

## **Foundation Investigation and Design Report**

Chippewa Creek Culvert  
Rehabilitation  
Site No. 46-362, Highway 11,  
North Bay, ON

G.W.P. 5144-06-00

Geocres No. 3IL 189



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Ministry of Transportation Ontario

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Project No. 165000836

February 2016

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# FOUNDATION INVESTIGATION AND DESIGN REPORT

February 2016

## FOUNDATION INVESTIGATION REPORT

For

G.W.P 5144-06-00

Geocres No. 41L-189

Chippewa Creek Culvert Rehabilitation,

Site No. 46-362, Highway 11

North Bay, Ontario

## 1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to complete a foundation investigation of the Chippewa Creek Culvert on Highway 11 at Station 14+577, north of North Bay, Ontario. The foundation investigation is required to support the design for the rehabilitation of the Chippewa Creek Culvert. Specifically, a stone wall section of the culvert is failing and it is proposed to build a new concrete box liner to rehabilitate the poor performing section. The northing and easting coordinates of the culvert are found in Table 1-1 below.

**Table 1-1: Coordinates of Chippewa Creek Culvert on Highway 11, north of North Bay, ON (MTM Zone 10)**

Culvert Name	Easting	Northing
Chippewa Creek Culvert	307401.7	5136644.9

This Foundation Investigation Report has been prepared specifically and solely for the foundation analysis of the Chippewa Creek Culvert at Station 14+577 on Highway 11.

Project Number: G.W.P. 5144-06-00, Geocres No. 41L-189

Project Location: Highway 11, Station 14+577, approximately 4.6 km north of the intersection of Highway 17 and 11, north of North Bay, Ontario

## **2.0 SITE DESCRIPTION AND GEOLOGY**

### **2.1 SITE DESCRIPTION**

#### Site Location

The site location is shown on the Key Plan inset to Drawing No. 1, provided in Appendix A. The existing Chippewa Creek Culvert crosses beneath Highway 11 at Station 14+577, approximately 4.6 km north of the intersection of Highway 17 and 11. Photographs showing the general site conditions of the culvert are provided in Appendix A.

#### General Site Description

Highway 11 runs north to south at the project location; chainage increases in the southern direction. In the vicinity of the culvert, Highway 11 has a four lane cross-section and approximately 3 m wide shoulders with cable guide rails.

Chippewa Creek flows beneath Highway 11, via the culvert, from west to east. The road embankment has side slopes of approximately 2H: 1V. The paved surface of the highway is approximately 5.0 m higher than the ground surface on both sides of the road. The area beyond the water course is covered with brush and trees. Site photographs are shown in Appendix A.

#### Existing Culvert

The existing culvert is a combination of precast concrete box culvert, concrete culvert, and concrete slab with stone walls. The 5.0 m long section of concrete slab with stone walls is the major poor performing area of the culvert. The culvert has a width of 3.0 m and a length of 45.7 m. The culvert is covered with approximately 3.0 m of fill.

The approximate alignment of the existing culvert is shown on Drawing No. 1 in Appendix A. The dimensions and preliminary proposed rehabilitation of the culvert are shown in Drawing No. P1 in Appendix A.

### **2.2 SITE GEOLOGY**

#### Physiographic Description

The project site is located within the Canadian Shield. Soil and bedrock rock mapping published by the Ontario Geological Survey suggests that the subsurface conditions at the site consist of gravel and sand of glaciofluvial origin underlain by Mesoproterozoic migmatitic rock and gneisses of the Grenville Province's Central Gneiss Belt.

## **3.0 INVESTIGATION PROCEDURES**

### **3.1 REVIEW OF PREVIOUS INVESTIGATION**

A review of the 1996 'WP 25-84-01, Chippewa Culvert Replacement Hwy. 11, District 54, North Bay' memorandum suggests that the surficial geology of the site consists of sand and silt fill, over an organic sand layer, over silty sand deposits. The depth of bedrock was found to be 11.2 to 13.3 m below the grade of the highway. The groundwater depth was recorded at approximately 5 m below the grade of the highway.

### **3.2 FIELD INVESTIGATION – CULVERT SITE**

A field investigation consisting of two boreholes was carried out for this assignment. The boreholes were designated BH15-1 and BH15-2 and their locations are shown on the Borehole Locations and Soil Strata, Drawing No.1 in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of public utilities.

The field drilling program was carried out on May 21, 2015. The two boreholes (BH15-1 and BH15-2) were advanced with 'NW' size casing using a rubber tire CME 550 drill rig equipped for soil and bedrock sampling. The drill rig was owned and operated by Landcore Drilling of Chelmsford, ON.

The subsurface stratigraphy encountered in each borehole was recorded in the field by experienced Stantec personnel. Split spoon samples were collected at regularly spaced intervals (typically every 760 mm) during the course of Standard Penetration Testing (ASTM D1586). All samples recovered were returned to Stantec's Ottawa laboratory for detailed classification and testing.

Boreholes were backfilled with auger cuttings mixed with bentonite and topped with cold patch asphalt.

A site reconnaissance was carried out on May 14, 2015, by Zachary Popper, P.Eng., of Stantec to observe the condition of the culvert and the soil sediment inside the culvert. Photographs from the site visit are presented in Appendix A. Soil samples were collected from the interior of the culvert, the creek bed, and beside the creek by hand auger and shovel.

### **3.3 LOCATION AND ELEVATION SURVEY**

The borehole locations and geodetic elevations were surveyed in the field by Stantec personnel using a Trimble Geo XH GPS. The elevations are accurate to 0.1 m. Table 3.1 summarizes the borehole information.

**Table 3-1: Borehole Summary**

	Boreholes	
	BH15-1	BH15-2
MTM Zone 10 Coordinates		
Northing	5136651	5136639
Easting	307402	307402
Approximate Station	14+572	14+584
Ground Surface Elevation, m	311.9	311.8
Total Depth Drilled, m	10.5	10.5
End of Borehole Elevation, m	301.4	301.3
Depth of Casing, m	9.9	9.9
Number of Soil Samples	13	14

### 3.4 LABORATORY TESTING

All samples were taken to the Stantec Ottawa laboratory where they were subjected to a detailed visual examination by a Geotechnical Engineer. Selected soil samples underwent gradation analysis and moisture content testing. The laboratory testing summary is shown in Table 3.2 below.

**Table 3-2: Laboratory Testing for Culvert Site**

Laboratory Testing	Moisture Content	Gradation Analysis
Number of Tests	34	10

Note: Moisture content includes seven samples from the culvert inlet and outlet not on borehole logs. Gradation analysis includes one culvert sediment sample not on borehole logs.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

## 4.0 SUBSURFACE CONDITIONS

### 4.1 SUBSURFACE PROFILE

The subsurface conditions observed in the Stantec boreholes are presented in detail on the Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided.

In general, the subsurface stratigraphy consisted of asphalt, over sand fill with varying amounts of gravel and silt, over an organic soil layer, underlain by sand and silt deposits.

A borehole location plan and profile with stratigraphic sections of the soil encountered within the boreholes is provided on Drawing No. 1 in Appendix A.

### 4.1.1 Pavement Structure

A 200 mm asphalt layer was encountered in boreholes BH15-1 and BH15-2.

### 4.1.2 Fill

Fill material was encountered in boreholes BH15-1 and BH15-2 beneath the asphalt. The fill was variable and consisted of brown gravel with sand, to sand with varying amounts of gravel and silt, to silty sand, to sandy silt. The fill was approximately 5.6 m thick and extended to an elevation of 306.1 m in borehole BH15-1 and was 5.1 m thick extending to elevation 306.5 in borehole BH15-2.

The Standard Penetration Test (SPT) N-values observed within the fill ranged from 5 to more than 50 blows per 0.3 m suggesting a loose to very dense state. It is noted that the high N-values were directly beneath the asphalt layers and that below a depth of about 0.8 m, the values ranged from 5 to 22.

Moisture content and grain size distribution tests carried out on representative samples of the fill yielded the following results:

Gravel:	0 to 19%
Sand:	41 to 89%
Silt and Clay:	8 to 59%
Moisture content:	8 to 20%

The grain size distribution curves for the fill layer are provided in Figure No. 1 of Appendix C.

### 4.1.3 Organic Soil

A layer of organic soil was encountered in boreholes BH15-1 and BH15-2 beneath the fill material. The organic soil contained wood.

The organic soil had a thickness of 0.9 m and 0.6 m in boreholes BH15-1 and BH15-2 respectively.

The Standard Penetration Test (SPT) N-values observed within the organic soil ranged from 0 to 8 blows per 0.3 m suggesting a very loose to loose state.

### 4.1.4 Sand

A sand layer with varying amounts of gravel and silt was encountered in borehole BH15-2 beneath the organic soil. The sand deposit contained some organic soil and wood directly beneath the organic soil layer. The borehole was terminated within the sand deposit at a depth of 10.5 m at elevation 301.3 m.

The SPT N-values for this deposit ranged from 5 to 17 blows per 0.3 m suggesting a loose to compact state.



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Moisture content and grain size distribution tests carried out on representative samples of the sand yielded the following results:

Gravel:	4%
Sand:	92%
Silt size:	4%
Clay size:	0%
Moisture Content:	16 to 21%

The grain size distribution curve for the sand material is provided in Figure No. 2 of Appendix C.

### 4.1.5 Silty Sand

A silty sand layer was encountered in borehole BH15-1 below the organic soil. The borehole was terminated in the silty sand deposit at a depth of 10.5 m at elevation 301.4 m.

The SPT N-values for this deposit ranged from 1 to 18 blows per 0.3 m suggesting a very loose to compact state.

Moisture content and grain size distribution tests carried out on representative samples of the silty sand yielded the following results:

Gravel:	0%
Sand:	67%
Silt size:	33%
Clay size:	0%
Moisture Content:	20 to 24%

The grain size distribution curve for the silty sand material is provided in Figure No. 2 of Appendix C.

### 4.1.6 Groundwater

The inferred groundwater levels in the boreholes at the time of drilling are provided in Table 4.1 below. The groundwater levels are approximately at the depth of the creek water level.

**Table 4-1: Inferred Groundwater Levels**

Borehole No.	Observation/Measurement Date	Groundwater Depth (m)	Ground Surface Elevation(m)	Groundwater Elevation (m)
BH15-1	May 21, 2015	5.2 (inferred)	311.9	306.7
BH15-2	May 21, 2015	5.2 (inferred)	311.8	306.6

Fluctuations in the groundwater due to seasonal variations or in response to a particular precipitation event should be anticipated.

## **5.0 SITE RECONNAISSANCE**

A site visit was carried out on May 14, 2015, by Zachary Popper, P.Eng., of Stantec to observe the condition of the culvert and the soil sediment inside the culvert. Photographs from the site visit can be found in Appendix A. Soil samples were collected from the interior of the culvert, the creek bed, and beside the creek by hand auger and shovel. The following observations were made during the site visit:

### **West Side – Culvert Inlet**

- The creek bed consists of poorly graded sand with gravel, cobbles and boulders.
- The groundwater level is 0.3 m above the culvert invert and 0.6 m above the creek bottom.
- Inside the culvert at the inlet there is a 25 mm to 150 mm thick layer of sand sediment on the south side of the culvert. The sand sediment layer varies from 0.3 m to 1.0 m wide from the south edge of the culvert.
- Cobbles and boulders are present approximately 5 m into the culvert from the inlet.
- The surface of the slope from Highway 11 to the culvert inlet consists of sand, gravel, cobbles and boulders (see Photo No. 3).
- There is evidence of concrete and stone wall deterioration including fallen concrete, loose stone fragments and deterioration of walls in the middle-west area of the culvert (see Photo No. 6, No. 9, No. 10 and No. 11).

### **East Side – Culvert Outlet**

- The creek bed consists of sand, gravel, and frequent cobbles and boulders at the culvert outlet (see Photo No. 8).
- The water level is 0.3 m above the culvert outlet.
- The water level is 50 mm above the creek bed on the south side of the culvert to 300 mm above creek bed on the north side.
- 3 m into the culvert from the outlet there are frequent boulders and sand sediment on the south half of the width of the culvert. Wood branches are also present (see Photo No. 8).
- Sand, gravel, cobbles and boulders are present on the slope from Highway 11 to the culvert outlet; frequent boulders are evident on the slope to the south side of culvert (see Photo No. 4).

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The table below summarizes soil samples taken from the interior of the culvert, the creek bed, and beside the creek by hand auger and by shovel:

**Table 5-1: Soil Samples at Culvert Inlet and Outlet**

Sample Number	Depth (m)	Hand Auger or Shovel Sample	Location of Sample	Soil Type
GS1	0 - 0.30	Shovel	Creek bed at culvert inlet	Brown poorly graded SAND (SP) with gravel, cobbles and boulders
GS2	0 - 0.15	Shovel	Soil sediment from culvert interior at inlet	Brown poorly graded SAND (SP)
GS3	0 - 0.30	Hand Auger	1 m west, 1 m north of culvert inlet, adjacent to creek	Brown organic soil (OL) with sand
GS4	0 - 0.20	Hand Auger	1 m west, 1 m south of culvert inlet, adjacent to creek	Brown organic soil (OL) with silty sand
GS5	0 - 0.10	Shovel	Soil sediment from culvert interior at outlet	Brown poorly graded SAND (SP) with silt and gravel
GS6	0 - 0.30	Shovel	Creek bed at culvert outlet	Brown poorly graded SAND (SP) with frequent gravel and cobbles
GS7	0 - 0.76	Hand Auger	1 m east, 1 m north of culvert outlet, adjacent to creek	Brown poorly graded SAND (SP) with organic soil

Moisture content and grain size distribution tests carried out on representative samples from the above table yielded the following results:

Gravel:	17%
Sand:	78%
Silt:	5%
Clay:	0%
Moisture Content:	8 to 47%

The grain size distribution curve for the sand sediment from the interior of the culvert is provided in Figure No. 2 of Appendix C.

## **6.0 MISCELLANEOUS**

The field work was carried out under the supervision of Zachary Popper, P.Eng., under the direction of Christopher McGrath., P.Eng.

USL-1 Underground Service Locators Inc. of Ottawa, Ontario, carried out the public utility locates for the boreholes.

The rubber tire CME 550 drilling equipment was supplied and operated by Landcore Drilling of Chelmsford, Ontario on May 21, 2015.

Elevation and location survey of the borehole locations was carried out by Stantec personnel.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory.

This report was prepared by Zachary Popper, and reviewed by Christopher McGrath and Raymond Haché, MTO Designated Principal Contact.

## 7.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectfully Submitted;

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# FOUNDATION INVESTIGATION AND DESIGN REPORT

February 2016

## FOUNDATION DESIGN REPORT

For

G.W.P 5144-06-00

Geocres No. 41L-189

Chippewa Creek Culvert Rehabilitation,  
Site No. 46-362, Highway 11  
North Bay, Ontario

## 8.0 GENERAL BACKGROUND

### Project Purpose/Justification

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to complete a foundation investigation of the Chippewa Creek Culvert on Highway 11 at Station 14+577, north of North Bay, Ontario. The foundation investigation is required to support the design for the rehabilitation of the Chippewa Creek Culvert. Specifically, a stone wall section of the culvert is failing and it is proposed to build a new concrete box liner to rehabilitate the poor performing section. The results of the foundation investigation and the geotechnical engineering recommendations for the rehabilitation of the culvert are presented in this report.

### Proposed Rehabilitation

The existing culvert is a combination of precast concrete box culvert, concrete culvert, and concrete slab with stone walls. The 5.0 m middle portion consisting of concrete slab with stone wall is the major poor performing area of the culvert. The culvert has a width of 3.0 m and a total length of 45.7 m. The culvert is covered with approximately 3.0 m of fill. The approximate alignment of the existing culvert is shown on Drawing No. 1 in Appendix A.

The proposed rehabilitation of the culvert involves relining the poor performing middle portion of the culvert, repairing deteriorated concrete for the remainder of the culvert, installing concrete lining at the streambed within the open bottom portions of the culvert, adding stone walls at the culvert inlet and providing rock protection at both ends of the culvert.

The middle portion of the existing culvert is shown on Section 2 on Drawing P1 provided in Appendix A. The concrete slab is depicted to rest on stone and mortar foundations which have been partially eroded by the creek flow. The stone and mortar foundations are approximately 0.75 m wide at the top and 1.3 m wide at the base. It is estimated that the footing embedment depth inside the culvert, below the streambed, is 1.8 m. The proposed rehabilitation includes the placement of a reinforced cast-in-place concrete box with a top of floor about 1.7 m above the underside of the existing stone and mortar foundation.

Construction Staging & Detours

The use of wellpoints is anticipated to be required at the site. Partial road closure of Highway 11 will be required to install the anticipated well points on the north and south sides of the culvert. The use of traditional wellpoints would likely require trench excavation in the road to approximately 2 m depth to install the wellpoint header pipe at a lower elevation. Construction staging would likely include closure of one side of the road at a time (northbound lanes or southbound lanes) for the installation of wellpoints.

## 9.0 ENGINEERING RECOMMENDATIONS

### 9.1 GEOTECHNICAL DESIGN PARAMETERS

The soil conditions at this site generally consisted of asphalt, over sand and gravel fill, over an organic soil layer, over sand and silt deposits, underlain by bedrock.

For design purposes, the following soils profile will be used:

**Table 9-1: Geotechnical Model for Culvert**

Approximate Elevation		Soil Type	Design Properties
From	To		
311.7	306.1	FILL: sand with silt and gravel to silty sand to sandy silt	Total Unit Weight = 22 kN/m <sup>3</sup> Friction Angle, $\phi$ = 30° E' = 10 MPa
306.1	305.2	ORGANICS	Total Unit Weight = 18 kN/m <sup>3</sup>
305.2	301.4	Poorly Graded SAND to Silty SAND	Total Unit Weight = 20.5 kN/m <sup>3</sup> Friction Angle, $\phi$ = 30° E' = 10 MPa

A design water level elevation of 306.7 m will be considered for the culvert site.

### 9.2 CULVERT REHABILITATION

The proposed scope of work for the rehabilitation of the culvert is as follows:

1. Install a concrete lining within the middle portion of the culvert to address the condition of the stone and mortar foundation walls
2. Provide a temporary support system to shore the top slab of the original middle portion of the culvert during construction
3. Repair deteriorated concrete for the remainder of the culvert
4. Install a concrete lining at the streambed within the open bottom portions of the culvert
5. Add stone walls at the inlet to improve efficiency of hydraulic performance
6. Provide rock protection at both ends of the culvert

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The dimensions and preliminary proposed rehabilitation of the culvert are shown in Drawing No. P1 in Appendix A. Special construction measures will be required for the culvert rehabilitation due to confined space of the interior of the culvert.

### 9.2.1 Foundations

Assuming the organic soil layer and any organic material (that is approximately at the elevation of the creek) was removed when the culvert was placed, the existing soils will provide a suitable bearing for the culvert rehabilitation. The concrete lining can be designed with the resistances outlined in Table 9.2.

**Table 9-2: Bearing Resistances for Shallow Foundations**

Bearing Surface	Footing Length (m)	Footing Width (m)	Founding Depth Below Streambed (m)	Geotechnical Resistances (kPa)	
				ULS	SLS
Poorly Graded Sand to Silty Sand	6.0	1.0	1.8	250	135
Poorly Graded Sand to Silty Sand	6.0	2.0	1.8	275	110
Poorly Graded Sand to Silty Sand	6.0	3.0	1.8	300	100
Poorly Graded Sand to Silty Sand	46.0	3.0	1.8	300	100

The factored bearing resistance at Ultimate Limit States (ULS) includes a resistance factor of 0.5. The bearing resistance at Serviceability Limit States (SLS) corresponds to the load that results in 25 mm of post-construction settlement; it is noted that the existing footings within the middle portion have previously undergone settlements associated with the embankment fill loads and very little new settlements should be expected as a result of the proposed modifications. The SLS values presented above correspond to the serviceability geotechnical resistance of a new footing.

The base of the working surface for the concrete liner should be examined by a geotechnical inspector prior to placing concrete. The engineer will confirm that the soils are consistent with those observed in the boreholes and will ensure that there is no loose or deleterious material present. All deleterious objects, soil sediment (including disturbed sand, loss cobbles, and boulders), fallen stone, deteriorated concrete, organic material and groundwater should be removed from the working surface prior to the placement of concrete. Any loose or disturbed material identified during the inspection will require removal to the satisfaction of the geotechnical inspector. Where construction is undertaken during winter conditions, the working surface subgrade should be protected from freezing and culvert walls should be protected against heave due to soil adfreeze.



### 9.2.2 Seismic Design Considerations

In general, the subsurface stratigraphy consists of asphalt, over sand fill with varying amounts of gravel and silt, over an organic soil layer, over sand and silt deposits, underlain by bedrock.

#### 9.2.2.1 Seismic Soil Profile Type

A Soil Profile Type I as defined in the Canadian Highway Bridge Design Code (CHBDC, 2006) Section 4.4.6 is recommended for seismic design.

For reference, the zonal acceleration ratio,  $A$ , for the North Bay area is 0.10 based on Table A3.1.1, of the Canadian Highway Bridge Design Code (CHBDC).

## 9.3 TEMPORARY PROTECTION SYSTEMS

A temporary support system installed inside the culvert is proposed to shore the original top slab of the middle portion of the culvert. Special construction measures will be required for this shoring system due to confined space of the culvert interior. Temporary shoring is addressed in Section 9.7.

As discussed in Section 9.9, unwatering of the inside of the culvert and an advanced dewatering scheme will be required for the installation of the temporary support system within the culvert. The use of well points is the preferred dewatering method and will require excavation to about 2m below the roadway surface to install header pipes. Excavation for the installation of a well point system would be within the sand to silty sand embankment fill material and at least 2 m above the groundwater level. Therefore, an open excavation with 1H:1V sideslopes would be appropriate.

A 1 m buffer should be provided between the end of the excavation for the well point system and the travelled portion of the road to be maintained. If there is not sufficient space to accommodate a 1 m buffer and a 1H:1V open excavation adjacent to the travelled roadway, a roadway protection system parallel to the Highway 11 centerline may be required to implement the dewatering system.

If required, roadway protection design should meet OPSS requirements and should consider traffic loading.

If required, roadway protection design should meet the requirements of Performance Level 2 as per OPSS 539 and should consider traffic loading. Performance Level 2 specifies a Maximum Angular Distortion of 1:200 and a Maximum Horizontal Displacement of 25 mm. Pile and raker spacing must be designed not to exceed these limits. Horizontal movement should be monitored throughout the construction process as described in OPSS 539. The monitoring requirements outlined in OPSS 539 are considered to be appropriate for this project.

### 9.3.1 Lateral Earth Pressures

#### 9.3.1.1 Lateral Earth Pressures under Static Conditions

Earth pressures will need to be considered during the rehabilitation of the culvert.

Computation of earth pressures should be in accordance with Section 6.9 of the CHBDC and the Occupational Health and Safety Act Regulation for Construction Projects. The distribution of earth pressures acting on the protection system could be estimated using the Canadian Foundation Engineering Manual. For retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design. The unfactored soil parameters provided in Table 9.1 may be used for design of walls and protection systems with a horizontal backfill. The effects of compaction should be accounted for by applying a compaction surcharge as shown in Figure 6.6 of the CHBDC.

Values for  $K_a$ ,  $K_o$ ,  $K_p$ , and  $\gamma$  are provided in Tables 9.3 and 9.4 for horizontal and 2V:1H backfill.

**Table 9-3: Recommended Non-Seismic Earth Pressure Parameters (Horizontal Backfill)**

Parameter	OPSS Gran A and Gran B Type II	Existing FILL	Poorly Graded Sand to Silty Sand
Bulk Unit Weight, $\gamma$ (kN/m <sup>3</sup> )	22	22	20.5
Effective Friction Angle	35°	30°	30°
Coefficient of Earth Pressure at Rest ( $K_o$ )	0.43	0.50	0.50
Coefficient of Active Earth Pressure ( $K_a$ )	0.27	0.33	0.33
Coefficient of Passive Earth Pressure ( $K_p$ )	3.69	3.00	3.00

**Table 9-4: Recommended Non-Seismic Earth Pressure Parameters (2H:1V Backfill)**

Parameter	OPSS Gran A and Gran B Type II	Existing FILL	Poorly Graded Sand to Silty Sand
Bulk Unit Weight, $\gamma$ (kN/m <sup>3</sup> )	22	22	20.5
Effective Friction Angle	35°	30°	30°
Coefficient of Earth Pressure at Rest ( $K_o$ )	0.43	0.50	0.50
Coefficient of Active Earth Pressure ( $K_a$ )	0.39	0.53	0.53
Coefficient of Passive Earth Pressure ( $K_p$ )	10.78	7.44	7.44

## 9.4 EMBANKMENTS

The roadway profile at the culvert location will not be raised above the existing profile.

### **9.4.1 Stability of Slopes**

No sign of embankment instability was observed during the foundation drilling. Stantec is not aware of a history of slope instabilities at the culvert location.

### **9.4.2 Embankment Settlement**

The profile and footprint of the existing embankment is not anticipated to be significantly altered.

Settlement of the underlying soil is anticipated to be less than 25 mm.

## **9.5 EROSION AND SCOUR PROTECTION**

All slopes within 2 m of the culvert inlets and outlets should be surfaced with rip-rap at least 300 mm thick placed on a Class II non-woven filter fabric.

The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site.

## **9.6 CONSTRUCTION STAGING**

The use of wellpoints is anticipated to be required at the site. Partial road closure of Highway 11 will be required to install the anticipated well points on the north and south sides of the culvert. The use of traditional wellpoints would likely require trench excavation in the road to approximately 2 m depth to install the wellpoint header pipe at a lower elevation; roadway protection as discussed in Section 9.3 would likely need to be implemented. Construction staging would likely include closure of one side of the road at a time (northbound lanes or southbound lanes) for the installation of wellpoints.

The anticipated requirement to construct a trench for the installation of suction well-points reflects the practical suction height of 4.5 m for this type of dewatering system. An alternative approach would consist of using induction well-points which can be used to effectively remove water to depths of over 50 m. The use of induction well-points would eliminate the requirement of trenching and the associated roadway protection. Generally, the cost of induction well-points is twice that of suction well-points.

## **9.7 TEMPORARY SHORING**

The use of temporary shoring is being proposed to support the existing culvert ceiling while the refacing repair work is being carried out on the existing stone and mortar foundations. The culvert section where the temporary shoring is proposed is 5 m in length.

The contractor will be responsible to design the temporary shoring supports based on the equipment he proposes to use. The following geotechnical bearing resistances would be considered appropriate for the case where well-points have been used to lower the water table

to at least 0.5 m below the footing support level and that the footing support is resting at the surface of the prepared surface where all loose streambed material is removed.

**Table 9-5: Bearing Resistances for Temporary Shoring**

Footing Support Size	Geotechnical Resistance (kPa)	
	ULS	SLS
1 m x 1 m	40	N/A
1 m x 2 m	50	N/A
1 m x 3 m	50	N/A
2 m x 2 m	60	N/A
3 m x 3 m	70	N/A

The low ULS values reflect the loose nature of the sand, the lack of footing embedment for the temporary footing support, and the high water table for the case where the water table is lowered to only 0.5 m below the underside of the footings.

The SLS geotechnical resistances are identified as non-applicable since the shoring supports are anticipated to be adjustable and the shoring members would be lengthened to accommodate any settlement.

## 9.8 EXCAVATION AND BACKFILLING

Any excavation and backfill for the culvert rehabilitation should be carried out in accordance with:

- OPSS 902
- OPSD 802 Series for Pipe Culverts
- OPSD 803 Series
- OPSS.PROV 501
- OPSS.PROV 1010

Bedding and backfill material should be provided for the culvert as per the appropriate OPSD specification. OPSS Granular A is recommended as a pipe bedding and backfill material. A minimum bedding thickness of 150 mm is recommended. Where additional material is excavated to remove exposed organic or disturbed materials, the backfill material should also consist of OPSS Granular A. OPSS Granular A should meet OPSS.PROV 1010 and should be placed and compacted as per OPSS.PROV 501.

Side slopes for open cut excavations (if any) should conform to Occupational Health and Safety Act (OHSA) regulations for Construction Projects. The soils encountered at the site may be classified as Type 3 Soil. The excavation walls should be sloped from its bottom with a slope having a minimum gradient of 1H:1V.

For excavations below the water level the excavation walls should be sloped from its bottom with a slope having a minimum gradient of 1.5H:1V.

## 9.9 UNWATERING AND DEWATERING

Rehabilitation of the Chippewa Creek Culvert will require work on the interior of the existing culvert where the creek water flows from west to east; the groundwater levels observed were 0.3 m above the inverts of the culvert. Control of groundwater during construction is required for the installation of the temporary support system, the placement of a concrete lining at the streambed and for the relining of the original middle portion of the culvert. The groundwater flowing inside the culvert should be controlled to provide a dry working area in the interior of the culvert during rehabilitation work.

The results of the grain size distribution tests (and Unified Soil Classifications) completed on the predominant soil strata encountered in the boreholes have been compared to the Grain size curves and soil types referenced in Supplementary Standard SB-6 of the 2006 Ontario Building Code (OBC). The OBC has been used as a guideline to estimate the likely range in the coefficient of permeability of the soils encountered in the investigation. It is noted that the industry typically refers to "hydraulic conductivity" rather than "coefficient of permeability" in this respect. The terms are often considered interchangeable, but for purposes of this report the values provided are in the form of length/time" (cm/sec) and are therefore considered strictly applicable to "hydraulic conductivity" as used herein.

Based on the comparison conducted, the following Values are provided:

<u>Soil Type</u>	<u>Estimated Hydraulic Conductivity</u>
• Poorly graded sand (SP)	$10^{-2}$ to $10^{-3}$ cm/sec
• Silty sand (SM)	$10^{-3}$ to $10^{-5}$ cm/sec

The OBC states, in part, that "it must be emphasized that, particularly for fine grained soils, there is no consistent relationship (between coefficient of permeability and soils of various types) due to the many factors involved". Such factors as structure, mineralogy, density (compactness or consistency), plasticity, and organic content of the soil can have a large influence on the hydraulic conductivity; variations in excess of an "order of magnitude" are common place in this respect.

The use of well points is anticipated to be required at the site. The use of traditional suction well points would likely require trench excavation in the road to approximately 2 m depth to install the well point header pipe at a lower elevation, to reduce the suction height to the maximum practical limit of 4.5 m. Induction well-points could also be considered which have significantly greater application depths, but are generally considered to be double the cost of suction well-points. The use of well-points requires partial road closure for the duration of the construction.

For stream flow control at the site, it is anticipated that a sheet-piled cutoff wall will be used and that the water will be pumped across Highway 11. Given the highly permeable nature of the sands encountered on site, the use of an Aquadam type system would need to consider the potential for erosion piping beneath the temporary dam.

## 10.0 SPECIFICATIONS

The following specifications are referenced in this report:

**Table 10-1: Specifications Referenced in Report**

Document	Title
OPSD 3090.101	Foundation, Frost Depths for Southern Ontario
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 902	Construction Specification for Excavation and Backfilling – Structures
OPSD 802 Series	Various
OPSD 803 Series	Various
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material

## 11.0 REFERENCES

ASTM. 1999. Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). ASTM International, West Conshohocken, PA.

ASTM. 2000. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) (ASTM D2487). ASTM International, West Conshohocken, PA.

CHBDC. 2006. Canadian Highway Bridge Design Code. Canadian Standards Association, Mississauga, Ontario.

## FOUNDATION INVESTIGATION AND DESIGN REPORT

February 2016

### 12.0 CLOSURE

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

This report was prepared by Zachary Popper, and reviewed by Christopher McGrath and Raymond Haché, Designated Principal MTO Foundation Contact.

Respectfully submitted,

**STANTEC CONSULTING LTD.**



Zachary Popper, P.Eng.  
Geotechnical Engineer



Christopher McGrath, P.Eng.  
Associate- Senior Geotechnical Engineer



Raymond Haché, M.Sc., P.Eng.  
Designated Principal MTO Foundation Contact



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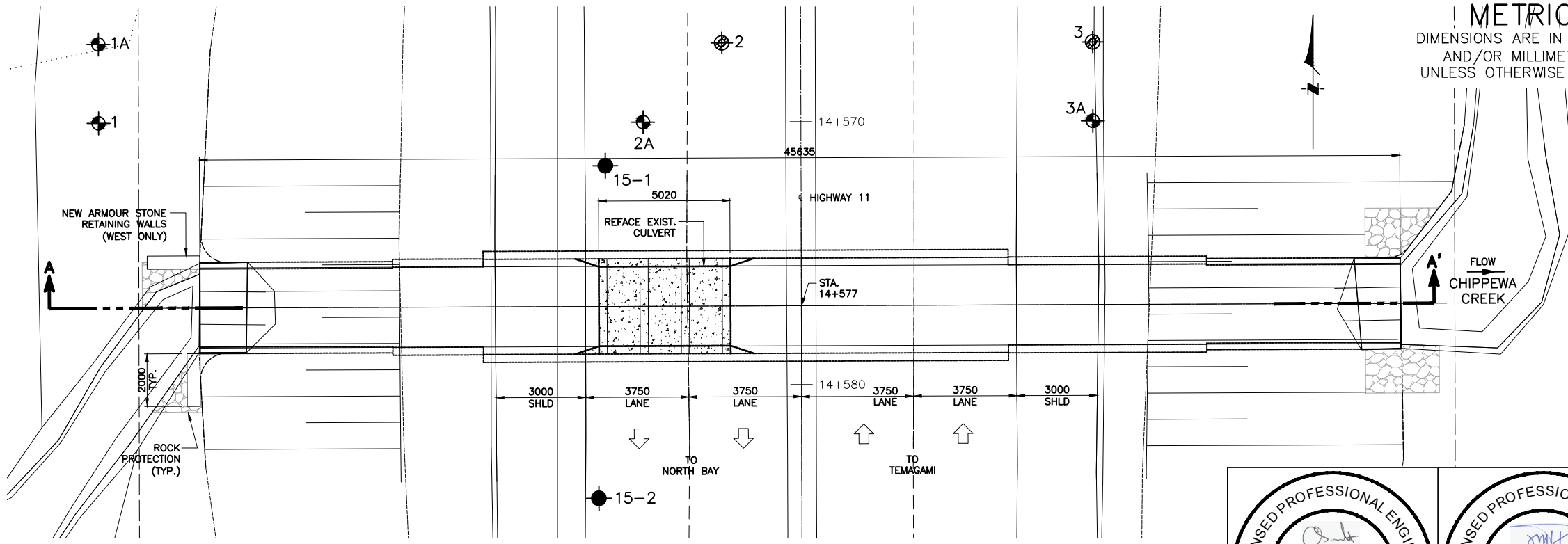
## **APPENDIX A**

Drawing No. 1 – Borehole Location Plan and Soil Strata Plot

Drawing No. P1 – Chippewa Creek Culvert Rehabilitation Preferred Plan

Site Photos



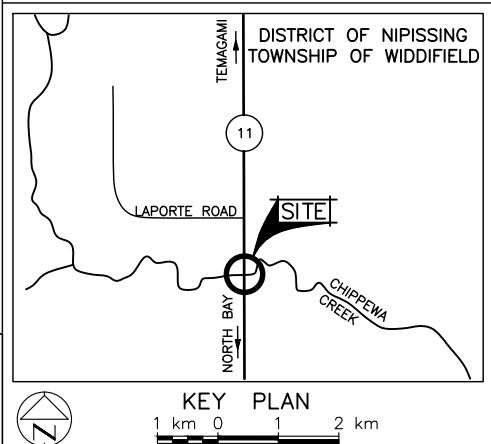


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

PLATE No  
**CONT**  
**WP** 5144-06-00

HWY 11 CHIPPEWA CREEK  
CULVERT AT 14+577  
BOREHOLE LOCATIONS & SOIL STRATA

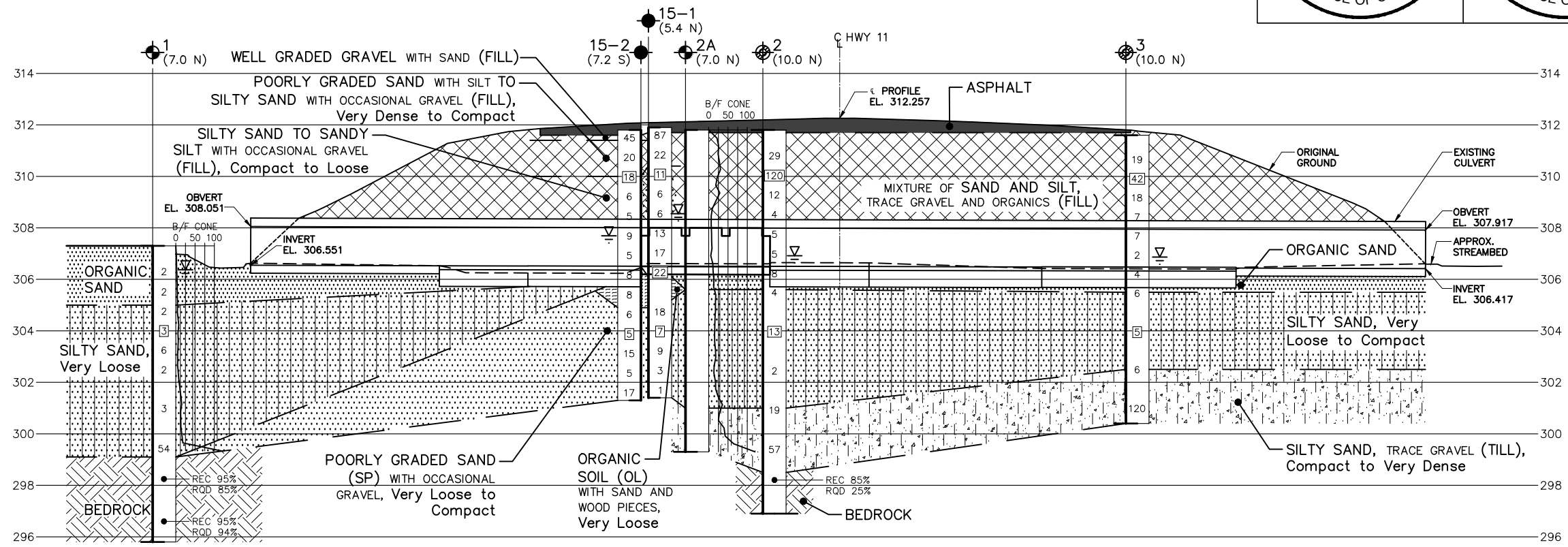
**SHEET**



LICENSED PROFESSIONAL ENGINEER  
C. McGRATH  
2016/02/23  
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER  
J.G.A.R. HACHÉ  
2016/02/23  
PROVINCE OF ONTARIO

PLAN  
SCALE  
2 m 0 2 4 m



LEGEND

Borehole  
(Locations are approximate based on Memorandum File No. 3162-2-4-113 issued By MTO, Soils and Aggregates Section, Engineering Materials office, Central Building, Room 311, dated 96/07/04.)

Existing Borehole & Cone  
N Blows/0.3m (Std Pen Test, 475 J/blow)  
CONE Blows/0.3m (60° Cone, 475 J/blow)

WL at time of investigation May 2015 & June 1995

(x.x N/S) Offset in metres, North or South of Cross Section Line A-A'

No	ELEVATION	MTM XONE 10	COORDINATES EAST
15-1	311.9	5 136 651.2	307 401.8
15-2	311.8	5 136 638.5	307 401.6
1	307.3	5 136 652.8	307 382.6
1A	307.3	5 136 655.8	307 382.5
2	311.8	5 136 655.9	307 406.2
2A	311.8	5 136 652.8	307 403.3
3	311.6	5 136 655.9	307 420.3
3A	311.6	5 136 652.9	307 420.4

NOTES

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

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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

REVISIONS

DATE	BY	DESCRIPTION

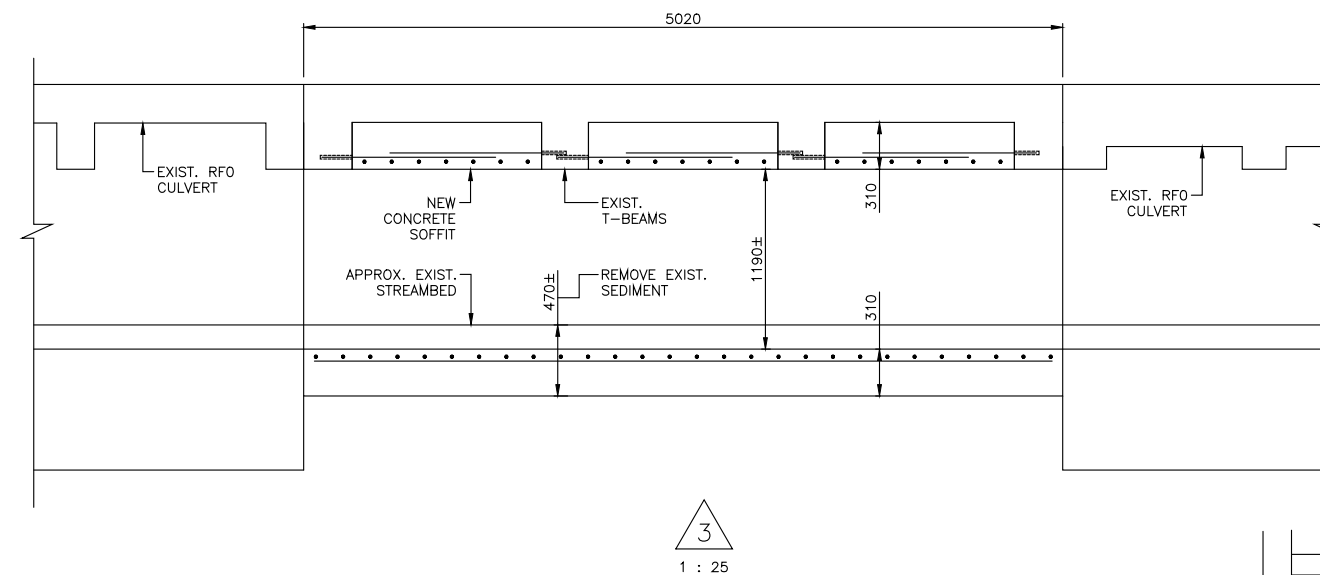
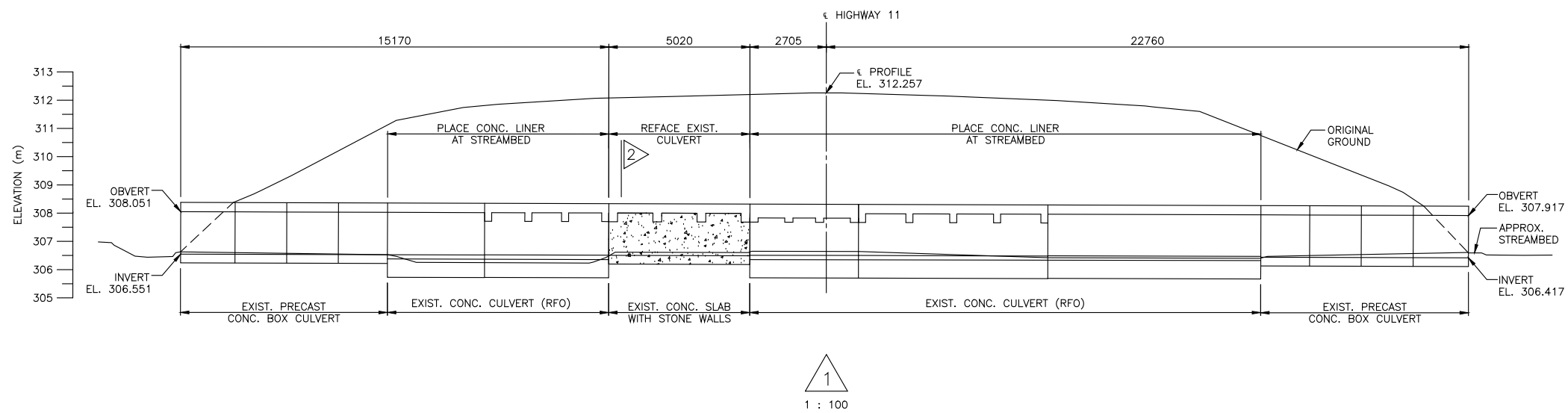
GEOCRES No 41L-189

HWY No HWY 11	DIST
SUBM'D	CHECKED
DATE 2015-06-23	SITE
DRAWN GBB	CHECKED
APPROVED	DWG 1

HWY 11	
CONT	
WP 5144-06-00	



SHEET



REVISIONS								
	DATE	BY	DESCRIPTION					
DESIGN	CHK		CODE CHBDC-2006	LOAD CL-625-ONT	DATE	MAR	2014	
DRAWN	A.P.	CHK M.T.	SITE 43-362/C	STRUCT	SCHEME	DWG.	P1	



Photo No. 1: Highway 11 looking south. Approximate borehole locations are painted on the asphalt.



Photo No. 2: Highway 11 looking south at culvert location.





Photo No. 3: Culvert inlet, west side of Highway 11.



Photo No. 4: Culvert outlet, east side of Highway 11 showing rock fill on slope.





Photo No. 5: Culvert inlet, west side of Highway 11.



Photo No. 6: Interior of culvert looking east.





Photo No. 7: Interior of culvert looking west.



Photo No. 8: Culvert outlet, showing creek bed and sediment in culvert.





Photo No. 9: Deterioration of stone wall and concrete in middle-west section of culvert.



Photo No. 10: Deterioration of stone wall and concrete in middle-west section of culvert.



Photo No. 11: Deterioration of stone wall and concrete in middle-west section of culvert.



## **APPENDIX B**

Symbols and Terms Used on Borehole Records

Borehole Records

## SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

### SOIL DESCRIPTION

#### Terminology describing common soil genesis:

<i>Rootmat</i>	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

#### Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- > 75 mm in thickness
<i>Seam</i>	- 2 mm to 75 mm in thickness
<i>Parting</i>	- < 2 mm in thickness

#### Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

#### Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 20%

#### Terminology describing compactness of cohesionless soils:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>50

#### Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25 - 0.5	12.5 - 25	2-4
<i>Firm</i>	0.5 - 1.0	25 - 50	4-8
<i>Stiff</i>	1.0 - 2.0	50 - 100	8-15
<i>Very Stiff</i>	2.0 - 4.0	100 - 200	15-30
<i>Hard</i>	>4.0	>200	>30

## ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

### Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	<i>Very Poor Quality</i>
25-50	<i>Poor Quality</i>
50-75	<i>Fair Quality</i>
75-90	<i>Good Quality</i>
90-100	<i>Excellent Quality</i>

Alternate (Colloquial) Rock Mass Quality	
<i>Very Severely Fractured</i>	<i>Crushed</i>
<i>Severely Fractured</i>	<i>Shattered or Very Blocky</i>
<i>Fractured</i>	<i>Blocky</i>
<i>Moderately Jointed</i>	<i>Sound</i>
<i>Intact</i>	<i>Very Sound</i>

**RQD (Rock Quality Designation)** denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

**SCR (Solid Core Recovery)** denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

**Fracture Index (FI)** is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

### Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	<i>Extremely Wide</i>	-
2000-6000	<i>Very Wide</i>	<i>Very Thick</i>
600-2000	<i>Wide</i>	<i>Thick</i>
200-600	<i>Moderate</i>	<i>Medium</i>
60-200	<i>Close</i>	<i>Thin</i>
20-60	<i>Very Close</i>	<i>Very Thin</i>
<20	<i>Extremely Close</i>	<i>Laminated</i>
<6	-	<i>Thinly Laminated</i>

### Terminology describing rock strength:

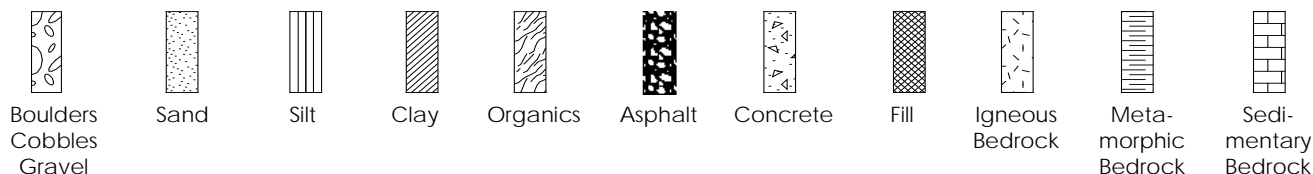
Strength Classification	Grade	Unconfined Compressive Strength (MPa)
<i>Extremely Weak</i>	R0	<1
<i>Very Weak</i>	R1	1 – 5
<i>Weak</i>	R2	5 – 25
<i>Medium Strong</i>	R3	25 – 50
<i>Strong</i>	R4	50 – 100
<i>Very Strong</i>	R5	100 – 250
<i>Extremely Strong</i>	R6	>250

### Terminology describing rock weathering:

Term	Symbol	Description
<i>Fresh</i>	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
<i>Slightly</i>	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
<i>Moderately</i>	W3	Less than half the rock is decomposed and/or disintegrated into soil.
<i>Highly</i>	W4	More than half the rock is decomposed and/or disintegrated into soil.
<i>Completely</i>	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
<i>Residual Soil</i>	W6	All the rock converted to soil. Structure and fabric destroyed.

## STRATA PLOT

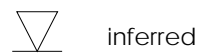
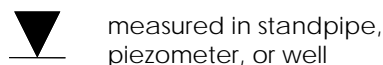
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



## SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

## WATER LEVEL MEASUREMENT



## RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

## N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

## DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

## OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
$\gamma$	Unit weight
$G_s$	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
$Q_u$	Unconfined compression
$I_p$	Point Load Index ( $I_p$ on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

# RECORD OF BOREHOLE No BH15-1

1 OF 1

METRIC

W.P. GWP 5144-06-00 LOCATION Hwy 11 Chippewa Creek Culvert, North Bay, ON N: 5 136 651 E: 307 402 ORIGINATED BY ZP  
DIST                      HWY 17B BOREHOLE TYPE NW Casing, Splitspoon Sampler COMPILED BY ZP  
DATUM Geodetic DATE 2015 05 21 - 2015 05 21 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>					
						○ UNCONFINED      ✕ FIELD VANE ● QUICK TRIAXIAL    ✕ LAB VANE								
311.9	Asphalt							20 40 60 80 100						
311.7	200 mm ASPHALT													
310.8	FILL: brown gravel with sand		1	SS	87									
0.4	Very dense FILL: brown poorly graded sand to silty sand with gravel													
	Very dense to compact		2	SS	22		311							19 56 (25)
310.4	FILL: brown silty sand to sandy silt													
1.5	Compact to loose		3	SS	11		310							7 47 45 1
			4	SS	6									
			5	SS	6		309							

$\times^3, \times^3$ : Numbers refer to Sensitivity  $\circ$  3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH15-2

1 OF 1

METRIC

W.P. GWP 5144-06-00 LOCATION Hwy 11 Chippewa Creek Culvert, North Bay, ON N: 5 136 639 E: 307 402 ORIGINATED BY ZP  
 DIST                      HWY 17B BOREHOLE TYPE NW Casing, Splitspoon Sampler COMPILED BY ZP  
 DATUM Geodetic DATE 2015 05 21 - 2015 05 21 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			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>		GR	SA	SI	CL	
311.8 0.0	Asphalt					▽															
311.8 0.0	200 mm ASPHALT																				
311.8 0.4	FILL: brown gravel with sand		1	SS	45														3	89	(8)
	Dense FILL: brown poorly graded sand with silt to silty sand																				
	Dense to compact		2	SS	20														4	50	45 1
310.0 1.8	FILL: brown silty sand to sandy silt		3	SS	18																
	Compact to loose																				
			4	SS	6														0	47	52 1
			5	SS	5																
			6	SS	9																
			7	SS	5																
306.5 5.3	Organic soil (OL) with sand																				
	Very loose		8	SS	8																
305.9 5.9	Brown																				
	Poorly graded SAND (SP) with organic soil and wood pieces																				
	Loose		9	SS	8																
	Brown																				
304.9 6.9	Poorly graded SAND (SP)																				
	Loose to compact		10	SS	6																
	Brown																				
			11	SS	5											4	92	(4)			
			12	SS	15																
			13	SS	5																
			14	SS	17																
301.3 10.5	End of Borehole																				

Numbers refer to Sensitivity  
 ○ 3% STRAIN AT FAILURE

ONTARIO MTO STANTEC 165000836 HWY 17B NORTH BAY.GPJ ONTARIO MOT.GDT 1/18/16

# RECORD OF BOREHOLE No 1

1 OF 1 METRIC

W.P. 25-84-01 LOCATION Sta. 14+570 e/s 26.7m RT of Centreline Hwy. 11 ORIGINATED BY L.V.  
 DIST 54 HWY 11 BOREHOLE TYPE H.S. Auger, Rock Coring COMPILED BY L.V.  
 DATUM Geodetic DATE 1995 06 27 CHECKED BY T.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC UNIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID UNIT 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		20	40	60	80	100					
307.3	Natural Ground Surface															
0.0	Organic Sand Wood Particles		1	SS	2											
			2	SS	2											
305.0																
2.3	Silty Sand Very Loose		3	SS	2											
			4	SS	3											
			5	SS	6											
			6	SS	2											
			7	SS	3											
			8	SS	54											
299.1																
8.2	Bedrock		9	RC	REC 95%											RCO 85%
			10	RC	REC 94%											RCO 94%
295.8																
11.5	End of Borehole															
	NOTE: BLOW UP CONDITIONS WERE ENCOUNTERED WITHIN THE SILTY SAND DEPOSIT 'N' VALUES MAY BE DISTURBED															

## RECORD OF BOREHOLE No 1A

1 OF 1 METRIC

W.P. 25-84-01 LOCATION Sta. 14+567 o/s 26.7m RT of Centaline Hwy.11 ORIGINATED BY L.V.  
DIST 54 HWY 11 BOREHOLE TYPE HS Auger, Rock Coring COMPILED BY L.V.  
DATUM Geodetic DATE 1996 06 25 CHECKED BY T.K.

[illegible]



# RECORD OF BOREHOLE No 2

1 OF 1 METRIC

W.P. 25-84-01 LOCATION Sta. 14+567 o/s 3m RT. of Centreline Hwy. 11 ORIGINATED BY L.V.  
 DIST 54 HWY 11 BOREHOLE TYPE HS Auger, Rock Coring COMPILED BY L.V.  
 DATUM Geodetic DATE 1998 08 26 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
311.8																	
0.0	Mixture of Sand and Silt Trace Gravel Trace Organics [FH]		1	SS	29												
			2	SS	120												
			3	SS	12												
			4	SS	4												
			5	SS	5												
307.0			6	SS	5												
4.9	Organic Sand Wood Particles		7	SS	8												
305.7																	
6.2	Silty Sand Very Loose to Compact		8	SS	4												
			9	SS	13												
			10	SS	2												
301.0																	
10.8	Silty Sand Trace Gravel [TH] Very Dense		11	SS	19												
			12	SS	57												
298.8																	
13.3	Bedrock		13	RC	REC 85%												
296.9																	
14.9	End of Borehole																

# RECORD OF BOREHOLE No 2A

1 OF 1 METRIC

W.P. 25-84-01 LOCATION Sta. 14+570 e/s 6m RT. of Centreline on Hwy. 11 ORIGINATED BY L.V.  
 DIST 54 HWY 11 BOREHOLE TYPE HS Auger, Rock Coring COMPILED BY L.V.  
 DATUM Geodetic DATE 1996 06 28 CHECKED BY T.K.

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								
311.8 0.0	Probable Mixture of Sand and Silt Trace Gravel Trace Organics [Fm]												
308.9 4.9	Probable Organic Sand Wood Particles												
305.6 6.2	Probable Silty Sand												
301.0 10.8	Probable Silty Sand Trace Gravel [m]												
299.3 12.5	REFUSAL Probable Bedrock												
	End of Cone Test												

# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 25-84-01 LOCATION Sta. 14+567 s/s 11.1m LT. of Centreline Hwy. 11 ORIGINATED BY L.V.  
 DIST 54 HWY 11 BOREHOLE TYPE HS Auger, Rock Coring COMPILED BY L.V.  
 DATUM Geodetic DATE 1996 08 26 CHECKED BY T.K.

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		20	40	60	80	100					
311.8	Highway Grade															
0.0	Mixture of Sand and Silt Trace Gravel Trace Organics [Fill]		1	SS	19											
			2	SS	42											
			3	SS	18											
			4	SS	7											
			5	SS	7											
306.9			6	SS	2											
4.7	Organic Sand Wood Particles		7	SS	4											
305.5			8	SS	6											
6.1	Silty Sand Loose		9	SS	5											
302.5			10	SS	6											
9.1	Silty sand Trace Gravel [Tail] Compact to Very Dense		11	SS	120											
300.4	•REFUSAL Probable Bedrock Surface															
11.2	End of Borehole															

# RECORD OF BOREHOLE No 3A

1 OF 1 METRIC

W.P. 25-84-01 LOCATION Sta. 14+570 o/e 11.1m LT of Centaline Hwy.11 ORIGINATED BY L.V.  
 DIST 54 HWY 11 BOREHOLE TYPE HS Auger, Rock Coring COMPILED BY L.V.  
 DATUM Geodetic DATE 1996 08 27 CHECKED BY T.K.

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			20	40						60	80	100	20	40	60	80	100	25
311.6	Highway Grade																						
0.0	Probable Mixture of Sand and Silt Trace Gravel Trace Organics [FIH]																						
308.9																							
4.7	Probable Organic Sand Wood Particles																						
305.5																							
6.1	Probable Silty Sand																						
302.5																							
9.1	Probable Silty Sand Trace Gravel [TIIH]																						
	• REFUSAL Probable Bedrock																						
300.8																							
11.0	End of Cone Test																						

# **ROCK CORE DESCRIPTION** **WP 25-84-01**

Page 1 of 1

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	9	8.18-9.85	95	85	8.18-11.48	BIOTITE GNEISS, greyish orange pink to greyish red to dark grey; medium to coarse grained; strong; unweathered to slightly weathered; fractures wide to close spaced, flat to near vertical, undulating to planar, smooth to rough.
	10	9.85-11.48	94	94		
2	13	13.28-14.91	89	25	13.28-14.91	BIOTITE GNEISS, greyish orange pink to greyish red to dark grey; medium to coarse grained; strong; unweathered to slightly weathered; fractures moderate to very close spaced, flat, planar to undulating, smooth to rough.

\*CR = CORE RECOVERY

\*RQD = ROCK QUALITY DESIGNATION

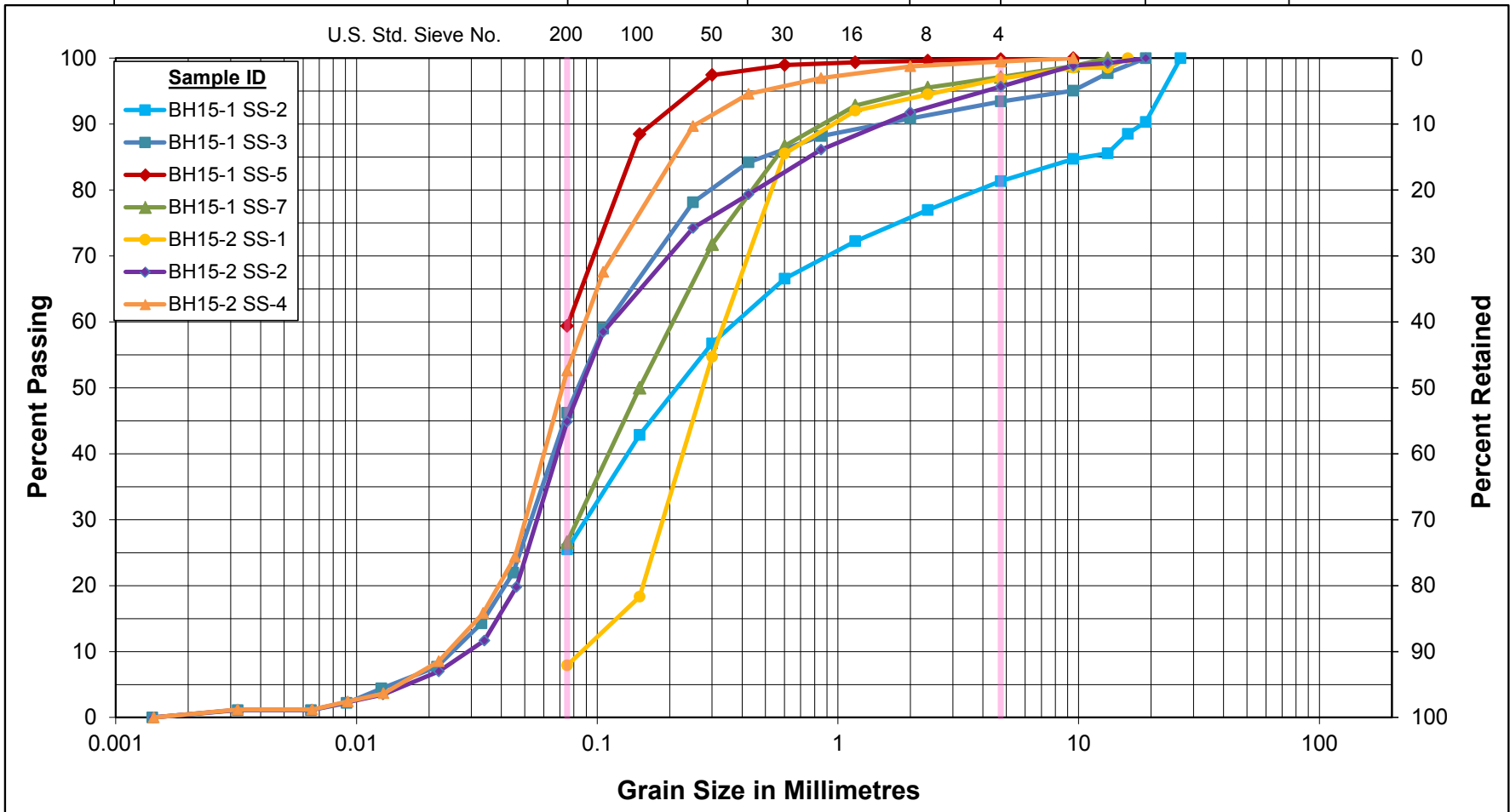
*Note: Depths are approximated where core recovery is less than 100%*  
 Logged by: DAW, Soils and Aggregates Section

## **APPENDIX C**

### Laboratory Test Results

# Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



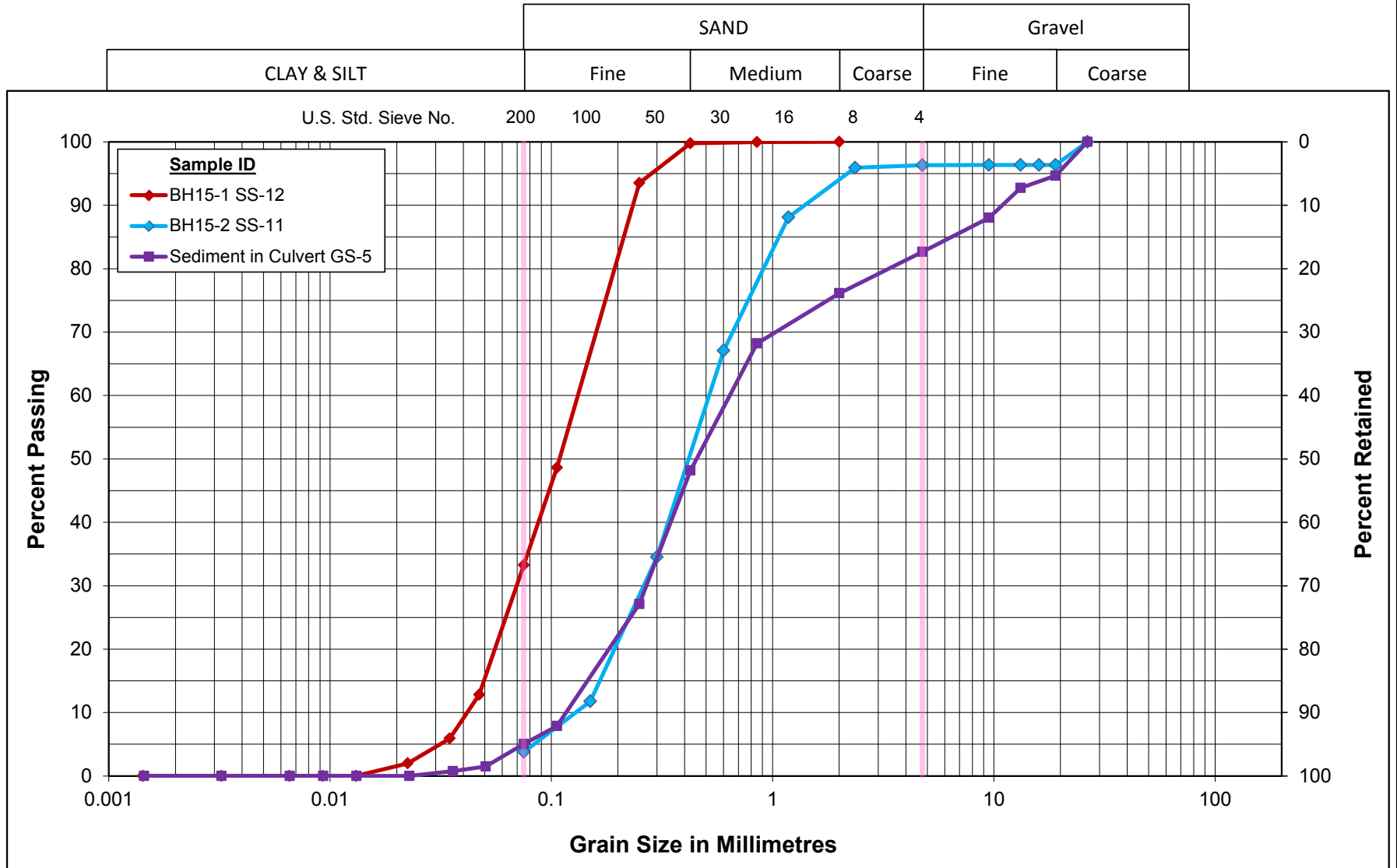
## GRAIN SIZE DISTRIBUTION

FILL: poorly graded sand with silt, silty sand with/without gravel, sandy silt

Figure No. 1

Project No. 165000836  
GWP 5144-06-00

# Unified Soil Classification System



## GRAIN SIZE DISTRIBUTION

Poorly graded SAND (SP) with/without Gravel  
and Silty SAND (SM)

Figure No. 2

Project No. 165000836  
GWP 5144-06-00