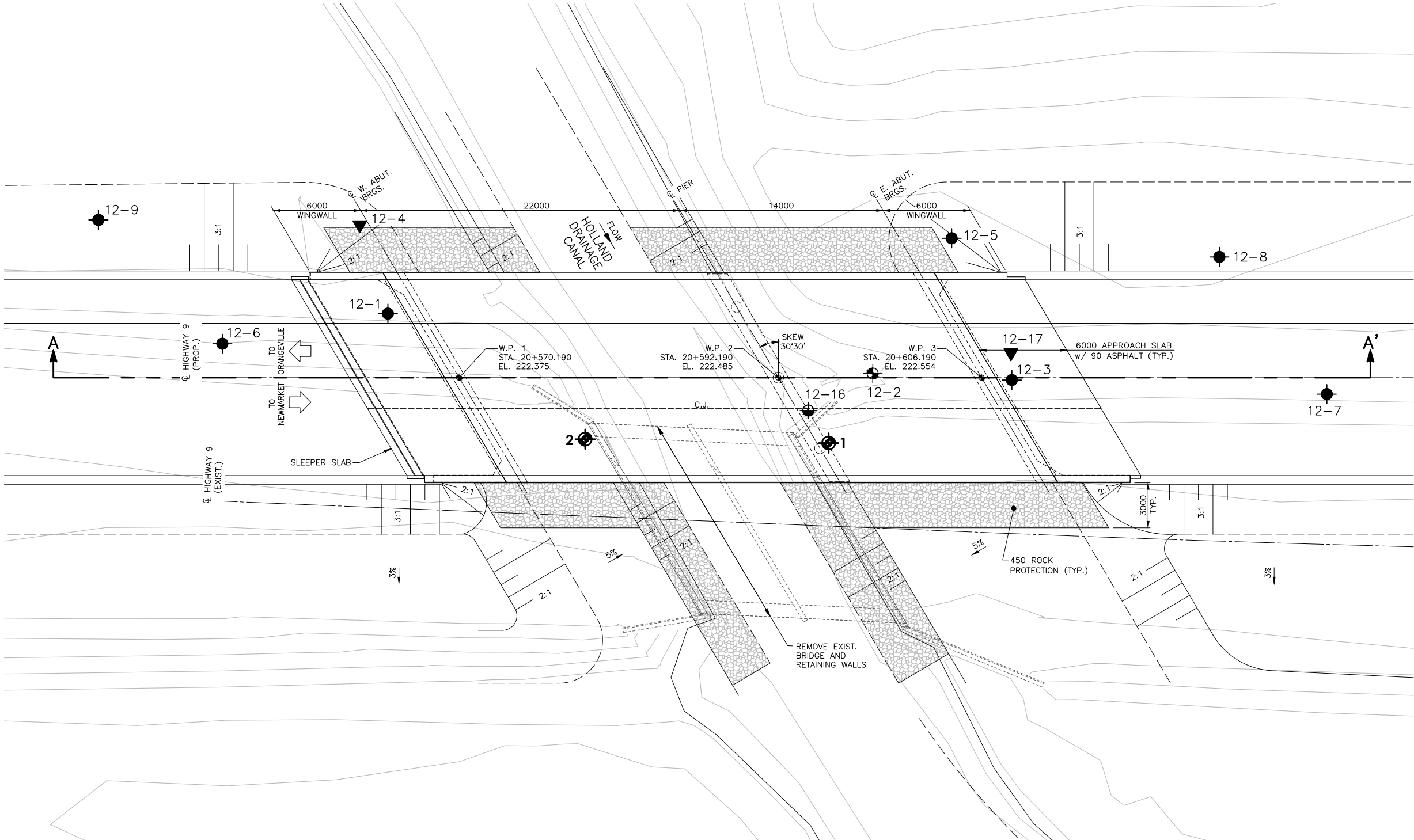


HOLLAND DRAINAGE CANAL BRIDGE BOREHOLE LOCATIONS

PLATE No  
CONT 2016-2014  
WP 2188-08-00

SHEET  
52

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



# RECORD OF BOREHOLE No BH 12-1

1 OF 3

METRIC

W.P. 2188-08-00 LOCATION Hwy 9 Holland Canal N: 4 875 305 E: 292 810 ORIGINATED BY JF  
DIST HWY 9 BOREHOLE TYPE H Casing, Split Spoon Sampler COMPILED BY JF  
DATUM Geodetic DATE 2012 04 12 - 2012 04 13 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	✕ FIELD VANE ✕ LAB VANE							
219.7	Tall Grass															
219.6	TOPSOIL		1	SS	1		219									
0.1	SAND (SP)		2	SS	9											
	Loose		3	SS	7		218									
	Grey to brown, wet	4	SS	6												
217.0							217									
2.7	SILTY SAND (SM) with gravel	5	SS	24												
	Compact															
	Grey, moist	6	SS	30	216											
	- with gravel below 3.7 m	7	SS	29												
214.9							215							29 55 (16)		
4.8	CLAYEY SILT (CL)		8	SS	15											
	Stiff to very stiff						214									
	Grey, moist		9	SS	9											
			10	SS	-	213	3.3						0 1 31 68			
			11	SS	8	212										
			12	SS	-	211	>>						- S <sub>u</sub> > 235 kPa			
			13	SS	21											
		14	SS	-	210							0 1 71 28				

Continued Next Page

3.3, 3.3 Numbers refer to Sensitivity 3% STRAIN AT FAILURE

ONTARIO MTO STANTEC 16500801 - HIGHWAY 9 HOLLAND CANAL GPJ ONTARIO MOT GDT 6/16/12

# RECORD OF BOREHOLE No BH 12-1

2 OF 3

METRIC

W.P. 2188-08-00 LOCATION Hwy 9 Holland Canal N: 4 875 305 E: 292 810 ORIGINATED BY JF  
 DIST HWY 9 BOREHOLE TYPE H Casing, Splitspoon Sampler COMPILED BY JF  
 DATUM Geodetic DATE 2012 04 12 - 2012 04 13 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	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						
	CLAYEY SILT (CL)							20 40 60 80 100	20 40 60 80 100	10 20 30			GR SA SI CL		
	Stiff to very stiff														
	Grey, moist (continued)														
			15	SS	36		209			>>✕				- S <sub>u</sub> > 235 kPa	
			16	SS	-		208			>>✕				- S <sub>u</sub> > 235 kPa	
			17	SS	26		207								
			18	SS	28		206							0 1 74 25	
			19	SS	31		205								
			20	SS	-		204			>>✕				- S <sub>u</sub> > 235 kPa	
			21	SS	30		203								
			22	SS	-		202								
			23	SS	-		201								
			24	SS	19		200								
			25	SS	18										

Continued Next Page

× 3, × 3

Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE



# RECORD OF BOREHOLE No BH 12-1

3 OF 3

METRIC

W.P. 2188-08-00 LOCATION Hwy 9 Holland Canal N: 4 875 305 E: 292 810 ORIGINATED BY JF  
 DIST HWY 9 BOREHOLE TYPE H Casing, Splitspoon Sampler COMPILED BY JF  
 DATUM Geodetic DATE 2012 04 12 - 2012 04 13 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			w <sub>p</sub>	w	w <sub>L</sub>		
								○ UNCONFINED      × FIELD VANE	● QUICK TRIAXIAL    × LAB VANE	WATER CONTENT (%)					
							20   40   60   80   100				10   20   30			GR   SA   SI   CL	
	CLAYEY SILT (CL)														
	Stiff to very stiff														
	Grey, moist (continued)														

ONTARIO MTO STANTEC 165000801 - HIGHWAY 9 HOLLAND CANAL GPJ ONTARIO MOT GDT 6/16/12



# RECORD OF BOREHOLE No BH 12-2

1 OF 4

METRIC

W.P. 2188-08-00 LOCATION Hwy 9 Holland Canal N: 4 875 312 E: 292 843 ORIGINATED BY JF  
 DIST HWY 9 BOREHOLE TYPE H Casing, Splitspoon Sampler COMPILED BY JF  
 DATUM Geodetic DATE 2012 04 02 - 2012 04 03 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED	● QUICK TRIAXIAL							✕ FIELD VANE	✕ LAB VANE	
219.9	Tall Grass																	
219.9	TOPSOIL																	
	FILL: Silty SAND (SM)		1	SS	4													
	Loose																	
	Brown, moist																	
219.0	ORGANIC SILT (muck) (OL)		2	SS	4		219											
0.9	Soft																	
	Black, moist to wet																	
	- frequent coiled shells throughout		3	SS	4		218							Org M = 23%				
			4	SS	1													
			5	SS	1		217							0 3 70 27				
215.8	Poorly graded SAND WITH SILT (SP-SM)		6	SS	-		216											
4.1	Loose to compact																	
	Grey, trace gravel, wet		7	SS	22		215							10 83 (7)				
			8	SS	9		214											
			9	SS	7													
213.4	CLAYEY SILT (CL)						213							0 0 62 38				
6.5	Stiff																	
	Grey, wet		10	SS	9		212											
212.4	SILTY SAND (SM)		11	SS	10		211							6 81 (13)				
7.5	Loose to compact																	
	Grey, wet		12	SS	11													
210.6	CLAYEY SILT (CL)		13	SS	8		210											
9.3	Firm to very stiff																	
	Grey, moist																	

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

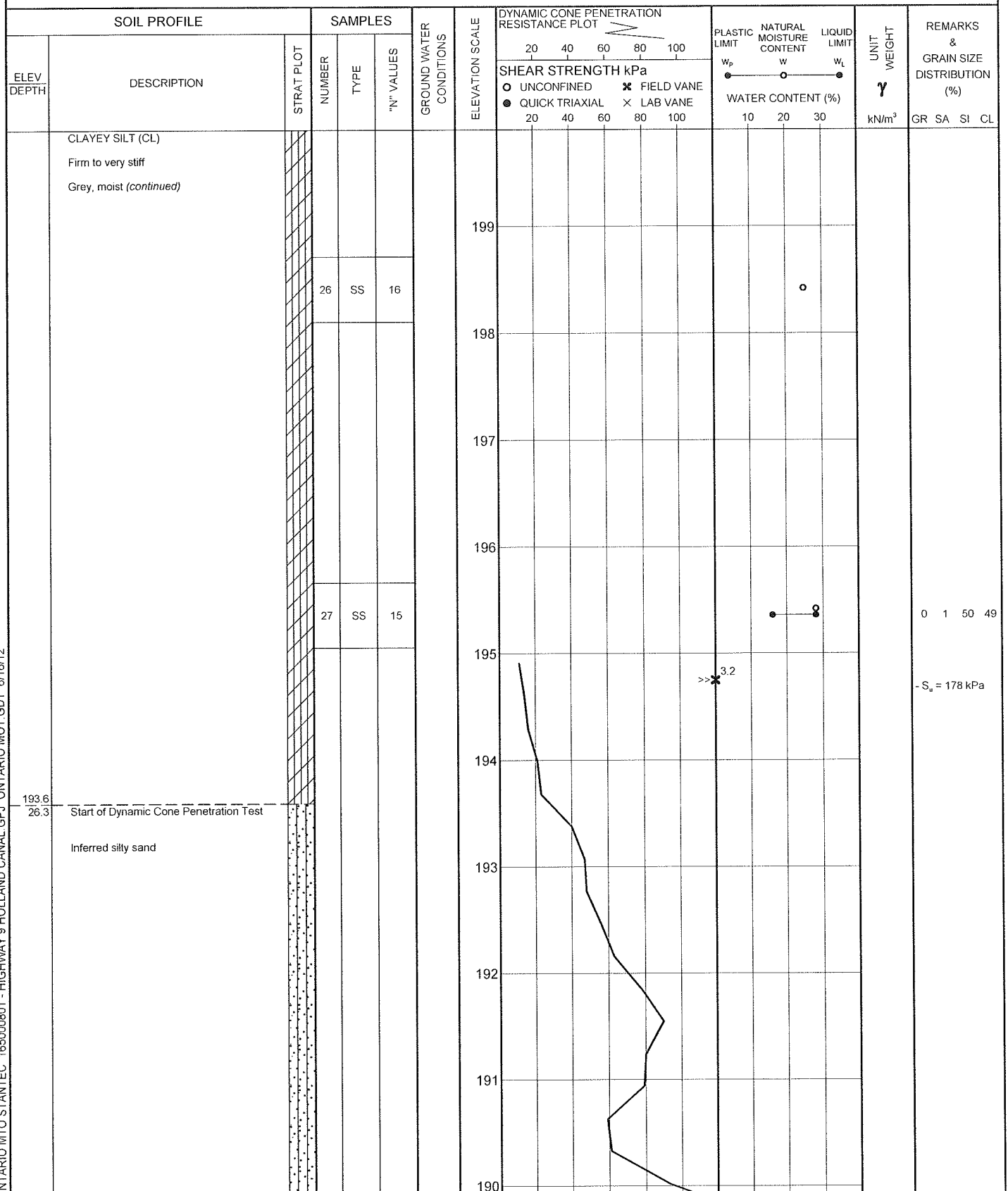


# RECORD OF BOREHOLE No BH 12-2

3 OF 4

METRIC

W.P. 2188-08-00 LOCATION Hwy 9 Holland Canal N. 4 875 312 E. 292 843 ORIGINATED BY JF  
DIST HWY 9 BOREHOLE TYPE H Casing, Splitspoon Sampler COMPILED BY JF  
DATUM Geodetic DATE 2012 04 02 - 2012 04 03 CHECKED BY CM



Continued Next Page

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

# RECORD OF BOREHOLE No BH 12-2

4 OF 4

METRIC

W.P. 2188-08-00 LOCATION Hwy 9 Holland Canal N: 4 875 312 E: 292 843 ORIGINATED BY JF  
 DIST HWY 9 BOREHOLE TYPE H Casing, Splitspoon Sampler COMPILED BY JF  
 DATUM Geodetic DATE 2012 04 02 - 2012 04 03 CHECKED BY CM

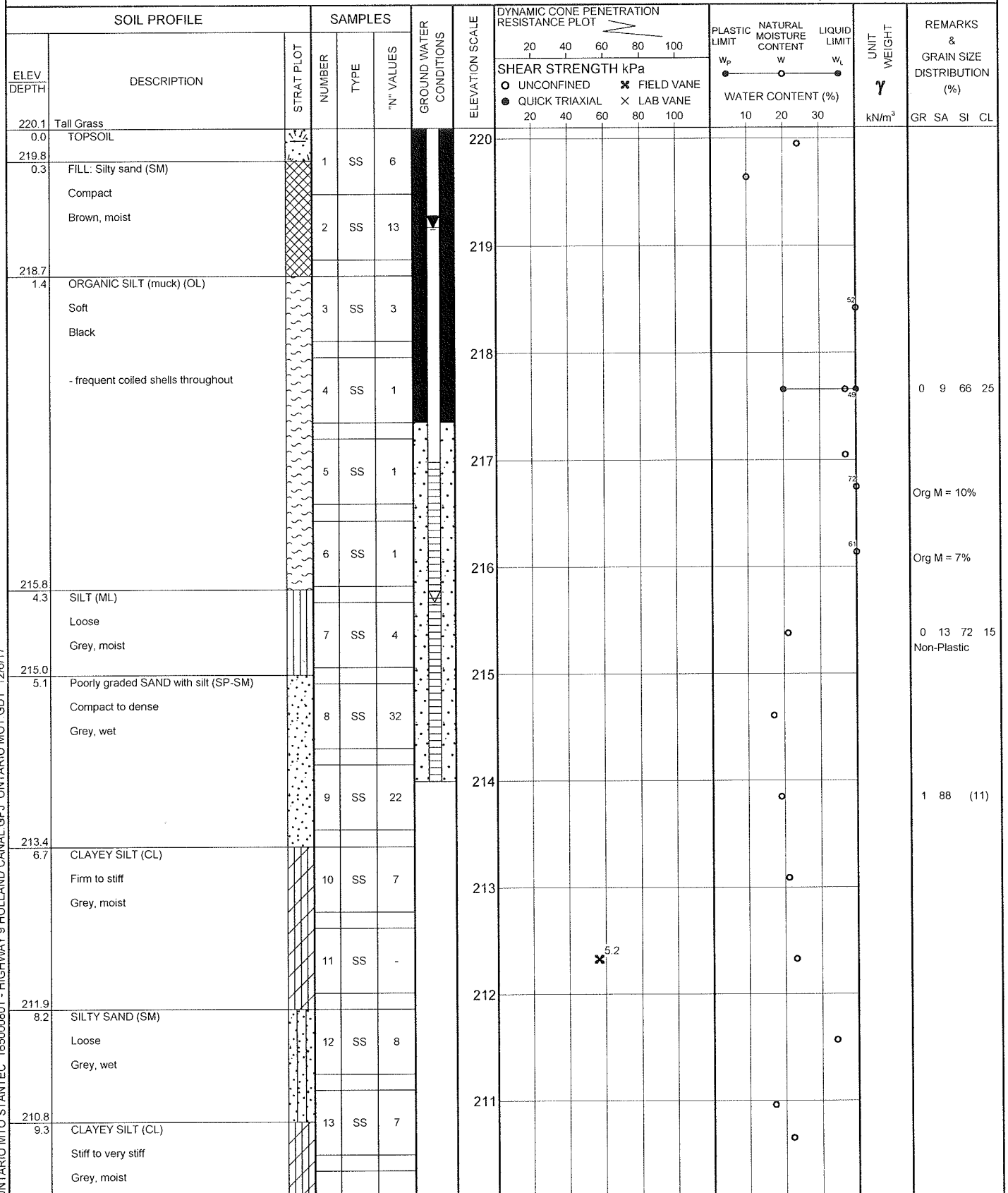
SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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# RECORD OF BOREHOLE No BH 12-3

1 OF 3

METRIC

W.P. 2188-08-00 LOCATION Hwy 9 Holland Canal N: 4 875 315 E: 292 852 ORIGINATED BY JF  
 DIST HWY 9 BOREHOLE TYPE H Casing, Splitspoon Sampler COMPILED BY JF  
 DATUM Geodetic DATE 2012 04 04 - 2012 04 05 CHECKED BY CM



Continued Next Page

Numbers refer to Sensitivity 3% STRAIN AT FAILURE

ONTARIO MTO STANTEC 16500801 - HIGHWAY 9 HOLLAND CANAL GPJ ONTARIO MOT GDT 12/6/17

# RECORD OF BOREHOLE No BH 12-3

2 OF 3

METRIC

W.P. 2188-08-00 LOCATION Hwy 9 Holland Canal N: 4 875 315 E: 292 852 ORIGINATED BY JF  
DIST HWY 9 BOREHOLE TYPE H Casing, Splitspoon Sampler COMPILED BY JF  
DATUM Geodetic DATE 2012 04 04 - 2012 04 05 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								○ UNCONFINED ● QUICK TRIAXIAL	✕ FIELD VANE ✕ LAB VANE					
	CLAYEY SILT (CL)		14	SS	7		210							
	Stiff to very stiff													
	Grey, moist (continued)													
			15	SS	-		209		2.7					
			16	SS	5		208							0 2 63 35
			17	SS	-		207		3.7					
			18	SS	7		206							
			19	SS	-		205		3.1					0 0 56 44
			20	SS	5		204							
			21	SS	-		203		2.7					
			22	ST			202		11.3%				19.3	0 4 69 27
			23	SS	-		201			>>				- S <sub>u</sub> > 108 kPa
			24	SS	23									0 3 65 32
			25	SS	11				2.3					

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×<sup>3</sup>, ×<sup>3</sup>. Numbers refer to Sensitivity ○<sup>3</sup>% STRAIN AT FAILURE





DEPARTMENT OF HIGHWAYS - ONTARIO

## RECORD OF BOREHOLE NO. 2

FOUNDATION SECTION

MATERIALS &amp; TESTING DIVISION

JOB 65-F-114 LOCATION West Abutment - North Corner ORIGINATED BY P.P.  
 W.P. 172-65 BORING DATE Oct. 25 & 26, 1965. COMPILED BY P.P.  
 DATUM Geodetic BOREHOLE TYPE Washbore - NX Casing. CHECKED BY dl

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	25	50	75	100	125	WP	WL		
726.0	Groundlevel															
0.0	Sand Brown V. loose Fill		1	SS	3	720										
717.0			2	SS	9											
9.0	Sandy silt to silty sand. Greyish brown Loose to compact.		3	SS	29	710										
			4	SS	39											
702.8			5	SS	37	700										
23.2	Clayey silt with traces of sand.		6	SS	29											
	Grey.		7	SS	22	690										
	Firm to hard.		8	SS	32											
			9	SS	19	680										
			10	SS	30											
673.0			11	SS	30											
53.0	End of borehole.					670										

End of cone test

Gr 0%  
Sa 12%  
Si 1%  
Cl 88%

Gr 6%  
Sa 84%  
Si 10%  
Cl 1%

Gr 0%  
Sa 1%  
Si 58%  
Cl 41%