



**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT  
EMBANKMENTS OVER SWAMPS**

**for**

**HIGHWAY 17 ROUTE PLANNING NORTH BAY TO BONFIELD  
CITY OF NORTH BAY AND TOWNSHIPS OF EAST FERRIS AND  
BONFIELD**

**DISTRICT OF NIPISSING, ONTARIO**

**GWP NO. 5105-09-00**

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PML Ref.: 10TF031A-1  
Index No.: 066FIDR  
GEOCRES No.: 31L-177  
March 10, 2014



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## TABLE OF CONTENTS

### PART A – PRELIMINARY FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION .....	1
2. SITE DESCRIPTION .....	3
3. SITE PHYSIOGRAPHY AND GEOLOGY .....	4
4. INVESTIGATION PROCEDURES .....	5
4.1 Site Field Investigation.....	6
4.2 Laboratory Testing.....	7
5. SUBSURFACE CONDITIONS .....	7
5.1 Swamp 101 (Drawing SW-1) .....	8
5.2 Swamp 102 (Drawing SW-1) .....	8
5.3 Swamp 103 (Drawing SW-1) .....	9
5.4 Swamp 104 (Drawing SW-2) .....	10
5.5 Swamp 105 (Drawing SW-2) .....	11
5.6 Swamp 106 (Drawing SW-3) .....	11
5.7 Swamp 107 (Drawing SW-3) .....	12
5.8 Swamp 108 (Drawing SW-4) .....	12
5.9 Highway 11 / Highway 17 Interchange (Drawing SW-5) .....	13
6. CLOSURE – FOUNDATION INVESTIGATION REPORT .....	14

#### Explanation of Terms Used in Report

##### Swamp 101

Figures GS-1 and GS-2 – Results of Grain Size Distribution Analyses  
 Record of Borehole Sheets

##### Swamp 102

Record of Borehole Sheets



Swamp 103

Figures GS-1 and GS-2 – Results of Grain Size Distribution Analyses  
Record of Borehole Sheets

Swamp 104

Figures GS-1 to GS-3 – Results of Grain Size Distribution Analyses  
Record of Borehole Sheets

Swamp 105

Record of Borehole Sheets

Swamp 107

Figure PC-1 – Results of Atterberg Limits Testing  
Figures GS-1 and GS-2 – Results of Grain Size Distribution Analyses  
Record of Borehole Sheets

Highway 11 / Highway 17 Interchange

Figure 11ES-PC-1 and 11ES-PC-2 – Results of Atterberg Limits Testing  
Figures 11ES-GS-1 to 11ES-GS-4 – Results of Grain Size Distribution Analyses  
Record of Borehole Sheets

Highway 11 / Highway 17 Interchange

Figure 11NE-PC-1 and 11NE-PC-2 – Results of Atterberg Limits Testing  
Figures 11NE-GS-1 to 11NE-GS-4 – Results of Grain Size Distribution Analyses  
Record of Borehole Sheets

Drawings SW-1 to SW-5 – Borehole Location Plans

Appendix A – Site Photographs



**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
EMBANKMENTS OVER SWAMPS**

for  
Highway 17 Route Planning North Bay to Bonfield  
City of North Bay and Townships of East Ferris and Bonfield  
District of Nipissing, Ontario  
G.W.P. No. 5109-09-00

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**1. INTRODUCTION**

A route planning study is being carried out for the section of Highway 17 that extends from the Highway 11 south junction to 2.7 km east of Highway 531 in the District of Nipissing. As part of the foundation assessment for this study, a limited preliminary subsurface investigation for the preferred alignment was completed for selected swamps and proposed structures. Investigation areas including swamp and structure locations were selected by PML and approved by MTO and MRC. The study was carried out for McCormick Rankin (MRC), a member of MMM Group on behalf of the Ministry of Transportation of Ontario (MTO).

The preferred alignment for the proposed four-laning Highway 17 is entirely in new alignment. MRC provided drawings of the preferred alignment horizontal and vertical profiles in December 2012 and made some minor changes to the preferred route alignment in April 2013.

This preliminary report summarizes the results of the foundation investigation carried out at the selected swamp locations. The preliminary foundation investigation results carried out for selected structure locations are provided in a separate Preliminary Foundation Investigation and Design Report for structures (PML Ref: 10TF031A-2).

The following swamp crossings were selected for the preliminary foundation investigation.



SWAMP NO.	APPROXIMATE STATIONS (Note1)	REMARKS
<b>Highway 17 Main line (Preferred Alignment)</b>		
101 (Note 2)	11+500 to 11+700	La Vase Portage Route Crossing, adjacent to active gravel and rock quarry
102	12+075 to 12+225	Adjacent to active rock quarry
103	12+350 to 12+650	Open water swamp
104	12+850 to 13+200	Open water swamp
105	13+925 to 14+300	Open water swamp
106	23+100 to 23+600	Open water swamp
107	23+875 to 24+125	Open water swamp
108	26+450 to 26+650	
<b>Highway 11 / Highway 17 Interchange (Preferred)</b>		
E-S Ramp	40+300 to 40+600	Swamp located adjacent to CNR corridor and existing Highway 11 SBL
N-E Ramp	50+250 to 50+450	Swamp located adjacent to CNR corridor and existing Highway 11 SBL

Notes

1. Stations are approximate and based on MRC drawings dated April 2013.
2. For Swamp 101, structures are proposed and investigations results are included in associated PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT FOR SLELECTED STRUCTURE LOCATIONS – GWP 5105-09-00 (PML Report, Ref: 10TF031A-2).
3. The drilling for swamp 106 was not carried out due to local flooding/wet conditions caused by the onset of mild winter weather. Boreholes were not carried out for swamp108 where no permission to enter was obtained.

The approximate extent of swamps along the preferred alignment dated April 2013 is shown on the Borehole Location Plans, Drawings SW-1 to SW-5.

All elevations in this report are expressed in meters.



## **2. SITE DESCRIPTION**

The study area is located in the City of North Bay and Townships of East Ferris and Bonfield. The study section of Highway 17 being reviewed extends for approximately 26 km - from the Highway 11 to about 2.7 km east of Highway 531.

Land uses in the vicinity of the study corridor include rock quarries just east of Highway 11 and south of the existing Highway 17 and scattered sand/gravel pits along existing Highway 17. Scattered residential houses are present along existing Highway 17 from Highway 11 to Highway 94. The residential houses are more numerous along Highway 17 from Highway 94 to Highway 531. In addition, residential properties are also located along Highway 94 and Highway 531. There are no houses along the preferred alignment except at its crossing with existing Highway 17. Local restaurants and businesses are located along existing Highway 17. The communities of Corbeil and Bonfield are located within the south limits of the study corridor.

The La Vase Portage Route traverses the study corridor approximately 1.2 km east of the existing Highway 11/Highway 17 interchange in an approximately north to south direction.

Highway 94 and Highway 531 connect existing Highway 17 to the communities of Corbeil and Bonfield, respectively.

The Ottawa Valley Railway (OVR) enters the study area from the west about 400 m north of the Highway 11 / Lake Shore Road interchange then primarily parallels the study corridor south of existing Highway 17. The Canadian National Railway (CNR) is located west of Highway 11 then crosses Highway 11 about 300 m north of the Birchs Road overpass at Highway 11.

A TransCanada Pipe Line (TCPL) corridor enters the study area from the north at a point about 1.7 km east of the existing Highway 11/Highway 17 interchange and approximately parallel to Highway 11 then exits the study corridor about 3 km east of Highway 11. A second TCPL corridor enters the study area from the north at about 1.1 km east of the existing Highway 17/ Highway 531 at-grade crossing and generally follows Highway 17 on south side.



### **3. SITE PHYSIOGRAPHY AND GEOLOGY**

The preferred alignment is located in the physiographic region known as the Algonquin Highlands which includes:

- Wetland areas containing peat, silt, sand and clay deposits, typical of the Northern Ontario region
- Glaciolacustrine plains comprising sands and silts and clays
- Bedrock knobs, where the granite bedrock is overlain by a relatively shallow soil cover
- Bedrock outcrops, where the bedrock is exposed or under a relatively thin soil veneer

The study area of the Highway 17 is located within the Central Gneiss Belt. The bedrock in this area consists of Precambrian rock of Mesoproterozoic age. The predominant bedrock types in the area are granites and gneisses. The local bedrock undulates from near or at ground surface and locally dips to more than 20 m below the ground surface. Bedrock outcrops/cuts are present in this area.

The local topography is undulating as the preferred alignment traverses areas that alternate between rock ridges and low lying swampy areas. Localized glaciolacustrine sandy/silty/clayey areas are present within the study corridor, particularly near Highway 94 and Highway 531 areas.

Swampy areas are present from west of the existing Highway 11 SBL to the CNR tracks. The proposed Highway 11 / Highway 17 interchange ramps (E-S Ramp and N-E Ramp) traverse through this swampy area.

Beyond the Highway 11 /Highway 17 interchange location, the terrain along the preferred alignment is undulating to approximately 2 km west of Highway 94 for a distance of about 7.5 km. The terrain consists of bedrock outcrops and bedrock knobs at higher elevations and swamps/wetlands at lower elevations. Most of the swamps/wetlands are characterized by open water with beaver dams.

From about 2 km west of the Highway 94 easterly for about 3.6 km to existing Highway 17 (west crossing), the terrain along the preferred alignment consists of bedrock knobs or deposits of



sand/silt/clay lacustrine plain and/or organic terrain over bedrock with flooded areas in the proximity of creeks.

The preferred alignment crosses/borders several swamps/wetlands for the 6 km section north of the existing Highway 17 between the west and east crossings.

Beyond the east crossing for about 3 km to about 100 m west of the Kaibuskong River Valley, the terrain along the preferred alignment section is generally hilly with localized low-lying swampy/wetland and creek areas.

The preferred alignment crosses the low-lying swampy areas west and east of Line 3S to north of Francoeur Road.

The study area of the Highway 17 alignment drains into a number of lakes through creeks and rivers. Twinline Lake and Dugas Bay (the southernmost bay in Trout Lake) are situated north of existing Highway 17. Jennings Lake, Passmore Lake and Dreany Lake are located to the south of the highway in the City of North Bay and Township of East Ferris. Laren and Barse Creeks cross existing Highway 17 in the Township of Bonfield. La Vase River flows approximately parallel and south of the CNR corridor. Kaibuskong River crosses the existing Highway 17 at Sta. 15+860 in the Township of Bonfield and flows in an approximate south to north direction. Also, surface water runoff along the study corridor drains into other water bodies such as unnamed streams, creeks, swamps and scattered ponds. Extensive swamps/wetlands are located south of existing Highway 17 between Highway 11 and Highway 94.

#### **4. INVESTIGATION PROCEDURES**

The investigation included a program of site reconnaissance, field drilling, in-situ testing and soil sampling that was carried out at the selected swamp areas referred to previously. Some boreholes, as indicated on the Record of Borehole logs, were terminated at shallow depths where hand augering had to be used due to access limitations with non-frozen conditions over swampy areas.



Rock coring was not within the scope of work for this preliminary investigation. A laboratory testing program was carried on selected soil samples recovered.

#### **4.1 Site Field Investigation**

The field work for this investigation was carried out between February 22 and June 5, 2013. A total of 21 test holes, comprising 12 hand auger probes and 9 boreholes (2 of which include dynamic cone penetration tests) were carried out at locations at locations are shown on the attached Borehole Location Plans, Drawings SW-1 to SW-4.

Two of the 8 swamps planned for investigation (106 and 108) were not drilled. Swamp 106 location was flooded and could not be accessed while Swamp 108 could not be accessed due to lack of permission to enter in swamp 108. The depths of test holes ranged from 0.0 to 20.6 m. The test holes were identified sequentially for each crossing using the 100 series of numbers to reference the test holes to each of the crossings.

The boreholes were advanced using continuous flight hollow stem augers and wash boring techniques, powered by a track-mounted D-50 drill rig and tripod set-up. Manual investigation techniques were used in several swamps due to the poor ice conditions. The equipment was supplied and operated by a specialist drilling contractor working under the full-time supervision of members of PML engineering staff.

Representative soil samples were recovered at frequent depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. Penetrometer and in-situ vane shear testing (using the MTO 'N' vane) were also performed to further assess the shear strength of the cohesive soils encountered. The penetrometer test results are typically less than the actual values due to sample disturbance. The results of the field tests and observations are reported on the appended Record of Borehole sheets.

The groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, when



appropriate, by measurement of the water level in the open borehole. Upon completion of drilling, boreholes were backfilled with a bentonite/cement mixture in accordance with the MTO and MOE Reg. 903 guidelines for borehole abandonment procedures.

Soils were identified in the field in accordance with the MTO Soil Classification procedures. The recovered samples were returned to our laboratory for detailed visual examination and classification. The laboratory testing programme consisted of moisture content determinations; Atterberg plasticity limits tests and grain size distribution analyses. Atterberg plasticity limits were not attempted on samples deemed to be non-plastic by visual and tactile examination.

The horizontal northing and easting co-ordinates were established in the field using a hand held GPS unit (GARMIN 62 st). The geodetic ground surface elevations were estimated based on the median profile provided by MRC. The horizontal northing and easting co-ordinates and elevations at the test holes are shown on the Record of Borehole Sheets and are listed on the Borehole Location Plans.

#### **4.2 Laboratory Testing**

The recovered soil samples were returned to the PML laboratory in Toronto for detailed visual examination, laboratory testing and classification.

The results of the laboratory testing are shown on the Record of Borehole Sheets and the associated figures.

### **5. SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole Sheets for soil classifications, inferred stratigraphy and standard penetration test N values, dynamic cone penetration test resistances, field vane test undrained shear strength values, penetrometer test results together with groundwater observations in the open boreholes. The boundaries between soil strata have been established at borehole locations only. Between and beyond the boreholes, the ground profile boundaries are based on interpretation and actual boundaries may vary.



The results of laboratory natural water content determinations, grain size analyses and Atterberg limits tests are shown on the Record of Borehole sheets. Refer to the Figures for selected grain size distribution and plasticity charts (presented in order of borehole number). The locations of the test holes carried out at each crossing are shown on Drawings SW-1 to SW-5.

The subsoil conditions identified in each swamp investigated are described below.

### **5.1 Swamp 101 (Drawing SW-1)**

Photographs P3, P3A, P3b and P4 (Appendix A) illustrate the surface conditions in Swamp 101 at the time of investigation.

The site is located in wetland and bedrock plain. Bedrock is deeper than 14m at the west edge and at the borehole location was overlain by silty sands and sands with N values generally increasing with depth from about 15 nearer the surface, to approximately 50 at 4 m depth and to over 60 at 8 m depth. Grain size distribution figures for the silty sand and for the sand are provided in the Figures.

Based on observations during drilling, the groundwater level is expected to be in the order of 2 m below surface.

It is noted that a gravel and rock quarry, active at the time of investigation, is located east of the Swamp 101 crossing.

### **5.2 Swamp 102 (Drawing SW-1)**

Photographs P5, P6 and P7 (Appendix A) illustrate the surface conditions in Swamp 102 at the time of investigation.

An active rock quarry with steep rock face (at the time of investigation) borders Swamp 102 on west side. One test hole extending to 1.5m was carried for this swamp by using the power augering method. Swamp 102 was not accessible from east side by the drill rig in order to avoid





significant tree cutting on private property. Consequently, a more detailed site investigation should be carried out during the detail design phase.

At least 1.5 m thick peat containing sand layers was encountered in test hole 102-1. A water content determination in the peat deposit was 681% and indicates saturated conditions.

The groundwater level was encountered at the surface during augering.

### **5.3 Swamp 103 (Drawing SW-1)**

Photographs P8 and P9 (Appendix A) illustrate the surface conditions in Swamp 103 at the time of investigation.

The two boreholes in Swamp 103 were advanced through 0.8 m thick ice and water. The soil stratigraphy in Swamp 103 included 0.4 to 0.9 m thick peat over loose to very dense sand and silty sand extending to probable bedrock at 1.6 and 7.2 m.

N values in sand and silty sand deposits ranged from 2 to 92. N values of 80 and 100 were obtained for 5 cm sampler penetration indicating that the sampler was probably bouncing on the probable bedrock. Some of the lower N values in the noncohesive deposit are due to hydraulic disturbances during sampling. The results of grain size distribution analysis for sand and for silty sand samples are included in the Figures. Water content varied from 14 to 25% indicating wet to saturated conditions.

The groundwater was observed and measured in boreholes and varied from being at the surface to 0.6 m depth (below the ice cover). The groundwater level in the Swamp 103 is estimated to be at the surface (open water swamp).



#### **5.4 Swamp 104 (Drawing SW-2)**

Photographs P11, P12, P13, P14 and P15 (Appendix A) illustrate the surface conditions in Swamp 104 at the time of investigation.

The ice and water in the Swamp 104 was up to 1.8 m thick on the west side and middle of the swamp and 0.5 m thick on the east side. Three boreholes, 104-1 to 104-3 inclusive, were advanced in Swamp 104. S2 series test holes were carried out for potential structure locations located on the edges of Swamp 104 and at higher elevations than swamp boreholes 104-1 to 104-3.

A 0.6 to 2.3 m thick peat was encountered at the surface in boreholes 104-1 to 104-3 extending to underlying cohesionless sandy silt/silty sand/ sand deposits. The cohesionless sandy silt/sand/ silty sand deposits were 1.1 to 5.4 m thick extending to the probable bedrock at depths from the surface of 4.8 to 7.2 m in boreholes 104-1 to 104-3 respectively.

The moisture content in the peat sample was 1416%.

N values of 4 to 60 were recorded in the sandy silt/sand/silty sand deposit. N values of 50 to 110 for 3 and 5 cm sampler penetration were recorded at the termination of boreholes indicating sampler bouncing on the probable bedrock. The compactness of silty sand/sand varied from loose to very dense. The results of grain size distribution analyses for sandy silt, for sand and for silty sand samples are included in the Figures. Water content determinations in cohesionless soils varied from 12 to 26% indicating wet to saturated conditions.

A 100 to 200 mm deposit of topsoil over sand was encountered in test holes S2-1 and S2-2, S2-5 and S2-6. Bedrock was exposed in two of the S2 series test holes S2-3 and S2-4. Probable bedrock was inferred by refusal at 0.5 to 1.5 m in three of the S2 series test holes.

The groundwater was observed and measured in boreholes and varied from 0.3 to 1.0 m depth (below the ice cover). The groundwater level in the Swamp 104 is estimated at the surface (open water swamp).



## **5.5 Swamp 105 (Drawing SW-2)**

Photographs P16 and P17 (Appendix A) illustrate the surface water conditions in Swamp 105 at the time of investigation.

Three test holes 105-1 to 105-3 were carried out using a hand auger. Swamp 105 was inaccessible for a drill rig due to flooding caused by beaver dams and mild winter weather.

Ice and water in the order of 1.2 m thick was encountered at the surface in Swamp 105. A peat deposit at least 0.1 and 0.2 m thick was encountered in two of the subject test holes.

The groundwater was observed in test holes to be 0.6 m below the surface ice cover. The groundwater level in the Swamp 105 is estimated to be located at the surface (open water swamp).

## **5.6 Swamp 106 (Drawing SW-3)**

Photographs P23 and P23A (Appendix A) illustrate the surface conditions in Swamp 106 at the time of investigation.

Boreholes were not carried out due flooded conditions caused by beaver dams and also due to the lack of ice cover during the mild winter weather conditions prevailing at the time of the investigation. Consequently, further site investigation should be carried out during detail design phase of the project.



### **5.7 Swamp 107 (Drawing SW-3)**

Photographs P23B and P23C illustrate the surface conditions in Swamp 107 at the time of investigation.

The investigation was limited to two test holes due to thin ice and access concerns. Ice and water over silty sand with clay was encountered in test hole 107-1. The silty sand with clay deposit extended to at least 1.5 m (termination of test hole). A 200 mm topsoil over soft silty clay was encountered in test hole 107-2. The results of grain size distribution analyses for silty sand and for silty clay samples are included in the Figures. The plasticity of the silty clay is illustrated in the Plasticity Chart in the Figures. The liquid and plastic limits of a silty clay sample were 49 and 22 with a corresponding plasticity index value of 27. Water content determination on silty sand with clay was 39% and 37 % for silty clay indicating wet to moist conditions.

The groundwater was observed at ground surface and 0.3 m (below the ice cover) in the test holes. The groundwater level in the Swamp 107 is estimated at the surface (open water swamp).

### **5.8 Swamp 108 (Drawing SW-4)**

No field investigation was carried out due to lack of permission to enter at the time of investigation.

Based on the desk top study, stratigraphy typical of the area is anticipated. That is, the overburden will typically consist of organics, and soft clays underlain by sand overlying bedrock and the thickness of the overburden will vary depending on the bedrock topography but is expected to be in the range from relatively thin to in the order of 8 m.



## **5.9 Highway 11 / Highway 17 Interchange (Drawing SW-5)**

The proposed E-S and N-E ramps for Highway 11 / Highway 17 interchange are located on a swamp between the existing CNR corridor and Highway 11 SBL.

Within this swamp area (boreholes 11-1 and 11-2) the upper soil stratigraphy consists of 100 mm topsoil over 0.8 and 1.3 m thick very loose to loose sand. Below the loose sand in both boreholes, 5.8 and 7.6 m thick deposits of soft to firm clayey soils extend to depths of 8.5 and 7.2 m respectively. Below the clayey soils, loose to very dense cohesionless sand/silty sand deposits extended to the probable bedrock at depths of 17.9 and 20.6 m.

In situ vane testing conducted in boreholes within the cohesive deposit indicated shear strength values generally ranging from 12 to 18 kPa and with sensitivities of 2 to 8. Water content determinations of clayey soils ranged from 25 to 70%, typically above the liquid limit.

Grain Size Distribution figures are provided for the silty clay, for the clay, for the sand and for the clayey silt deposits. Related Plasticity Charts are provided for the silty clay, for the clay and for the clayey silt.

Groundwater was encountered in boreholes at ground surface and measured in borehole 11-2 at 0.6 m depth. Based on the predominantly wet soil conditions and results of water content determinations the groundwater table is expected to be at or near the ground surface. Perched water may occur seasonally due to the presence of relatively impervious subsoil near the surface.



## 6. CLOSURE – FOUNDATION INVESTIGATION REPORT

This report was initiated by Mrs. N.S Balakumaran, P. Eng. and reviewed by Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact, and Mr. D. Dundas, P.Eng., Senior Engineer. Mr. C.M.P Nascimento P.Eng., Project Manager conducted an independent review of the Report.

Yours very truly,

Peto MacCallum Ltd.



David Dundas, P.Eng.  
Senior Engineer



Carlos M. P. Nascimento, P. Eng.  
Project Manager



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

BRG/CN-dd-mi

## 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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
$E$	kPa	MODULUS OF LINEAR DEFORMATION
$G$	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

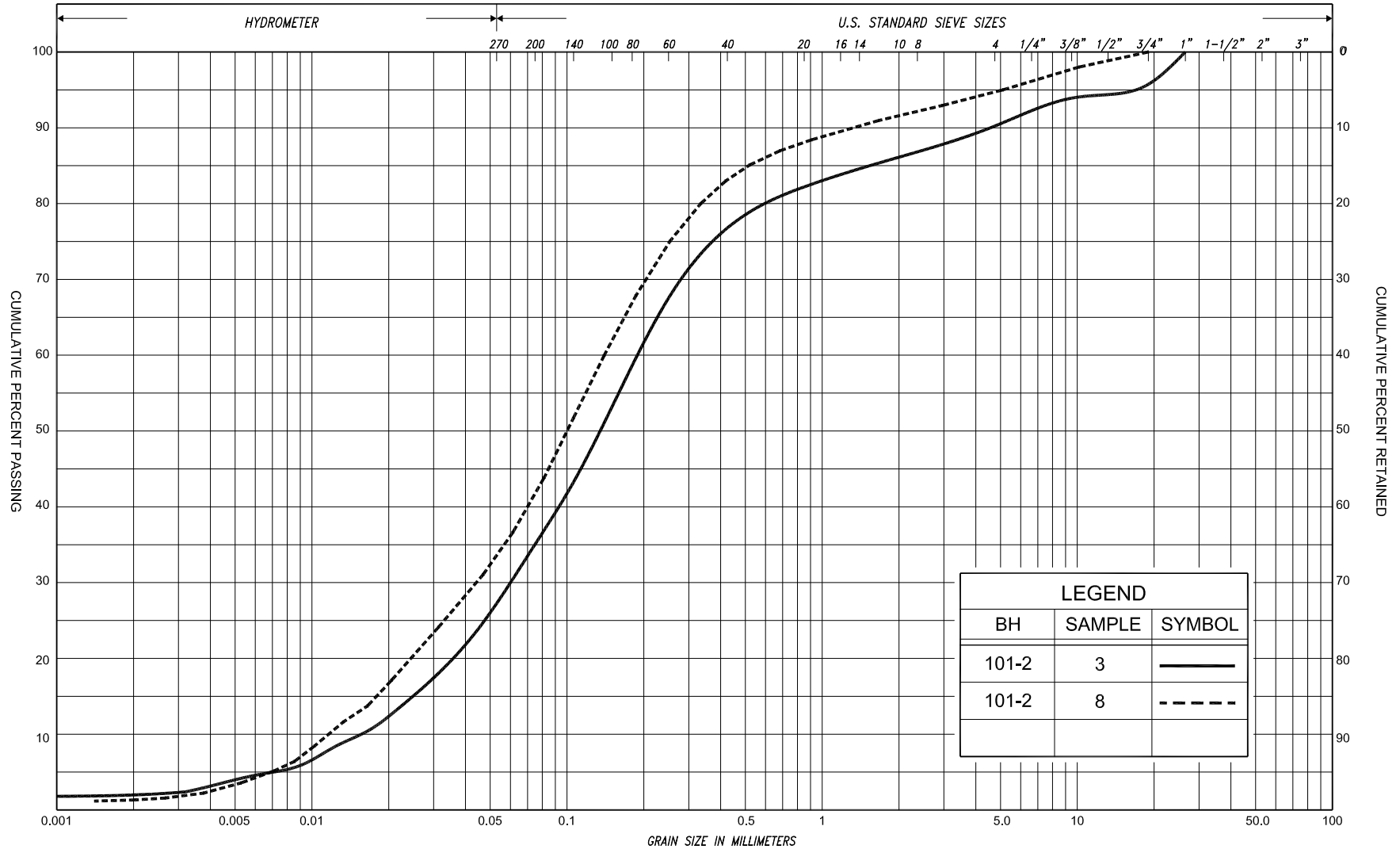
$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$n$	1, %	POROSITY	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$w$	1, %	WATER CONTENT	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$S_r$	%	DEGREE OF SATURATION	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$w_L$	%	LIQUID LIMIT	$D$	mm	GRAIN DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_p$	%	PLASTIC LIMIT	$D_n$	mm	n PERCENT - DIAMETER
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_s$	%	SHRINKAGE LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$v$	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL				$i$	1	HYDRAULIC GRADIENT
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	$j$	kN/m <sup>3</sup>	SEEPAGE FORCE
$e$	1, %	VOID RATIO	WTPL		WETTER THAN PLASTIC LIMIT			

## **SWAMP 101**

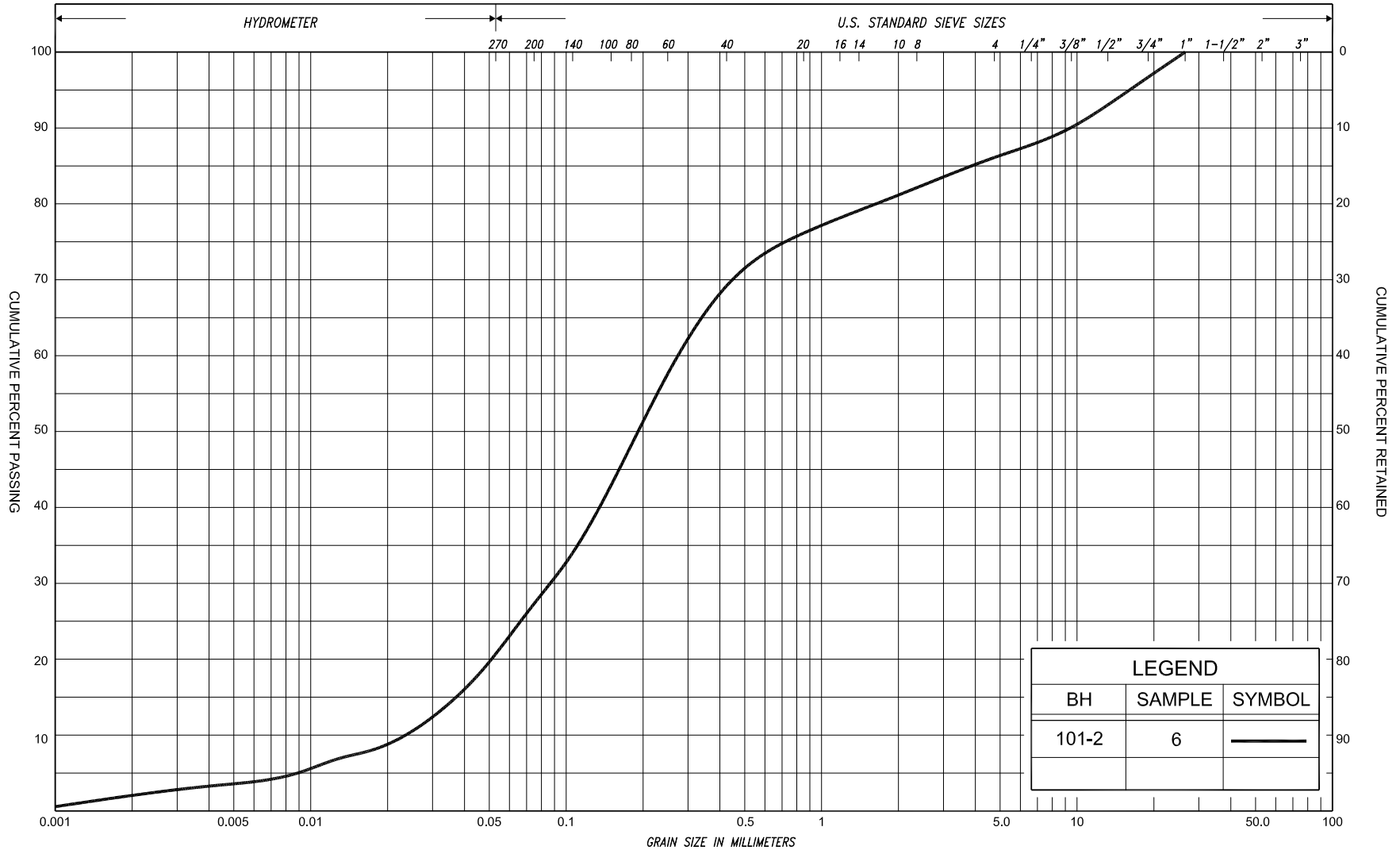
Figures GS-1 and GS-2 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets





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												



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



**GRAIN SIZE DISTRIBUTION**

SAND, with silt, some gravel, trace clay

FIG No. 101-GS-2

HWY: 17

G.W.P. No. 5105-09-00

**RECORD OF BOREHOLE No 101-2**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 858.7 N ; 311 952.7 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers      **COMPILED BY** B.R.  
**DATUM** Geodetic      **DATE** June 03, 2013      **CHECKED BY** B.R.G.

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/m³	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										20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
203.4	Ground Surface																			
0.0	Topsoil																			
203.3	Sand, trace silt rock fragments		1	SS	6		203						○							
0.1																				
202.6	Loose Brown Moist																			
0.8	Silty sand some gravel, trace clay		2	SS	15								○							
	Compact Brown Wet						202													
			3	SS	23								○			10 55 33 2				
			4	SS	13		201						○							
			5	SS	14		200						○							
199.1																				
4.3	Sand, with silt some gravel, trace clay						199													
	Dense to Brown Wet very dense		6	SS	46								○			14 59 25 2				
							198													
			7	SS	54		197						○							
196.0							196													
7.4	Silty sand trace clay, trace gravel		8	SS	60								○			6 52 40 2				
	Very dense Greyish Wet brown						195													
			9	SS	79		194						○							
							193													
192.9																				
10.5	Sand some gravel, trace silt		10	SS	58		192													
	Very dense Greyish Wet brown																			
							191													
			11	SS	102															
							190													
189.7																				
13.7	End of borehole																			
	<div>* 2013 06 03</div> <div>▽ Water level observed during drilling</div>																			

\* 2013 06 03

▽ Water level observed during drilling

## **SWAMP 102**

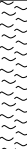
Record of Borehole Sheets

**RECORD OF BOREHOLE No 102-1**

1 of 1

**METRIC**

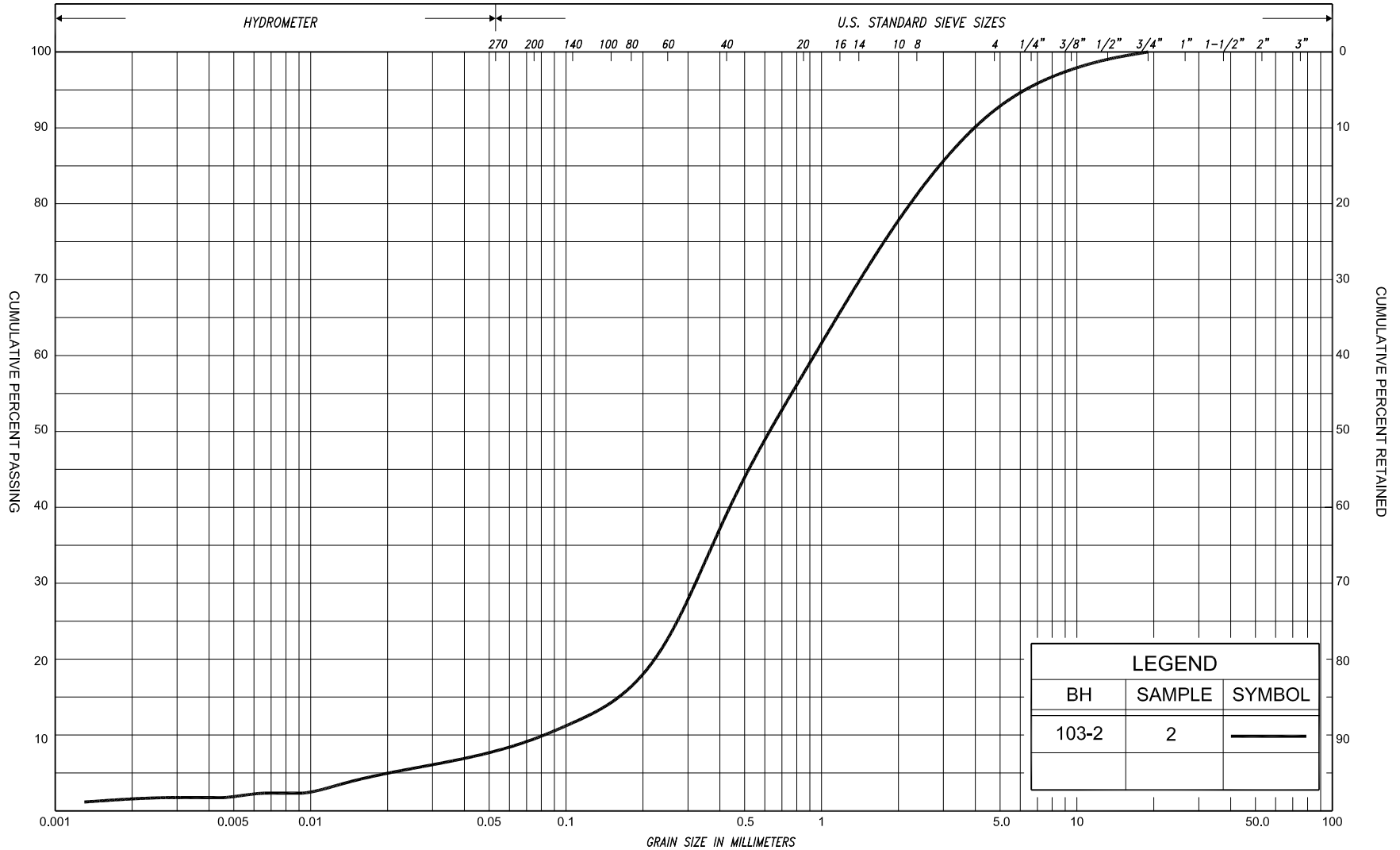
**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 575.7 N; 314 052.9 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 10, 2013      **CHECKED BY** B.R.G.

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      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE												
203.0	Top of Ice					▽														
0.0	Peat, amorphous sand layers  Black		1	AS			202								681					
201.5	End of borehole																			
1.5																				
	* 2013 03 10																			
	▽ Water level observed during drilling																			

## **SWAMP 103**

Figures GS-1 and GS-2 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets



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



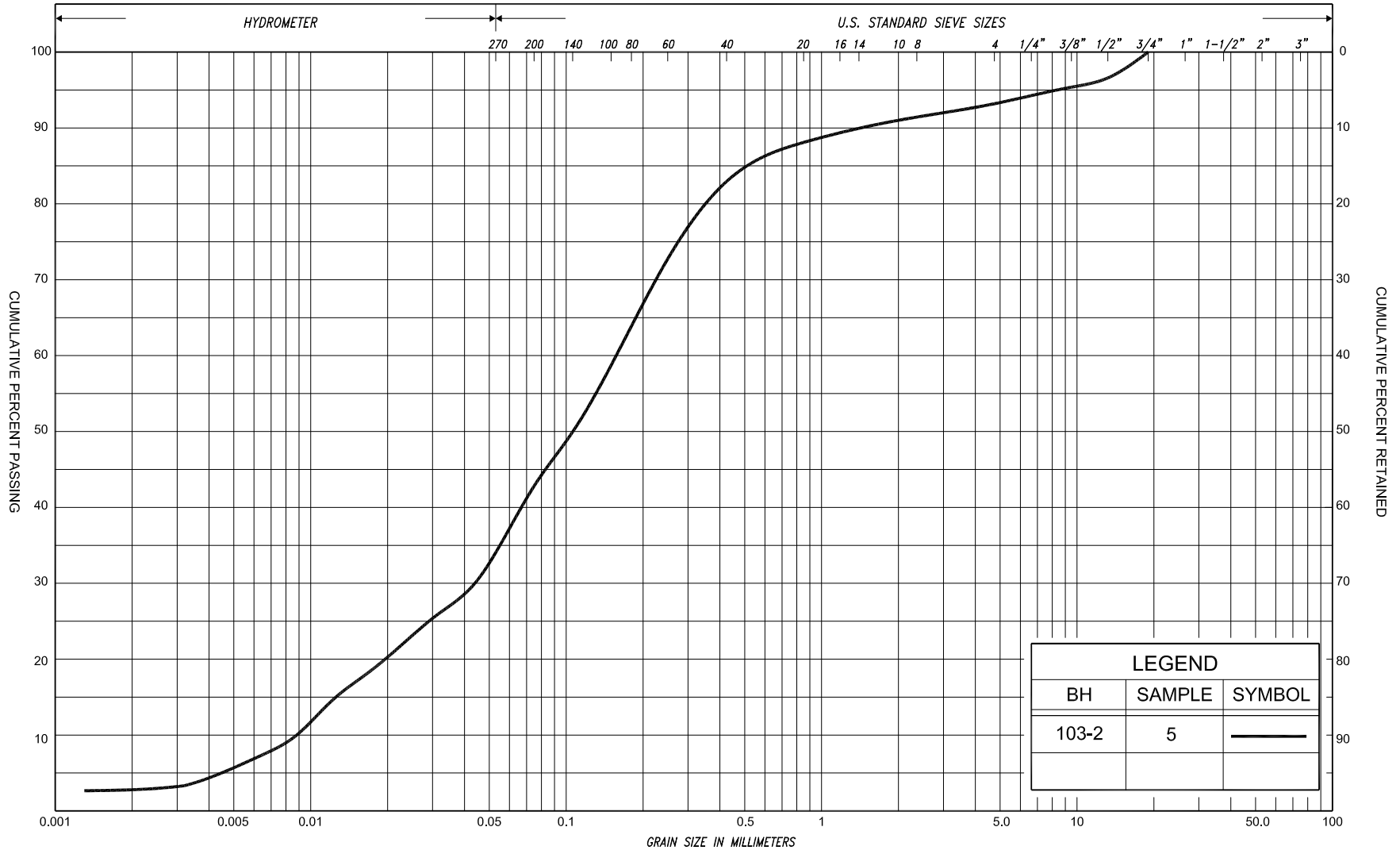
## GRAIN SIZE DISTRIBUTION

SAND, trace silt, trace clay, trace gravel

FIG No. 103-GS-1

HWY: 17

G.W.P. No. 5105-09-00



LEGEND		
BH	SAMPLE	SYMBOL
103-2	5	—

SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COB BLES	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												



# RECORD OF BOREHOLE No 103-1

1 of 1

METRIC

G.W.P.	5105-09-00	LOCATION	Coords: 5 126 498.7 N; 314 317.5 E	ORIGINATED BY	D.W.
DIST	North Bay	HWY	17	BOREHOLE TYPE	Tripod
DATUM	Geodetic	DATE	March 10, 2013	COMPILED BY	N.S.B.
				CHECKED BY	B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  $\gamma$  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										w <sub>p</sub> w w <sub>L</sub>		
								● QUICK TRIAXIAL × LAB VANE												
213.1 0.0	Top of Ice Ice Water						*	*	213											
212.3 0.8	Peat		1	SS	WH**															
211.9 1.2	Sand																			
211.5 1.6	Compact Greyish Wet brown		2	SS	80/5cm															
<div>End of borehole</div> <div>Refusal on probable bedrock</div> <div>Sample 2: Sampler bouncing</div> <div>* 2013 03 10</div> <div> Water level observed during drilling</div> <div> Water level measured after drilling</div> <div>WH** denotes penetration due to weight of rods and hammer</div>																				

**RECORD OF BOREHOLE No 103-2**

1 of 1

**METRIC**

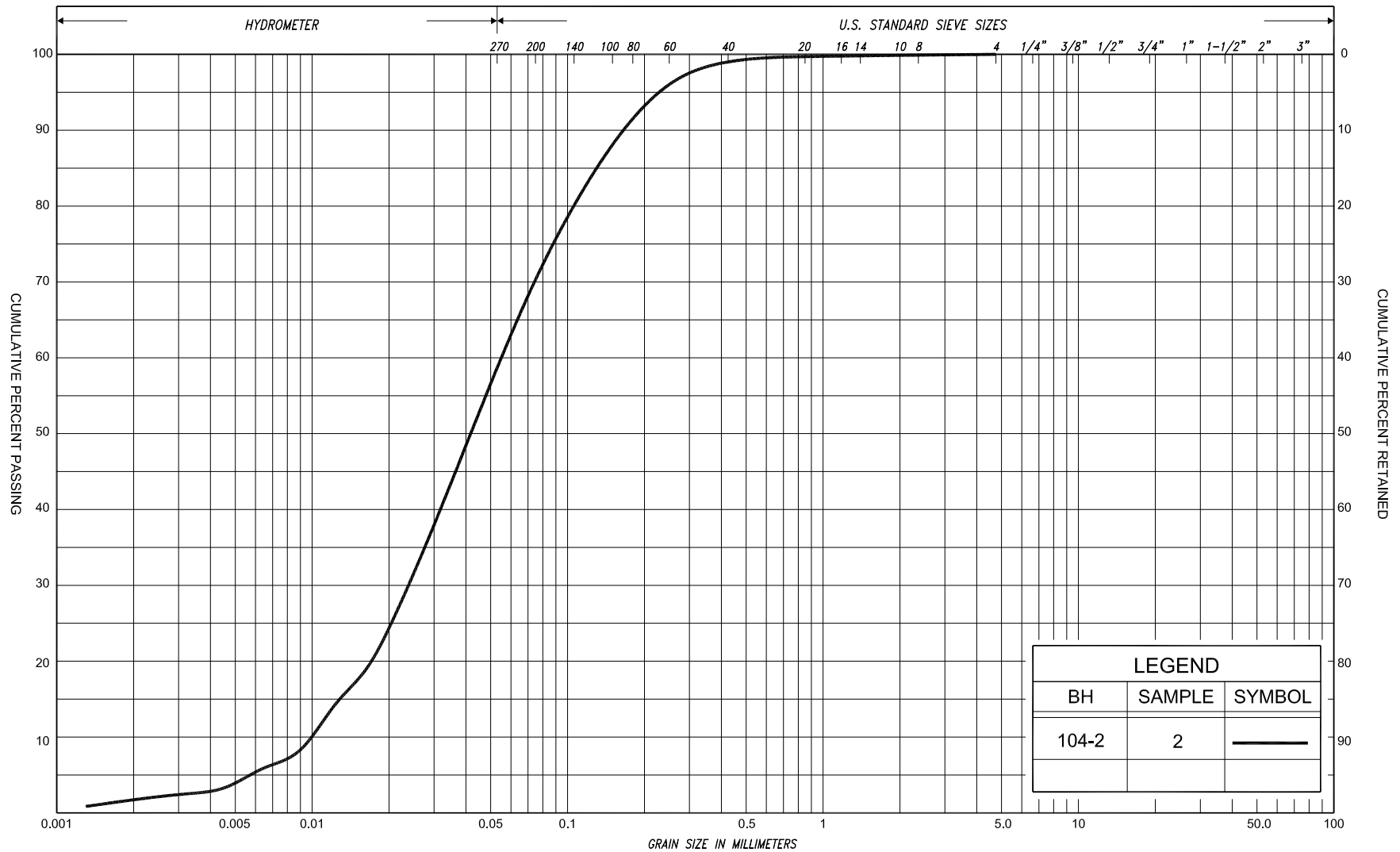
**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 504.4 N; 314 442.8 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Tripod      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 09, 2013      **CHECKED BY** B.R.G.

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									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
					WATER CONTENT (%)												
213.1	Top of Ice						213										
0.0	Peat, amorphous frozen to 0.6m					▽* ▼*											
	Dark brown																
212.2	Sand, trace silt trace clay, trace gravel		1	SS	8		212										
0.9	Loose to Brown Wet compact		2	SS	26											8 83 7 2	
							211										
							210										
	rock fragments		3	SS	15												
							209										
			4	SS	2**		208										
							207									7 50 40 3	
	silty sand layers																
			5	SS	25												
	Very dense Greyish brown		6	SS	92												
205.9			7	SS	100/5cm		206										
7.2	End of borehole																
	Refusal on probable bedrock																
	Sample 7: Sampler bouncing																
	* 2013 03 09																
	▽ Water level observed during drilling																
	▼ Water level measured after drilling																
	** Low 'N' values due to hydraulic disturbance during drilling																

## **SWAMP 104**

Figures GS-1 to GS-3 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets



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



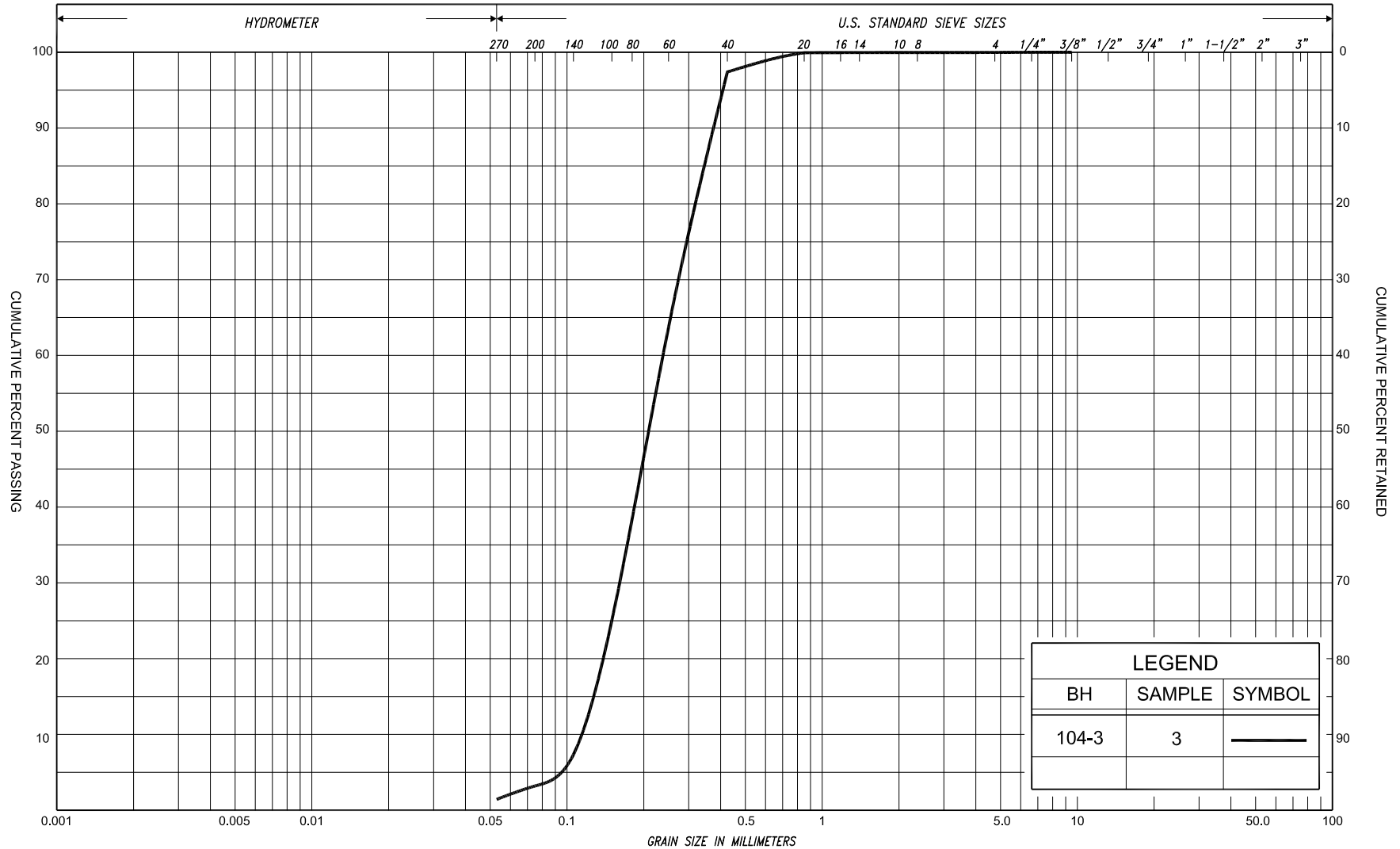
## GRAIN SIZE DISTRIBUTION

SANDY SILT, trace clay

FIG No. 104-GS-1

HWY: 17

G.W.P. No. 5105-09-00



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



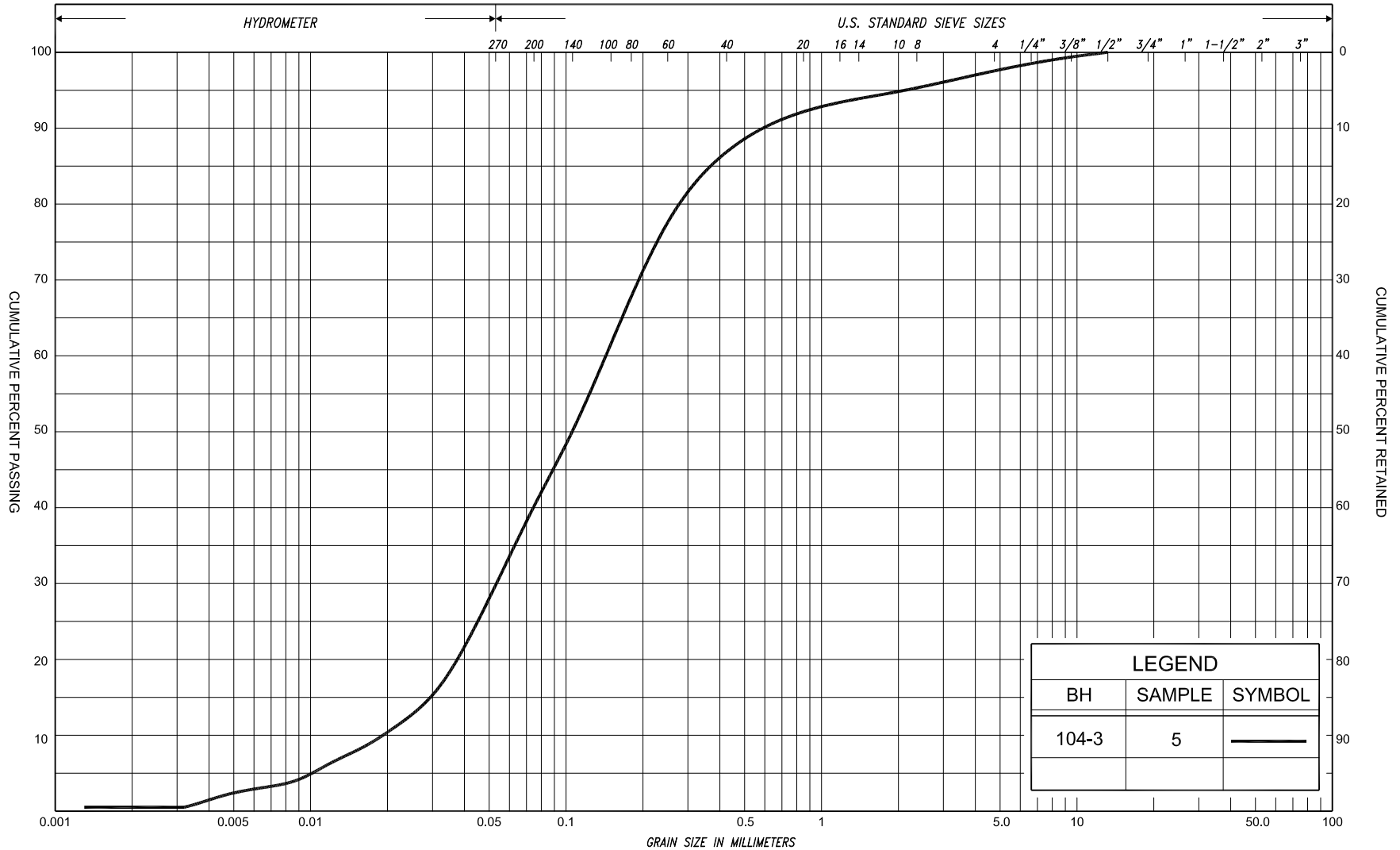
## GRAIN SIZE DISTRIBUTION

SAND, trace silt

FIG No. 104-GS-2

HWY: 17

G.W.P. No. 5105-09-00



LEGEND		
BH	SAMPLE	SYMBOL
104-3	5	—

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



# GRAIN SIZE DISTRIBUTION

SILTY SAND, trace clay, trace gravel

FIG No. 104-GS-3

HWY: 17

G.W.P. No. 5105-09-00

**RECORD OF BOREHOLE No 104-1**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 559.4 N; 314 860.8 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Tripod      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 06 and 07, 2013      **CHECKED BY** B.R.G.

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												
215.6	Top of Ice						20	40	60	80	100	20	40	60	kN/m³	GR SA SI CL				
0.0	Ice					▽* ▼*	215													
	Water																			
213.8							214													
1.8	Peat, amorphous sand layers		1	SS	WH**									1416						
	Dark brown						213													
			2	SS	WH		212													
211.5																				
4.1	Silty sand, with gravel						211													
	Very dense Grey Wet		3	SS	60															
210.4			4	SS	110/3cm															
5.2	End of borehole																			
	Refusal on probable bedrock																			
	Sample 4: Sampler bouncing																			
	 * 2013 03 6 & 7																			
	▽ Water level observed during drilling																			
	▼ Water level measured after drilling																			
	WH** denotes penetration due to weight of rods and hammer																			

**RECORD OF BOREHOLE No 104-2**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 607.5 N; 314 959.7 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Tripod      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 07, 2013      **CHECKED BY** B.R.G.

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		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE		
215.6	Top of Ice						20	40	60	80	100									
0.0	Ice					▽* ▼*	215													
	Water						214													
213.8							213													
1.8	Peat, amorphous sand layers						212													
213.2	Dark brown		1	SS	22															
2.4	Sandy silt, some gravel																			
	Compact to Brownish Wet very dense grey		2	SS	18											0 30 68 2				
210.8	End of borehole		3	SS	50/5cm		211													
4.8	Refusal on probable bedrock																			
	Sample 3 : Sampler bouncing																			



**RECORD OF BOREHOLE No 104-3**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 573.0 N; 315 040.1 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Tripod      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 07, 2013      **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE		SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
215.6	Top of Ice					20	40	60	80	100					
0.0	Ice				▽* ▼*										
215.1	Water														
0.5	Peat, amorphous		1	SS	WH**										
	Dark brown														
213.8			2	SS	20										
1.8	Sand, trace silt														
	Loose to Brownish Wet compact grey														
	Brown		3	SS	8										
	some to trace gravel		4	SS	4***										
209.8															
5.8	Silty sand trace clay, trace gravel														
	Compact Grey Wet		5	SS	12										
	Very dense														
208.4			6	SS	80/5cm										
7.2	End of borehole														
	Refusal on probable bedrock														
	Sample 6: Sampler bouncing														
	* 2013 03 07														
	▽ Water level observed during drilling														
	▼ Water level measured after drilling														
	WH** denotes penetration due to weight of rods and hammer														
	*** Low 'N' values due to hydraulic disturbance during drilling														

**RECORD OF BOREHOLE No. S2-1**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 517.0 N; 314 785.9 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 08, 2013      **CHECKED BY** B.R.G.


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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
216.6	Ground surface							20	40	60	80	100								
0.0	Topsoil																			
216.5	Sand, with cobbles						216													
0.1																				
215.1																				
1.5	End of borehole																			
	Borehole terminated due to hand auger equipment limitations.																			
	* Borehole dry																			

**RECORD OF BOREHOLE No. S2-2**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 555.80 N; 314 792.2 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 08, 2013      **CHECKED BY** B.R.G.

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										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
217.6 0.0	Ground surface					*		20	40	60	80	100						
217.4 0.2	Topsoil																	
	Sand, some cobbles																	
216.1 1.5	Brown						217											

**RECORD OF BOREHOLE No S2-3**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 527.4 N; 314 870.7 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 08, 2013      **CHECKED BY** B.R.G.

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			● QUICK TRIAXIAL	+		×	FIELD VANE					
219.6	Ground surface					*											GR SA SI CL	
0.0	Bedrock at surface																	
	* Borehole dry																	

**RECORD OF BOREHOLE No S2-4**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 571.1 N; 314 953.2 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 08, 2013      **CHECKED BY** B.R.G.


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			● QUICK TRIAXIAL	+		×	FIELD VANE					
217.6	Ground surface					*											GR SA SI CL	
0.0	Bedrock at surface																	
	* Borehole dry																	

**RECORD OF BOREHOLE No S2-5**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 535.3 N; 315 008.4 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 08, 2013      **CHECKED BY** B.R.G.

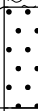
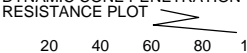
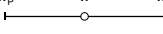
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											WATER CONTENT (%)		
								○ UNCONFINED			+ FIELD VANE								● QUICK TRIAXIAL		
216.6 0.0	Ground surface							20	40	60	80	100									
216.4 0.2	Topsoil																				
	Sand, with cobbles																				
	Brown						216														
215.4 1.2	End of borehole																				
	Refusal on probable bedrock																				
	* Borehole dry																				
	NOTE: Additional two auger probes were carried out adjacent to borehole S2-5, refusal on probable bedrock at 1.1m																				

**RECORD OF BOREHOLE No S2-6**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 572.4 N; 315 082.0 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 08, 2013      **CHECKED BY** B.R.G.

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/m³	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									
217.6 0.0	Ground surface						217										
217.4 0.2	Topsoil																
216.4 1.2	Sand, with cobbles  Brown																
216.4 1.2	End of borehole Refusal on probable bedrock																

## RECORD OF BOREHOLE No S2-7

1 of 1

**METRIC**

<b>G.W.P.</b> <u>5105-09-00</u>	<b>LOCATION</b> <u>Coords: 5 126 534.3 N; 315 100.1 E</u>	<b>ORIGINATED BY</b> <u>D.W.</u>
<b>DIST</b> <u>North Bay</u> <b>HWY</b> <u>17</u>	<b>BOREHOLE TYPE</b> <u>Hand power auger</u>	<b>COMPILED BY</b> <u>N.S.B.</u>
<b>DATUM</b> <u>Geodetic</u>	<b>DATE</b> <u>March 08, 2013</u>	<b>CHECKED BY</b> <u>B.R.G.</u>

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>
								20	40	60	80	100								
216.1 0.0	Top of Ice					▽*   ▼*	216													
215.6 0.5	Ice Water End of borehole Refusal on probable bedrock																			
<div>*    2013   03   08</div> <div>▽    Water level observed during drilling</div> <div>▼    Water level measured after drilling</div> <div>NOTE: Additional two auger probes were carried out adjacent to borehole S2-7, refusal on probable bedrock at 0.5m</div>																				



## **SWAMP 105**

Record of Borehole Sheets

**RECORD OF BOREHOLE No. 105-1**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 126 348.4 N; 315 910.4 E      **ORIGINATED BY** A.D.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** February 22, 2013      **CHECKED BY** B.R.G.

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												
217.0	Top of Ice							20	40	60	80	100								
0.0	Ice																			
	Water																			
215.8							216													
1.2	End of borehole																			
	Borehole terminated due to hand auger equipment limitations.																			
												</								

## RECORD OF BOREHOLE No. 105-2

1 of 1

METRIC

<b>G.W.P.</b>	5105-09-00	<b>LOCATION</b>	Coords: 5 126 376.6 N; 315 905.6 E	<b>ORIGINATED BY</b>	A.D.
<b>DIST</b>	North Bay	<b>HWY</b>	17	<b>BOREHOLE TYPE</b>	Hand power auger
<b>DATUM</b>	Geodetic	<b>DATE</b>	February 22, 2013	<b>CHECKED BY</b>	B.R.G.

[illegible]

# RECORD OF BOREHOLE No. 105-3

1 of 1

METRIC

<b>G.W.P.</b> 5105-09-00	<b>LOCATION</b>	Coords: 5 126 554.3 N; 316 099.0 E	<b>ORIGINATED BY</b> A.D.
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DIST	North Bay	HWY	17	BOREHOLE TYPE	Hand power auger	COMPILED BY	N.S.B.
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<b>DATUM</b>	Geodetic	<b>DATE</b>	February 22, 2013	<b>CHECKED BY</b>	B.R.G.
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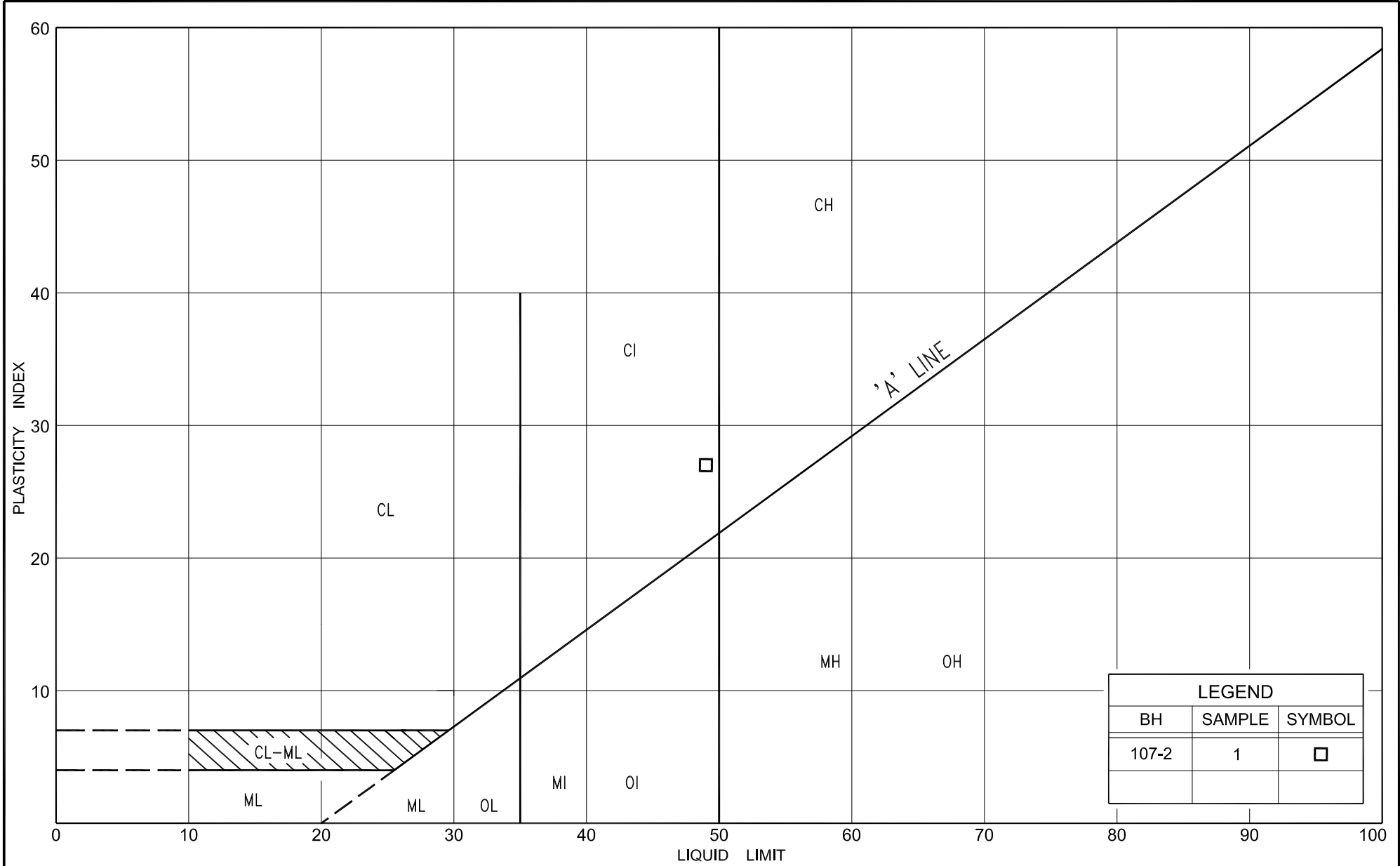
[illegible]

## **SWAMP 107**

Figure PC-1 – Results of Atterberg Limits Testing

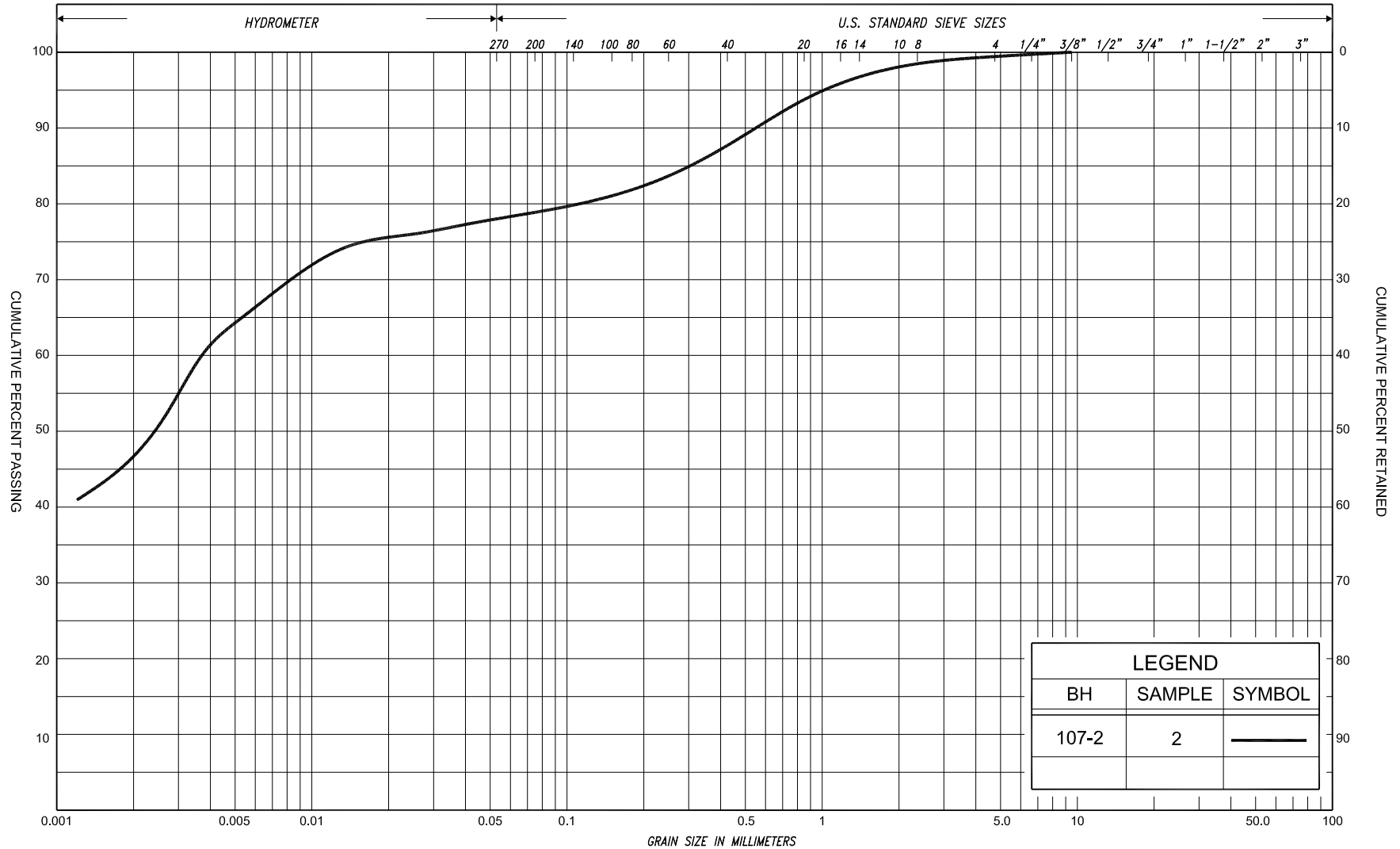
Figures GS-1 and GS-2 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets

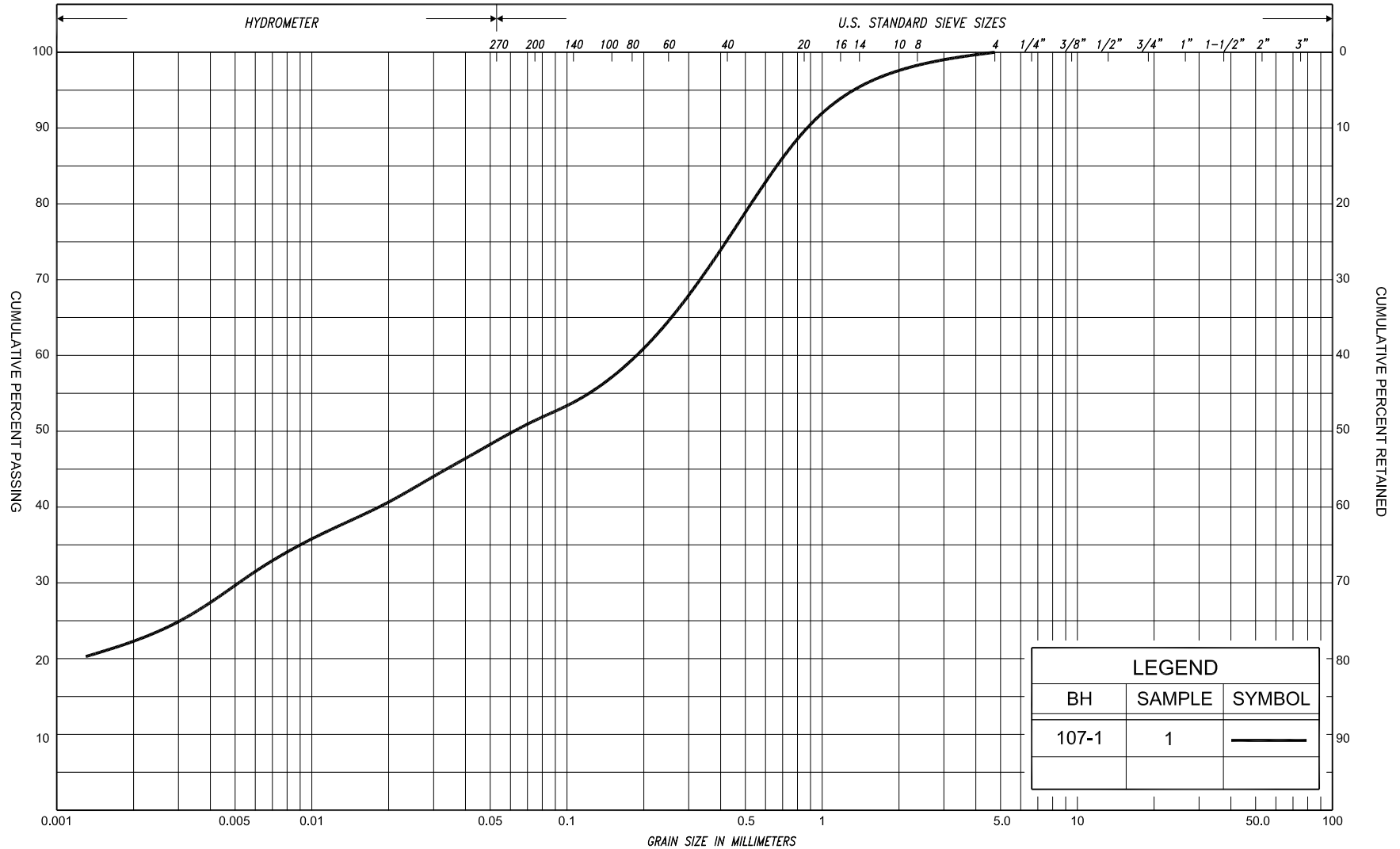


**PLASTICITY CHART**  
 SILTY CLAY, with sand, trace gravel

FIG No. 107-PC-1  
 HWY: 17  
 G.W.P. No. 5105-09-00



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL				COB BLES	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													



LEGEND		
BH	SAMPLE	SYMBOL
107-1	1	—

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										





**RECORD OF BOREHOLE No. 107-1**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 125 972.7 N; 325 673.6 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 10, 2013      **CHECKED BY** B.R.G.







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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
228.9	Top of Ice																			
0.0	Ice																			
228.4	Water																			
0.5	Silty sand																			
	Grey brown		1	AS	-		228										0 48 30 22			
227.4	clay layers																			
1.5	End of borehole																			
	Borehole terminated due to hand auger equipment limitations.																			
	* 2013 03 10																			
	▽ Water level observed during drilling																			
	▼ Water level measured after drilling																			

**RECORD OF BOREHOLE No. 107-2**

1 of 1

**METRIC**

**G.W.P.** 5105-09-00      **LOCATION** Coords: 5 125 953.3 N; 325 743.3 E      **ORIGINATED BY** D.W.  
**DIST** North Bay      **HWY** 17      **BOREHOLE TYPE** Hand power auger      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** March 10, 2013      **CHECKED BY** B.R.G.

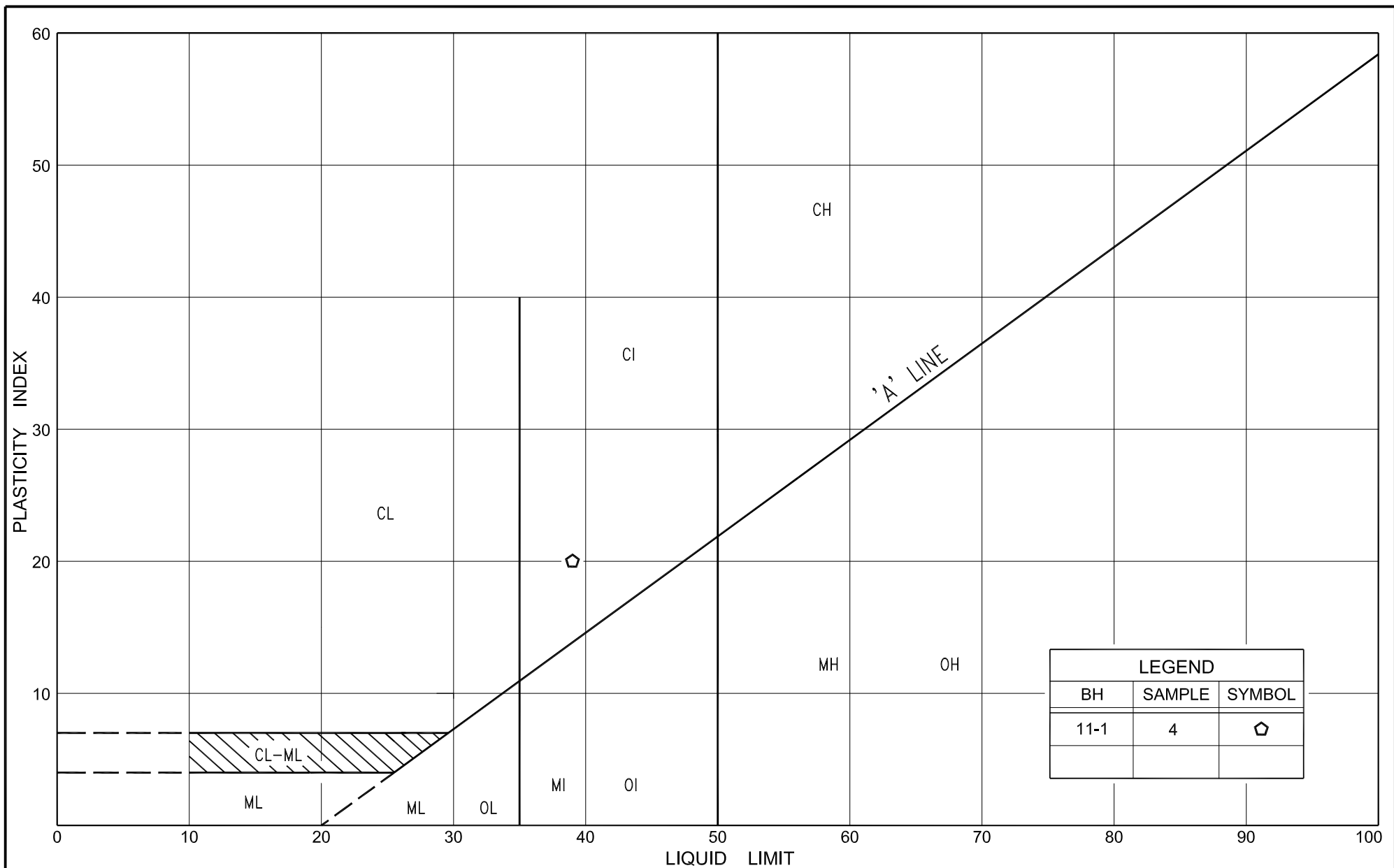
SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+	FIELD VANE							
228.9 0.0	Ground surface																
228.7 0.2	Topsoil																
	Silty clay trace sand, trace gravel																
	Soft Brownish Wet grey		1	AS			228										1 21 31 47
227.4 1.5	End of borehole																
	Borehole terminated due to hand auger equipment limitations.																
	* 2013 03 10																
	 Water level observed during drilling																
	 Water level measured after drilling																

## **HIGHWAY 11 / HIGHWAY 17 INTERCHANGE**

Figure 11ES-PC-1 and 11ES-PC-2 – Results of Atterberg Limits Testing

Figures 11ES-GS-1 to 11ES-GS-4 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets



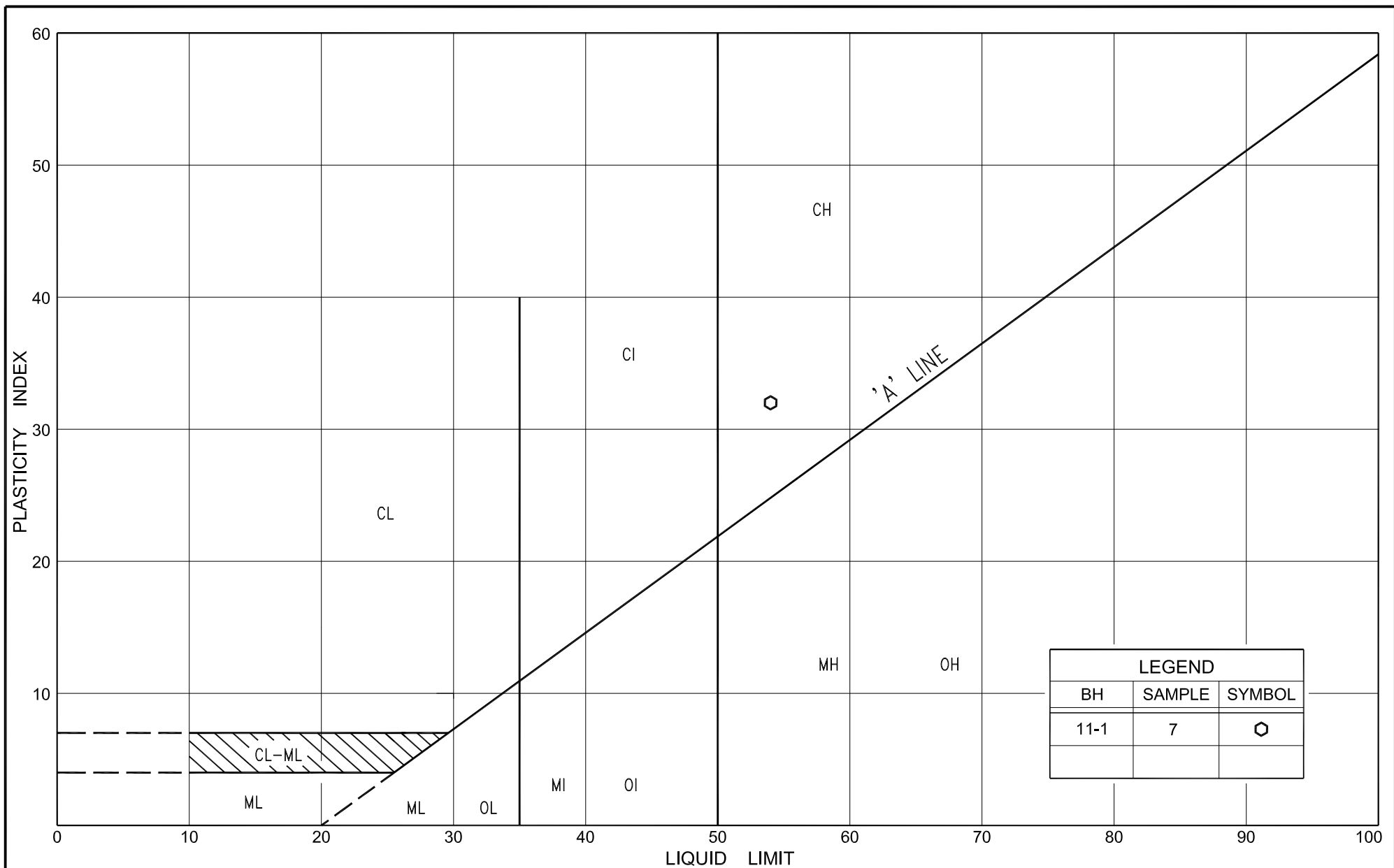
## PLASTICITY CHART

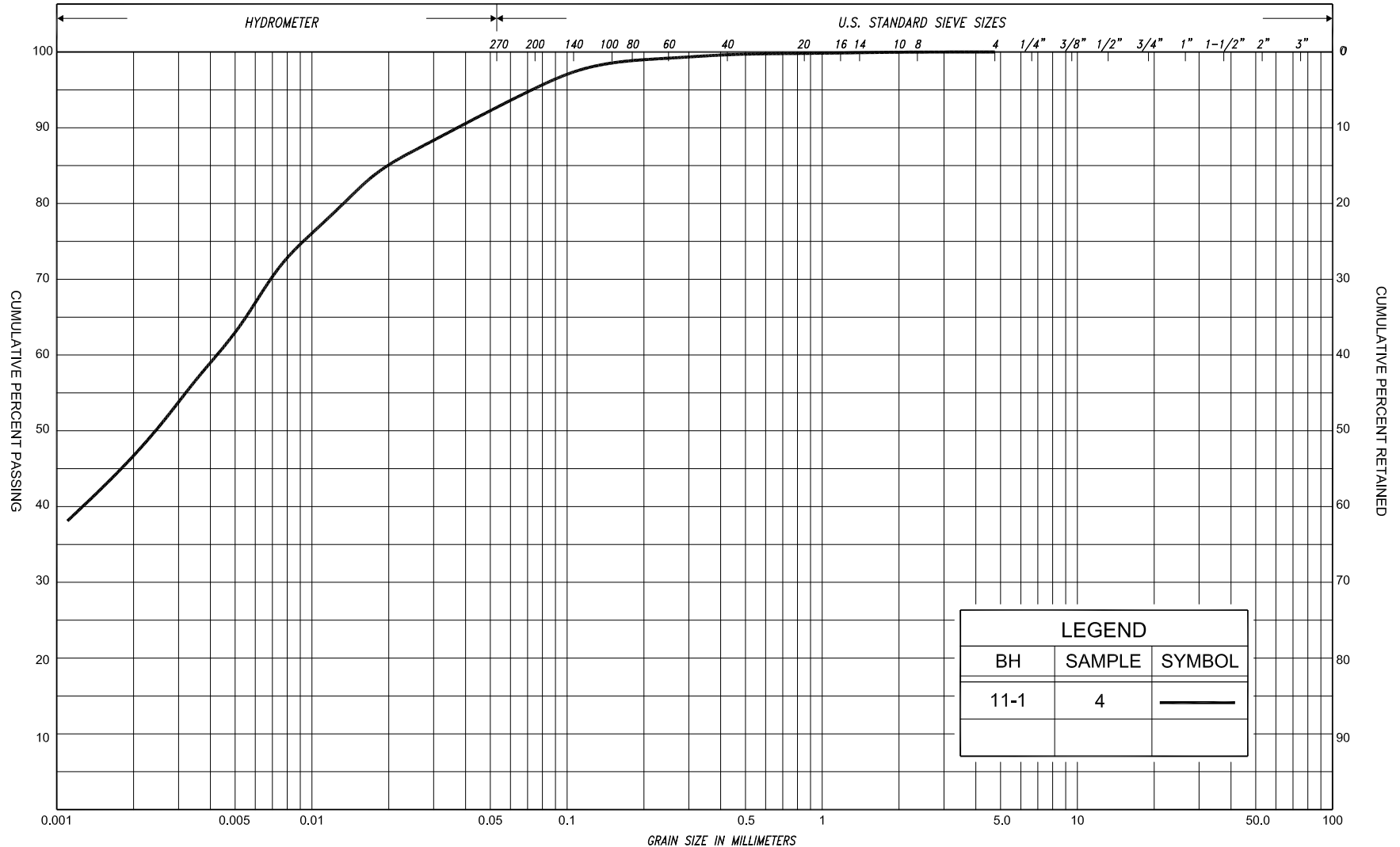
SILTY CLAY, trace sand

FIG No. 11ES-PC-1

HWY: 17

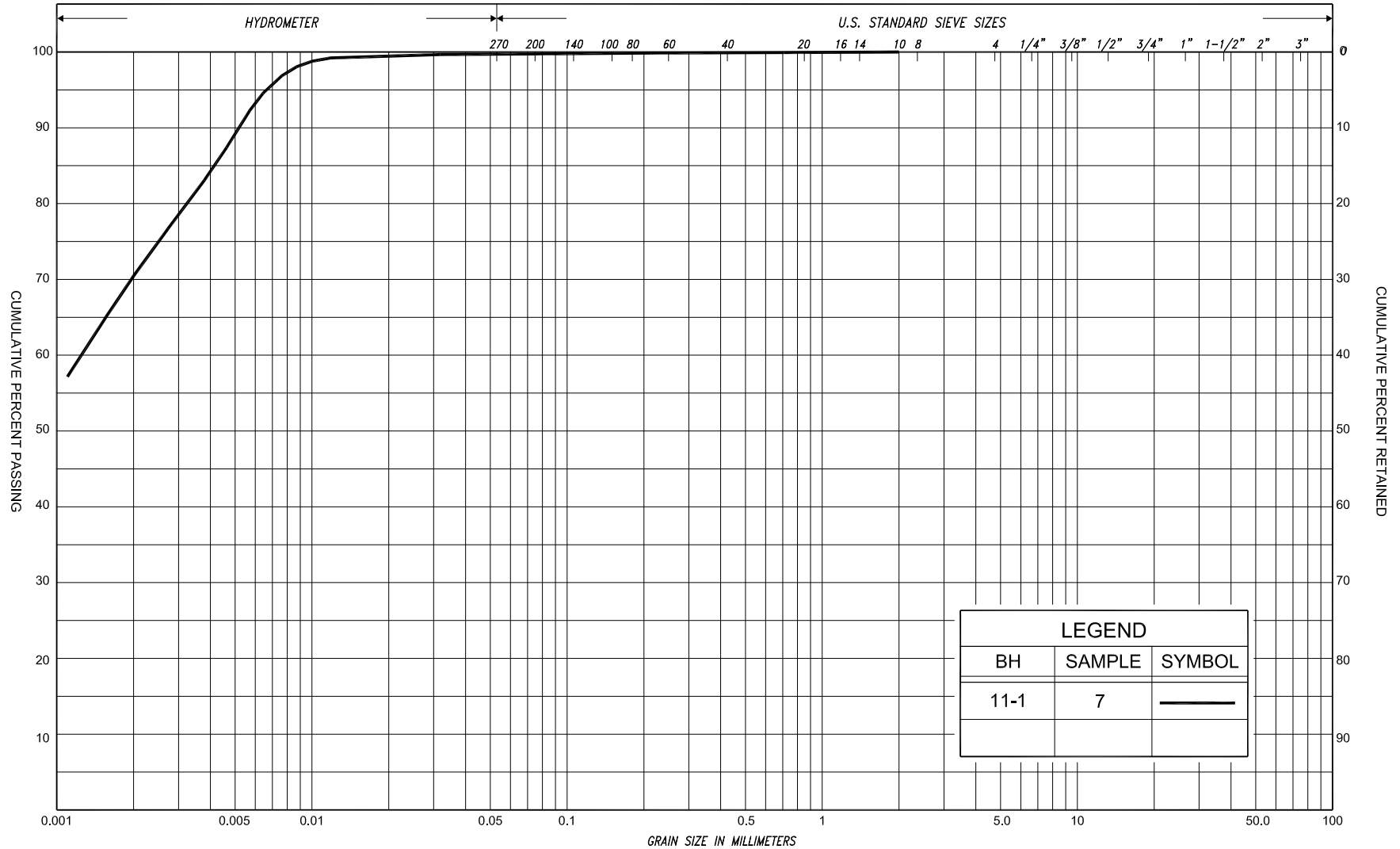
G.W.P. No. 5105-09-00





LEGEND		
BH	SAMPLE	SYMBOL
11-1	4	—

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													



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



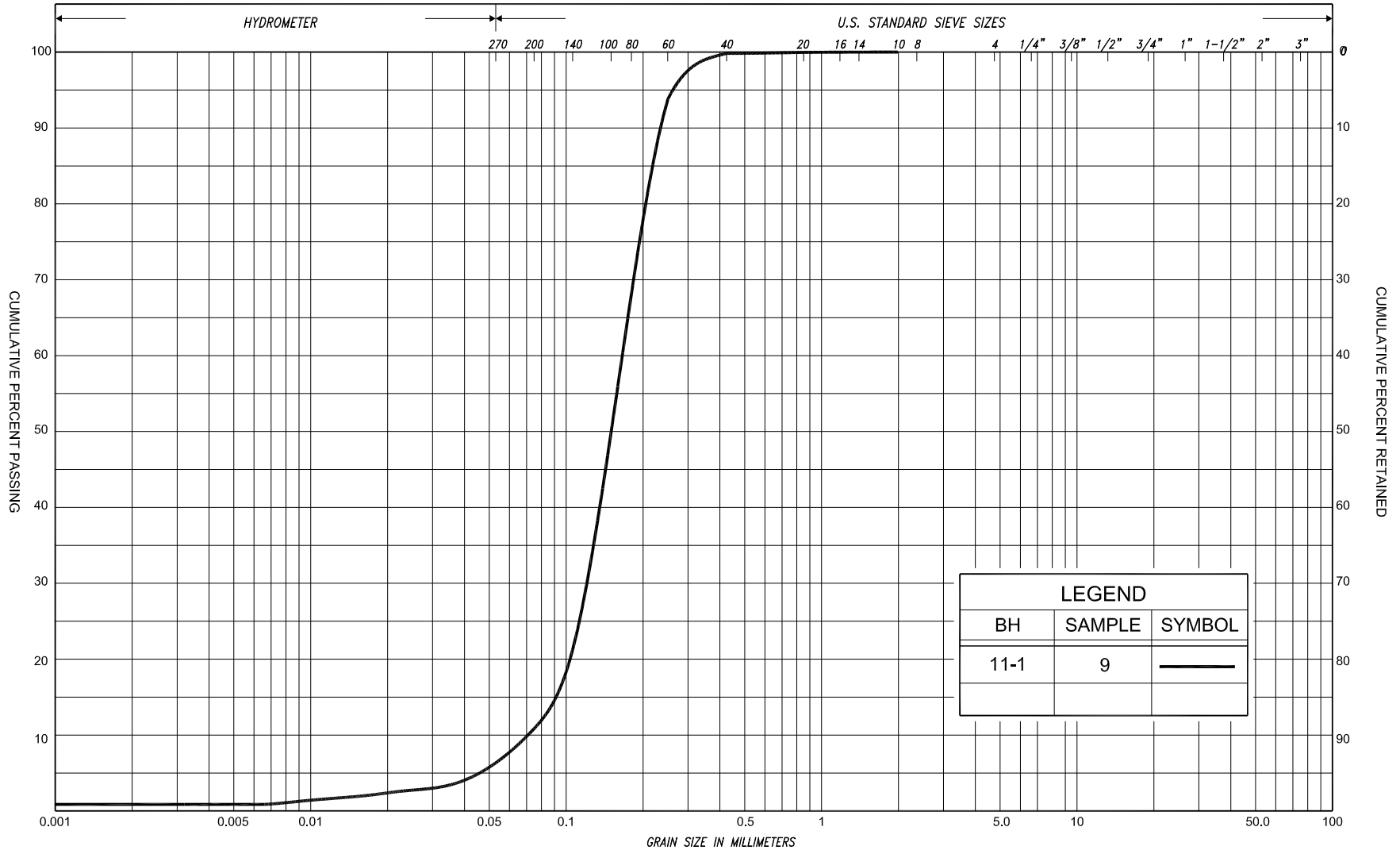
## GRAIN SIZE DISTRIBUTION

CLAY

FIG No. 11ES-GS-2

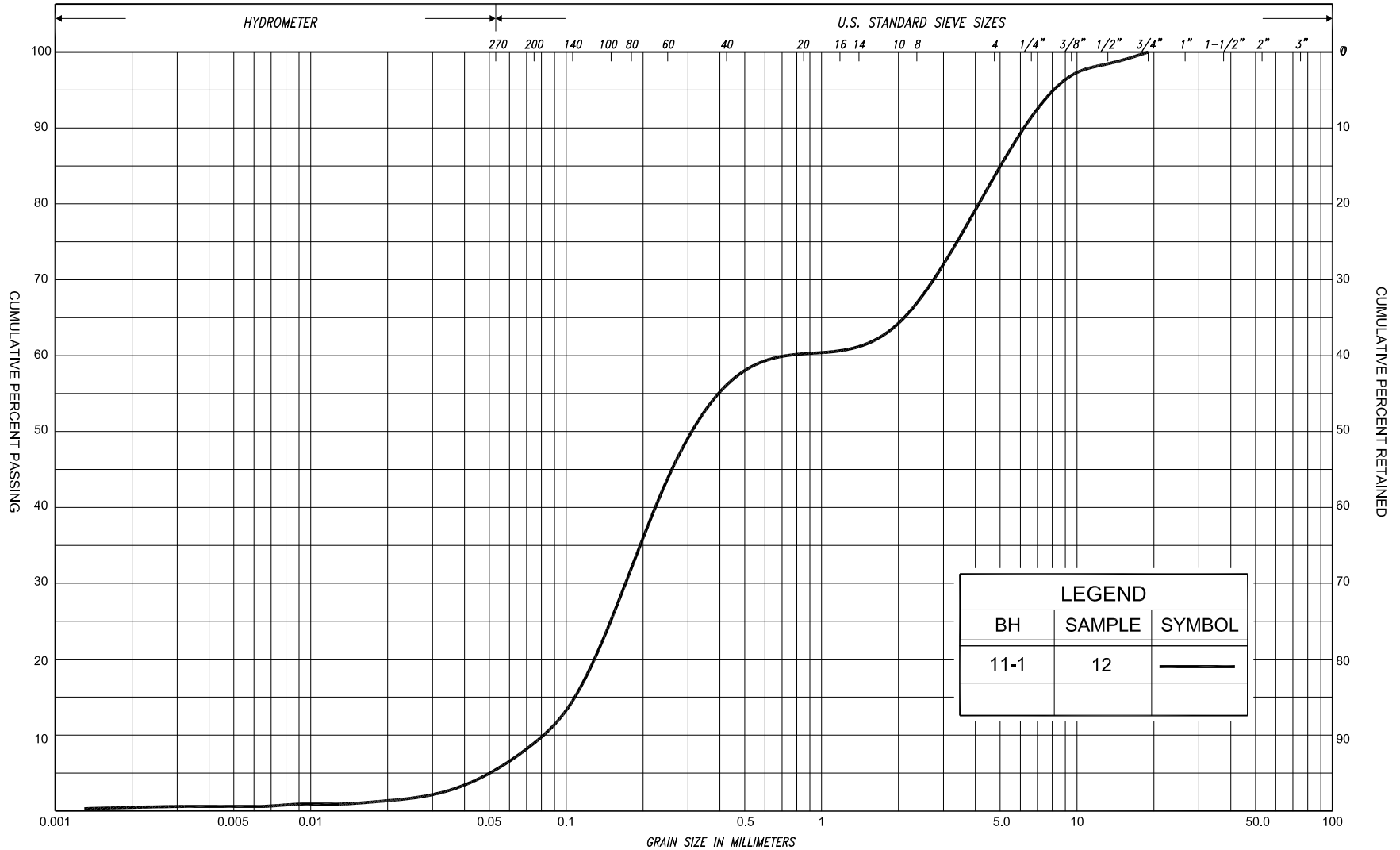
HWY: 17

G.W.P. No. 5105-09-00



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												





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													

# RECORD OF BOREHOLE No 11-1

1 of 2

METRIC

G.W.P. 5105-09-00

LOCATION

Hwy 11/Hwy 17 Interchange, E-S Ramp

Coords: 5 126 858.7 N ; 311 952.7 E

ORIGINATED BY D.W.

DIST North Bay

HWY 17

BOREHOLE TYPE C.F.H.S.A. + 'N' Casing + Dynamic Cone Penetration Test

COMPILED BY B.R.

DATUM Geodetic

DATE

June 05, 2013

CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			*GROUND WATER CONDITIONS	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 (%)
203.4	Ground Surface						20	40	60	80	100					
203.0	Topsoil		1	SS	5											
203.3	Sand, trace silt organics		2	SS	4											
202.5	Loose Brown Wet		3	SS	2											
0.9	Silty clay, trace sand		4	SS	1											
	Soft Grey Wet															
			5	SS	WH**											
				FV												
			6	SS	1											
197.8	Clay															
	Soft Grey Wet		7	SS	WH											
				FV												
			8	SS	2											
				FV												
194.9	Sand trace silt, trace clay		9	SS	7											
8.5	Loose Greyish Wet brown		10	SS	3											
	some gravel		11	SS	8											
			12	SS	7											
188.4	Cont'd															

# RECORD OF BOREHOLE No 11-1

2 of 2

METRIC

**G.W.P.** 5105-09-00

**LOCATION**

Hwy 11/Hwy 17 Interchange, E-S Ramp

Coords: 5 126 858.7 N ; 311 952.7 E

ORIGINATED BY D.W.

DIST North Bay HWY 17

**BOREHOLE TYPE**C.F.H.S.A. + 'N' Casing + Dynamic Cone Penetration Test

COMPILED BY B.R.

**DATUM** Geodetic

**DATE** June 05, 2013

CHECKED BY B.R.G.

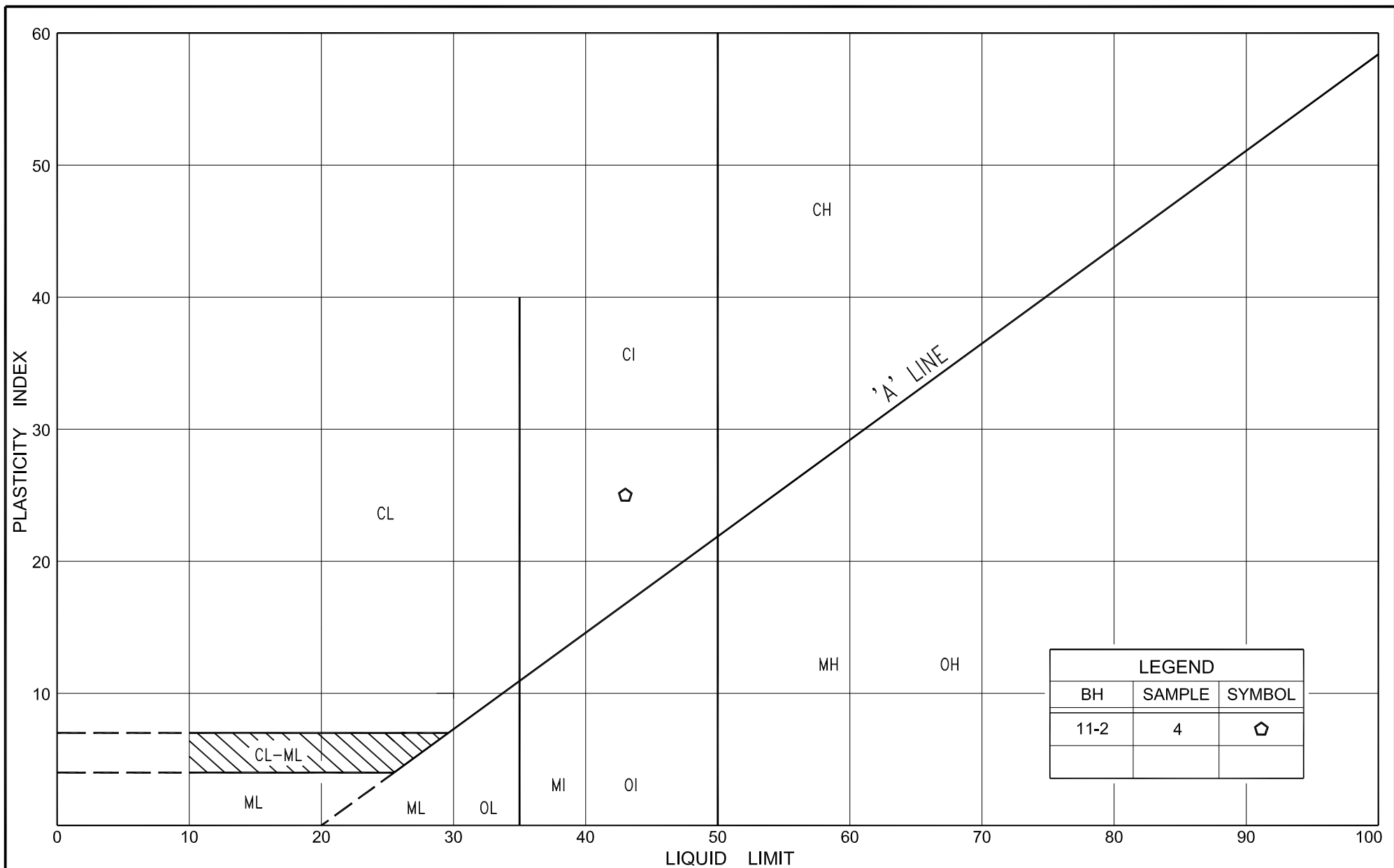
[illegible]

## **HIGHWAY 11 / HIGHWAY 17 INTERCHANGE**

Figure 11NE-PC-1 and 11NE-PC-2 – Results of Atterberg Limits Testing

Figures 11NE-GS-1 to 11NE-GS-4 – Results of Grain Size Distribution Analyses

Record of Borehole Sheets



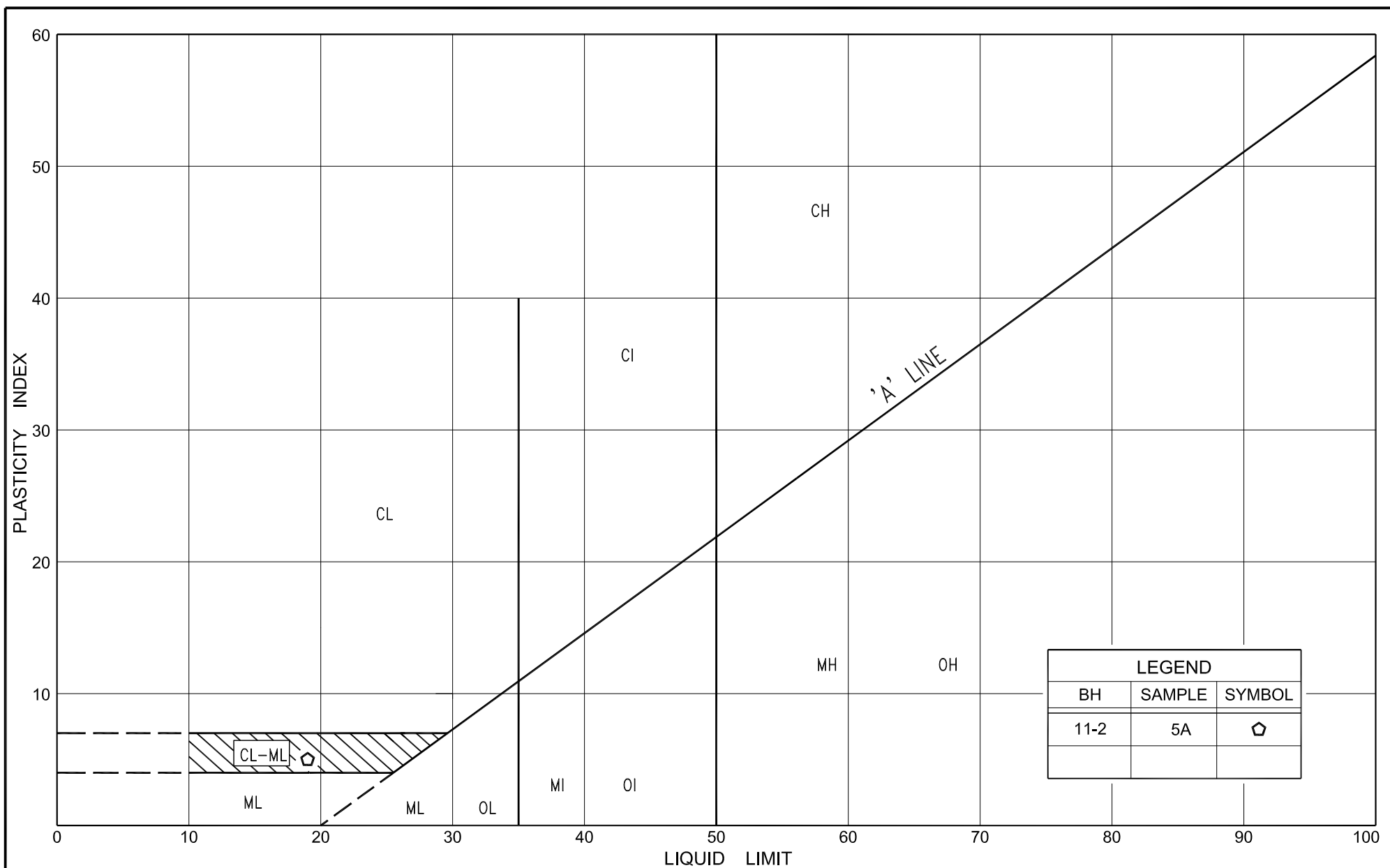
## PLASTICITY CHART

SILTY CLAY, trace sand

FIG No. 11NE-PC-1

HWY: 17

G.W.P. No. 5105-09-00



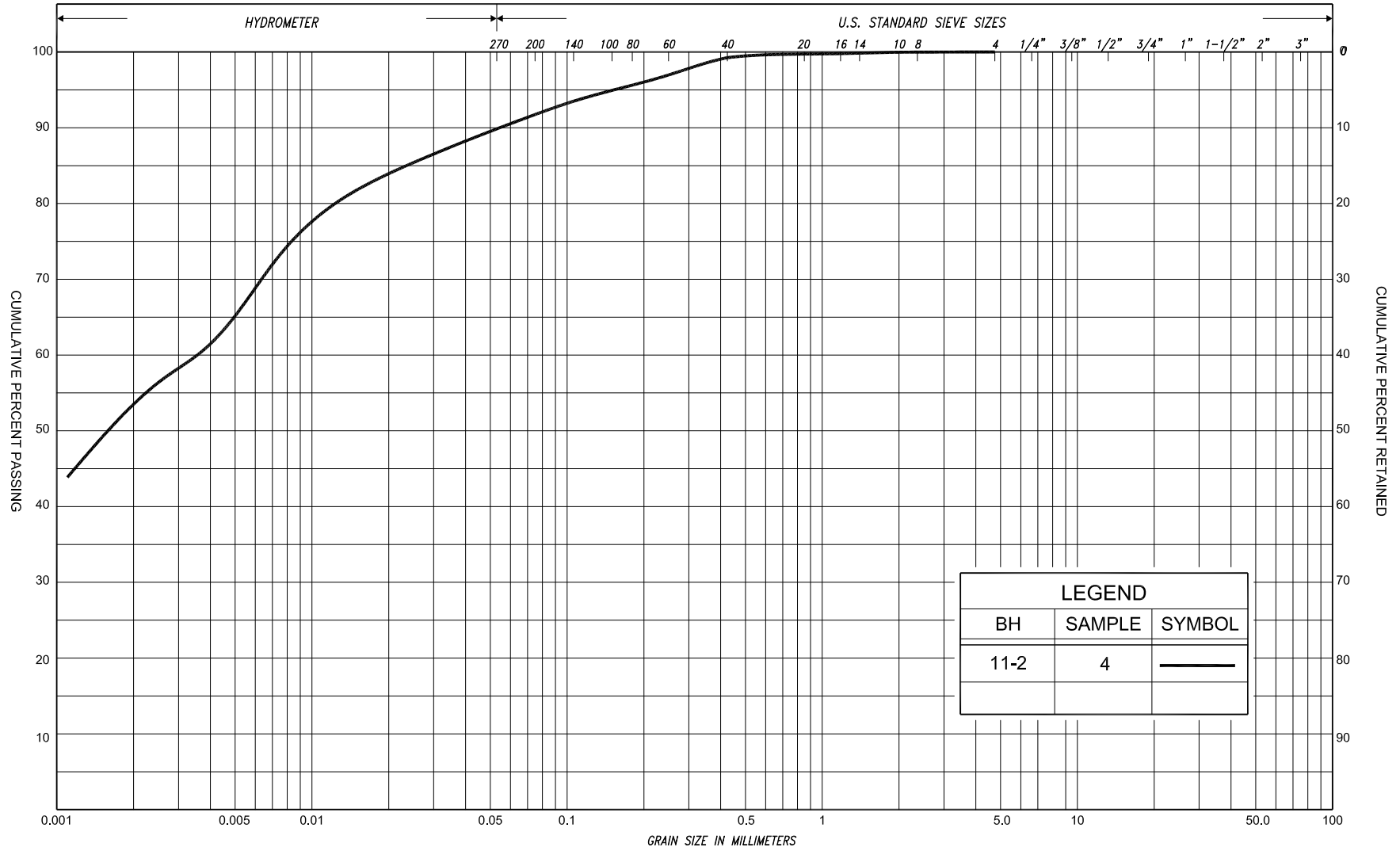
## PLASTICITY CHART

CLAYEY SILT, some sand

FIG No. 11NE-PC-2

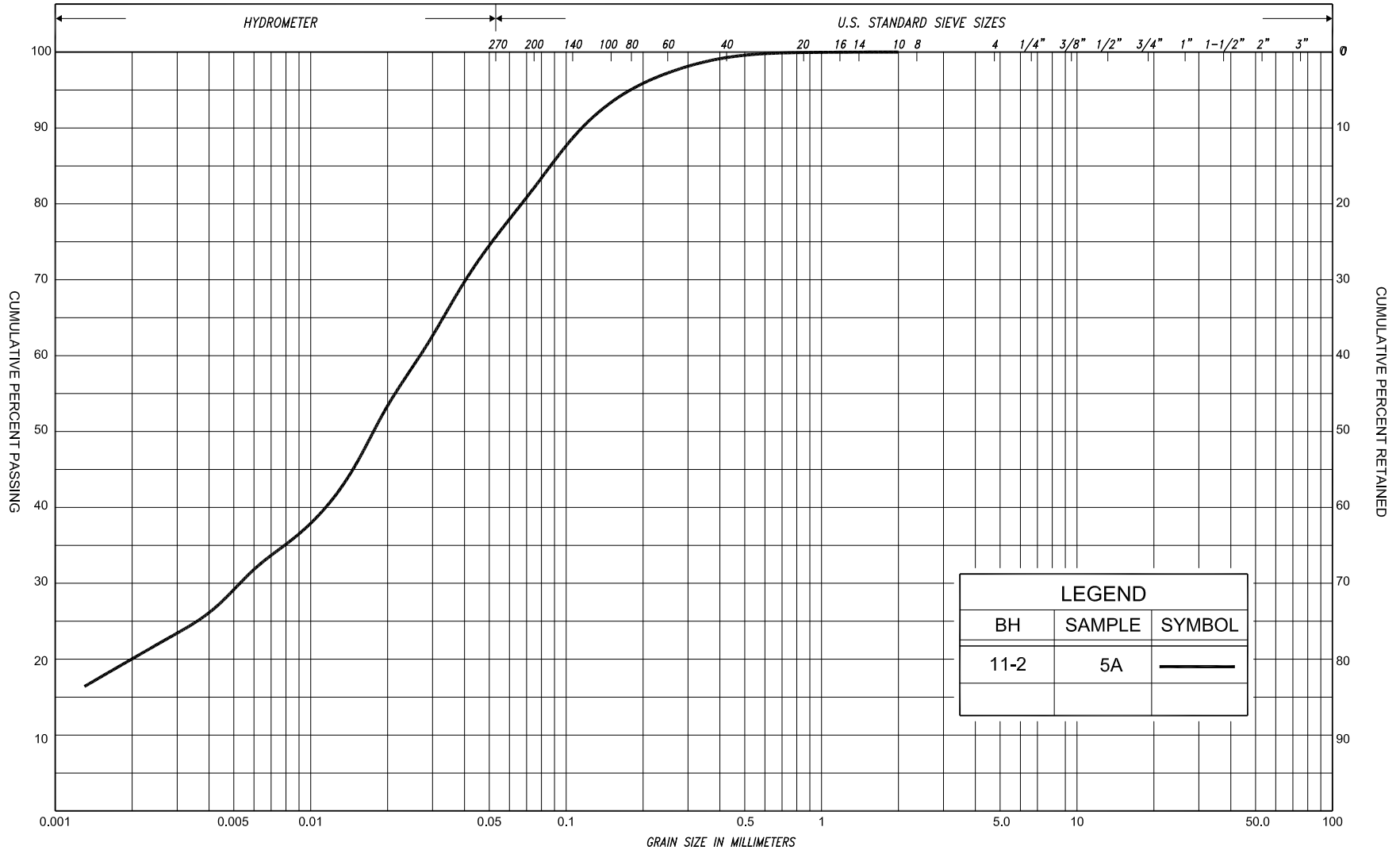
HWY: 17

G.W.P. No. 5105-09-00



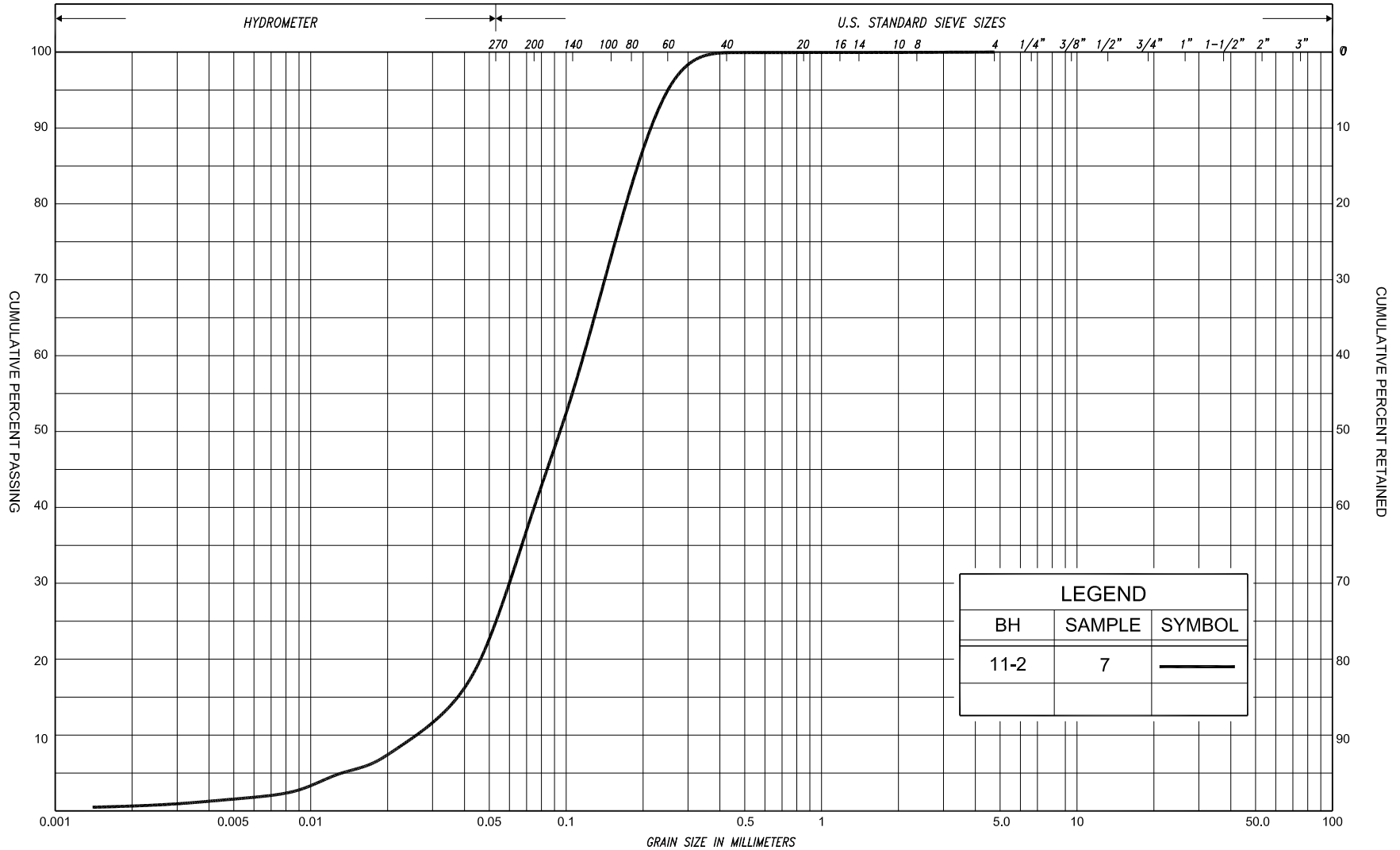
LEGEND		
BH	SAMPLE	SYMBOL
11-2	4	—

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

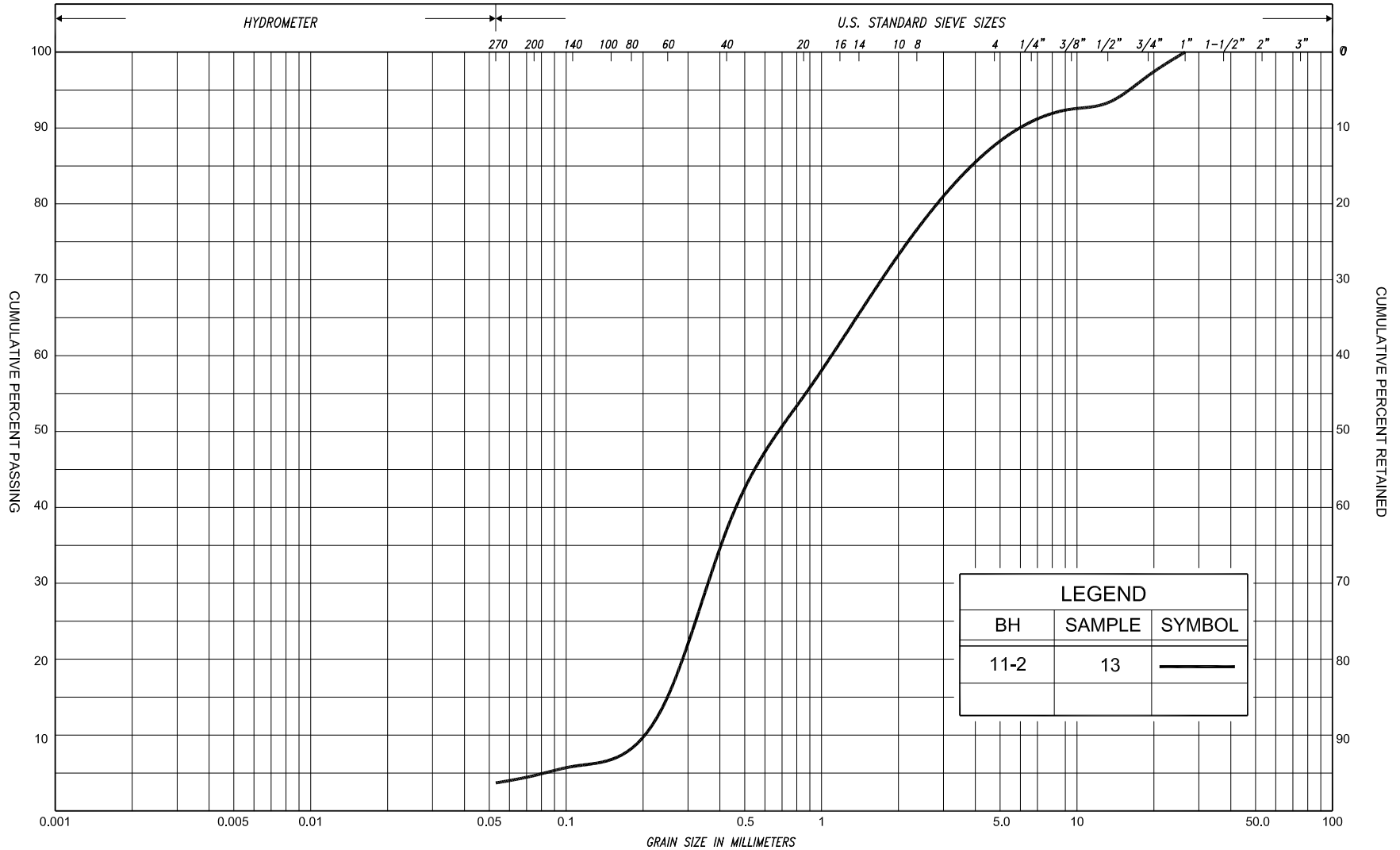


SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL				COBBLES	UNIFIED		
					SAND													
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL				COBBLES	M.I.T.
	SILT																	
CLAY			SILT			V. FINE	FINE	MED.	COARSE		GRAVEL						U.S. BUREAU	
					SAND													





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												



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												

**RECORD OF BOREHOLE No 11-2**

1 of 2

**METRIC**

G.W.P. 5105-09-00

LOCATION

Hwy 11/Hwy 17 Interchange, N-E Ramp

Coords: 5 126 954.2 N ; 311 869.3 E

ORIGINATED BY D.W.

DIST North Bay

HWY 17

BOREHOLE TYPE C.F.H.S.A. and Dynamic Cone Penetration Test

COMPILED BY B.R.

DATUM Geodetic

DATE

June 04, 2013

CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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      + FIELD VANE										W <sub>p</sub> W      W <sub>L</sub>		
							● QUICK TRIAXIAL      × LAB VANE												
203.4	Ground Surface						20	40	60	80	100								
0.0	Topsoil																		
203.3	Sand, trace silt organics to 1.1m		1	SS	1														
0.1	Very loose Brown      Wet to loose		2	SS	6														
202.0	some gravel																		
1.4	Silty clay with gravel, trace sand		3	SS	1														
	Soft      Grey      Wet		4	SS	WH**														
			5	SS	WH														
				FV															
199.0	Clayey silt, some sand																		
4.4	Soft to      Grey      Wet firm		5A	SS	PM														
				FV															
			6	SS	WH														
				FV															
196.2	Silty sand, trace clay																		
7.2	Very loose Brown/      Wet to compact grey		7	SS	WH														
			8	SS	6														
			9	SS	2														
			10	SS	2														
189.6	Sand, trace silt		11	SS	13														
13.8	Compact      Grey to      Wet to loose      brown																		
	Cont'd																		

Cont'd

## RECORD OF BOREHOLE No 11-2

2 of 2

**METRIC**

**G.W.P.** 5105-09-00

LOCATION

Hwy 11/Hwy 17 Interchange, N-E Ramp

Coords: 5 126 954.2 N ; 311 869.3 E

ORIGINATED BY D.W.

DIST North Bay HWY 17

**BOREHOLE TYPE**C.F.H.S.A. and Dynamic Cone Penetration Test

COMPILED BY B.R.

**DATUM** Geodetic

DATE June 04, 2013

**CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL			
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 (%)						
188.4								20   40   60   80   100		20   40   60								
	some gravel, trace clay  Compact to Brown   Wet very dense		12	SS	8													
			13	SS	12													
			14	SS	14													
											</							

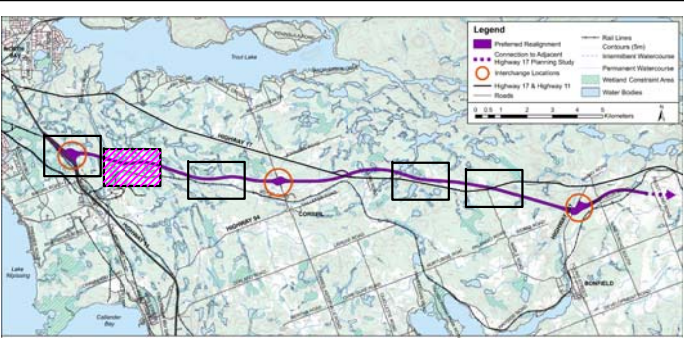


CONT No  
GWP No 5105-09-00

PREFERRED ALIGNMENT  
HIGHWAY 17 ROUTE PLANNING  
From Highway 11 South Junction to  
2.7 km east of Highway 531 about 26.0 km  
BOREHOLE LOCATIONS



SHEET



KEY PLAN

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone

Location and direction of photograph

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
101-2	205.2	5 126 669.5	313 638.5
102-1	203.0	5 126 575.7	314 052.9
103-1	213.1	5 126 498.7	314 317.5
103-2	213.1	5 126 504.4	314 442.8

Referenced MRC Drawings: 3210158 - Hwy 17 North Bay Interchange  
Plans & Profile - April 10, 2013.dwg; P 8086-basemap in one colour.dwg;  
P8086-Contour base.dwg; Street names.dwg; and Existing Highway 17.dwg

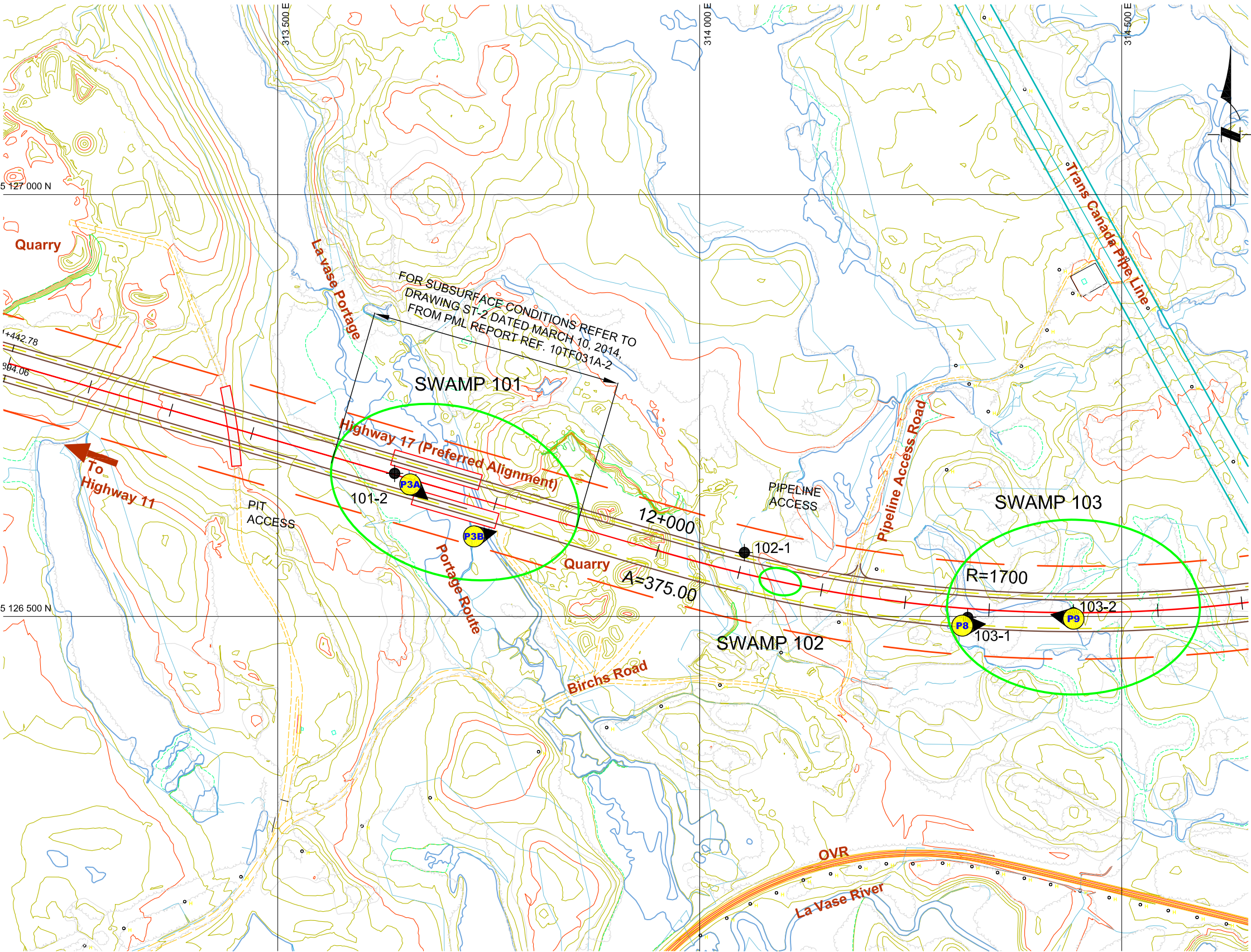
NOTE

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. 31L-177

HWY No	17	CHECKED	NSB	DATE	Mar. 10, 2014	DIST	NORTH BAY
SUBM'D	NA	CHECKED	BRG/DD	APPROVED	CN	SITE	DWG SW-1



NOTES:

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PLAN  
SCALE



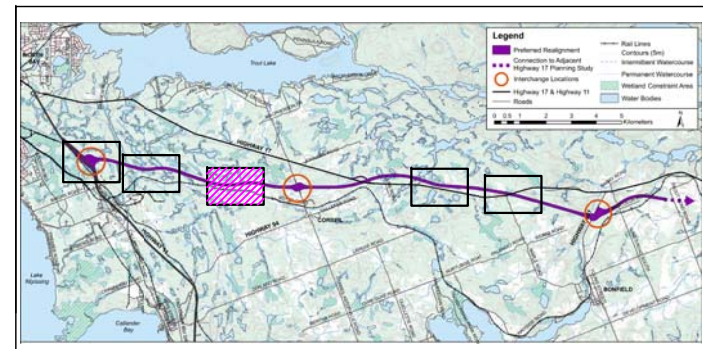


CONT No  
GWP No 5105-09-00

PREFERRED ALIGNMENT  
HIGHWAY 17 ROUTE PLANNING  
From Highway 11 South Junction to  
2.7 km east of Highway 531 about 26.0 km  
BOREHOLE LOCATIONS



SHEET



KEY PLAN

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone

Location and direction of photograph

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
104-1	215.6	5 126 559.4	314 860.8
104-2	215.6	5 126 607.5	314 959.7
104-3	215.6	5 126 573.0	315 040.1
S2-1	216.6	5 126 517.0	314 785.9
S2-2	217.6	5 126 555.8	314 792.2
S2-3	219.6	5 126 527.4	314 870.7
S2-4	217.6	5 126 571.1	314 953.2
S2-5	216.6	5 126 535.3	315 008.4
S2-6	217.6	5 126 572.4	315 082.0
S2-7	216.1	5 126 534.3	315 100.1
105-1	217.0	5 126 348.4	315 910.4
105-2	217.0	5 126 376.6	315 905.6
105-3	217.0	5 126 554.3	316 099.0

Referenced MRC Drawings: 3210158 - Hwy 17 North Bay Interchange Plans & Profile - April 10, 2013.dwg; P 8086-basemap in one colour.dwg; P8086-Contour base.dwg; Street names.dwg; and Existing Highway 17.dwg

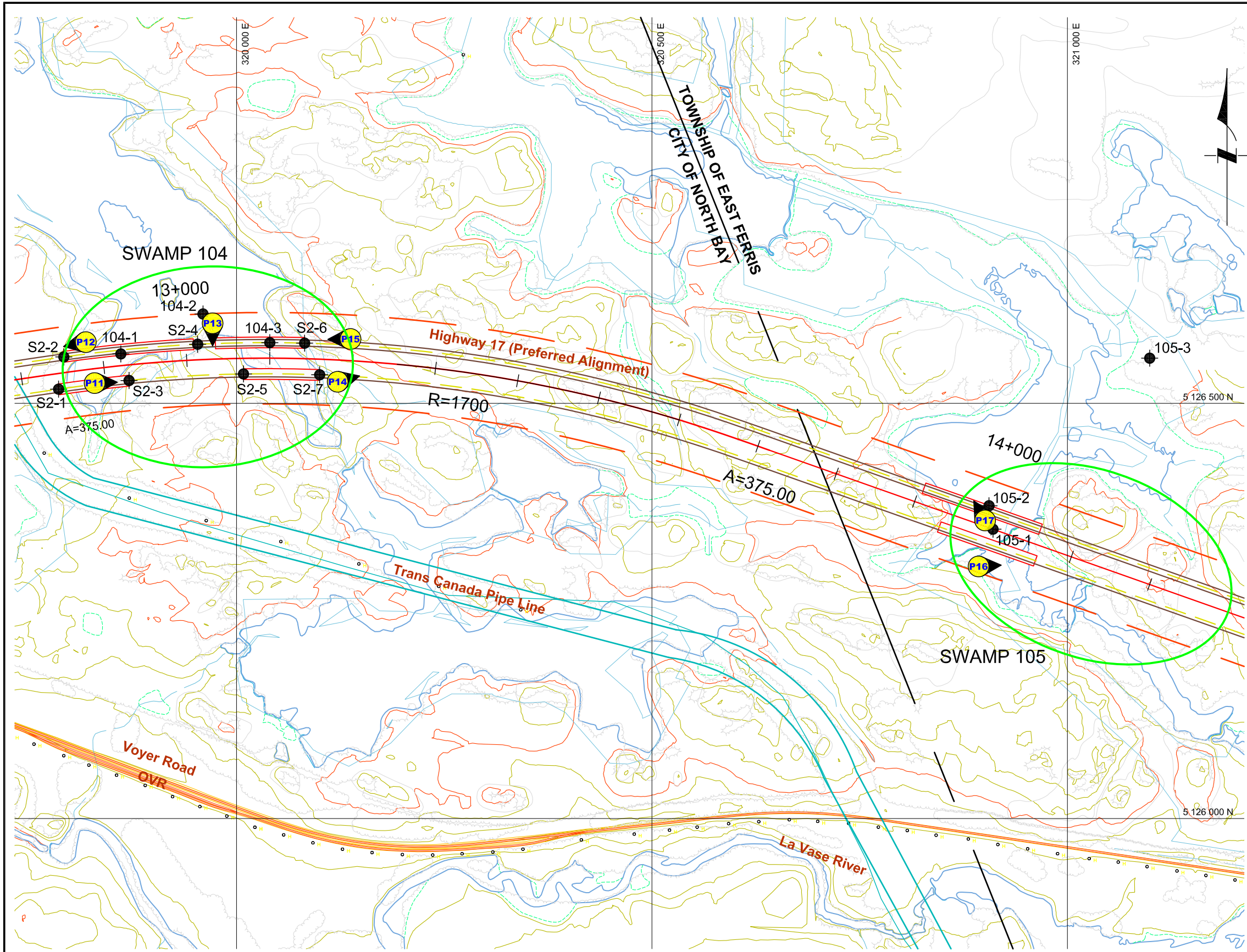
NOTE

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REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 31L-177

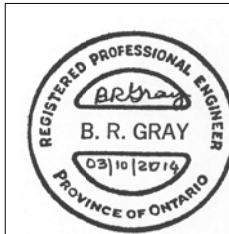
HWY No	17	CHECKED	NSB	DATE	Mar. 10, 2014	DIST	NORTH BAY
SUBM'D	NA	CHECKED	BRG/DD	APPROVED	CN	SITE	DWG SW-2
DRAWN	NA	CHECKED	BRG/DD	APPROVED	CN	SITE	DWG SW-2



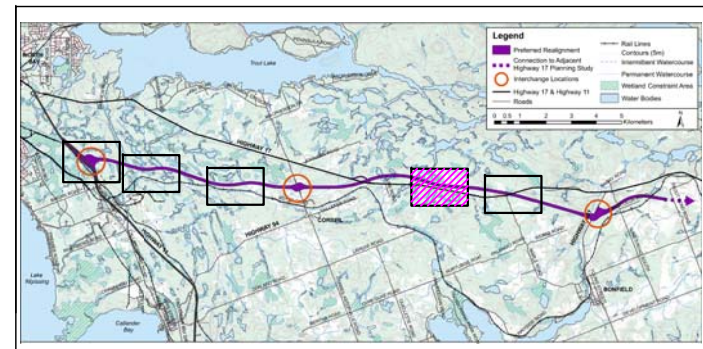
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PLAN  
SCALE







KEY PLAN

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone

Location and direction of photograph

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
107-1	228.9	5 125 972.7	325 673.6
107-2	228.9	5 125 953.3	325 743.3

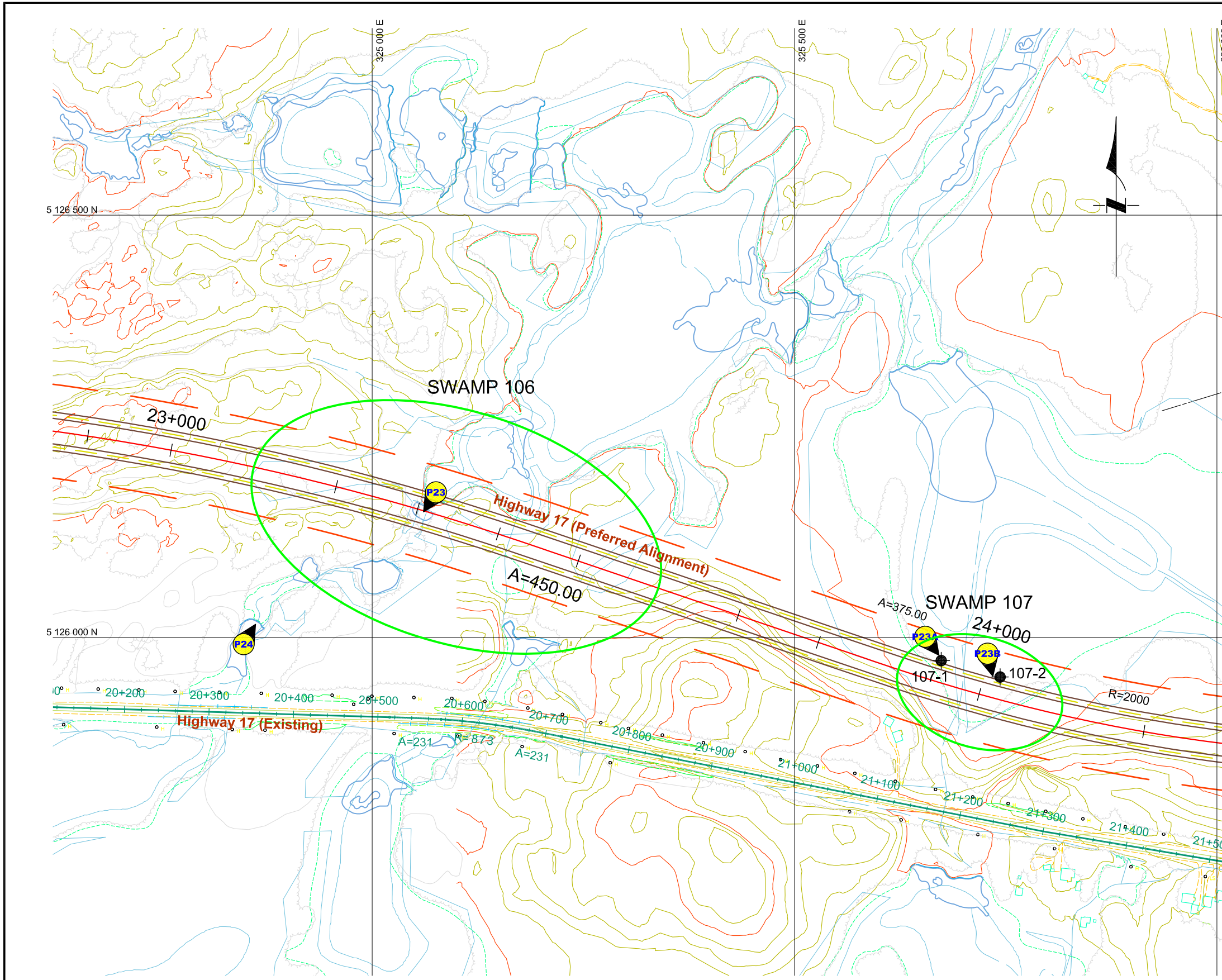
Referenced MRC Drawings: 3210158 - Hwy 17 North Bay Interchange Plans & Profile - April10, 2013.dwg; P 8086-basemap in one colour.dwg; P8086-Contour base.dwg; Street names.dwg; and Existing Highway 17.dwg

NOTE

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

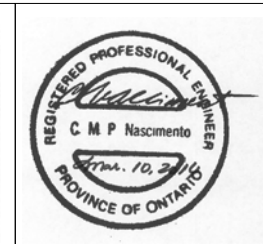
REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 31L-177				
HWY No	17	CHECKED	NSB	DIST NORTH BAY
SUBM'D	NA	CHECKED	BRG/DD	SITE
DRAWN	NA	CHECKED	BRG/DD	DWG SW-3
DATE	Mar. 10, 2014	APPROVED	CN	

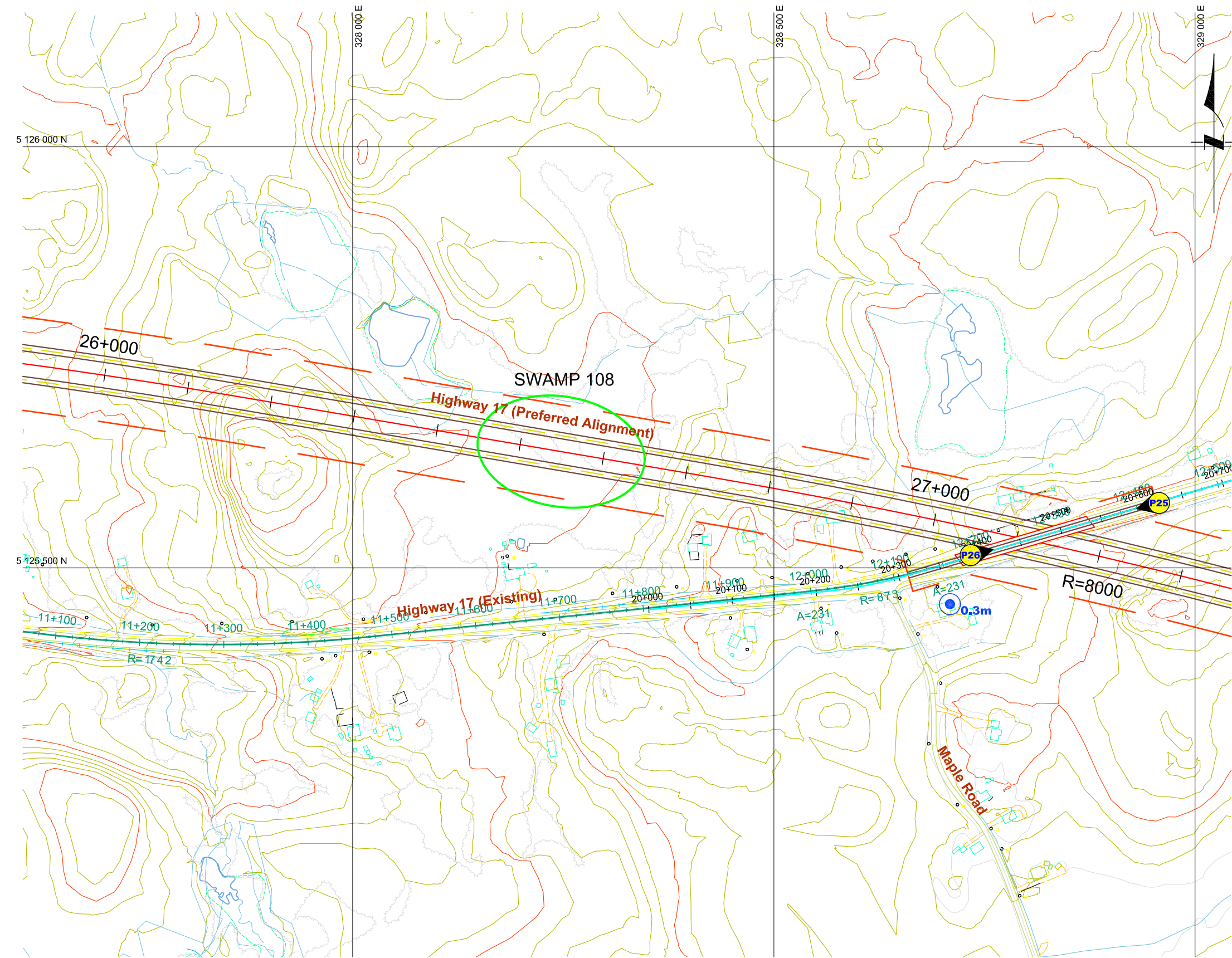


- NOTES:
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  - DIMENSIONS ARE IN METRES AND MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

PLAN SCALE





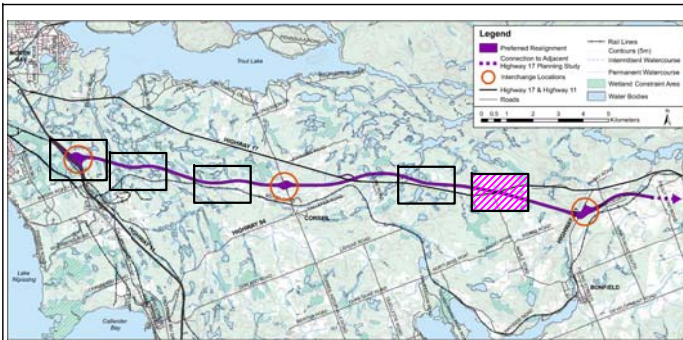


CONT No  
GWP No 5105-09-00

PREFERRED ALIGNMENT  
HIGHWAY 17 ROUTE PLANNING  
From Highway 11 South Junction to  
2.7 km east of Highway 531 about 26.0 km  
BOREHOLE LOCATIONS



SHEET



KEY PLAN

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone

Location and direction of photograph

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS

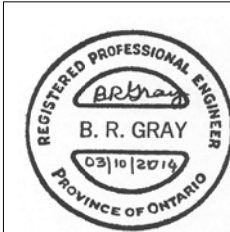
Referenced MRC Drawings: 3210158 - Hwy 17 North Bay Interchange  
Plans & Profile - April 10, 2013.dwg; P 8086-basemap in one colour.dwg;  
P8086-Contour base.dwg; Street names.dwg; and Existing Highway 17.dwg

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

NOTES:

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PLAN  
SCALE



REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 31L-177

HWY No	17	DIST	NORTH BAY
SUBM'D	NA	CHECKED	NSB
DRAWN	NA	CHECKED	BRG/DD
DATE	Mar. 10, 2014	APPROVED	CN
SITE		DWG	SW-4









HEET

The map displays the proposed rail alignment from Cambridge to Concord, New Hampshire. The alignment is shown as a dashed purple line, with a solid black line representing the existing rail line. Key features include the Concord River, Lake Umbagog, and various towns like Concord, Dover, and Portsmouth. A legend identifies symbols for rail lines, connections, interchanges, and water bodies. A scale bar indicates distances up to 5 kilometers.

### KEY PLAN

	Borehole
	Dynamic Cone Penetration Test (Cone)
	Borehole & Cone

 Location and direction of photograph

BH No	ELEVATION	CO-ORDINATES	
		NORTHINGS	EASTINGS
11-1	203.4	5 126 858.7	311 952.7
11-2	203.4	5 126 954.2	311 869.3

Referenced MRC Drawings; 3210158 - Hwy 17 North Bay Interchange  
Plans & Profile - April10, 2013.dwg; P 8086-basemap in one colour.dwg;  
P8086-Contour base.dwg; Street names.dwg; and Existing Highway 17.dwg

- 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	

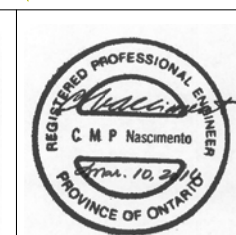
Geocres No. 31L-177

HWY No <b>17</b>		DIST <b>NORTH BAY</b>	
SUBM'D <b>NA</b>	CHECKED <b>NSB</b>	DATE <b>Mar. 10, 2014</b>	SITE
DRAWN <b>NA</b>	CHECKED <b>BRG/DD</b>	APPROVED <b>CN</b>	DWG <b>SW-5</b>

NOTES:

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PLAN  
SCALE





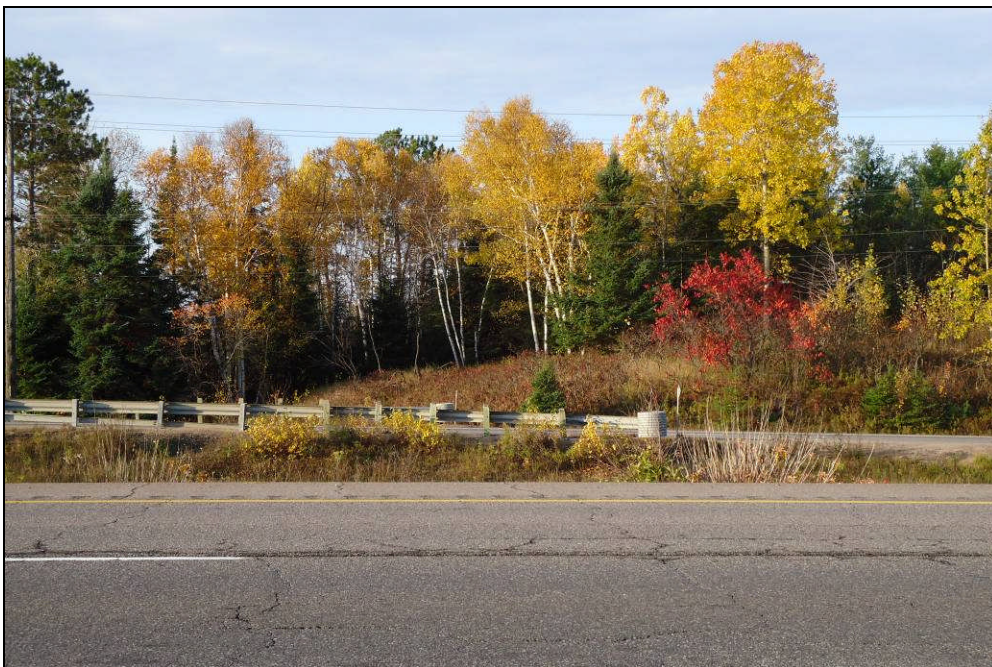
## **APPENDIX A**

### **SITE PHOTOGRAPHS**





**Photograph P1:** Looking north from east shoulder of northbound lane of Hwy 11. Hwy 17 (preferred) starting point at Hwy 11 will be located about 200 m north of above bedrock area. (October 18, 2012)

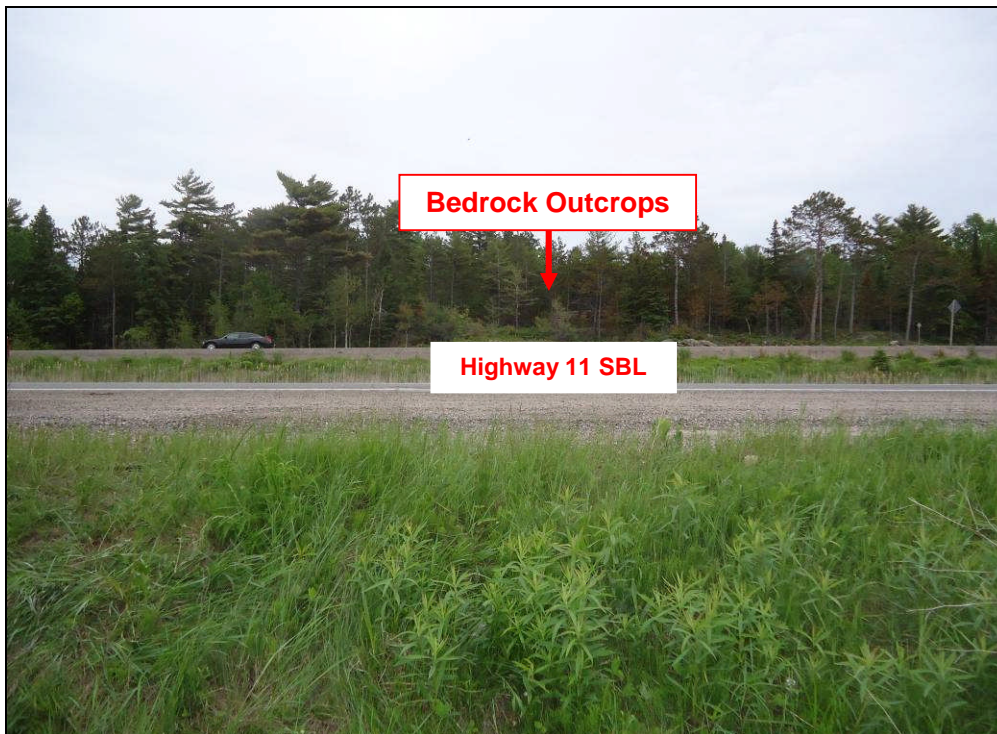


**Photograph P2:** Looking west from east shoulder of northbound lane of Hwy 11 and about 200 m south of Hwy 17 (preferred) starting point at Hwy 11. Extensive swampy areas present west of Hwy 11 and east of CNR tracks. (October 18, 2012)



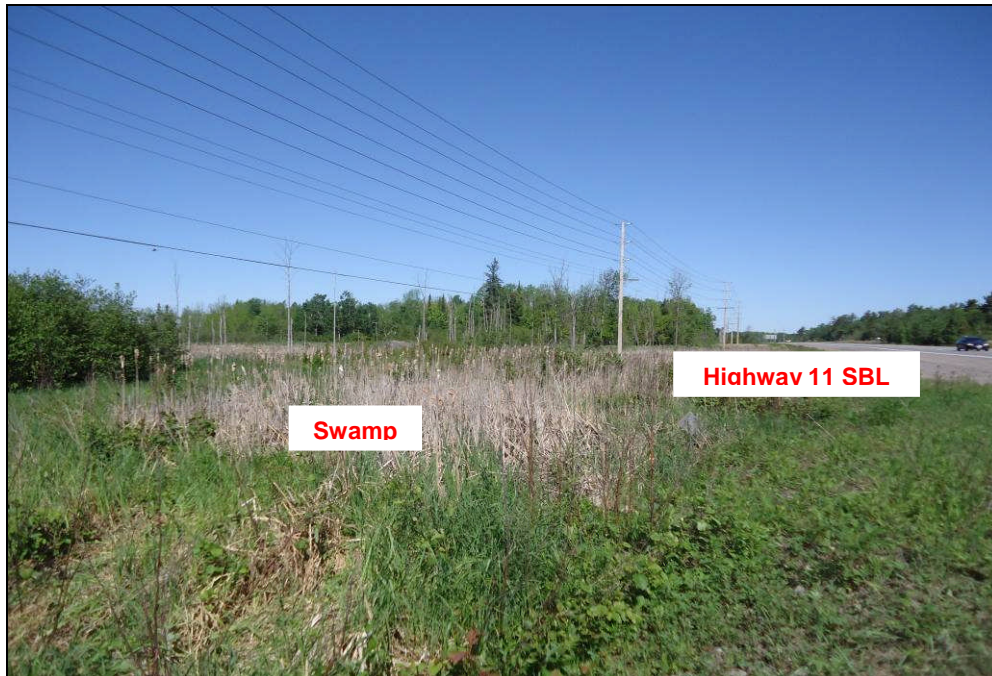


**Photograph P1A:** Looking north from west embankment slope of SBL of Highway 11. Borehole 11-1 was drilled at this location where is near the west abutment of Ramp E-S structure of Highway 11/Highway 17 interchange. (June 5, 2013)



**Photograph P1B:** Looking east from west embankment slope of SBL of Hwy 11. Bedrock outcrops near the east abutment location were observed for ramp E-S structure. (June 5, 2013)



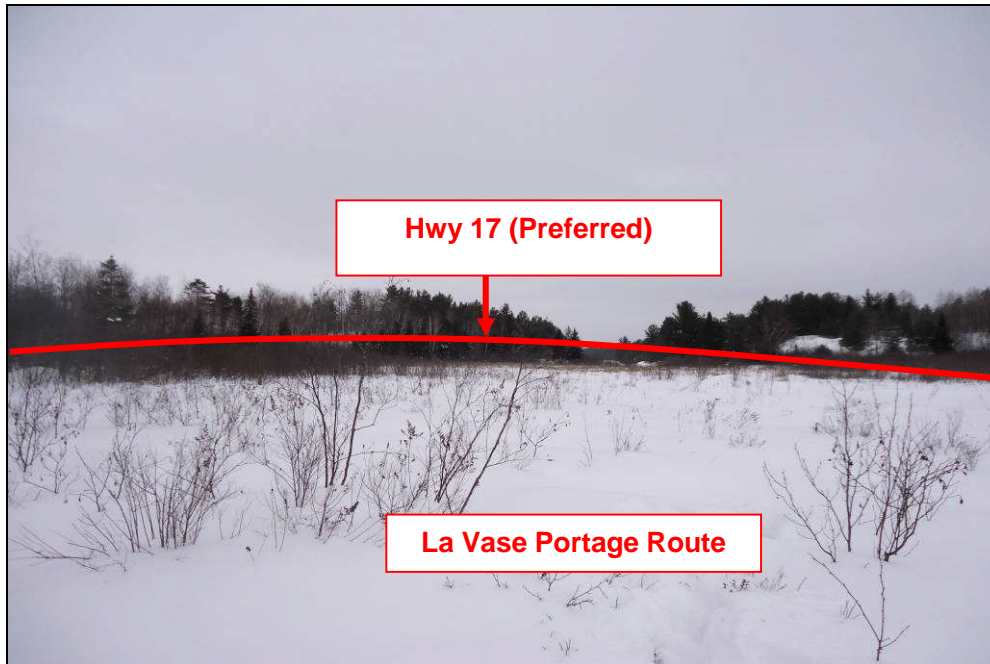


**Photograph P1C:** Looking north from west embankment slope of SBL of Highway 11. Borehole 11-2 was drilled at this location where is near the west abutment of Ramp N-E structure of Highway 11/Highway 17 interchange. (June 4, 2013)



**Photograph P1D:** Looking east from west embankment slope of SBL of Hwy 11. Bedrock outcrops near the east abutment location were observed for ramp N-E structure. (June 4, 2013)





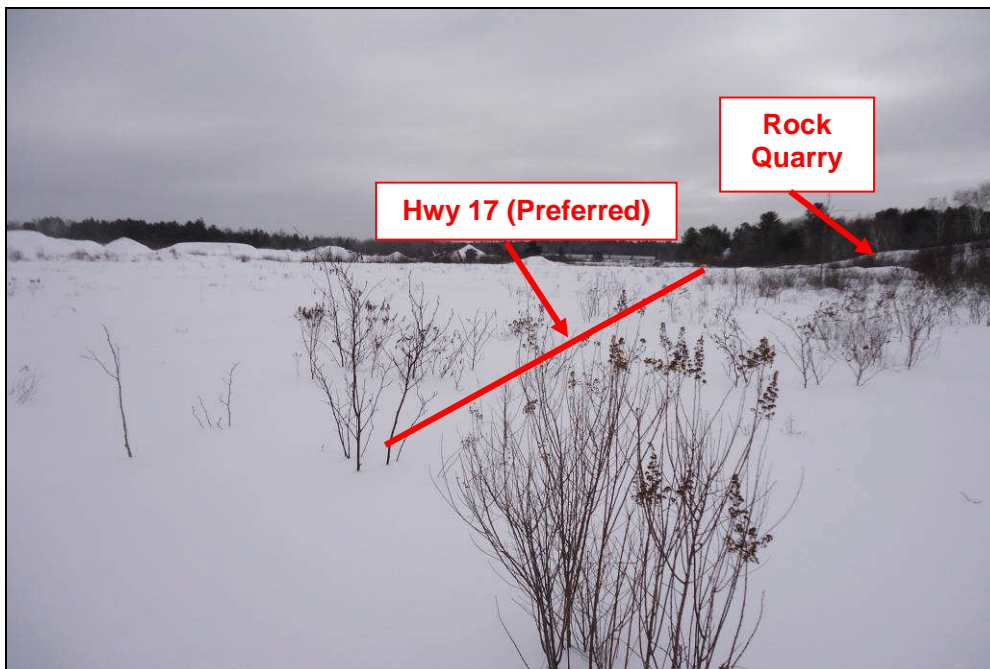
**Photograph P3:** Looking north from approximately 20 m south of Sta. 11+850. Hwy 17 (Preferred) crosses the La Vase Portage route. Structures are proposed for this crossing. (February 21, 2013)



**Photograph P3A:** Looking southeast from west bank of La Vase Portage Route. Highway 17 (Preferred Alignment) will pass La Vase Portage Route at this location. (June 3, 2013)

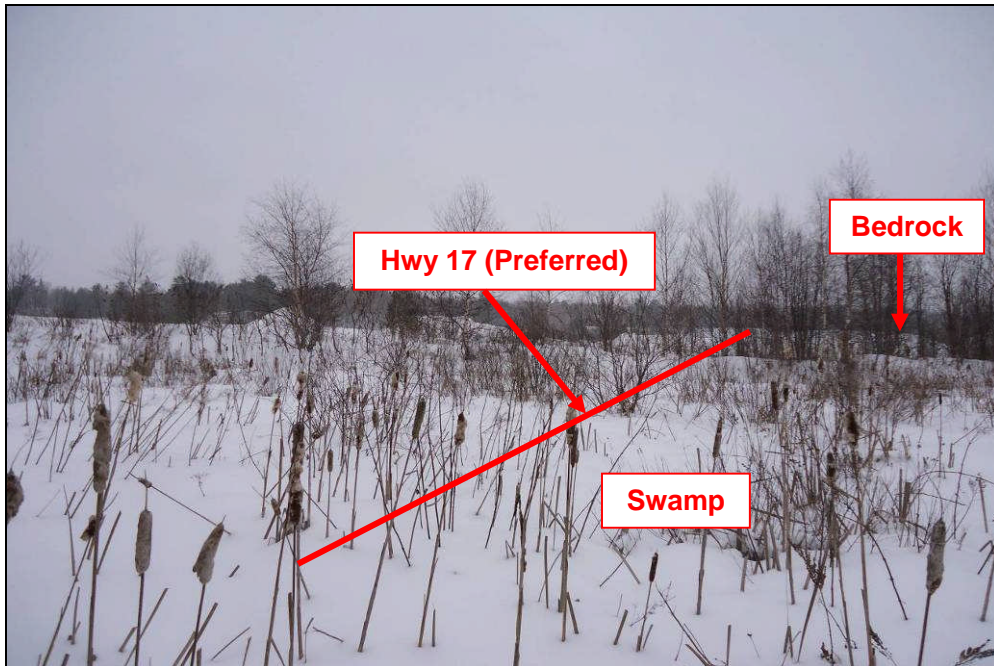


**Photograph P3B:** Looking east from west bank of a stream in La Vase Portage Route. The rock quarry is at east side of La Vase Portage Route. (June 3, 2013)



**Photograph P4:** Looking east from about 20 m east of west end of the La Vase Portage route. Active rock quarry located east of the La Vase Portage route crossing at Hwy 17 (preferred). (February 21, 2013)



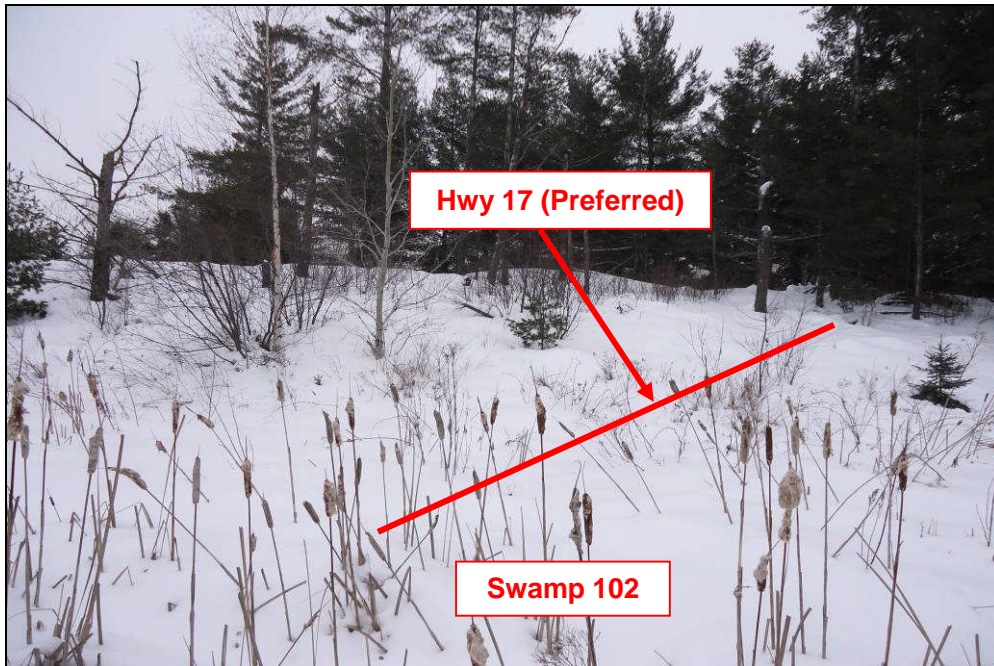


**Photograph P5:** Looking west from about Sta. 12+100 Hwy 17 (preferred) crosses swamp. (February 21, 2013)

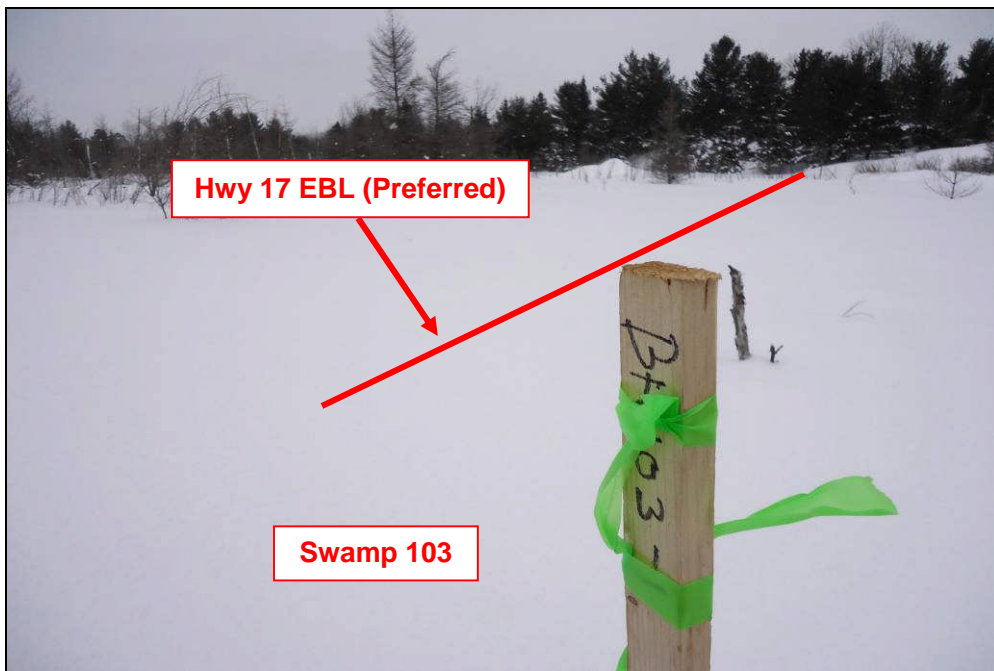


**Photograph P6:** Close up view of bedrock at west end of swamp. (February 20, 2013)

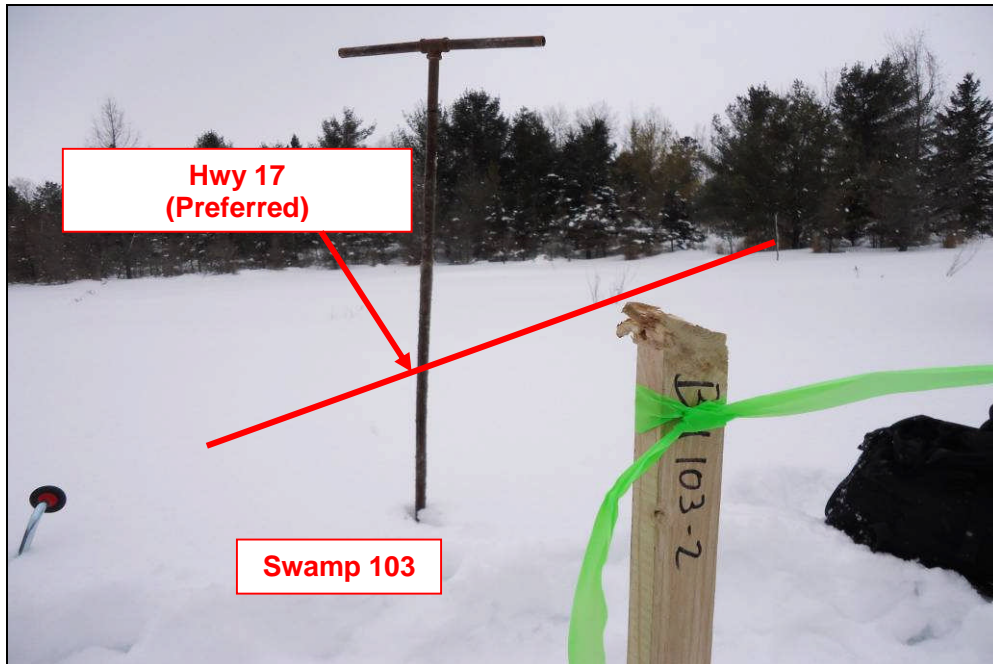




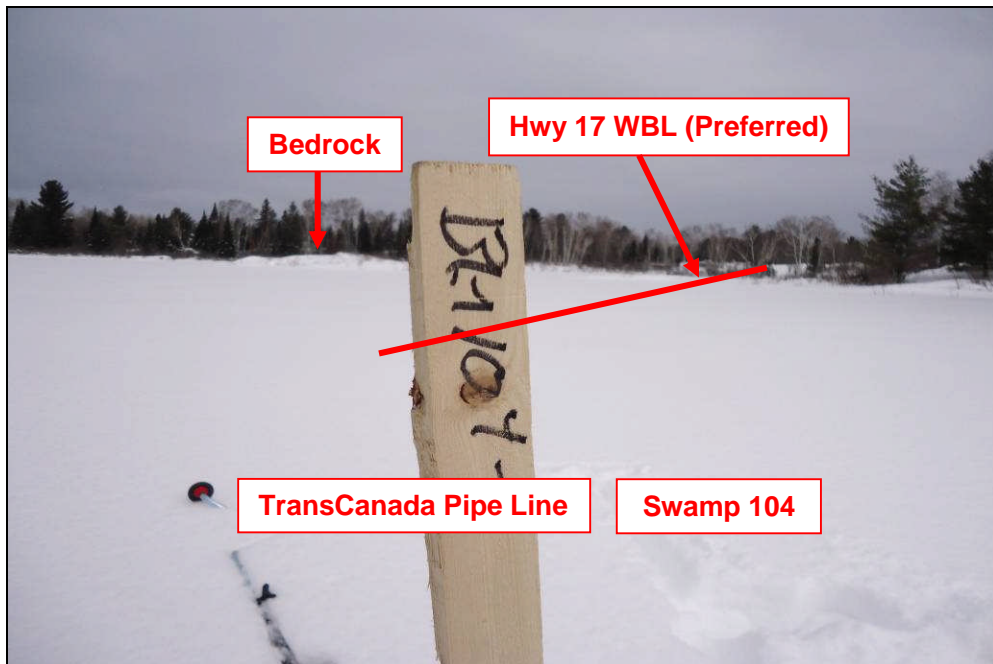
**Photograph P7:** Looking east at about Sta. 12+150. Heavily treed area is on the east end of swamp. (February 21, 2013)



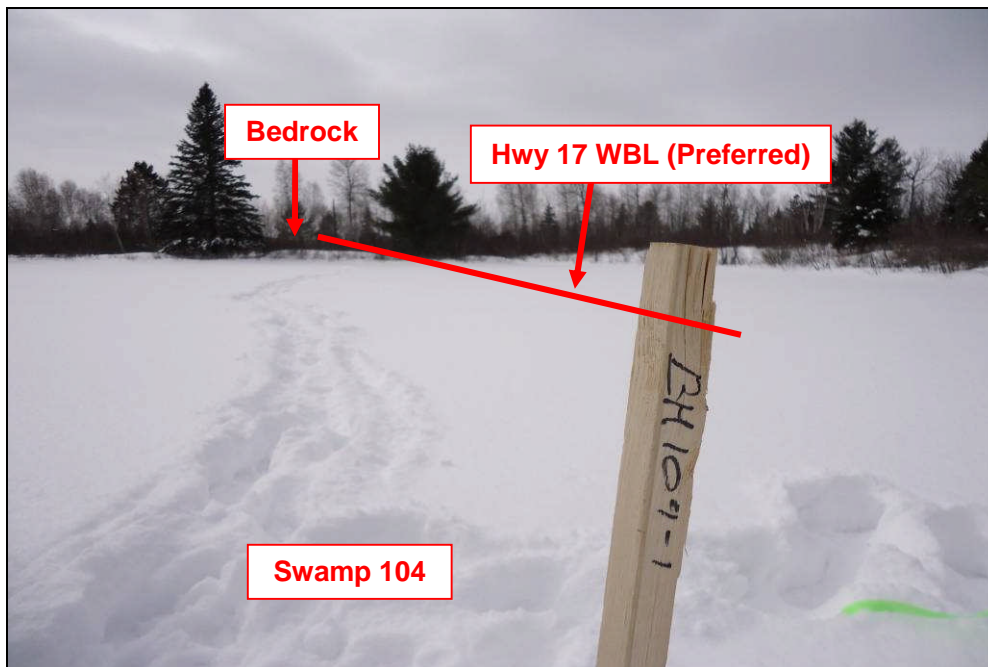
**Photograph P8:** Looking east from at about Sta. 12+380. Hwy 17 (preferred) crosses swamp 103. (February 20, 2013)



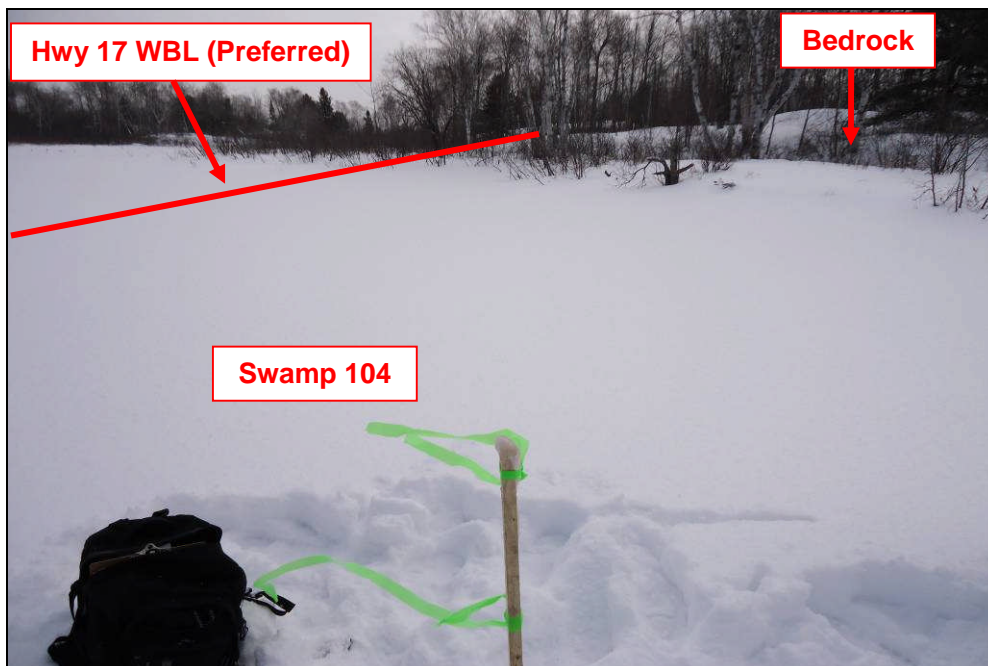
**Photograph P9:** Looking west from swamp 103, about 0.9 and 1.5 m thick peat over sandy soils. Probable bedrock was inferred by auger refusal at 1.6 and 7.2 m. (February 20, 2013)



**Photograph P11:** Looking east at about Sta. 11+920 and about 150 m east TCPL corridor, Hwy 17 (preferred) crosses swamp 104. (February 20, 2013)

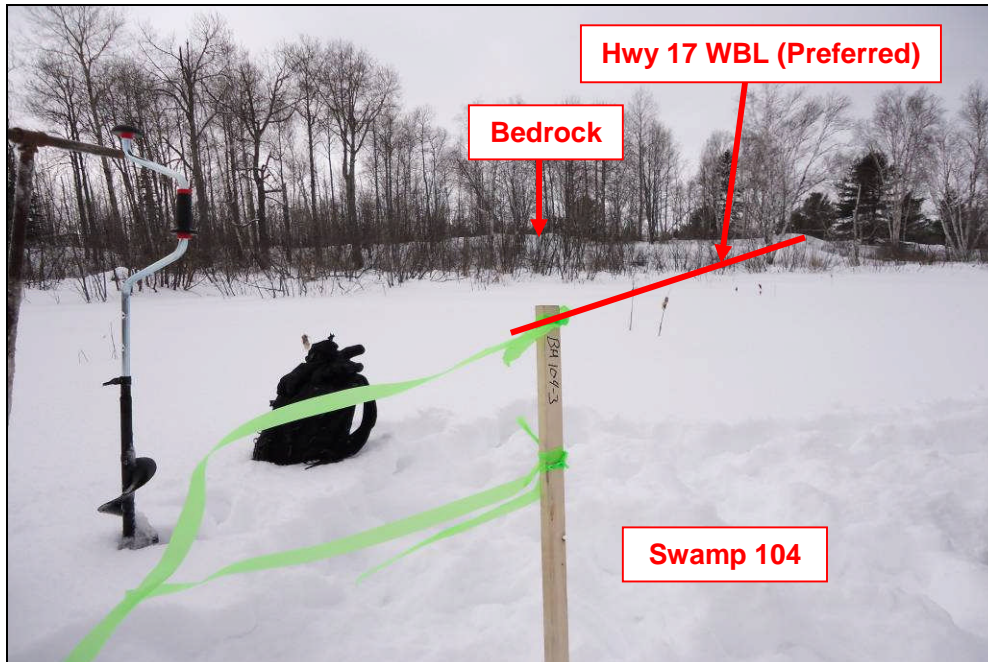


**Photograph P12:** Looking west from swamp borehole 104-1. Bedrock outcrops visible in distance. About 1.8 m thick ice and water over 2.3 m thick peat underlain sandy soils was encountered in borehole 104-1. Bedrock inferred by spoon refusal at 5.2 m. (February 20, 2013)

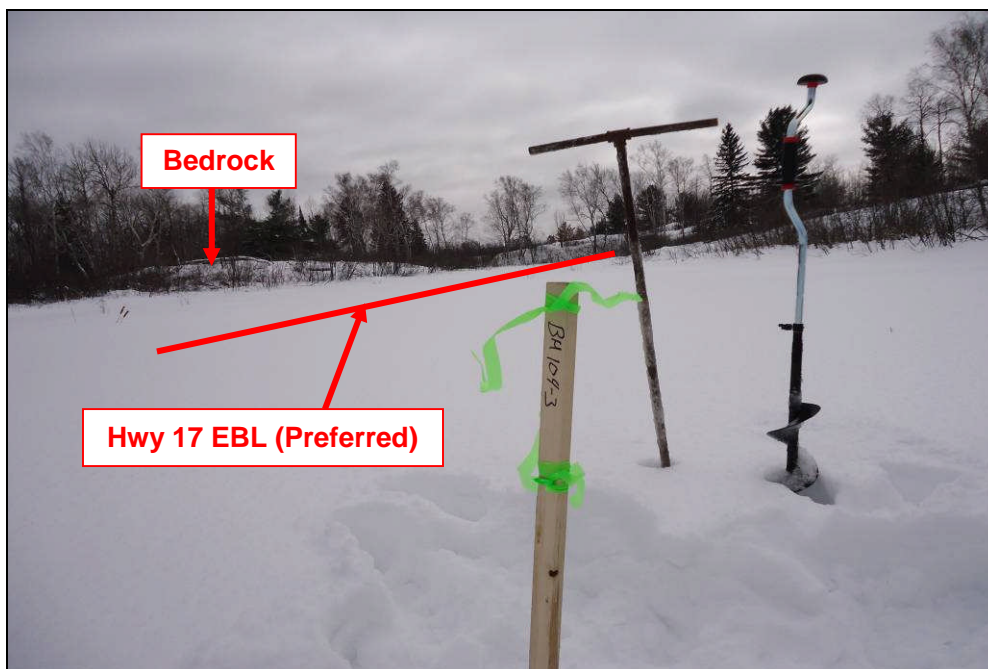


**Photograph P13:** Looking south from about 20 m north of Hwy 17 WBL (preferred) at about Sta. 13+020. About 1.8 m thick ice and water over 0.6 m thick peat underlain by sandy soils was encountered. Probable bedrock inferred by auger refusal at 4.8 m. (February 20, 2013)

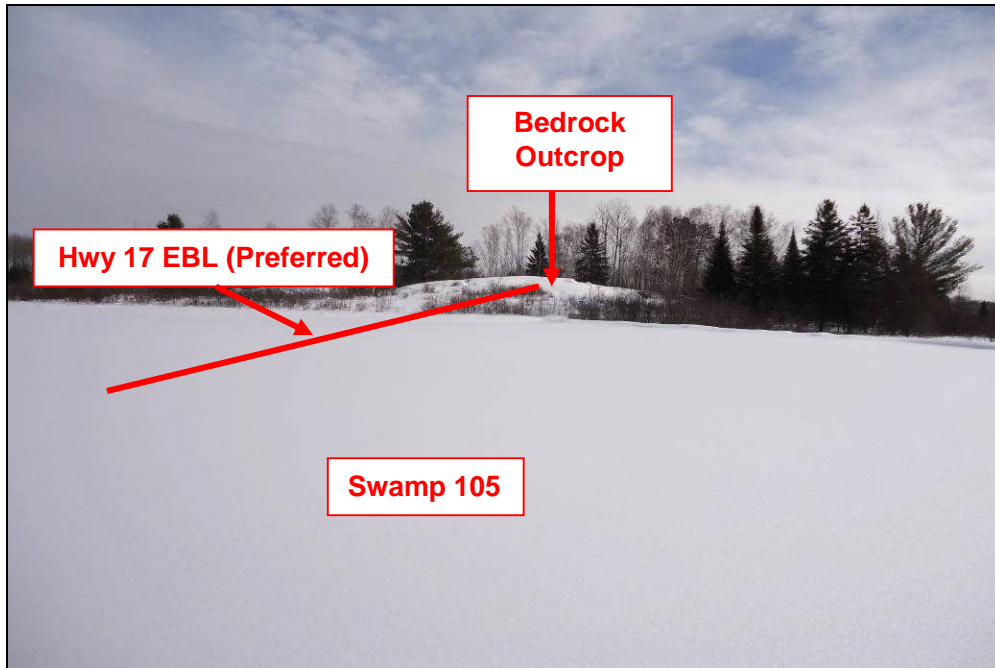




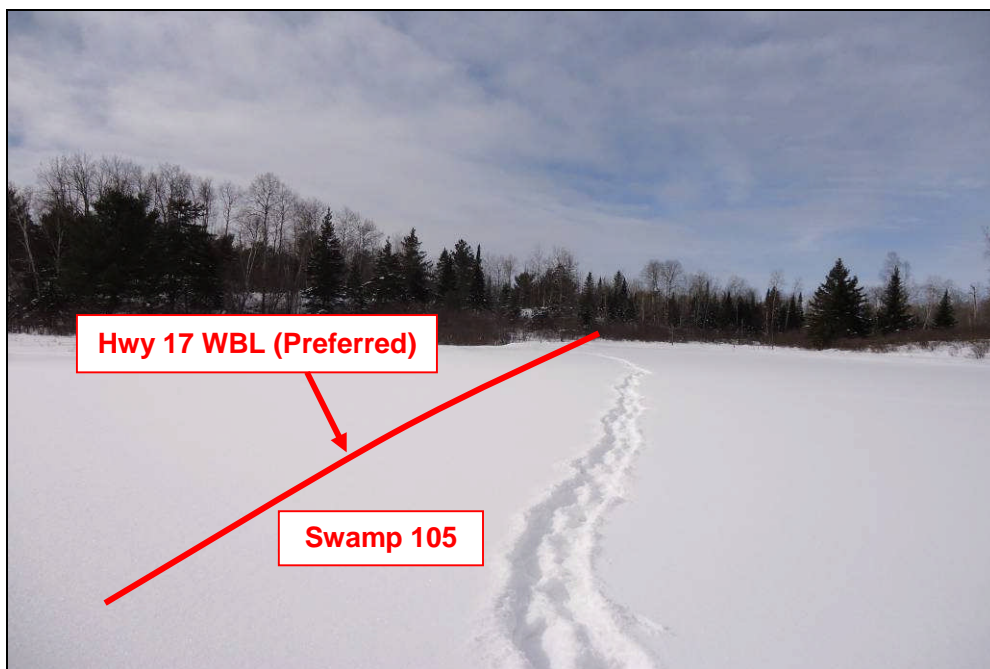
**Photograph P14:** Looking west from at about Sta. 13+120. About 0.5 m ice and water over 1.3 m thick peat underlain by sandy soils was encountered. Probable bedrock was inferred by refusal at 7.2 m. (February 20, 2013)



**Photograph P15:** Looking south from swamp borehole 104-3. (February 20, 2013)



**Photograph P16:** Looking east from at about Sta. 14+000, structure crossing is proposed. Bedrock outcrop visible at east end of the swamp. (February 22, 2013)



**Photograph P17:** Looking west from about Sta. 14+000 (preferred route chainage) along preferred Hwy 17 WBL. Structure crossing is proposed over swamp 105. No bedrock outcrop visible at west end of swamp. (February 22, 2013)



**Photograph P23:** Looking south from about Sta. 23+400 Hwy 17 WBL (preferred) crosses swamp. (February 21, 2013)



**Photograph P23A:** At location borehole 107-1 looking south. (March 10, 2013)





**Photograph P23B:** At location of borehole 107-2 looking south. (March 10, 2013)



**Photograph P24:** Beaver dam/creek between south of Hwy 17 (preferred) Sta. 23+400 and Hwy 17 (existing). (February 21, 2013)



**Photograph P25:** Looking west from north shoulder of Hwy 17 (existing) approximately 200 m east of Maple Road. Hwy 17 (preferred) east crossing is behind the cars on up to 6 m cut. (October 18, 2012)



**Photograph P26:** Looking southwest from north shoulder of Hwy 17 (Existing) at proposed Hwy17 (preferred) east crossing area. Shallow overburden up to 2m thick over bedrock based on Geotechnical Survey Data (GWP 174-98-00). (October 18, 2012)





**PRELIMINARY FOUNDATION DESIGN REPORT  
EMBANKMENTS OVER SWAMPS**

**for**

**HIGHWAY 17 ROUTE PLANNING NORTH BAY TO BONFIELD  
CITY OF NORTH BAY AND TOWNSHIPS OF EAST FERRIS AND  
BONFIELD  
DISTRICT OF NIPISSING, ONTARIO  
GWP NO. 5105-09-00**

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## TABLE OF CONTENTS

### PART B – PRELIMINARY FOUNDATION DESIGN REPORT

7. DISCUSSION AND RECOMMENDATIONS .....	15
8. SWAMP CROSSING TREATMENTS .....	15
8.1 General .....	15
8.2 New Embankment Construction Methods .....	16
9. EMBANKMENT DESIGN CONSIDERATIONS.....	20
10. CONSTRUCTION CONSIDERATIONS .....	21
11. ADDITIONAL STUDIES .....	21
12. CLOSURE .....	22

Table 1-FDR – Summary of Subsoil Conditions and Alternative Treatments

**PRELIMINARY FOUNDATION DESIGN REPORT  
EMBANKMENTS OVER SWAMPS**

for  
Highway 17 Route Planning North Bay to Bonfield  
City of North Bay and Townships of East Ferris and Bonfield  
District of Nipissing, Ontario  
G.W.P. No. 5105-09-00

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**7. DISCUSSION AND RECOMMENDATIONS**

The preferred alignment for the proposed four-laning Highway 17 is entirely in new alignment. MRC provided drawings of the preferred alignment horizontal and vertical profiles (for preferred alignment median) in December 2012 and made some minor changes to the preferred route alignment in April 2013. The height of the embankment of the preferred alignment through the swamps ranges from a 2 m to 16 m.

A summary of the subsoil conditions and preliminary discussions and recommendations embankments for each swamp investigated is provided in Table 1 – FDR. The interpretation and recommendations in this report are intended for preliminary planning purposes only and to provide the information necessary for the feasibility study. Additional fieldwork and analysis are required for design. Any comment concerning on construction is provided only to highlight those aspects which could affect the preliminary design of the project.

**8. SWAMP CROSSING TREATMENTS**

**8.1 General**

The construction method for each section of the roadway embankments under consideration was reviewed and recommended primarily using the following criteria.

- i) Post-construction settlement of the embankment surface due to settlement of the earth fill and consolidation of subgrade material to be acceptable (March 2, 2010 Guidelines)
- ii) Stability of the embankment fill
- iii) Stability of excavation slopes
- iv) Maximum practical depth of excavation for the "long stick" excavator is 12 m, if required



The selection of the preferred treatment option for each swamp will require further investigation and design analysis during future preliminary or detail design in order to determine the horizontal and vertical extents of soft materials under the plan limits of the proposed highway embankments and to provide recommendations for design and construction of the embankments.

The stable inclination of the embankment fill slope as well as the magnitude of post-construction settlement of the embankment surface and time required for essential completion of primary consolidation for each treatment option are dependent on the embankment height, the composition of the subgrade soil as well as the thickness and pertinent engineering properties of the clayey subgrade soil for those treatment options that do not call for full-depth excavation. The stability and settlement of these soil layers under the proposed embankment were discussed in the previous sections of this report. The following sections provide a review of each embankment foundation area and recommend the mitigation treatment option, as required.

The existing topsoil, peat and very soft cohesive soils are highly compressible and generally not adequate to support the weight of the embankment to be placed. Excavation of the surficial peat/topsoil and organic deposits is a requirement for all construction methods.

The cohesionless soils underlying the clayey soils such as, silts and sands are considered to be competent and capable of supporting the proposed earth fill embankments. As such, the loose silty/sandy soils may be left in place since settlement of these materials occurs rapidly and during construction.

## **8.2 New Embankment Construction Methods**

Several alternative methods of construction are available for the construction of the new embankments and were considered for this project. A summary of the methods, their general advantages and disadvantages is provided in the following table.



ALTERNATIVE EMBANKMENT CONSTRUCTION METHOD		ADVANTAGES	DISADVANTAGES
Option 1	Full excavation (Involves removing all compressible cohesive soils and replacement by rockfill)	<ul style="list-style-type: none"> <li>- Standardized MTO method of embankment construction</li> <li>- Reduced and predictable long-term settlements</li> </ul>	<ul style="list-style-type: none"> <li>- Requires disposal of excavated soil</li> <li>- May cause instability of existing embankments for twinning sections</li> </ul>
Option 2	Preloading and/or surcharging (Leaves compressible cohesive soils in place and allows for preloading and/or surcharging to reduce post-construction settlements)	<ul style="list-style-type: none"> <li>- Disposal of excavated soil not required</li> <li>- Reduction of long-term settlements</li> </ul>	<ul style="list-style-type: none"> <li>- Requires a long construction period</li> <li>- Post-construction settlement may be excessive</li> <li>- At some areas, it may require toe berms or minimum soil strength for surcharging</li> </ul>
Option 3	Partial excavation and preloading / surcharging (The upper zones of compressible cohesive soils are excavated and replaced with rockfill followed by a preloading or surcharge period)	<ul style="list-style-type: none"> <li>- Reduced disposal of excavated soil</li> <li>- Maintains stability of existing embankment on twinning construction</li> <li>- Reduction of long-term settlements</li> </ul>	<ul style="list-style-type: none"> <li>- Requires a long construction period</li> <li>- Large post-construction settlement possible</li> <li>- At some areas, it may require minimum soil strength for surcharging</li> <li>- Time to complete estimated settlements may be exceeded leading to delay of construction schedule</li> </ul>
Option 4	Construction of a bridge to span the area / compressible soil	<ul style="list-style-type: none"> <li>- No post-construction settlements on bridge section</li> </ul>	<ul style="list-style-type: none"> <li>- Typically too costly and impractical</li> <li>- Differential settlement of approach embankments needs to be engineered</li> </ul>
Option 5	Lengthening the construction schedule and/or advance contracts to increase the time period between construction of the embankment and construction of the roadway pavement	<ul style="list-style-type: none"> <li>- Reduced disposal of excavated soil</li> <li>- Reduced post-construction settlements</li> </ul>	<ul style="list-style-type: none"> <li>- Requires a long construction period</li> <li>- Post-construction settlement possible</li> </ul>



ALTERNATIVE EMBANKMENT CONSTRUCTION METHOD	ADVANTAGES	DISADVANTAGES
Option 6    Use of lightweight fill to minimise the stress imposed on the underlying soil (independently and in conjunction with surcharging and/or wick drains)	<ul style="list-style-type: none"> <li>- Reduced disposal of excavated soil</li> <li>- Can be constructed over weak soils</li> </ul>	<ul style="list-style-type: none"> <li>- Requires prior treatment of reduce or eliminate excessive embankment settlement to avoid damage to the EPS</li> </ul>
Option 7    Installation of wick drains to increase the rate of consolidation and minimise the magnitude of post-construction settlement	<ul style="list-style-type: none"> <li>- Reduced disposal of excavated soil</li> <li>- Maintain stability of existing embankment</li> <li>- Reduction of long-term settlements</li> </ul>	<ul style="list-style-type: none"> <li>- High mobilization charges for one fill area</li> <li>- Not practical for shallow compressible deposits</li> <li>- Very weak deposits may require a long and/or staged construction period</li> <li>- Potential additional costs due to inaccurate prediction of expected progress of settlement</li> </ul>

Selection of the preferred alternative will require more information on the horizontal and vertical extent of soft materials under the plan limits of the proposed highway embankments. The ultimate solution will probably consist of a practical combination of various options. For example, Option 1 may be preferable at locations where the depth of soft material to be excavated can be verified to be less than the practical depth of excavation (up to 5 m), while the other options, such as Options 6 and/or 7 may be considered for deeper deposits of soft material depending on the circumstances such as cost and construction schedule.

Option 1 (full excavation) is a standard method employed by MTO in areas with low strength compressible soils that are not so deep as to complicate excavation. It involves the excavation of weak and soft ground down to competent material where practical and backfilling the excavation with rockfill following the procedures stipulated in OPSD 203.010. This method would probably be the most practical approach where feasible. However, where full excavation is not feasible, other options may be considered. In this case, the selection of the preferred treatment option would also be influenced by the soil profile at the particular area, environmental considerations, the accepted post-construction performance (settlement), design requirements, the construction schedule, construction constraints and economic considerations.



Preliminary recommendations for planning of the embankment fills at selected sites are provided in Table 1-FDR: Summary of Subsoil Conditions and Alternative Treatments.

Further investigation and analysis should be carried out during future preliminary or detail designs.

Embankment construction through swamps (for ramps Highway 11/ Highway 17 interchange) located west Highway 11 SBL may require non-standard design and construction involving partial excavation and surcharging or wick drains, lightweight fill to accomplish the preferred alignment selected. In addition, these swamps are located between the existing CNR corridor and Highway 11 SBL. Further investigations should be carried out during detail design.

For planning purposes, it may be assumed that rockfill should be placed in accordance with OPSS 206 and OPSS 209. Settlement of the embankment fill surface both during and following completion of construction due to 'consolidation' of the rockfill is likely to occur. Settlement of the rockfill should be calculated based on the latest MTO directive dated September 14, 2010 'Post-Construction Rockfill Settlement and Guidelines for Estimating Rockfill Quantity'. The magnitude of the rockfill settlements depends on the preferred/selected treatment for the swamps. In addition, longitudinal and transverse post-construction differential settlement of embankment should be checked for conformance with MTO guidelines 'Embankment Settlement Criteria for Design' dated March 2, 2010. These settlements should be evaluated during future preliminary or detail design.

Non-conventional construction procedures may be required to reduce post-construction settlements to tolerable levels, such as the use of lightweight fill, wick drains and/or preloading.

The impact on the regional hydrogeology by changes made to the natural groundwater level by installation of wick drains could be a consideration. Further, lightweight fill is not locally available and would require a considerable transportation cost, which could have adverse impacts on both air quality and non-renewable resources.



## **9. EMBANKMENT DESIGN CONSIDERATIONS**

The embankments would likely be comprised of rockfill and occasionally of earth fill since the fill will be generated through cuts along the preferred alignment. Conventional embankment design and construction procedures for rockfill and /or earth fill embankment should be suitable.

Embankments placed on competent material should be constructed in accordance with OPSD 202.010, OPSD 203.010, OPSD 203.020, OPSD 203.030, OPSS 206 and OPSS 209. The embankments should be made of noncohesive fill such as rockfill in fill sections requiring construction below the water table in swampy areas. Where earth fill is placed on rockfill, the two fill types should be separated by a layer of geotextile layer should be included between two fill types. Also, the top of rockfill line should be carried at least 1.0 m above the water level in the swamps where earth fill used over rockfill to construct the embankments. The side slopes of the embankments should be inclined no steeper than 2H:1V for earth fill and 1.25H:1V for rockfill.

A 2 m wide mid-height bench should be provided where the design slope height of embankments is more than 8 m for earth fill and 10 m for rock fill. The embankment firm base founding platforms should extend at least 1 m beyond each toe (the outer edge of the fill at the base founding level) for embankments founded on bedrock, 2 m beyond each toe for embankments founded on firm bottom, and more than 2 m beyond each toe if required to satisfy the platform width requirements resulting from post-construction settlements called for in Northern Region Engineering Directive NRE 98-200.





## **10. CONSTRUCTION CONSIDERATIONS**

It is anticipated that the typical embankment construction for the swamps 102 to 105 less than 10 m deep will be accomplished with conventional excavation and preloading methods. These swamps typically contain organics over sandy soils mantling the bedrock. However, it should be noted that these swamps are open water wetlands extending over relatively large areas and the slope of these new embankments will extend into the open water. Particular attention will be required for the design and construction of these embankments to address deep excavation to remove organic materials, densification of significant depth of rockfill placed below water and the need for preloading/surcharging to reduce post construction settlement and enhance overall performance.

Special construction methods will be required for swamp located west of Highway 11 SBL. It should be further analysed when final grade profiles becomes available.

## **11. ADDITIONAL STUDIES**

The recommendations in this report are for preliminary planning purposes only and are based on interpretations of site reconnaissance and limited ground proofing investigations. Detailed foundation investigations will be required for each of the swamps and high fill crossings during the detailed design phase of the project. In particular, the depth and extent of organic/soft/wet soils in swamps and low-lying areas should be investigated in further detail.



## 12. CLOSURE

This report was prepared by Mrs. N.S Balakumaran, P. Eng. and reviewed by Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact, and Mr. D. Dundas, P.Eng., Senior Engineer. Mr. C.M.P Nascimento P.Eng., Project Manager conducted an independent review of the Report.

Yours very truly,

Peto MacCallum Ltd.



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**TABLE 1-FDR**  
**SUMMARY OF SUBSOIL CONDITIONS AND ALTERNATIVE TREATMENTS**

SWAMP AREA NO.	STA. TO STA. (Note 1)	MAXIMUM FILL HEIGHT (m) (Note 2)	DEPTH TO FIRM BOTTOM (m) (Note 3)	DEPTH TO PROBABLE BEDROCK (m) (Note 4)	SOIL PROFILE	ALTERNATIVES			
						A - EXCAVATION		B - 2 m SURCHARGE/P RELOAD (3 MONTH PERIOD)	C - OTHER TREATMENT AND NOTES
						OPSD	EXCAVATION DEPTH (m)		
101	11+500 to 11+800	5			In the sole borehole advanced, the overburden was composed of sands and silty sands	To be determined during detail design	May be minimal but actual requirement needs to be determined during detail design	Probably not required except at immediate approaches to abutments of structure	May need to preload immediate approaches to abutments in order to minimize differential settlements at that location
102	12+075 to 12+225	4	Note 5	>1.5	1.5 m thick peat was encountered and test hole terminated with in peat layer. Active rock quarry located at the west of the swamp at the time of investigation	To be determined during detail design	>1.5 and potential to be considerably deeper	May be required	Probably not required
103	12+350 to 12+650	6	0.9 and 1.2	1.6 and 7.2	0.4 to 0.9 m thick peat over cohesionless loose to very dense sand over probable bedrock. The probable bedrock was inferred on refusal at 1.6 and 7.2 m. Up to 0.8 m of ice and water encountered.	OPSD-203.010	Probably in the order of 2m	May be required	Probably not required
104	12+850 to 13+200	4	1.8 to 4.1	0.0 to 7.2	0.1 to 2.3 m thick peat over cohesionless sand/silty sand mantling the probable bedrock. The probable bedrock was encountered at 0.5 to 7.2 m. Bedrock was exposed in two test holes. Up to 1.8 m thick ice and water encountered.	OPSD-203.010	Probably less than 5m variable depth	May be required	Probably not required



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						A - EXCAVATION		B - 2 m SURCHARGE/P RELOAD (3 MONTH PERIOD)	C - OTHER TREATMENT AND NOTES
						OPSD	EXCAVATION DEPTH (m)		
105	13+950 to 14+300	6	Note 5	>1.4	Up to 1.2 m thick of ice and water encountered. 0.1 to 0.2 m thick of peat encountered below the ice and water. Test holes terminated within the peat.	To be determined during detail design	>1.4 and probably considerably deeper	Probably required	Probably not required
106	23+100 to 23+600	3	Note 6					May be required	• Partial excavation and surcharging may be an option.
107	23+900 to 24+100	2	> 1.5	>1.5	0.5 m thick ice and water encountered. 0.2 m thick topsoil over soft silty clay encountered at least up to 1.5 m in one test hole and silty sand with clay in one test hole.	To be determined during detail design	>1.5	May be required	• Partial excavation and surcharging may be required.
108	26+450 to 26+650	3	Note 6					May be required	• Partial excavation and surcharging may be an option.



**TABLE 1-FDR**  
**SUMMARY OF SUBSOIL CONDITIONS AND ALTERNATIVE TREATMENTS**

SWAMP AREA NO.	STA. TO STA. <small>(Note 1)</small>	MAXIMUM FILL HEIGHT (m) <small>(Note 2)</small>	DEPTH TO FIRM BOTTOM (m) <small>(Note 3)</small>	DEPTH TO PROBABLE BEDROCK (m) <small>(Note 4)</small>	SOIL PROFILE	ALTERNATIVES			
						A - EXCAVATION		B - 2 m SURCHARGE/P RELOAD (3 MONTH PERIOD)	C - OTHER TREATMENT AND NOTES
						OPSD	EXCAVATION DEPTH (m)		
Highway 11 / Highway 17 Interchange Ramps									
E-S Ramp	50+250 to 50+450	10	8.5	17.9	100 mm topsoil over 0.8 m thick loose sand over 7.6 m thick soft clayey soils underlain by loose to dense sand. Probable bedrock was inferred on auger refusal at 17.9 m.	To be determined during detail design	To be determined during detail design	Probably required	Other possible options are <ul style="list-style-type: none"><li>• Partial excavation and surcharging.</li><li>• Wick drains and surcharging</li></ul>
N-E Ramp	40+300 to 40+600	16	7.2	20.6	100 mm topsoil over 1.3 m thick loose to very loose sand over 5.8 m thick soft to firm clayey soils underlain by very loose to very dense silty sand/sand. Probable bedrock was inferred on auger refusal at 20.6 m.	To be determined during detail design	To be determined during detail design	Probably required	Other possible options are <ul style="list-style-type: none"><li>• Partial excavation and surcharging.</li><li>• Wick drains and surcharging</li></ul>

- NOTES:** (1) Area limits provided may change for final alignment of the highway.  
(2) Fill height based on longitudinal profile provided by MRC dated April 2013.  
(3) Depth to firm bottom (bottom of organics or clayey deposits) measured from top of ice/water or ground surface in boreholes.  
(4) Depth of probable bedrock was based on limited boreholes.  
(5) Auger probes were only carried out due to thin ice conditions and terminated at 1.2 m. Based on the desktop study, organics over silty/sandy soils anticipated.  
(6) Drilling was not carried out due to local flooding conditions for swamp 106 and no permission to enter was obtained for swamp 108.